Enterprise Social Networks – Contributions to Research with respect to Actor Roles in Knowledge Management, the Role of Formal Hierarchies, and Network Evolution

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To my family and friends

And especially, to Stefan

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Katharina Wiesneth

Summary of Contents

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List of Appreviations

ECIS	European Conference on Information Systems
ESN	Enterprise Social Networks
GAF	German Armed Forces
HICSS	Hawaii International Conference on System Sciences
ICIS	International Conference on Information Systems
IS	Information System
OSN	Online Social Networks
SNA	Social Network Analysis
VHB	Verband der Hochschullehrer für Betriebswirtschaft
WWW	World Wide Web

1 Introduction

In the first subsection, a short motivation as well as the focal points of the dissertation are presented. Afterwards, in the second subsection, its research objectives are motivated. In the third subsection the underlying methodological framework is introduced. Finally, the last subsection presents the structure and content of this dissertation.

1.1 Motivation and Problem Context

In recent years, a new class of information technologies, called social media, has soared in popularity, and increasingly becomes part of people's daily lives. To date social media services have reached enormous scale and rival the traditional world wide web (WWW) in terms of usage: in July 2015, 76% of all adult internet users have actively used at least one social media service (PewResearch 2015) and forecasts expect that in 2020 the number of active users will even reach 2.95 billion people (Statista 2016a). Nowadays, there is a great variety of social media services, allowing people to connect and communicate (Bernoff and Li 2008). These can be distinguished with respect to their scope and functionality (cf. Delerue et al. 2012; Kietzmann et al. 2011). For instance, content communities like YouTube or Instagram enable to share photos and videos while microblogging services like Twitter allow users to exchange messages. In the broad field of social media, particularly online social networks (OSN), such as Facebook, LinkedIn or Google+, have become the focus of attention and evolved to a mass medium (Heidemann et al. 2012). They enable people to "stay connected with friends and family, to discover what's going on in the world, and to share and express what matters to them" (Facebook 2013).

Although originally designed for private use, an increasing number of organisations have begun to adopt social media for organisational purposes and to use it, for instance, for marketing (Kane 2015). The global social media advertising revenue is expected to grow from about USD 27 billion in 2016 to nearly USD 50 billion in 2021 (Statista 2016b). However, social media in general and OSN in particular cannot only be used for marketing purposes. Research on OSN, for instance, has dealt with word of mouth and the viral distribution of advertising messages (cf. e.g., Kumar and Mirchandani 2012; Li et al. 2012). Indeed, they can be used by a company along the whole value chain (Chui et al. 2012). Thus, the usage of OSN and other social media services and their impact on business have become of increasing interest for both research and practice (Heidemann et al. 2012; Kane et al. 2014). This includes the development of new products and the generation of new ideas using the crowd (Antorini et al. 2012; Jain 2010) or social media services as a new channel for customer services (Gunarathne et al. 2014; Storni and Griffin 2009). By posting new content and replying to customer messages, companies may, for instance, actively encourage their customers to interact with them

via OSN (Huber et al. 2012). Moreover, initial research underlines the potential of using social media in human resource management to recruit business professionals (Drake and Furner 2015; Klier et al. 2015). In addition, social media can help organisations to support communication and collaboration within the organisation and to "work more effectively across geographic and cultural boundaries" (Kane 2015, p. 1). Already in 2012, a study estimated the economic impact of social media, mostly gained from more efficient communication and collaboration between USD 900 billion and USD 1.3 trillion (Chui et al. 2012).

However, publicly available social media services cannot support all needs of an organisation, especially when used for internal processes, since they do not provide sufficient functionalities for document storage or knowledge management (Avanade 2013). Moreover, publicly available social media services also lack a proper management of access rights or the support of required privacy policies. Thus, with enterprise social networks (ESN) a new class of social media services designed for internal use has emerged. In recent years, many organisations have started implementing ESN on the one hand to foster internal collaboration, communication, and knowledge-sharing (Aral et al. 2013; von Krogh 2012) and on the other hand to strengthen social relationships among its users (Holtzblatt et al. 2013). Broadly speaking, ESN are a kind of social media service that can only be used by a selected circle, i.e. employees of a company and selected stakeholders. Although, a comparison with OSN seems most suitable, ESN also incorporate functionalities of other social media services such as microblogging services or wikis. Indeed, they facilitate at least one of six major applications: (1) Information Dissemination and Sharing, (2) Communication, (3) Collaboration and Innovation, (4) Training and Learning, (5) Knowledge Management, and (6) Management Activities, and Problem Solving (Turban et al. 2011).

Many organisations have recognized the potential of ESN with respect to the creation of competitive advantage by serving as a driving force to build effective and efficient business (Turban et al. 2011). According to Deloitte (2013), 90% of the Fortune 500 have already fully or partly implemented an ESN. This means a huge increase compared to 2011 where the percentage was about 53% (Deloitte 2013). The worldwide ESN market revenue is expected to grow from USD 1.46 billion in 2014 to USD 3.5 billion by 2019 (Thompson 2015) which accounts for an increase of more than 200%. Moreover, 71% of business leaders state that ESN increase the speed with which employees get access to knowledge within the company (McKinsey 2013).

Like research on social media in general, also research on ESN gains increasing importance. First research, for example, was conducted with respect to the creation of relationships among employees (DiMicco et al. 2009), the emergence of ESN in organisations (Riemer et al. 2012), and the motives of users voluntarily contributing knowledge and helping others

through electronic networks (Wasko and Faraj 2005). In addition, first contributions on potential benefits of ESN in the corporate realm, including, for instance, information seeking, expert finding, and opinion sharing (Richter and Riemer 2013) can also be found. Research findings also indicate that ESN foster user participation in creating web content (e.g., Holtzblatt et al. 2010; Ip and Wagner 2008) and allow new ways of interacting with other people (e.g., DiMicco et al. 2009; Zhang et al. 2010). While some topics have already been covered by prior research, vast amounts of topics have not been considered in-depth so far. In this context, calls to research different aspects of ESN can be found (cf. Richter and Bullinger 2010; Viol and Hess 2016).

Against this background, the two subject areas that this dissertation focuses on are of increasing interest to both research and practice (cf. Figure 1).

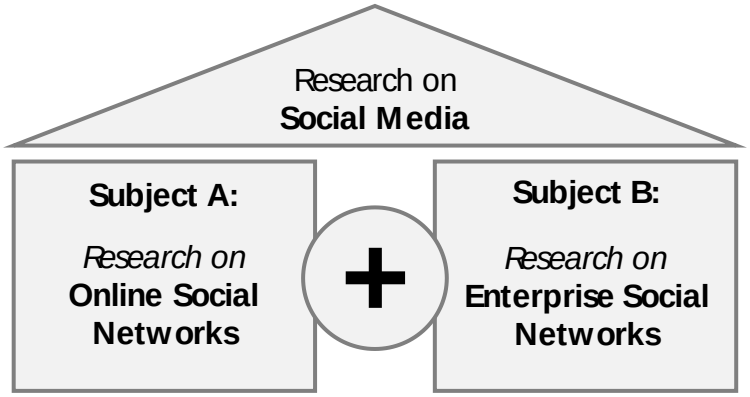

Figure 1: Overview of the Dissertation's Subjects

First, this dissertation addresses research on OSN (Subject A) as OSN are amongst the most popular and most widely used social media services. The most popular OSN Facebook counts more than 1.7 billion monthly active users (Facebook 2016). Moreover, internet users spend on average 1.72 hours per day using OSN which equates to 28% of their total time online (Social Times 2015). For one in five users OSN are the main source for up-to-date news thus replacing traditional media like television, radio, or newspapers (Bitkom 2015b). These figures illustrate how deeply OSN have penetrated people's lives and transform the ways they communicate. But also organisations have recognized the potential of OSN: 70% of German business organisations use OSN as a channel for external communication or customer service (Bitkom 2015a). Thus, OSN have gained enormous social as well as economic impact and it seems not surprising that a large number of researchers have started to explore OSN. Thus, this leads to a steadily growing number of publications in most major outlets of the global information systems (IS) community (Richter et al. 2011). To assess the knowledge and the research fields that have been predominantly addressed by the IS community so far (Scandura and Williams 2000), this dissertation aims to provide a structured literature overview on

the prior IS literature, including the recent developments in the field as well as fields that need to be addressed in further research.

Second, this dissertation aims at adding to research on ESN (Subject B). As noted, the potential of ESN for knowledge management, has been noticed by organisations and led to an increasing demand to better understand their role in knowledge practices like information seeking, knowledge sharing or expert finding (Bharadwaj et al. 2013; Herzog et al. 2013; Richter et al. 2013). Prior research found that only a few individuals receive a majority of the attention in ESN (Yardi et al. 2009). In this line of argument, there is a need to investigate different actor roles in ESN usage (Trier and Richter 2015) to better understand the role and potential of ESN as well as their users' behaviour (Koo et al. 2011), especially with respect to information diffusion and knowledge exchange (Ortbach and Recker 2014). Information dissemination (Chau and Xu 2012) and contribution behaviour (Zhang and Wang 2012) are also influenced by the emergent network structures of ESN that are also said to transform power relations and hierarchies (Bobsin and Hoppen 2013). Formal organisational hierarchy is an essential and pervasive organisational characteristic, which might influence the creation of social relations and communication in ESN. Practice-orientated contributions argue that ESN can lead to flatter organisational hierarchy in companies (McAfee 2009). However, it is still largely unanswered, whether and how formal organisational hierarchies influence users' networking behaviour in ESN and if these effects inside the ESN differ from those in the work place outside the ESN. Moreover, it has to be considered that the underlying networking structures are not static. Indeed, the structure of an ESN is highly dynamic as more and more users are participating and creating new relations to other users (Ghosh and Ganguly 2014). From the perspective of a company, it is important to know how the structure of an ESN changes in time to support the implementation of ESN or the identification of key users. While the evolution of other social media networks already has been investigated (cf. e.g., Ghosh and Ganguly 2014; Kumar et al. 2010), scarce attention has been paid to the structure and evolution of ESN. Hence, this dissertation focuses on three aspects of ESN. First, different actor roles in the knowledge management of ESN are classified and characterized. Second, the impact of formal hierarchies on users' social networking behaviour in ESN is investigated and compared to their behaviour in their daily work outside the ESN. Finally, the evolution of ESN and users' attachment behaviour in ESN are analysed.

1.2 Research Objectives and Research Questions

Based on the motivation above, four selected topics (Topic 1-4) are addressed. Figure 2 provides an overview of the research objectives and their relation to this dissertation's subjects. The topics are covered in six papers. Each paper's topic as well as the respective research questions are presented in Table 1.

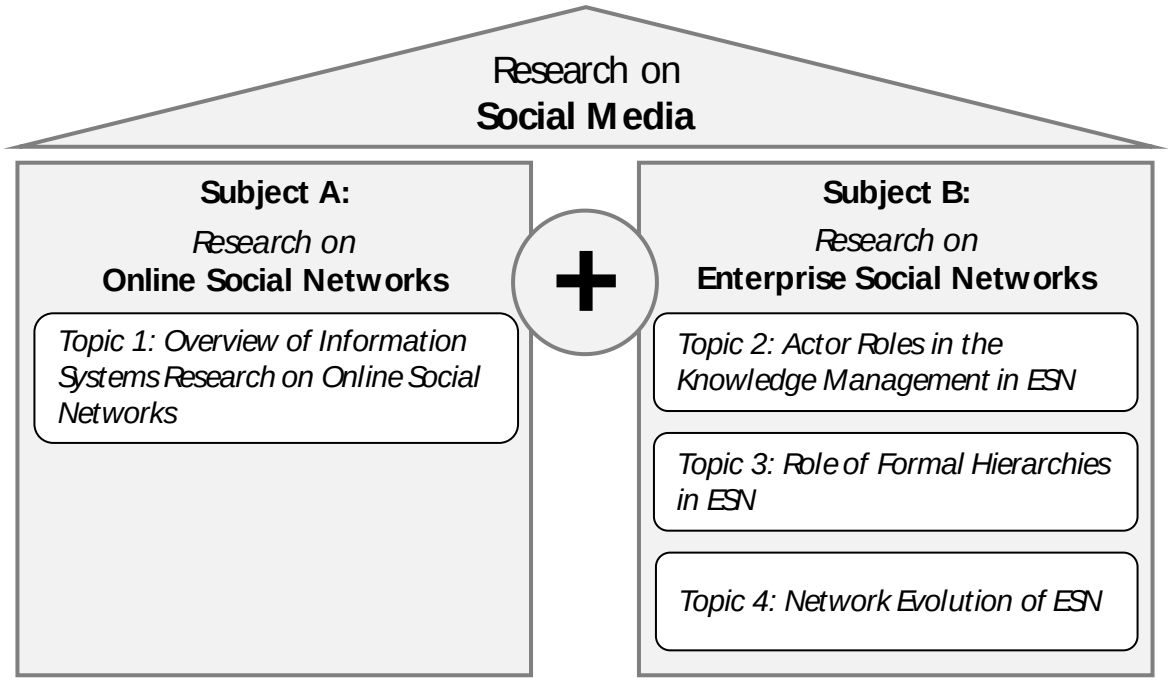

Figure 2: Overview of the Dissertation's Topics

Subject A: Research on Online Social Networks

Topic 1: Overview of Information Systems Research on Online Social Networks

The first topic of this dissertation aims to provide a structured overview on the research on OSN from an IS perspective. There is a rapidly growing number of research in the field of OSN (Richter et al. 2011) that contributes to the growing body of knowledge on OSN. This knowledge provides the materials (i.e. theories or models) that can serve as a basis for new research (Hevner et al. 2004). Although there are prior literature reviews on OSN (cf. boyd and Ellison 2007; Richter et al. 2011), none of them gives a current overview on OSN research in general. As a result, these literature overviews cannot provide a comprehensive view of the knowledge on OSN. In order to address this issue, this dissertation provides a structured literature overview (Webster and Watson 2002) about the knowledge as well as the research fields that have been predominantly addressed by the IS community so far. The results of this part of the dissertation are further used as starting points for other topics that are investigated within this dissertation.

Subject B: Research on Enterprise Social Networks

Topic 2: Actor Roles in the Knowledge Management in Enterprise Social Networks

With more and more employees using ESN in their daily work practices for sharing and searching knowledge, there is an increasing demand to better understand the role and impact of these social technologies in and on knowledge-intensive corporate work (Bharadwaj et al. 2013; Herzog et al. 2013; Richter et al. 2013). In addition, research requests to investigate the behaviour of users in ESN (Koo et al. 2011; Kuegler and Smolnik 2014), especially with respect to knowledge exchange in ESN (Ortbach and Recker 2014; Recker and Lekse 2015) as well as different actor roles in ESN usage (Trier and Richter 2015).

Social network theory implies that not all nodes in a social network can be considered as equal. They largely differ in terms of their connectivity, communication behaviour, and frequency, volume, and quality of the user-generated content (Trusov et al. 2010). In this regard, it is essential to know which users add value to the organisation by contributing and communicating their knowledge in the ESN and thus helping others to get their work better done. However, so far, the role and behaviour of these value adding users in view of knowledge-intensive corporate work is still not fully understood. Against this background, this dissertation aims to investigate the structural characteristics of value adding key users in ESN.

Furthermore, social networking behaviour in ESN with respect to employees' knowledge practices, i.e. how users share and seek knowledge in ESN, is still widely unexplored. Here, more specifically, users' reciprocities in terms of giving and taking knowledge within an ESN and their structural characteristics have not yet been subject of academic discussion. In order to address this issue, two measures for the classification of users with respect to their amount of sharing and seeking knowledge are proposed. Moreover, the structural characteristics of these different actor roles are investigated in-depth.

Topic 3: Role of Formal Hierarchies in Enterprise Social Networks

ESN play a crucial role for organisations (Aral et al. 2013) as they effect and change existing ways of collaboration, communication, and knowledge management processes (von Krogh 2012). More specifically, the emergent network structures are also said to transform power relations and hierarchies (Bobsin and Hoppen 2013) by "giving many more people within the organisation a voice, letting them interact as equals (…)" (McAfee 2009). Formal organisational hierarchy is an essential and pervasive organisational characteristic which heavily influences informal social relations and strongly limits the variety of potential network structures (Corominas-Murtra et al. 2013; West et al. 1999). The effects of hierarchies also account for ESN, as online communication rather complements than replaces offline

communication (Zhang and Venkatesh 2013). While first studies have shown that communication behaviour of employees has a much stronger effect on response behaviour than their formal hierarchical position (Stieglitz et al. 2014), there is still a lack of studies which analyse the interplay of hierarchy and ESN in detail. Thus, this dissertation aims to analyse the interplay of formal organisational hierarchies and users' behaviour in ESN. Therefore, their effects on users' behaviour in ESN are investigated. Furthermore, it is widely unexplored if the effects of formal hierarchies inside the ESN differ from those in the daily work practices outside the ESN. Against this background, within this dissertation, the effects of formal hierarchies inside and outside the ESN are compared and differences are investigated.

Topic 4: Network Evolution of Enterprise Social Networks

Prior studies have shown (e.g., Golder and Yardi 2010; Wang et al. 2013) that the structure of ESN is of great importance. On the one hand, the network structure of ESN plays a decisive role in understanding and explaining user behaviour (Wang et al. 2013). On the other hand, structural characteristics like transitivity and mutuality are significant predictors of the desire to form new ties in microblogging services (Golder and Yardi 2010). As the network structure of an ESN is invoked by the connections among its users, it evolves with respect to a growing number of users and interactions among users (Ghosh and Ganguly 2014). In prior research, models have been proposed that explain and illustrate the dynamics for different kinds of real world networks like communication networks, information networks, and social networks (e.g., Banks and Carley 1996; de Solla Price 1965; Jin et al. 2001; Klemm and Eguiluz 2002) as well as social media services (e.g., Ghosh and Ganguly 2014; Kumar et al. 2010). However, it is rather unclear if these models can also be applied to ESN as they differ from other social media services with respect to some of their topological characteristics (cf. Chelmis and Prasanna 2012). Against this background, this dissertation analyses how the topological characteristics of ESN evolve over time. In addition, possible drivers for users' attachment behaviour are investigated.

Table 1: Overview of Papers and Research Questions

Paper		Research questions	
Topic 1	***Overview of Information Systems Research on Online Social Networks***		
Paper 1	*A Review of Information Systems Research on Online Social Network*	RQ. 1 RQ. 2 RQ. 3 RQ. 4	*How has the academic discussion on OSN developed in the IS literature over time?* *Which IS publication outlets are most receptive to research on OSN?* *Which research areas have already been covered by IS research on OSN?* *What are potential future research areas that have not been covered by IS research yet?*
Topic 2	***Actor Roles in the Knowledge Management in Enterprise Social Networks***		
Paper 2	*"Who is Key?" – Value Adding Users in Enterprise Social Networks*	RQ. 5	*How can value adding key users be distinguished with respect to their structural characteristics like for example the number of followers, group memberships, or the centrality in ESN?*
Paper 3	*The Blessing of Giving: Knowledge Sharing and Knowledge Seeking in Enterprise Social Networks*	RQ. 6 RQ. 7	*How can users be classified with respect to their knowledge exchanging behaviour in ESN?* *How can users in the different categories be distinguished with respect to their structural position in the ESN and in the organizational hierarchy?*
Topic 3	***Role of Formal Hierarchies in Enterprise Social Networks***		
Paper 4	*The Impact of Formal Hierarchies on Enterprise Social Networking Behaviour*	RQ. 8	*What is the impact of formal organizational hierarchy on users' network position in ESN?*
Paper 5	*Two Sides of the Same Coin? – Distinguishing Formal Hierarchical Effects Inside and Outside Enterprise Social Networks*	RQ. 9	*How do the effects of formal hierarchies on employees' interaction inside and outside an ESN differ?*
Topic 4	***Network Evolution of Enterprise Social Networks***		
Paper 6	*Evolution, Structure and Users' Attachment Behaviour in Enterprise Social Networks*	RQ. 10 RQ. 11	*How do the topological characteristics of ESN evolve in time?* *How is users' attachment behaviour characterized with respect to the creation of social relationships during the evolution of ESN?*

1.3 Methodological Framework

Most research in the field of IS can be assigned to one of the two general research paradigms – behavioural science and design science (Gregor and Hevner 2013; Hevner et al. 2004; March and Smith 1995; Peffers et al. 2007). On the one hand, design Science is used to build and evaluate new and innovative IT artifacts, i.e. constructs, models, methods and instantiations. On the other hand, behavioural science develops and justifies theories, i.e. principles and laws. These are used to explain and predict organisational and human behaviour with respect to the effects of the usage of IS (Hevner et al. 2004).

Figure 3 presents the two research paradigms and their interplay with the environment (i.e. people and organisations) and the knowledgebase that contains prior research (Hevner et al. 2004). Most of the artifacts and theories arise from needs or problems that are articulated by the environment (Hevner et al. 2004) (cf. left hand side of Figure 3). By framing IS research to the identified needs, its relevance is assured (Hevner et al. 2004).

All contributions to prior research of both paradigms add to the so-called knowledge base for further research, which concludes the foundations, i.e. theories, frameworks, models, methods, or instantiations that are used to develop theories or to build artifacts (cf. right hand side of Figure 3). Moreover, it comprises methodologies for the justification of theories and the evaluation of artifacts. The latter concludes a large variety of data analysis techniques, measures and validation criteria (Hevner et al. 2004).

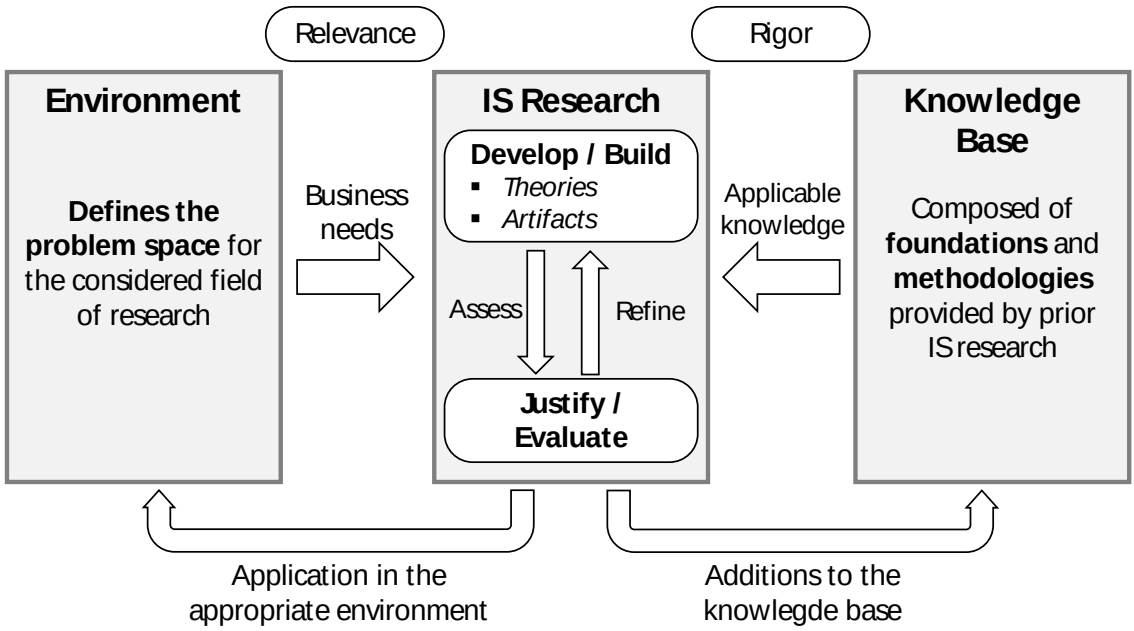

Figure 3: Information Systems Research Framework based on Hevner et al. (2004)

Although design science and behavioural science show a distinct orientation, both paradigms can be seen as inseparable, since they complement each other (Hevner et al. 2004). The goal

of design science is utility, i.e. an effective artifact, while the goal of behavioural science is truth, i.e. a justified theory. According to Hevner et al. (2004), truth can lead to the design of new artifacts, while utility leads to new theories. ESN are a relatively new phenomenon. Here, behavioural science approach is initially needed to better understand the role and impact of ESN. Based on the developed and justified theories implications and guidance are derived. These can serve as a basis for the development of new IT artifacts for ESN. Therefore, this dissertation mainly follows the behavioural science approach (cf. Papers 2 - 6). Nevertheless, also the design science approach is applied to build two new measures for user classification in ESN (cf. Paper 3).

In the following, the methods and methodologies that are applied within this dissertation are presented. First, a structured literature review (Bandara et al. 2011; vom Brocke et al. 2009; Webster and Watson 2002) was conducted (cf. Paper 1) to comprise the existing knowledge since it "provides the raw materials from and through which IS research is accomplished" (Hevner et al. 2004, p. 80). According to Hevner et al. (2004), appropriate methods and methodologies, that provide guidelines, are needed as a base for the development and justification of theories as well as the building and evaluation of artifacts. Moreover, the application of existing methodologies helps to achieve rigor (Hevner et al. 2004). Hence, as a base for further research within the scope of this dissertation, a comprehensive and profound knowledge base on IS research on OSN is build.

Case study research is used as the main evaluation and justification methods within the scope of this dissertation (Hevner et al. 2004; Wilde and Hess 2007; Yin 2009). According to Yin (2009) a case study "investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident". The usage of case study research allows to get profound insights into a research field by means of a holistic, in-depth investigation (Dubé and Paré 2003). Moreover, it allows the triangulation of evidence from multiple sources to ensure that the research objectives are not explored through one lens only (Yin 2009, 2012). Therefore, case study research seems to be wells suited to investigate different aspects of OSN and ESN as well as their role in an organisation's information management. This requires to consider not only data about the ESN, but also data and information from apart the ESN (cf. e.g., Papers 4 - 5).

To investigate the research questions stated in Chapter 1.2, diverse suitable data collection methods and data analysis techniques are used within this dissertation. By means of company log files (Baur and Blasius 2014; Schmitz and Yanenko 2014), information about users' interaction and communication in ESN is gathered. For some research objectives (cf., Papers 4 - 5) these data are complemented by data collected via semi-structured interviews

(Bryman and Bell 2007; Schultze and Avital 2011) or an online survey (Saris and Gallhofer 2014) to get deeper and complementary insights.

Within this dissertation the most applied methodology for data analysis is, amongst others, social network analysis (SNA) (Wasserman and Faust 2009). In prior IS research SNA has been intensively used, for example to investigate users' network creation behaviour (e.g., Krasnova et al. 2010) or social capital as a result of the usage of an OSN (e.g., Ellison et al. 2007). According to Freeman (2000, p. 350), SNA "involves theorizing, model building, and empirical research focused on uncovering the patterning of links among actors". On the one hand, by measuring topological characteristics SNA can be used to describe a network based on its structure (Newman 2003; Newman and Park 2003). In Paper 6, for instance, these topological characteristics are used to investigate the evolution of an ESN's structure.

On the other hand, SNA also provides user-centric measures and metrics to investigate a user's importance with respect to his or her position in the network. In this context, there exist several measures (Bonacich 1972; Freeman 1979) to quantify the centrality of a user in the network. Within this dissertation, centrality measures are applied to characterize and identify influential users of ESN (cf. e.g., Papers 2 - 4) or to investigate users' attachment behaviour for the creation of new links (cf. Paper 6).

In addition, a diverse set of further data analysis techniques, such as correlation analysis, is applied. Here, for instance, Spearman rank correlation (Spearman 1904) is used to measure the correlations between users' centrality and the number of new contact requests in subsequent periods (cf. Paper 6).

Next to the analysis of mere quantitative data, some research objectives are addressed by using a mixed methods approach. Mixed methods research builds on a combination of qualitative and quantitative methods, where the results of both methods are compared and interpreted to allow a diverse and comprehensive view on the respective research objectives. The usage of only one method would not be able to capture all circumstances adequately (Ågerfalk 2013). Therefore, content analysis techniques (Bryman and Bell 2007; Miles and Huberman 1994) are added to the set of data analysis techniques that are used within this dissertation. On the one hand, they are used to analyse the content of articles as well as the development of different research topics as part of the structured literature review (cf. Paper 1). On the other hand, they are applied to investigate the purpose of messages to qualify them as value adding (cf. Paper 2) or to analyse interview data (cf. Paper 3).

Statistical tests (Cramér 1999) are used to ensure the significance and validity of the different data analysis techniques such as Chi-square test (Pearson 1900) (cf. Papers 4 - 5), Bowker-Test (Bowker 1948) (cf. Paper 3), or Kolmogorov-Smirnov test (cf. Hollander et al. 2013) (cf.

Paper 6). Moreover, measures for inter-rater reliability, like Fleiss' Kappa (Fleiss 1971) (cf. Paper 2) or Krippendorff's alpha (Hayes and Krippendorff 2007; Krippendorff 2004) (cf. Paper 1) have been used.

For each paper, overviews of its research paradigms as well as the methods used are presented in Table 2.

1.4 Structure and Content of the Dissertation

The dissertation is organised as illustrated in Figure 4: Subsequent to the introduction, which concludes the motivation of this dissertation as well as its research objectives and methods, the dissertation is organised according to the four topics presented above. In each of the Chapters 2 to 5, the papers addressing the respective topic are presented in detail. Finally, the dissertation concludes with a presentation and discussion of the major findings across all topics as well as some limitations that can be seen as starting points for further research.

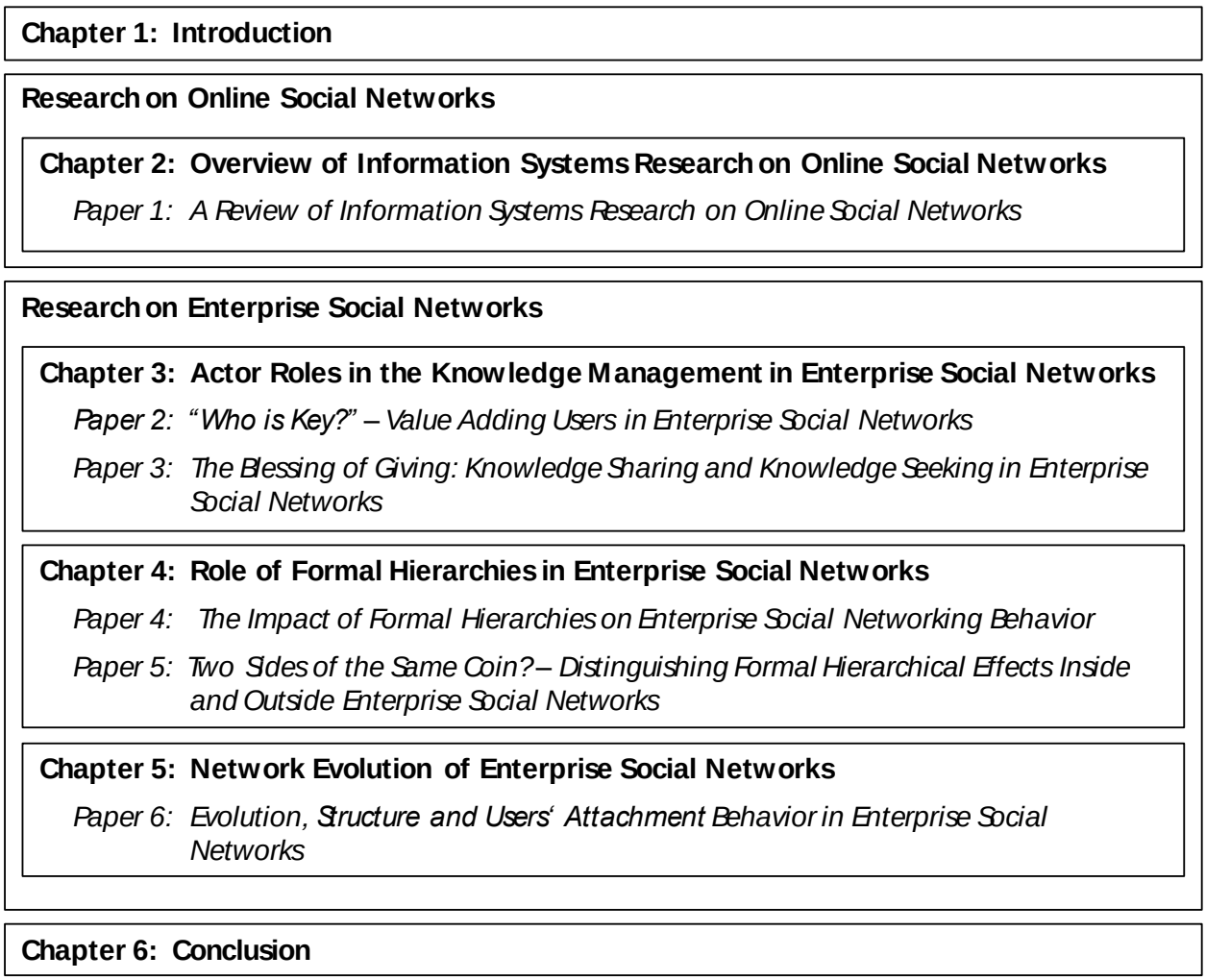

Figure 4: Structure and Content of the Dissertation

The respective research papers within this dissertation aim at addressing the research questions stated in Chapter 1.2. Table 3 shows an overview of the six papers. Here, for each paper its title, authors, status, as well as the respective outlet are presented. The outlets are classified based on the ranking[1] of the Verband der Hochschullehrer für Betriebswirtschaft (VHB).

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[1] http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/

Paper		Research Paradigm (cf. Hevner et al. 2004)	Evaluation / Justification Method (cf. Hevner et al. 2004; Wilde and Hess 2007)	Data (cf. Baur and Plasius 2014)	Methodologies
Paper 1	*A Review of Information Systems Research on Online Social Network*		Structured literature review	Prior research on OSN	Content analysis, measure for inter-rater reliability
Paper 2	*"Who is Key?" – Value Adding Users in Enterprise Social Networks*	Behavioral science	Case study	Company owned log files	Content analysis, measure for inter-rater reliability SNA
Paper 3	*The Blessing of Giving: Knowledge Sharing and Knowledge Seeking in Enterprise Social Networks*	Behavioral science and design science	Case study	Company owned log files	SNA, statistical tests
Paper 4	*The Impact of Formal Hierarchies on Enterprise Social Networking Behavior*	Behavioral science	Case study	Company owned log files, interview data	Content analysis, SNA, statistical tests
Paper 5	*Two Sides of the Same Coin? – Distinguishing Formal Hierarchical Effects Inside and Outside Enterprise Social Networks*	Behavioral science	Case study	Survey data, company owned log files	Online survey, SNA, statistical tests
Paper 6	*Evolution, Structure and Users' Attachment Behavior in Enterprise Social Networks*	Behavioral science	Case study	Company owned log files	Correlation analysis, SNA, statistical tests

Table 2: Overview of Research Paradigm, Methods, Data, and Methodologies

Table 3: Overview of the Papers' Title, Authors, Status, and Outlet

Title		Authors	Status	Outlet	VHB-Ranking
Paper 1	*A Review of Information Systems Research on Online Social Network*	Katharina Berger* Julia Klier Mathias Klier Florian Probst	Accepted	Communications of the Association for Information Systems (CAIS)	C
Paper 2	*"Who is Key?" – Value Adding Users in Enterprise Social Networks*	Katharina Berger* Julia Klier Mathias Klier Alexander Richter	Accepted	Proceedings of the European Conference on Information Systems (ECIS) 2014, Tel Aviv, Israel	B
Paper 3	*The Blessing of Giving: Knowledge Sharing and Knowledge Seeking in Enterprise Social Networks*	Alexandra Cetto Julia Klier Mathias Klier Alexander Richter Katharina Wiesneth	Accepted	Proceedings of the European Conference on Information Systems (ECIS) 2016, Istanbul, Turkey	B
Paper 4	*The Impact of Formal Hierarchies on Enterprise Social Networking Behavior*	Sebastian Behrendt Julia Klier Mathias Klier Alexander Richter Katharina Wiesneth	Accepted	Proceedings of the International Conference on Information Systems (ICIS) 2015, Fort Worth, Texas	A
Paper 5	*Two Sides of the Same Coin? – Distinguishing Formal Hierarchical Effects Inside and Outside Enterprise Social Networks*	Julia Klier Mathias Klier Alexander Richter Katharina Wiesneth	Under Review	Proceedings of the European Conference on Information Systems (ECIS) 2017, Guimarães, Portugal	B
Paper 6	*Evolution, Structure and Users' Attachment Behavior in Enterprise Social Networks*	Katharina Wiesneth	Accepted	Proceedings of the Hawaii International Conference on System Sciences (HICSS) 2016, Koloa, Hawaii	C
*These papers were published under the author's maiden name					

References (Chapter 1)

Ågerfalk, P. J. 2013. "Embracing Diversity through Mixed Methods Research," *European Journal of Information Systems* (22:3), pp. 251–256.

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2 Overview of Information Systems Research on Online Social Networks

In this section, Topic 1 and the respective research questions RQ.1 - 4 are addressed by means of a structured literature review (cf. Bandara et al. 2011; Webster and Watson 2002). As already mentioned before, there is a growing body of IS research on OSN in most of the major IS outlets (Richter et al. 2011). Based on a search in more than 40 IS journals as well as eight IS conferences the knowledge and the research fields that the IS community has addressed so far are carved out (Scandura and Williams 2000) (cf. RQ. 3) and research gaps for future research are identified (Webster and Watson 2002) (cf. RQ. 4). It is further analysed how IS research on OSN developed in time (cf. RQ. 1) as well as which outlets are especially receptive for research on OSN (cf. RQ. 4).

2.1 Paper 1: A Review of Information Systems Research on Online Social Networks

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2.2 Conclusion to Chapter 2

The research questions addressed in this chapter were:

RQ. 1 How has the academic discussion on OSN developed in the IS literature over time?

RQ. 2 Which IS publication outlets are most receptive to research on OSN?

RQ. 3 Which research areas have already been covered by IS research on OSN?

RQ. 4 What are potential future research areas that have not been covered by IS research yet?

By answering the research questions, the article gives an overview on the state of art of more than ten years IS research on OSN and identifies research gaps that have not been addressed so far. However, it was already published in 2014. With respect to the increasing number of papers, which is published every year, it might be assumed that nowadays some of its content might be outdated. Nevertheless, it contributes to prior and future IS research on OSN in various ways:

On the one hand, its perspective on prior research (RQ.1 - 3) gives an overview on the state of art of more than ten years IS research on OSN. The article is used as a reference regarding different aspects, such as to define OSN to highlight the impact of OSN on people and organisations (Wenninger, 2016) or to refer to the growing body of research in the field of OSN (Viol and Hess, 2016; Wehner et al., 2017). Moreover, other literature reviews base on the methodical proceeding and the search strategy. Eismann et al. (2016), for instance, extended the selection of their search terms based on those in this article. Other researchers use the literature review to motivate and to substantiate their research (Chin et al., 2015; Medaglia and Zheng, 2016). Here, for instance, Chin et al. (2015) use the literature review to motivate their research on the adoption of ESN.

On the other hand, RQ. 4 invokes a perspective on future research, as the article identified topics that have not been addressed so far. While some of these topics are made subject of this dissertation (cf. e.g., Topic 3) other researchers have also addressed these topics. In their research on frustration and negative emotions in Facebook Laumer et al. (2015) explicitly refer to the respective research gap stated in the literature overview.

Summing up, the article in this chapter helps interested parties in and beyond the IS community to gain an initial overview research conducted during the last several years of IS research on OSN. Moreover, it also supports them to motivate their own research. It was published in October 2014 and according to Google Scholar, was cited more than 40 times.

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3 Actor Roles in Knowledge Management in Enterprise Social Networks

This section answers to calls to research behaviour of users in ESN (Koo et al. 2011; Kuegler and Smolnik 2014), especially with respect to knowledge exchange in ESN (Ortbach and Recker 2014; Recker and Lekse 2015) as well as different actor roles in ESN usage (Trier and Richter 2015). The first part addresses these calls by investigating the structural characteristics of value adding users who add value to an organisation by actively sharing their knowledge in the ESN (RQ. 5). Next to analysing mere social structures (cf. e.g., Borgatti 2006) the analyses within this dissertation also incorporate the value add from a user, by helping others to get their work better done. The second section proposes two novel measures for the classification of different actor roles, based on users' behaviour with respect to sharing and seeking knowledge in ESN (RQ. 6). By applying the measures to a real world data set, the characteristics of the different actor roles are investigated in-depth (RQ. 7).

3.1 Paper 2: "Who is Key…?" – Value Adding Users in Enterprise Social Networks

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Abstract

Whereas the use of Enterprise Social Networks (ESN) is a pervasive topic in research and practice, both parties are still struggling to come to a better understanding of the role and impact of ESN in and on knowledge-intensive corporate work. As a part of this phenomenon, employees who communicate their knowledge in ESN helping other users to do their daily work play a decisive role. We need to come to a better understanding of the role and behaviour of such value adding users. This is a prerequisite, for example, for understanding knowledge support hubs or for enabling more effective internal information and knowledge sharing. Against this background, we investigate the structural characteristics of value adding users in ESN using qualitative text analysis and Social Network Analysis. Based on a large scale dataset of a global consulting company using the ESN Yammer.com we analyse the social relationships of value adding users. We confirm their significant position and draw conclusions for research and practice.

Keywords: *Enterprise Social Network, Social Network Analysis, Social Software, CSCW.*

1 Introduction

In recent years, many organizations have started to implement Enterprise Social Networks (ESN) in their companies to foster collaboration, communication, and knowledge-sharing among employees (Aral et al., 2013; von Krogh, 2012). According to a recent study, more than 90% of all Fortune 500 companies had partially or fully implemented an ESN by the end of 2013, a 70% increase compared to 2011 (Deloitte, 2013). As more and more employees are using ESN in their daily work practices, there is an increasing demand to better understand the role and impact of these social technologies in and on knowledge-intensive corporate work (Bharadwaj et al., 2013; Herzog et al., 2013; Richter et al., 2013). First studies have shown that ESN can for instance support expert finding, information seeking, idea sharing, or team coordination, depending on the existing work practices (DiMicco et al., 2008; Thom-Santelli et al., 2011).

In this context, it has been argued that analysing the network structure of users of social networks in view of the value add bears a huge potential (Katona et al., 2011). The underlying idea is that understanding the network structure of individual users helps to determine the key users with respect to the said value add (Trusov et al., 2010). In the context of ESN, these users are in the managerial interest particularly with respect to understanding knowledge support hubs, that means employees helping other users with their daily work, or to designing targeted internal communication strategies, for instance in enterprise transformation programs. For the understanding of key users in general, literature in the context of Social Network Analysis indicates that both users' connectivity, for example the number of followers (e.g., Staab et al., 2005), and users' communication activity (e.g., Cheung and Lee, 2010), for example the number of messages, are particularly important. However, even though these studies provide meaningful insights in the context of social networks in general, we cannot simply confer these insights to specific ESN, since the interpretations of important nodes or key users strongly depend on the particular context (Borgatti, 2005; Borgatti and Everett, 2006; Freeman et al., 1980). In addition, most of the previous studies focus on mere social structures (e.g., Borgatti, 2006) without incorporating the value add of a user into their investigations.

Therefore, the aim of this paper is to investigate the structural characteristics of value adding key users in the context of ESN and thus to distinguish these users. In so doing, we address the following research question: How can value adding key users be distinguished with respect to their structural characteristics like for example the number of followers, group memberships, or the centrality in ESN? To answer this question, we analysed a large scale dataset of a global consulting company using the ESN Yammer.com. Our results indicate how it helps to not only consider the social structures of users in ESN (by analysing centrality measures),

but rather try to incorporate the idea of the value add of a user into our analysis. We also illustrate how value adding key users are characterized in terms of their connectivity in the social graph as well as the activity graph. These insights can help organizations to get a deeper understanding of the role and characteristics of key users in ESN. Given that social technologies like ESN are a core phenomenon of the 21st century at the heart of the IS discipline, our findings contribute to developing a more refined understanding of ESN in general.

The remainder of this paper is structured as follows: In Section 2, we review the existing literature. Section 3 describes the research method, the case setting, and the data collection and analysis process. In Section 4, we present our findings based on a qualitative text analysis and Social Network Analysis of the dataset of the ESN Yammer.com at a global consulting company. In Section 5, we critically discuss implications and limitations of our work and provide directions for further research. Finally, we conclude with a brief summary of our results.

2 Theoretical Background

In this section, we focus the relevant literature on ESN and their underlying network structure. We also review prior research on the role and identification of key users in social networks. Drawing on the existing literature, we finally identify the research gap.

2.1 Enterprise Social Networks

In recent years, we have seen a continuously increasing demand for ESN to support knowledge transfer and collaboration in companies (e.g., Benbya and van Alstyne, 2010; Bughin and Manyika, 2007; Haefliger et al., 2011). Many organizations started to experiment with the implementation of ESN as a particular phenomenon in the social media ecosystem of large organizations (Riemer et al., 2012a). Some leading companies (such as IBM) have been using the power of ESN to transform their internal organizations from "command-and-control to connect-and-coordinate" (Agarwal et al., 2008). Thereby, ESN platforms "put emphasis on social relationships, interactive communication and adhoc sharing" (Riemer et al., 2012c, p. 5). While some organizations decided to develop own solutions (e.g. Siemens), others have opted for on-premise vendor platforms (e.g. Jive SBS, IBM Connections) or web service solutions (e.g. Yammer.com, Salesforce Chatter).

Prior research on ESN was conducted, for example with the goal of understanding how employees build relationships (DiMicco et al., 2009), how ESN dynamically emerged in organizations (Riemer et al., 2012b), and why people voluntarily contribute knowledge and help others through electronic networks (Wasko and Faraj, 2005). Further research focuses on investigating the potential benefits of ESN in the corporate realm, including information seeking, expert finding, problem solving, work coordination, and opinion sharing (Brzozowski,

2009; Richter and Riemer, 2013; Thom-Santelli et al., 2011). Research findings also show that ESN foster user participation in creating web content (e.g., Holtzblatt et al., 2010; Ip and Wagner, 2008) and allow for new ways of connecting, interacting, and communicating with other people (e.g., DiMicco et al., 2009; Zhang et al., 2010). In this context, research has been indicating that ESN have implications not only for company performance, but also with respect to career paths of employees. Wu (2013), for instance, studied the impact of introducing an ESN in the consulting division of a large information technology company. Specifically, he found that the ESN transformed network positions of individuals over time and that there were significant correlations with both job performance and job security (Wu, 2013). Moreover, Matthews et al. (2013) analysed how leaders enhance the value of their communities. Further work in this context includes research aiming at understanding how diversity influences collaboration, teaming, and innovation (Muller et al., 2012). In addition, as more and more employees are using ESN, there is an increasing demand to understand how the use of these technologies can be evaluated (Herzog et al., 2013; Lehner and Haas, 2011; Muller et al., 2009; Richter et al., 2013). To sum up, there is a growing body of knowledge that addresses a huge amount of research topics, since ESN have become an important phenomenon in the corporate context finding increasing attention in recent years.

2.2 Enterprise Social Networks and their structures

Latest research has shown that the network structures of ESN play a decisive role in understanding and explaining user behaviour in ESN (Wang et al., 2013). Golder and Yardi (2010), for example, found that the structural characteristics transitivity and mutuality are significant predictors of the desire to form new ties in microblogging services. In general, structural characteristics have been extensively studied to describe, for instance, human behaviour in multiple social networks (Shapiro and Varian, 1999). The structure invoked by the binary connections among users in ESN can be mostly perceived as "a set of actors connected by a set of ties. The actors (often called 'nodes') can be persons, teams, organizations, concepts, etc. Ties connect pairs of actors and can be directed (i.e. potentially one-directional, as in giving advice to someone) or undirected (as in being physically proximate) and can be dichotomous (present or absent, as in whether two people are friends or not) or valued (measured on a scale, as in strength of friendship)" (Borgatti and Foster, 2003, p. 922). These nodes and ties determining the network structure can be analysed by Social Network Analysis (SNA) (Trier, 2008; Wasserman and Faust, 2009) that forms the theoretical basis for understanding the network structure of social networks, and ESN in particular.

Social Network Theory implies that not all nodes in a social network can be considered as equal. They largely differ in terms of their connectivity (e.g. number of friends), their communication activity (e.g. number of messages) as well as their frequency, volume, and quality of

the user-generated content (Trusov et al., 2010). For the context of ESN, earlier research notes that only a few individuals receive a majority of the attention in ESN (Yardi et al., 2009) and that there is often a small number of very active users as opposed to a large number of rather passive users (so called lurkers) (Muller et al., 2010; Yeow et al., 2006; Yuqing et al., 2007). Therefore, from a management perspective, it is essential to know who is a "key user" to enable, for instance, better expert identification or more effective communication strategies (e.g. a targeted communication campaign in a large organization) by addressing users on purpose. Goldenberg et al. (2009), for instance, found that key users in a social network have a decisive role in diffusion and adoption processes and can be used as an efficient target for word-of-mouth campaigns. Literature indicates that a person's importance can be inferred from his or her structural position in the network (Iacobucci, 1996). The most common concept to determine the importance of a user in a social network is network centrality. For the specific context of social networks, several network measures were developed to better capture the "centrality" of individuals and to identify prestigious nodes in the network (Bonacich, 1987; Wasserman and Faust, 2009). Some of the most commonly used centrality measures include degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality (Bonacich, 1972; Freeman, 1979). Further research on the identification of central nodes was done with respect to their social position in the network, which can be determined, for example, by means of equivalence relations (e.g., Brynielsson et al., 2012), in combination with workflow management (van der Aalst and Song, 2004) or cluster analysis (e.g., Zygmunt et al., 2012).

In the related research context of online social networks (e.g. Facebook), there are first articles using these centrality measures to identify influential users, for example to foster more effective advertising or marketing strategies (e.g. viral marketing campaigns or targeted marketing) (e.g., Heidemann et al., 2010; Hinz et al., 2011; Trusov et al., 2010). In addition, approaches for the identification and understanding of important nodes can be found not only in Social Network Analysis, but also in many other fields as for instance in biology for the identification of genes (e.g., Özgür et al., 2008) or in scientometrics for the ranking of scientific journals (e.g., Bollen et al., 2006). However, the interpretations of important nodes or key users highly depend on the particular context (Borgatti, 2005; Borgatti and Everett, 2006; Freeman et al., 1980).

Altogether, researchers emphasize the importance of both the network structure of ESN and the specific context for the interpretation of central nodes. To date, to the best of our knowledge, there is not a single approach in the context of ESN describing the characteristics of value adding key users and thus bringing together concepts from both Social Networks Analysis and value based thinking. Therefore, the aim of this paper is to investigate the struc-

tural characteristics of value adding key users in ESN. Our contribution for theory and practice is threefold: First, we do not only consider the mere social structures of users in ESN (by analysing centrality measures), but rather try to incorporate the idea of the value add of a user into our analysis. Second, in that realm, we illustrate that most of the messages which receive likes and bookmarks have a professional purpose. Finally, we show how value adding key users are characterized in terms of their connectivity in the social graph as well as the activity graph.

3 Research Method

In this section, we provide an overview of the setting and the data collection. Then, we discuss the analysis process and the applied methods, qualitative text analysis and Social Network Analysis.

3.1 Setting

The study was conducted at a large multinational consulting company, in the following called BIG, with more than 100,000 employees in more than 30 countries worldwide. In 2008, the first BIG employee started to use the ESN Yammer.com. Yammer itself had been launched the same year. Yammer is a cloud service that means it is not installed on companies' webservers, but can be accessed from any web browser. Yammer is organised around networks, with one network typically representing one company. Anyone can create a network for their company by registering with their email address on the platform. New users can join their Yammer network by registering with their corporate email address, which serves as an identifier. When Microsoft acquired Yammer in 2012, the service was used by more than 200,000 companies worldwide. The functionalities of Yammer always resembled those of Twitter.com and have continuously been advanced. From the beginning, Yammer was based on the "follower"-principle, i.e. users choose whom they follow and see who follows them. Thus, the resulting network is directed and displayed as a list sorted by name, as part of an employee's profile. In addition, users can create groups that form sub networks of the entire ESN, for example based on certain topics like "Cloud Computing" or "IT Security Matters". Further early platform features included profile information, options to send direct messages, and the possibility to like and bookmark posts. These functionalities are of special interest for our study.

3.2 Data collection and preparation

BIG provided us with the complete Yammer dataset, ranging from September 2008 to July 2010, for 10,434 unique users of the platform. 7,304 of these users followed at least one other user of the platform. Moreover, the data contain 101,132 messages that were posted inside

the ESN over this period. These messages were written by a total of 9,806 users. Each message consists of metadata such as a message ID, a reply ID, a thread ID, a user ID, and the content of the message. In Yammer, a message is either a reply to another message that inherits the thread ID of this original message, or it is a new message commencing a thread with a new ID. Thus thread IDs can be used to analyse related communications in the data. Furthermore, the data comprises 14,946 likes in reply to messages that were sent by 984 users of the platform. In addition, the Yammer dataset includes 599 bookmarks that were stored by users for later retrieval. Finally, the datasets contains information about 282 subgroups to which the users were belonging. To ensure confidentiality, all personally identifying information (user names and client names) had been removed prior to handing over the data.

3.3 Data analysis and measures

Our initial study on this topic aims to investigate the structural characteristics of value adding users in ESN to distinguish these users. By this means it intends to provide first insights on their structural positions in the network which can serve as a starting point for further analyses (cf. Section 5.2). At BIG, the ESN was amongst others used for knowledge transfer among employees. Against this background, those users of the ESN are regarded as value adding who contribute and communicate their knowledge in the ESN thus helping other users to work more successfully and efficiently. Yammer.com provides functionalities to like and bookmark posts in terms of messages by other users which are deemed helpful. Hence, value adding contributions in the ESN receive likes and bookmarks. One may assume that the vast majority of the users' likes and bookmarks in the ESN have a professional background marking important and value adding contributions. Against this background, in our specific context likes and bookmarks seem to be better suited as measurements for key users as compared to the mere number of written messages or followers which do not provide such a concrete indication with respect to a user's value add. Thus, for our data analyses we define and identify key users as those users of the ESN whose messages received the most likes and bookmarks.

To substantiate this definition of key users for our setting, we applied a qualitative text analysis (e.g., Bryman and Bell, 2007). Whereas the application spectrum of qualitative text analysis is already quite broad (a still broader term is qualitative content analysis), our aim was to find out whether the vast majority of likes and bookmarks had a professional background to qualify them to be considered as value adding (from the perspective of BIG). To do so, we selected all messages with at least one like or one bookmark from our dataset, respectively. All messages automatically generated by the system (e.g. "a new user has joined the network") as well as messages written in another language than English or German were excluded. The latter was due to the language skills of the researchers and concerns only a small

proportion of the messages with at least one like (5%) or bookmark (2%). The final dataset contained 8,142 messages with at least one like and 450 messages with at least one bookmark. A team of three researchers manually coded the messages to one of the two categories "professional" and "non-professional" (Miles and Huberman, 1994). Each message was screened independently by at least two persons. In the event of any disagreement we decided on the best fitting genre in a team discussion. The reliability of agreement between the researches was measured with Fleiss' Kappa (Fleiss, 1971). We observed a value for Fleiss' Kappa of nearly 83%. According to Landis and Koch (1977) this reflects an almost perfect agreement between the team of researchers.

To investigate the structural characteristics of the key users based on our dataset, we apply Social Network Analysis (SNA). Social Network Analysis has been intensively used in IS research, for example to investigate users' network creation behaviour (e.g., Krasnova et al., 2010) or social capital as a result of the usage of an OSN (e.g., Ellison et al., 2007). According to Freeman (2000, p. 350), Social Network Analysis "involves theorizing, model building, and empirical research focused on uncovering the patterning of links among actors". In this context, there exist several measures to quantify the centrality of a node within a network. The most common centrality measures are degree centrality, closeness centrality, betweenness centrality (Freeman, 1979), and eigenvector centrality (Bonacich, 1972). An ESN can be represented as a graph with a set of nodes (users) and a set of edges (ties) linking pairs of nodes (Wasserman and Faust, 2009). The edges may be directed or undirected and can represent either social links like friendship relationships (social graph) or communication activities (activity graph) like messages amongst users (e.g., Adamic and Adar, 2003; Bampo et al., 2008; Heidemann et al., 2010). To get profound insights into the structural characteristics of key users in ESN, we base our research on both the social graph and the activity graph of the ESN. The social graph consists of the follower relations between the users (i.e. who follows whom) as social links and is represented as a graph with 10,434 nodes and 137,550 directed edges. The activity graph is formed by the users' communication activities, i.e. all messages among the users, with some messages like group or status messages having more than one receiver. It consists of 10,434 nodes and 9,645,500 directed edges. For the network analysis, we used the igraph package for R to calculate the degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality for each node of the social as well as of the activity graph.

4 Findings

This section is dedicated to the results of our study. First, we focus on the results of the qualitative text analysis. The second part concentrates on the results of the Social Network Analysis.

4.1 Results of the qualitative text analysis

The results of the qualitative text analysis reveal that the content of most of the messages which received likes and bookmarks have a professional purpose (cf. Figure 1). More specifically, distinguishing only the categories "professional" and "non-professional", we observed that about 81% of the messages which were liked and 94% of the messages which were bookmarked have a professional background. The professional messages included, for example, hints on (new) ESN functionality (e.g. "Yammer also offers kind of auto-completion when entering a hashtag to reduce different spellings or namings"), further information on work-related topics (e.g. "Cloud security paper from the point of view of using clouds as massive computational resources published by the European Space Agency. http://www.enisa.europa.eu/act/rm/files/deliverables/cloud-computing-risk-assessment") as well as problem solving and support (e.g. "Have we got good examples of Ecosystems that we enable on an ongoing basis?"). Only a relatively small proportion of liked (19%) and bookmarked (6%) messages dealt with topics that were not work-related (e.g. jokes and latest soccer news). Hence, the results of the qualitative text analysis substantiate our definition of key users which serves as a basis for the following analyses.

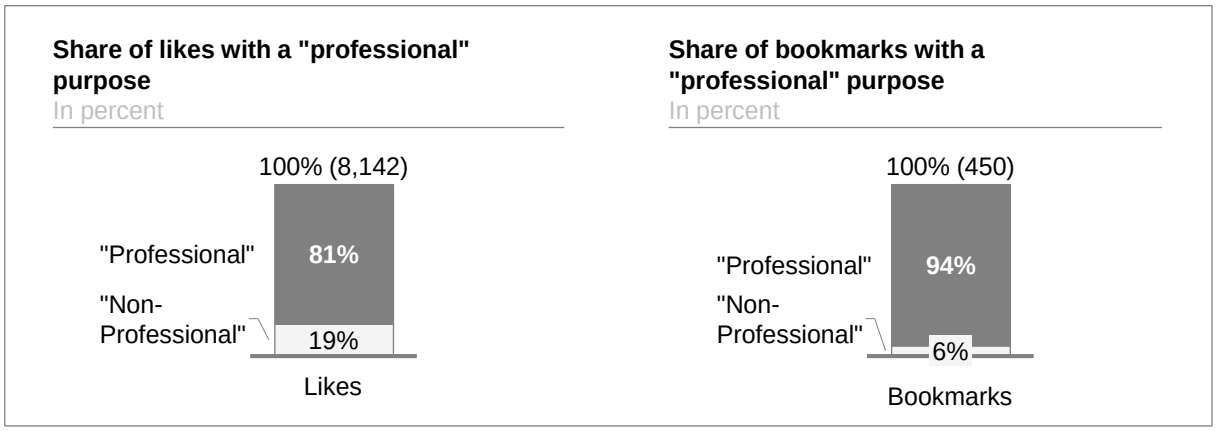

Figure 1. Share of likes and bookmarks with a professional purpose.

4.2 Results of the Social Network Analysis

As explained earlier, we define and identify key users as those users of the ESN whose messages received most likes and bookmarks (cf. Section 3.3). To get deeper insights into the characteristics of these key users, in a first step, we looked at whether the users whose messages received the most likes are also among the ones whose messages received the most bookmarks and vice versa. To do so, we derived two user rankings: first, we ranked the users with respect to their number of likes and their number of bookmarks, respectively. On this basis, we compared the top segments of both user rankings. For the top 1% segments of both rankings we observed a big overlap: 51% of the top 1% users with respect to the number of likes are also among the top 1% users with respect to the number of bookmarks. Only 25% of

the top 1% users with respect to the likes are not among the top 5% users with respect to the bookmarks (cf. Figure 2).

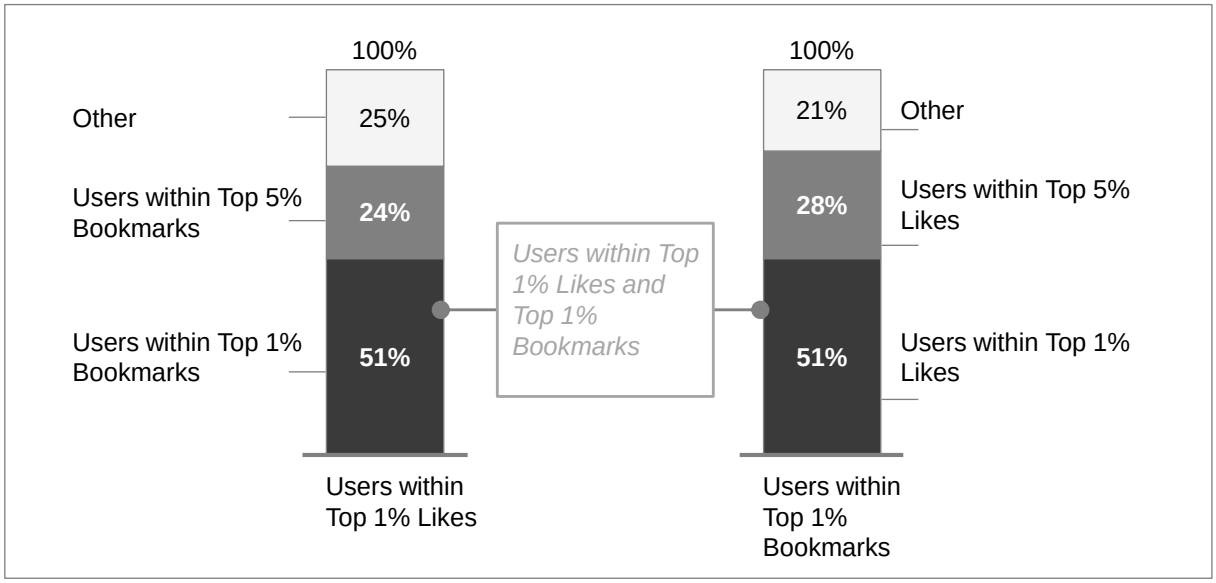

Figure 2. Overlap of users who received the most likes and bookmarks.

We conducted our analyses to identify the structural characteristics of key users for both users who received most likes and users who received most bookmarks. Due to the very similar results and the big overlap of users whose messages received the most likes and bookmarks, respectively, for this paper we decided to focus on the number of likes only (cf. page length restriction). Compared to analysing the number of bookmarks we expect the results to be more reliable: (1) our dataset contains much more likes (14,946) than bookmarks (599); (2) the number of users whose messages received at least one like (1,112) is much higher compared to those who received at least one bookmark (220); (3) in the context of ESN the like functionality seems much more common compared to the bookmark functionality. Hence, for the following analyses, we define and operationalise key users as those users of the ESN whose messages received the most likes (top 1% and top 5% segments).

To identify the structural characteristics of key users in ESN, we first investigate how key users are characterized with respect to their number of followers, written messages, and group memberships. We ranked the users for each of these characteristics and derived the top 1% and top 5% categories. The remaining users were classified as the "rest". We then calculated the percentage of key users (top 1%, top 5%, and the "rest") belonging to the respective category. Table 1 highlights that 51% of the top 1% key users are also among the top 1% users with the most followers; 93% of them are among the top 5% users with the most followers. Only 7% of the top 1% key users belong to the "rest". Hence, we found that key users have a large number of followers. The results of our analysis regarding the number of written messages are as follows: All top 1% key users belong to the category of the top 5% users who

wrote the largest number of messages; 65% of them even fall into the category of the top 1% message writers. Furthermore, key users are characterized by a quite large number of group memberships: 65% of the top 1% key users are among the top 5% users with the most group memberships.

Summing up the results of these analyses, it is evident that key users take an active part in ESN. Most of them belong to the top categories with respect to the number of followers, written messages, and group memberships. Thus the biggest overlap is observed for key users and those users who wrote the most messages, followed by those with the most followers and group memberships (cf. Table 1).

Key User	**Number of Followers**			**Number of Written Messages**			**Number of Group Memberships**		
Top	Top 1%	Top 5%	Rest	Top 1%	Top 5%	Rest	Top 1%	Top 5%	Rest
1%	51%	93%	7%	65%	100%	0%	28%	65%	35%
5%	15%	49%	51%	19%	65%	35%	11%	38%	62%
Rest	0%	3%	97%	0%	2%	98%	0%	3%	97%

Table 1. Overlap of key users and those users with the most followers, written messages, and group memberships.

In a second step, we analysed the key users' centrality in the social graph (10,434 nodes and 137,550 directed edges) which is based on social links in terms of follower relations among the users. We applied in-degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality to the social graph. We then ranked the users for each centrality measure and classified them with respect to the categories top 1%, top 5%, and "rest". Table 2 shows the percentage of key users (top 1%, top 5%, and "rest") in the respective categories. Here, a user's in-degree centrality corresponds to his or her number of followers (cf. also Table 1). However, the results in Table 2 do not only illustrate that key users are characterized by a large number of direct connections to other users (cf. in-degree centrality). Rather, the results for closeness centrality reveal that they are generally close to all other users in the network and therefore might be able to spread their contributions easily in the whole ESN (note that closeness centrality is based on a user's shortest paths to all other users in the network): 54% of the top 1% key users belong to the category of the top 1% users with respect to closeness centrality. The results for betweenness centrality and eigenvector centrality further underline that key users are very well connected in the social graph: 43% of the top 1% key users are among the top 1% users with the highest betweenness centrality; 48% of them among those with the highest eigenvector centrality.

Altogether, our analyses of the social graph show that many key users are among the best-connected users in the ESN. This holds for all centrality measures taken into account. However, in this context, it is remarkable that the biggest overlaps are observed for the key users and those users with the highest centrality with respect to the simple centrality measures in terms of closeness centrality and in-degree centrality. This is in keeping with Kiss and Bichler (2008) who derived similar results for the analysis of influence in customer networks.

Key User Top	**In-degree Centrality**			**Closeness Centrality**			**Betweenness Centrality**			**Eigenvector Centrality**		
	Top 1%	Top 5%	Rest	Top 1%	Top 5%	Rest	Top 1%	Top 5%	Rest	Top 1%	Top 5%	Rest
1%	51%	93%	7%	54%	80%	20%	43%	86%	14%	48%	91%	9%
5%	15%	49%	51%	16%	37%	63%	14%	40%	60%	14%	49%	51%
Rest	0%	3%	97%	0%	3%	97%	0%	3%	97%	0%	3%	97%

Table 2. Overlap of key users and those users with the highest centrality for each centrality measure applied to the social graph.

In a third step, we analysed key users' centrality in the activity graph (10,434 nodes and 9,645,500 directed edges) representing the users' communication activities in the form of directed links between senders and receivers of messages. In this context, we proceeded like we did for our analyses of the social graph. We applied in-degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality to the activity graph and classified the users with respect to their centrality for each centrality measure (top 1%, top 5%, and "rest"). Then, we calculated the percentage of key users in the respective categories. Our prior results (cf. Table 2 and the discussion above) have already shown that key users are characterized by a large number of written messages. The analysis of the activity graph highlights that key users are not only very active message writers, but are also among the users who receive the largest numbers of messages (cf. in-degree centrality): 45% of the top 1% key users belong to the top 1% category with respect to users' in-degree centrality. In addition, key users are strongly connected in the activity graph of the ESN with respect to closeness centrality: 53% of the top 1% key users are among the 1% users with the highest closeness centrality. Thus, their messages can reach a large number of users in a relatively short time. With respect to betweenness centrality, 57% of the top 1% key users fall into the category of the 1% users with the highest centrality. This means that key users are often included in the shortest paths between two other users in the network, may bridge structural holes in the network, and are therefore essential for a fast and effective exchange of information in the ESN. Finally, key users are also characterized by a rather high eigenvector centrality: 43% of the top 1% are among the top 1% users with the highest eigenvector centrality.

Summing up our analyses of the activity graph, we found that key users are not only involved in major parts of users' communication activities in the ESN (cf. number of messages written and received) but can also contribute to a fast and effective exchange of information due to their high (closeness and betweenness) centrality. As for the activity graph, the biggest overlaps with the key users are observed for centrality measures taking into account the shortest paths between users in the ESN (i.e. betweenness and closeness centrality).

Key User Top	**In-degree Centrality** Top 1%	Top 5%	Rest	**Closeness Centrality** Top 1%	Top 5%	Rest	**Betweenness Centrality** Top 1%	Top 5%	Rest	**Eigenvector Centrality** Top 1%	Top 5%	Rest
1%	45%	71%	11%	53%	87%	13%	57%	89%	29%	43%	73%	27%
5%	15%	39%	52%	18%	49%	51%	18%	48%	61%	14%	38%	62%
Rest	0%	3%	97%	0%	3%	97%	0%	3%	97%	0%	3%	97%

Table 3. Overlap of key users and those users with the highest centrality for each centrality measure applied to the activity graph.

In this subsection, we identified structural characteristics of key users in ESN by applying common centrality measures to the social graph and the activity graph of the ESN. The results underline that key users are generally well connected in terms of social links (cf. social graph) and communication activities (cf. activity graph) in the ESN. Comparing the results for both graphs (cf. Table 2 and Table 3), we found bigger overlaps of key users and the top categories for the centrality measures, if these were applied to the social graph. This holds for all centrality measures except for the betweenness centrality which leads to better results if it is applied to the activity graph.

5 Discussion, Limitations, and Future Research

In this section, we discuss how the findings of our analysis contribute to a better understanding of the role of key users in ESN, and look at implications of our research regarding both theory development and practical application. In addition, we also consider several limitations of our study as starting points for future research.

5.1 Discussion and implications for theory and practice

In this study, we primarily investigated the structural characteristics of key users in ESN. In doing so, we used data about the Yammer-provided functionalities to like and bookmark a message as indicators for its added value. We considered those users as value adding key users in the ESN whose messages received the largest number of likes (top 1% and top 5%

segments). These users contribute and communicate their knowledge in the ESN thus helping other users to solve their daily problems and to get their professional work done more successfully and efficiently. By liking or bookmarking their messages, other users appreciate their help.

One theoretical contribution of our paper is that we brought together concepts from both Social Network Analysis and value based thinking. Prior studies focused mostly on mere social structures (e.g., Borgatti (2006)) without incorporating the value add of a user into their investigations. In that realm, a further contribution of our paper based on the Yammer dataset is that 81% of the likes and 94% of the bookmarks were attributed to messages that can be categorized as "professional". This high share of professional related content is all the more surprising as the organization's Yammer network was not organized by BIG's management, but rather arouses organically by employees. So far, although first studies have analysed parts of messages exchanged in their datasets (Richter and Riemer, 2013), it remained unclear whether "likes" and "bookmarks" reflected a practice to highlight professional content or were rather used to applaud private or social content, as it is the case with Facebook or Twitter (Naaman et al., 2010). To the best of our knowledge our study is the first to show how likes and bookmarks can be applied as indicators for the added value of a message. This result is of special interest for practitioners as they often hesitate to push ESN in their companies because of the fear that the content of communication is not work related. In addition, practitioners may use the number of likes in ESN as an indicator to identify knowledge support hubs. The sum of these hubs can be seen as an informal service helpline for employees where people help other people with their knowledge to solve their daily problems. This becomes especially important in an increasing dynamic work environment where employees more often change their jobs and work at distributed places. Thus, the role of ESN can be seen as "support information systems".

These results serve as a prerequisite for our further analysis allowing us to investigate the structural characteristics of the group of the top 1% (top 5%) key users who received more likes than 99% (95%) of all registered users. Our analysis showed that, first, key users are characterized by a high number of written messages, a large number of followers and group memberships (in this ranking order). Thus, this group plays an active part in ESN. Second, the top 1% key users are well connected with respect to different centrality measures both in the social as well as in the activity graph. Structurally, in our context, key users have a central position in the network (Iacobucci, 1996). As regards practitioners, this means that key users (knowledge hubs) can help for example to effectively distribute information in an ESN (as they are characterized by short paths to the other users resulting in a high closeness centrality). In addition, they can for instance contribute to bridging structural holes (Burt, 1992) be-

tween sub-networks in the ESN which do not or only little overlap (as they are often positioned on the shortest path between two other users resulting in a high betweenness centrality). Hence, key users can enable a more effective and rapid exchange of information between different working groups which are only sparsely connected, for example. More generally speaking, if key users (knowledge hubs) have a central position in the ESN, they are crucial for the diffusion of innovative ideas which essentially depends on how people are connected and influence each other (Ciriello et al., 2013). That could also be important in large enterprise transformation programs where targeted internal communication strategies are needed in order to disseminate information across the entire company within a short timeframe. Furthermore, the insight that key users are well connected could also be used for example in cases where companies do not have the "like feature" in their internal enterprise communication systems but aim to identify those people who act as an informal service helpline for other employees.

Regarding methodology, our results have implications for the application of Social Network Analysis, too. First of all, our findings show that the social graph is at least as appropriate to characterize key users as the activity graph. This is surprising, because prior studies have argued that the activity graph leads to better results (Heidemann et al., 2010; Xu et al., 2008; Chun et al., 2008). Against the background that analysing the activity graph yields a considerably higher effort because of a much higher number of ties (which may be important in practice), we recommend a thoughtful choice when deciding for or against using the activity graph. Alongside with this, it was even more surprising to see that simple centrality measures like in-degree centrality proved to be more beneficial than complex measures like eigenvector centrality. While the scientific community has constantly been discussing new, more complex measures (Heidemann et al., 2010; Lu et al., 2012), we would like to state that in this case simple centrality measures outperform more complex measures and are easier to be implemented in practice.

5.2 Limitations and further research directions

Our research provides first insights into this interesting field. However, there are several limitations which can serve as starting points for future research. First, we only considered one single company which provided us with the relevant data needed to conduct this research. Nevertheless, the ESN of this multinational consulting company was intensively used by a large number of users from all over the world. Thus, we assume that our results also hold for other companies using (other) ESN or similar communication systems. Second, for our data analyses, we defined and operationalised key users as those users of the ESN whose messages received the highest number of likes. Obviously, likes cannot completely reflect the

concrete effect and the value add of a message or a user for the company. However, the qualitative text analysis conducted for 8,142 messages indicates that 81% of the messages which received likes are work-related. Hence, it may well be assumed that these messages contribute relevant knowledge helping to get professional work done more successfully and efficiently. While in a first step it seems appropriate to use likes to operationalize the value add for the company, further studies are needed to analyse this aspect in-depth (i.e. how can value add be measured in ESN?). Finally, we did not consider all aspects of the social connections and communication activities of the key users in our analysis of the social graph and the activity graph of the ESN. Nevertheless, we applied the most common centrality measures to both of these graphs. Hence, profound statements about the key users' centrality could be made, but future research is needed to analyse key users' inter-relationships (e.g. are the key users (strongly) connected among themselves?). In this context, graphical analyses (e.g. with Social Network Analysis tools like Commetrix) or cluster analyses based on the social graph and the activity graph seem to be promising starting points to get deeper insights into the structural characteristics of value adding users. In the course of this development it would also be of interest to incorporate further characteristics of key users beyond the social embeddedness (e.g., demographics, position in the organization, and hierarchies) in order to get a comprehensive picture of value adding key users.

6 Conclusion

Ever more organizations are adopting ESN as a means to facilitate collaboration, communication, and knowledge sharing between their employees within and across organizational boundaries (Faraj et al., 2011; von Krogh, 2012). An important aspect of understanding the phenomenon ESN is to identify and characterise those users who contribute and communicate their knowledge in the ESN and help other users to get their daily work done. Despite emerging scientific work in the field of ESN, the role and behaviour of these value adding users in view of knowledge-intensive corporate work is still not fully understood. Thus, the aim of this paper was to investigate the structural characteristics of value adding key users in the context of ESN and to characterize these users. Our analysis is enabled because a plethora of data are generated in ESN when users exchange and connect with others (Giles, 2012). This data wealth allows for unprecedented opportunities to analyse and understand value adding key users in ESN. Against this background, we analysed a large scale dataset of a global consulting company using the ESN Yammer.com. First, using qualitative text analysis and Social Network Analysis, we found that 81% of the likes and 94% of the bookmarks were attributed to messages that can be categorized as "professional". This result has to be seen in the light that the Yammer network was not organized by BIG's management, but rather arouses organically by employees. Second, we could show that key users, defined as users

whose messages received the highest number of likes (top 1% and top 5% segments), are characterized by a high number of written messages, a large number of followers, and also a remarkable number of group memberships. Third, our analysis indicates that key users are well connected both in the social and in the activity graph giving them, from a structural perspective, a central position in the ESN. In sum, from a practical perspective, ESN can be seen as an informal service helpline for employees where people help other people with their knowledge to solve their daily problems. This generates value for the entire firm.

In addition to these results, with respect to theory, we could show that, contrary to prior studies, the social graph is at least as appropriate to characterize key users as the activity graph, and that simple centrality measures like in-degree centrality have proved to be more beneficial than complex measures (like eigenvector centrality). With these results, we hope to contribute to a better understanding of ESN. Summing up, we believe that our study is a first but indispensable step with regard to studying value adding key users in ESN. In future research, we need to come to a much clearer understanding of how these users act, communicate, and connect with others. We hope that our present results will stimulate further research on that fascinating topic and support practitioners to better understand and use ESN.

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3.2 Paper 3: The Blessing of Giving: Knowledge Sharing and Knowledge Seeking in Enterprise Social Networks

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Abstract

Whereas more and more companies use Enterprise Social Networks (ESN) for internal knowledge management, there is still a lack of understanding how employees communicate their knowledge in ESN to support their colleagues. We approach this gap by analysing users' roles and knowledge exchanging behaviours in a rich data set comprising more than two years of ESN usage. We identify three user roles, namely givers, takers, and matchers, regarding knowledge sharing and seeking behaviour and analyse their position in the organisational hierarchy. By applying means of Social Network Analysis, we contribute to a clearer picture of the significant role of givers and confirm findings of other studies that the majority of users behave as takers. Generally, our findings help to come to a more refined understanding of ESN usage and its role in knowledge practices.

Keywords: *Enterprise Social Network, Social Network Analysis, Knowledge sharing, Knowledge seeking*.

1 Introduction

In recent years, many organisations have started implementing Enterprise Social Networks (ESN) to foster internal collaboration, communication, and knowledge sharing (Aral et al., 2013; von Krogh, 2012). According to a recent study the worldwide ESN market revenue is expected to grow from $1.24 billion in 2013 to $3.5 billion by 2018 (Thompson, 2014). Many organisations have recognised the potential of ESN with respect to the creation of competitive advantage by serving as a driving force to build effective and efficient business (Riemer et al., 2015a; Turban et al., 2011) as well as the generation of social capital within organisations, for instance by enhancing an employee's reputation in the company (Riemer et al., 2015a; Wasko and Faraj, 2005). At the same time, there is an increasing demand to better understand the role and impact of these social technologies in knowledge practices like information seeking, knowledge sharing or expert finding (Bharadwaj et al., 2013; Herzog et al., 2013; Richter et al., 2013a; Richter et al., 2013b).

In this line of argument, there are calls to research different actor roles in ESN usage (Trier and Richter, 2015) to better understand the potential of ESN for knowledge transfer and the network structures that influence, for instance, information dissemination (Chau and Xu, 2012) and contribution behaviour (Zhang and Wang, 2012). However, social networking behaviour in ESN with respect to employees' knowledge practices, i.e. how users share and seek knowledge in ESN, is still widely unexplored. More specifically, analysing the users' reciprocities in terms of giving and taking knowledge within an ESN and their structural characteristics have not yet been subject of academic discussion.

Therefore, our objective in this paper is to investigate the knowledge exchanging behaviour of users in ESN. Based on a Social Network Analysis approach, we classify users with respect to their amount of sharing and seeking knowledge. Moreover, we analyse the structural characteristics of user groups in each category. In so doing, we consider two aspects for characterising the user categories: knowledge sharing and seeking behaviour in a knowledge base (i.e. wiki) as well as communication activities and connectedness between users. In so doing, we address the following research questions: 1) How can users be classified with respect to their knowledge exchanging behaviour in ESN? 2) How can users in the different categories be distinguished with respect to their structural position in the ESN and in the organisational hierarchy?

Our results indicate that the users who outstandingly contribute knowledge for other users in the ESN without receiving respective return are amongst the most connected users in terms of writing messages to and having social relationships with other users. We also find that the allocation of the users in the different categories changes within hierarchical levels

which implies a change in some users' characteristics over time, depending on how long he or she is within one level.

From a theoretical perspective, our findings contribute to the development of a more refined understanding of ESN usage in knowledge intensive work. From a practical point of view, our insights can help organisations to better understand the social networking behaviour of their employees and thereupon take measures to improve in knowledge exchange. Moreover, we suggest to and illustrate how to refine methodology, namely "Absolute Distance Measure" and "Relative Distance Measure" to identify user groups in ESN based on their knowledge sharing behaviour.

The remainder of this paper is structured as follows: In Section 2, we provide an overview of the existing literature on knowledge sharing and knowledge seeking in ESN. Section 3 describes the research method, the case setting, and the data collection and analysis process. In Section 4, we present the findings of our analysis of the dataset. In Section 5, we discuss implications and limitations of our work and provide directions for further research. Finally, we conclude with a brief summary.

2 Theoretical Background

2.1 Enterprise Social Networks

In recent years, organisations discovered the growing need of their employees to be connected through an internal network in terms of information exchange, easier expert finding, ideation or team coordination (DiMicco et al., 2008; Thom-Santelli et al., 2011). ESN can facilitate easy corporationwide knowledge exchange without being subject to departmental or geographic boundaries (Aoun and Vatanasakdakul, 2012) and contribute to more open and participative communication practices (Denyer et al., 2011; Holtzblatt et al., 2010; Ip and Wagner, 2008). Meanwhile ESN are a crucial means for companies to stay competitive (Aral et al., 2013).

The increasing usage of ESN also led to an increasing scholarly interest. Prior research addressed amongst others the adoption of ESN in organisations (Overfeld et al., 2012), the development of relationships between employees (DiMicco et al., 2009; Zhang and Wang, 2012), and the potential benefits of ESN in the corporate realm, including expert finding, problem solving, work coordination, and opinion sharing (Brzozowski, 2009; Richter and Riemer, 2013; Thom-Santelli et al., 2011). Researchers also showed that ESN usage does not only affect company performance, but also the career paths of employees. For instance, Wu (2013) revealed that ESN transfer the network positions of employees over time and found significant correlations with job performance and job security. In addition, the emergent network structures of ESN can transform power relations and hierarchies (Bobsin and Hoppen,

2013). In this context, research shows that formal organisational hierarchies (Behrendt et al., 2015) and the level of communication activity (Riemer et al., 2015b; Stieglitz et al., 2014) significantly influence ESN networking behaviour. Muller et al. (2012) examined how diversity influences collaboration, teaming, and innovation, and Matthews et al. (2013) aimed at understanding how leaders enhance the value of their communities. Other research (Herzog et al., 2015; Herzog et al., 2013; Richter et al., 2013a) analysed how the use of these technologies can be evaluated.

2.2 Knowledge sharing and seeking in Enterprise Social Networks

Sharing and demanding with others is deeply rooted in human nature. Every time individuals interact with others, they have to decide within the two extremes of whether to claim as much value as possible or contribute value without expecting anything in return (Grant, 2014). Over the past decades, social scientists have discovered that people differ tremendously in their preferences for reciprocity – their desired mix of giving and taking. Grant (2014) classifies people as givers (i.e. people who give more than they get), takers (i.e. people who get more than they give) and matchers (i.e. people who try to trade evenly). This framework helps us to differentiate between people with preferences for sharing knowledge or seeking knowledge and can serve as an important basis of our study.

There is an increasing demand to understand the behaviour of users in ESN (Koo et al., 2011; Kuegler and Smolnik, 2014), especially in respect of information diffusion (Stieglitz et al., 2014) and knowledge exchange in ESN (Ortbach and Recker, 2014; Recker and Lekse, 2015), since ESN influence information dissemination (Chau and Xu, 2012) and contribution behaviour (Zhang and Wang, 2012). In this context, research focuses in particular on exploring the individuals' rationales behind online knowledge sharing (e.g., Phang et al., 2009; Schroder and Hertel, 2009) and seeking (e.g., Kankanhalli et al., 2005; Wasko and Faraj, 2005; Zhang and Wang, 2012). Further studies investigate the relation between online sharing and seeking knowledge (Phang et al., 2009; Yan and Davison, 2013).

Concerning knowledge exchanging behaviour in networks, Wasko and Faraj (2005) analyse why some users contribute more than others. They identify four reasons: 1) users perceive an enhancement of their professional reputation, 2) they enjoy helping others, 3) they are structurally embedded in the network, and 4) they have experience which is worth sharing with others. In this context, Kankanhalli et al. (2005) find that knowledge self efficacy and enjoyment in helping others significantly impact knowledge contribution to electronic repositories whereas the loss of knowledge power and image do not appear to have any impact. Moreover, a person's position in the network influences the decisions about his or her total contribution and also the allocation of his or her efforts on the platform (Zhang and Wang, 2012).

Referring to the example of Wikipedia, Schroer and Hertel (2009) examine predictors of contributors' engagement and satisfaction and show that satisfaction of contributors is determined by perceived benefits, identification with the community, and task characteristics, whereas their engagement depends on their tolerance for opportunity costs and the experienced characteristics of their tasks which again is partially mediated by intrinsic motivation. Other studies argue that collaborative norms (Bock et al., 2006), identity management (Ma and Agarwal, 2007), and knowledge validation processes (Durcikova and Gray, 2009) also influence knowledge contribution. Prior research has shown that approximately 90% of online community members take over a passive role – they are so-called lurkers (e.g., Katz, 1998; Mason, 1999). Nonnecke and Preece (2000) found that lurking varies and can range from as much as 99% to a low of 1%. In another study they revealed that there are many reasons for lurking in online social communities (e.g. reluctance or usability problems) but many lurkers are no selfish free riders (Nonnecke and Preece, 2001). Schneider et al. (2013) draw the connection between epistemic curiosity as personality trait and emotional-motivational state to lurkers' contribution behaviour in online communities and find that the psychology of curiosity generally holds great promise for research on online communities in information systems. Understanding users' knowledge exchanging behaviour is especially important with respect to ESN, as users largely differ in terms of their connectivity (e.g. number of friends), their communication activity (e.g. number of messages) as well as their frequency, volume, and quality of the user-generated content (Trusov et al., 2010). Trier and Richter (2015) identify two different and interrelated actor roles as an explanation for uneven levels of user contributions to ESN. They call them discourse drivers and information retrievers as two mutually interdependent actors which together shape the dynamics of the online interaction. Moreover, Berger et al. (2014) find that users who add value to the organisation by sharing their knowledge in the ESN are amongst the best connected users and thus enable a more effective and rapid exchange of information between different working groups.

Research focussing on knowledge seeking on platforms addresses either knowledge seeking behaviour of individuals (Bock et al., 2006; Kankanhalli et al., 2005) or its relation to knowledge sharing (Phang et al., 2009; Yan and Davison, 2013). For instance, Kankanhalli et al. (2005) examine electronic knowledge repositories (EKR) that serve the purpose of storing codified knowledge for future reuse within companies and investigate potential antecedents to EKR usage for knowledge seeking. Their results reveal that EKR usage for knowledge seeking is influenced by perceived output quality, resource availability, and incentives. Moreover, knowledge seeking and knowledge contribution in online communities are influenced by different aspects of usability and sociability (Phang et al., 2009). For instance, ease of use and system reliability are considered as more important for usability when individuals seek

knowledge, whereas tracking fulfilment is more important for usability when individuals contribute knowledge. In addition, Yan and Davison (2013) analyse the mediating role of an individual's intrinsic motivation for the behavioural transfer from knowledge seeking to knowledge contribution in knowledge management in Web 2.0 applications.

From a management perspective it is essential to know which users outstandingly contribute their knowledge, allowing others to benefit from their experience, and which users primarily acquire knowledge without contributing much themselves. Therefore, the aim of this paper is to 1) propose two methods to classify users based on their knowledge sharing and seeking behaviour as givers, takers, and matchers (cf. Grant, 2014) and 2) investigate their structural characteristics as well as their position in the formal organisational hierarchy.

3 Research Method

3.1 Setting

We approach our research objective with the case of the medical service unit (MSU) of the German Armed Forces (Deutsche Bundeswehr). MSU is composed of, amongst others, 2,700 medical officers and 1,600 trainee medical officers for military medicine, military pharmacy, veterinary medicine, and dental medicine. They are distributed amongst five major military hospitals in Germany, 37 German universities offering medical studies, and 200 other facilities. In 2009, MSU decided to implement an ESN, MSU-Net, with the following aims: (1) encouraging knowledge transfer and collaborative learning among colleagues, (2) creating a collaborative knowledge base, (3) improving the quality of education as well as the inservice training of new colleagues, and (4) strengthening the corporate identity and the networking of the employees. MSU-Net, which was launched in November 2010, enables the employees to become virtual friends, write messages to other users, and post blog entries which can be commented by others. To foster the knowledge transfer, MSU-Net also includes a knowledge base to which employees contribute publically available (scientific) content.

A preliminary analysis of the dataset showed a high amount of information available about the users' communication (i.e. written and received direct messages) and knowledge exchange behaviours (i.e. written, modified and read articles in the knowledge base) so that the dataset is ideal for our research objective. As the activities in the knowledge base deliver us information about users' write accesses (i.e. written and modified articles) and read accesses (i.e. read articles), we can see who shares and who seeks knowledge. This enables us to classify the users as people who predominantly give knowledge, people who predominantly take knowledge, or people who give and take to a relatively balanced extent.

3.2 Data collection and preparation

The dataset contains the users' military ranks which follow the formal organisational hierarchies of the German Armed Forces. In our case, the military hierarchies are divided into six levels: enlisted soldier (level 1), non-commissioned officer (NCO) (level 2), officer candidate (level 3), officer (level 4), staff officer (level 5), and general (level 6). During data export, all personal information (such as user names) was removed to guarantee confidentiality. The dataset, referring to the time period between November 2010 and February 2015, was supplied in table format. It contains, amongst others, information about each user's confirmed contact requests to other users (in the following referred to as "social relationships"), direct messages exchanged with other users (written and received messages) as well as written, modified, and read articles in the knowledge base in MSU-Net. Of the 2,941 users, 1,732 users have at least one social relationship (total number of social relationships: 7,679). Furthermore, the data contains 19,571 direct messages between two users. Read accesses as well as write accesses in the knowledge base were provided on a monthly base ranging from January 2013 to March 2015. 2,034 users were active in the knowledge base: among those, 114 users wrote at least one article, 152 users made at least one article modification. A total of 1,041 articles were authored, 5,577 modifications were undertaken. Altogether, we observe a total of 6,618 write accesses and 91,082 read accesses.

3.3 Data analysis

To classify the users of the ESN as givers, takers, or matchers we focus on their knowledge sharing and seeking behaviour in the knowledge base. Indeed, the knowledge base in MSU-Net was created to support the knowledge exchange among employees. On the one hand, it allows users to write and modify articles to share their knowledge with others; on the other hand it allows users to read articles from other users to acquire knowledge. Against this background, those users of MSU-Net are regarded as givers who outstandingly share their knowledge in the knowledge base thus enabling others to gain more knowledge. Takers are regarded as users who outstandingly seek knowledge to their own benefits, whereas matchers share and seek knowledge to a relatively balanced extent. To assess each user's amount of knowledge shared and acquired in the knowledge base, we focus on his or her number of write accesses and read accesses in total and for each of the observed periods (i.e. 2013, 2014 and 2015), respectively. On this basis, we classify them as givers (users whose relative amount of write to read accesses is comparably high), takers (users whose relative amount of write to read accesses is comparably low), and matchers (users with a comparably balanced amount of write and read accesses). Write accesses potentially reach multiple users whereas read accesses refer to only one single user. Indeed, the total number of read accesses is much higher

compared to the total number of write accesses. Therefore, for further analyses we use a factor to weight the number of write accesses to enable 1:1 comparisons. For 2014, for instance, the total number of read accesses is 47,067 and the total number of write accesses is 3,001 and we used the factor 15.68 (= 47,067 / 3,001) for weighting. We define a "pure giver" as a user with no read but one or more write accesses and a "pure taker" as a user with no write but one or more read accesses. A perfect matcher is characterised by an equal number of weighted write and read accesses.

Based on his or her number of read accesses and weighted write accesses each user can be represented in a Cartesian coordinate system (cf. Figures 1 and 2). The x-axis refers to the user's number of read accesses; the y-axis refers to his or her number of weighted write accesses. Thereby, pure givers and pure takers are directly located on the y-axis or the x-axis, respectively; perfect matchers can be found on the bisectrix. In the following, we propose two different methods to classify a user as giver, taker, or matcher. Methodically, both methods are founded on users' Euclidean distance to the lines representing pure givers (cf. y-axis), pure takers (cf. x-axis), and perfect matchers (cf. bisectrix) in this Cartesian coordinate system.

The first method is based on whether a user u is closest to being a perfect matcher, to being a pure giver, or to being a pure taker, respectively. Therefore, we determine his or her Euclidean distance to the bisectrix (see $d_M(u)$ in Figure 1), the y-axis (see $d_G(u)$ in Figure 1) and the x-axis (see $d_T(u)$ in Figure 1) and classify the user according to the minimum absolute distance. Thus, in the following this method is referred to as "Absolute Distance Measure". Figure 1 provides illustrative examples of users classified as giver, taker, and matcher, respectively.

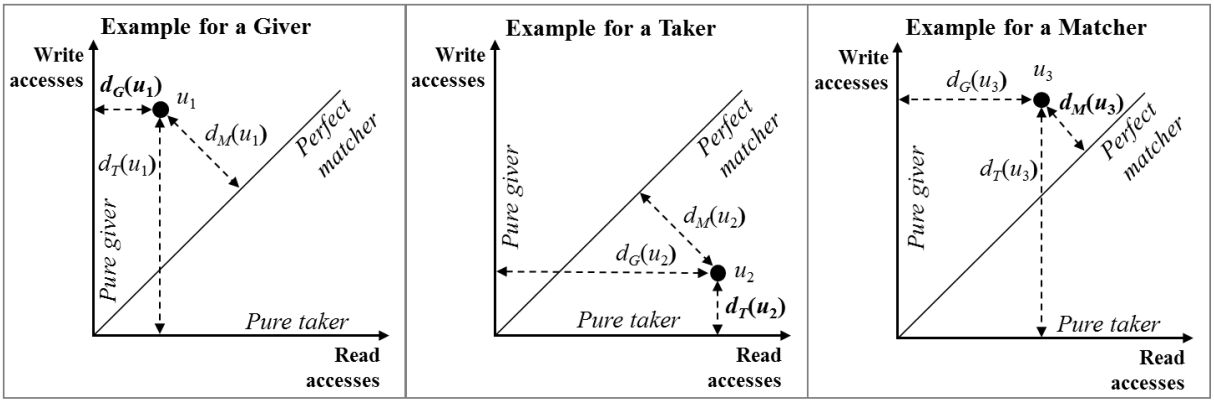

Figure 1. "Absolute Distance Measure" to classify users as givers, takers, or matchers.

The "Absolute Distance Measure" allows to classify a user independent from other users. To classify users as givers, takers, or matchers considering the knowledge exchanging behaviour of the other users of the ESN in comparison as well, we propose a second method, in the following referred to as "Relative Distance Measure". Thereby, we calculate each user's Euclidean distance (see $d_M(u)$ in Figure 2) to a perfect matcher in relation to his or her respective

greatest possible Euclidean distance to a perfect matcher (see $d_{max}(u)$ in Figure 2). Here, $d_{max}(u)$ corresponds to the Euclidean distance of a perfect matcher to a pure giver or pure taker lying on a perpendicular to the bisectrix through user u. Putting $d_M(u)$ in relation to $d_{max}(u)$ allows us to compare users with high and low values of weighted write or read accesses. We then calculate the average of these relative distances. In our case, due to the large number of pure takers, this results in a value of 0.958 for all periods aggregated, 0.967 for 2015, 0.969 for 2014, and 0.953 for 2013. Based on this average and the respective user's individual relative distance to the perfect matcher, he or she is then classified as giver, taker, or matcher accordingly. Thereby, users whose individual relative distance differs less than average from the perfect matcher are classified as matchers; users whose individual relative distance differs more than average from the perfect matcher are classified as givers (more weighted write than read accesses) or takers (more read than weighted write accesses), respectively. Figure 2 provides illustrative examples of users clasified as giver, taker, and matcher, respectively.

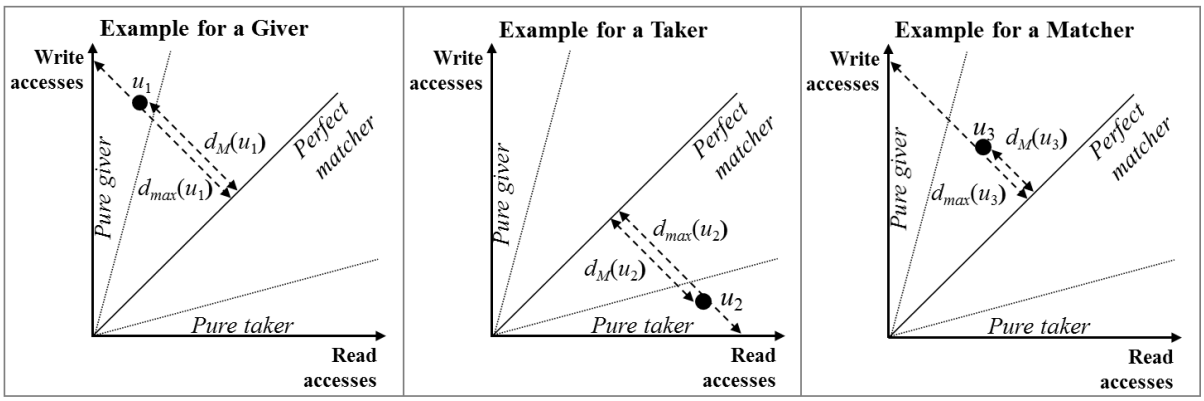

Figure 2. "Relative Distance Measure" to classify users as givers, takers, or matchers.

We applied both methods to all users in our dataset who participated (i.e. they had read and/or write accesses) in the knowledge base. The reason is that users who are only enrolled in the ESN without reading or writing in the knowledge base would influence the resulting allocations and finally distort our findings. Therefore, we conduct our further analyses focussing on the participating users only (2,034 for all periods, 690 in 2015, 1,673 in 2014 and 1,066 in 2013).

To investigate the structural characteristics of givers, takers, and matchers in ESN, we apply Social Network Analysis (SNA) (Wasserman and Faust, 2009). SNA was prior used in IS research to analyse for instance users' social networking behaviour in OSN and ESN (Behrendt et al., 2015; Krasnova et al., 2010), social capital as a result of the usage of OSN (e.g., Ellison et al., 2007), and the characteristics of key users in ESN (Berger et al., 2014). According to Freeman (2000, p. 350), SNA "involves theorizing, model building, and empirical research focused on uncovering the patterning of links among actors" by, for instance, quantifying the

centrality of nodes within a network. In this context, there exists a variety of centrality measures, whereby the most common centrality measures are degree centrality, closeness centrality, and betweenness centrality (Freeman, 1979) as well as eigenvector centrality (Bonacich, 1972). Degree centrality assumes that a node with many direct connections to other nodes is central to the network. Closeness centrality expands the definition of degree centrality by focusing on how close a node is to all other nodes in the network. These nodes can, for instance, contribute to a fast exchange of ideas and information in the network. The idea behind betweenness centrality is that a node which is on many shortest paths between other nodes is central to the network. Users with high betweenness centrality are supposed to control the information flows in networks. Eigenvector centrality extends the logic of degree and closeness centrality and incorporates a node's connectivity in the whole network. Here, a node is more central to the network, if it is connected to other central nodes.

ESN can be represented as a graph with a set of nodes (users) and a set of edges (ties) linking pairs of nodes (Wasserman and Faust, 2009). The edges can be either directed or undirected and represent either social links like social relationships (social graph) or communication activities like messages among the users (activity graph) (Adamic and Adar, 2003; Bampo et al., 2008; Heidemann et al., 2010). We ground our research on both graphs in order to get profound insights into the structural characteristics of givers, takers and matchers in ESN. The social graph representing the social relationships comprises 2,941 nodes and 7,679 undirected edges (confirmed contact requests). The activity graph is inferred by the direct messages exchanged between a pair of users. It consists of 2,941 nodes and 4,830 directed and weighted edges (messages sent between two users). For the network analysis, we use Gephi (https://gephi.org/) to calculate degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality for each node of the social graph as well as of the activity graph. In addition, to gain deeper insights into the characteristics of givers, takers, and matchers with respect to their participation in the knowledge base, we also analyse their average numbers of written or modified articles (write accesses) and read articles (read accesses).

Finally, we also investigate the hierarchical positions of givers, takers, and matchers based on their level in the formal hierarchy of the organisation. To make our results transferable to a non-military organisational setting, we categorise levels 1 and 2 as lower hierarchical level, 3 and 4 as middle hierarchical level, and 5 and 6 as higher hierarchical level and compare them to common organisational roles based on the Administrative Order on the Position of the Military Superior (Bundesministerium der Verteidigung, 1956). Against this background, level 1 is the lowest level where the persons have no authority over others, whereas persons in level 2 can be compared to team leaders who give commands to level 1 employees with decision

making power only in their own team. Level 3 can be compared to managers who lead a collection of teams (e.g., a department) and level 4 to business unit managers with responsibility for the management, training and staffing of a business unit or sub-division and authority over all lower levels of hierarchy. Level 5 can be compared to executive directors who are typically not involved in the daily business but lead divisions. They have authority over all lower levels and decide on strategic aspects. Level 6 can finally be compared to board members in the top management that have authority over all lower levels. They fulfil representative and strategic tasks covering the entire organisation.

4 Results

4.1 Classification of givers, takers, and matchers

In this subsection, we classify the users of the ESN as givers, takers or matchers. Table 1 shows the resulting allocations of givers, takers and matchers for the Absolute Distance Measure as well as for the Relative Distance Measure and illustrates that for both measures the majority of the users are classified as takers. This holds for each of the observation periods.

	2015 (*n* = 690)		**2014** (*n* = 1,673)		**2013** (*n* = 1,066)	
	Distance Measure		**Distance Measure**		**Distance Measure**	
Category	**Absolute**	**Relative**	**Absolute**	**Relative**	**Absolute**	**Relative**
Givers	3% (19)	1% (4)	1% (22)	0% (0)	2% (22)	0% (0)
Takers	95% (655)	95% (654)	95% (1,595)	95% (1,586)	93% (995)	92% (979)
Matchers	2% (16)	4% (32)	4% (56)	5% (87)	5% (49)	8% (87)

Table 1. Allocation of givers, takers, and matchers.

Similar results can be observed for the aggregation of all periods (cf. Table 2): only 2% or 0% of all users are classified as givers, while more than 90% of all users are takers. The Bowker-Test (Bowker, 1948) reveals that the results of both methods, the "Absolute Distance Measure" and the "Relative Distance Measure", do not differ significantly ($\alpha = 0.05$). Therefore, as well as for reasons of clarity and the page length restriction we base our further analyses on users' classification based on the "Absolute Distance Measure" and for the aggregation of all periods.

Category	**Absolute Distance Measure**	**Relative Distance Measure**
Givers	2% (30)	0% (3)
Takers	94% (1,917)	93% (1,882)
Matchers	4% (87)	7% (149)

Table 2. Allocation of givers, takers, and matchers for all periods.

4.2 Structural characteristics of givers, takers, and matchers

To investigate the structural characteristics of givers, takers, and matchers in ESN, we first analyse how they are characterised with respect to their average numbers of write accesses and read accesses in the knowledge base as well as written and received direct messages, and social relationships.

The results (cf. Table 3) reveal that givers are very active users in the knowledge base of MSU-Net with an average of 141 written or modified and 464 read articles. Takers on the other hand write no articles on average but still read 31 articles. In average, matchers also read a lot of articles with 201 articles per user, whereas their write access is moderate with 23 written or modified articles per user. Concerning the communication in the ESN (i.e. direct messages), givers are very active with 151 written and 117 received messages per user, closely followed by matchers with 97 written and 99 received messages per user, while takers seem very passive in the ESN with only three written and four received messages. As far as social relationships are concerned, givers and matchers are amongst the best connected users, with on average 24 or 23 social relationships, respectively, whereas again takers only have 6 social relationships on average. Summing up the results of these analyses, givers are the highest contributors to the knowledge base by writing and modifying most articles per user. Moreover, givers and matchers are amongst the most active users concerning communication activity and have most social relationships per user. Takers show opposite characteristics. They are amongst the least active users concerning their participation in the knowledge base as well as their number of social relationships and direct messages per user.

Category	Average no. of write accesses	Average no. of read accesses	Average no. of written direct messages	Average no. of received direct messages	Average no. of social relationships
Givers	141	464	151	117	24
Takers	0	31	3	4	6
Matchers	23	201	97	99	23

Table 3. User behaviour of givers, takers, and matchers.

To get further insights into users' connectedness in the ESN, we further analyse the centrality of givers, takers, and matchers in the social graph (i.e. social relationships based on confirmed contact requests) and the activity graph (i.e. communication based on direct messages). We apply closeness centrality, betweenness centrality, and eigenvector centrality to both graphs whose nodes represent all 2,941 users in MSU-Net (i.e. users who participate in the knowledge base as well as users who do not participate in the knowledge base). We do not consider users' degree centrality, since it represents the number of social relationships in the social graph and the number of direct messages in the activity graph respectively, which we already analysed before. We then rank all users in the network for each centrality measure in

a decreasing order and classify them with respect to quartiles, with quartile 1 containing the 25% of the users with the highest and quartile 4 containing the 25% of the users with the lowest centrality scores. Tables 4 and 5 show for each category (givers, takers, and matchers) the percentage of the respective users belonging to the quartiles 1, 2, 3, and 4 (please note that all users of the ESN are considered for the ranking of the users and the quartiles for reasons of comprehensibility).

Category	Closeness Centrality Quartile				Betweenness Centrality Quartile				Eigenvector Centrality Quartile			
	1	2	3	4	1	2	3	4	1	2	3	4
Givers	77%	10%	10%	3%	83%	13%	0%	3%	73%	12%	10%	3%
Takers	30%	30%	22%	18%	29%	28%	25%	18%	30%	30%	22%	18%
Matchers	80%	14%	5%	1%	87%	11%	1%	0%	79%	14%	6%	1%

Table 4. Closeness, betweenness, and eigenvector centrality in the social graph.

The results for the social graph indicate that givers and matchers are very well connected. Indeed, more than 70% of givers and matchers belong to quartile 1 for closeness centrality, betweenness centrality, and eigenvector centrality. For instance, regarding betweenness centrality 83% of the givers and 87% of the matchers are in quartile 1, only 3% of the givers and 0% of the matchers are in quartile 4. This shows that nearly three out of four of the givers and matchers are amongst the best connected users in the social graph. Takers are in general less well connected (at most 30% in quartile 1). Again, this can be observed for closeness, betweenness as well as eigenvector centrality.

Similar to the social graph, givers and matchers are very well connected in the activity graph with more than 80% of the givers and matchers being in quartile 1 whereas takers again show lower centrality regarding all observed centrality measures. For instance, 83% of the givers and 82% of the matchers are in quartile 1 with respect to closeness centrality. In keeping with the social graph, at most 30% of the takers are in quartile 1.

Category	Closeness Centrality Quartile				Betweenness Centrality Quartile				Eigenvector Centrality Quartile			
	1	2	3	4	1	2	3	4	1	2	3	4
Givers	83%	10%	4%	3%	83%	10%	4%	3%	83%	10%	3%	4%
Takers	30%	27%	25%	18%	30%	27%	25%	18%	29%	28%	25%	18%
Matchers	82%	17%	1%	0%	84%	15%	1%	0%	87%	11%	2%	0%

Table 5. Closeness, betweenness, and eigenvector centrality in the activity graph.

In summary, the results underline that givers and matchers are better connected than takers in terms of social links (cf. social graph) and communication activities (cf. activity graph) in the ESN. This holds for all analysed centrality measures. Taking also into consideration that givers are amongst the most active users who share most knowledge by writing most articles

in the knowledge base, they can be identified as most important users for distributing and sharing knowledge in ESN.

4.3 Hierarchical levels of givers, takers, and matchers

To get further insights into the representation of givers, takers, and matchers in the hierarchy of organisations, we finally investigate the allocation of each user category in the higher, middle, and lower hierarchy.

As depicted in Figure 3, the majority of the members in all hierarchical levels are takers, for instance 99% in level 1, 85% in level 2, or 99% in level 3. There are similar patterns within the lower hierarchy (i.e. levels 1 and 2) and the middle hierarchy (i.e. levels 3 and 4): whereas there are nearly only takers in the lower sublevel within the hierarchies (i.e. levels 1 and 3), there is an increase in givers and matchers in the next higher sublevels (i.e. levels 2 and 4). Whereas levels 1 and 3 can be compared to newly qualified members or candidates, levels 2 and 4 signify members who have already been within the lower or middle hierarchy for a certain time. In the higher hierarchy, the share of matchers also increases from 9% to 17% between level 5 and level 6, while the share of givers in contrast decreases from 2% to 0%, respectively. In sum, the share of takers decreases steadily after the lower hierarchical level, starting with 99% in level 3 and ending in 83% in level 6.

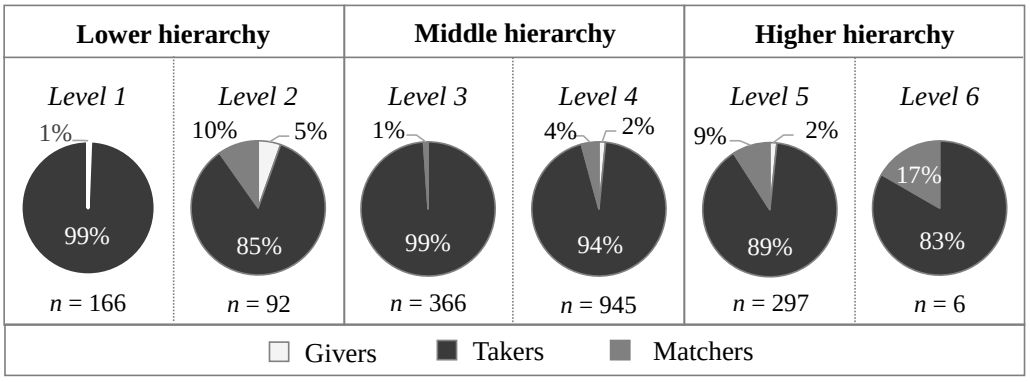

Figure 3. Allocations of givers, takers, and matchers within hierarchical levels.

5 Discussion, Limitations, and Future Research

5.1 Implications for theory and practice

In this study, we investigated knowledge exchanging behaviour in ESN as well as the structural characteristics of knowledge sharing and seeking users. In doing so, we used data about read and write accesses in the knowledge base of MSU-Net as indicator for sharing and seeking knowledge.

First of all, we proposed two novel methods to distinguish between givers, takers, and matchers in ESN. To do so, we developed the "Absolute Distance Measure" and the "Relative Distance Measure". We could show that both methods lead to very similar results. Indeed, we observed no statistically significant change in the assignment of users to the categories. Since the "Relative Distance Measure" is more complex to apply, one may tend to apply the "Absolute Distance Measure" when classifying users based on their role in the ESN's knowledge sharing activities. On this methodological basis, we found that the clear majority of all users of the ESN behave as takers. This is in keeping with Nielsen (2006) who states that only 10% of all users of a social community create 100% of its content and Katz (1998) who identified 90% of online community members as lurkers. In addition, Trier and Richter (2015) state that a smaller group of information contributors in organisational network domains competes for a large group of retrievers in order to grow their topic. The large number of takers in the knowledge base might be due to an uncertainty of the users if their knowledge is important enough to be published. Also a lack in experience in how to correctly author articles which are accessible by all other users can be a barrier, as in the case of errors it could redound upon the author. Moreover, writing an article always involves effort which some users might not be willing to make. From a practical point of view, our results imply that the small group of "givers" needs to be identified and addressed individually as key users in order to support an effective and successful exchange of knowledge within the organisation.

Second, the classification of users as givers, takers, and matchers allows us to investigate the structural characteristics of each category. Our analysis shows that givers and matchers are characterised by a high amount of written direct messages as well as a large number of social relationships and therefore are very active users. Concerning the knowledge base, givers are by far the highest contributors by writing more than six times the amount of articles than matchers do. Surprisingly, takers have only few read accesses as well as written and received messages and social relationships and therefore are overall rather passive users. They could have been expected to be more active in order to gain knowledge from the network. Our study is the first considering two aspects for characterising the user categories: knowledge sharing and seeking behaviour in the knowledge base as well as communication activities and connectedness between users. Prior studies in other contexts like tagging (Thom-Santelli et al., 2008) or blogging (Jackson et al., 2007) focussed on only one aspect for the classification of user groups. For instance, Thom-Santelli et al. (2008) investigated merely the use of tags, or Jackson et al. (2007) only considered writing and commenting blogs of users, without taking into consideration network structures. Our study does not only support the identification of important users for the knowledge exchange within an organisation, but also helps to understand how these users are characterised in terms of their connectivity and activity in ESN. Additionally, givers and matchers are well connected with respect to different centrality

measures both in the social as well as in the activity graph. As regards practitioners, this means that givers and matchers are not only important for knowledge exchange in the ESN, but they can also help for example to effectively distribute information in an ESN (due to high closeness centrality). Moreover, they can for instance contribute to bridging structural holes (Burt, 1992) between sub networks in the ESN which do not or only little overlap (due to high betweenness centrality). Hence, givers and matchers can enable a more effective and rapid exchange of information between different working groups which are for instance only sparsely connected, or more generally speaking are crucial for the diffusion of innovative ideas which essentially depends on how people are connected and influence each other (Ciriello and Richter, 2015; Ciriello et al., 2013). For this part, our results are also in accordance with Berger et al. (2014) who showed that users adding value for others are amongst the best connected users in ESN.

Third, our results also indicate that the allocations of the user categories change within hierarchical levels. Although the majority in all levels are the takers, their percentage decreases whereas the matchers' percentage increases, the higher the position in the formal organisational hierarchy is. This holds true for all observed periods. Whereas the decrease of the takers is in accordance with Grant's findings, we cannot confirm his statement that givers are the most likely to reach the end of the success ladder for the context of ESN. This might be due to the fact that ESN are an environment in which contents can be shared easily and thus the consumption of knowledge is facilitated which in turn leads to rather a matching than a pure giving mentality. Although the share of givers increases within the lower and middle hierarchy, which shows that having a giving mentality may benefit promotions to the next hierarchical level, this does not hold true for the higher hierarchy. A reason for the shift from a taking to a giving or matching behaviour within hierarchical levels can be that at the beginning, they are careful and uncertain about the competitive situation and thus aim at gaining knowledge themselves without caring about others, yet as they want to prove themselves in a first step. But the longer they are within a hierarchical level, the more confident they become to post relevant knowledge and the more they give to others. Therefore, they lose the fear of actively contribute to the knowledge base but still mostly expect knowledge in return (i.e. these people rather behave as matchers than as givers). For practice this means that it is the members of the higher hierarchical levels that need to be addressed in order to spread knowledge through the organisation. An exception can be recognised in level 3 where the proportion of givers and matchers decreases back compared to level 2. The reason may be that right after being promoted to the next higher hierarchy for the first time (i.e. after the lower hierarchy) the willingness to share knowledge decreases but increases again after being a member of this hierarchy for a certain time. Another prominent observation is the exceptional portion of givers in level 2 which we explain in such a way that new members in level

1 are still very uncertain whereas they gain their first self-confidence in level 2 after being member for a while and start giving even more than they expect in return. But already after being promoted to the next higher level (i.e. level 3) this giving mentality decreases back and rather turns into a matching mentality due to an increasing competitive environment in higher levels which finally even culminates in a 0% share of givers in the highest level (i.e. level 6).

5.2 Limitations and further research directions

Although our results provide first interesting insights into the classification and characteristics of givers, takers, and matchers in ESN, there are several limitations, which can serve as starting points for future research. First, we only considered one single organisation, which provided us with the relevant data needed to conduct this research. Nevertheless, the ESN was actively used by a large number of users for sharing and gaining knowledge. Thus, we assume that our findings also hold for other organisations. Second, military organisations might differ from business organisations in some points. But according to the work descriptions in the Administrative Order on the Position of the Military Superior military ranks can be seen as equivalent to formal job titles in organisations like upper, middle, and lower management. Hence, we do not think that users' behaviour in MSU-Net differs from users' behaviour in other ESN. Third, we classified users as givers, takers, and matchers based on their number of write and read accesses in the knowledge base. Obviously, the participation in the knowledge cannot completely reflect users' knowledge exchanging behaviour in the whole ESN, which also takes part in direct messages. Moreover, we did not consider the extent and quality of write accesses as well as the length of read accesses. However, it may well be assumed that the knowledge base is the main feature for knowledge sharing in the ESN. While in a first step it seemed appropriate to use users' write and read accesses for the classification, further studies are needed to analyse this aspect in-depth. Besides these limitations, we see promising starting points for future research. First, we focused on users' hierarchical level as a first indicator for the professional performance of givers, takers, and matchers. Further in-depth analysis on this topic seems to be a promising starting point for future research. Are givers the most successful employees in the organisation? Does it pay off being a giver or is it more beneficial to behave as a taker (e.g., are there differences in wages or bonuses)? Do givers really reach the next hierarchical level more easily? Second, it would also be of interest to analyse if givers, takers, or matchers in the online context change to another category in the offline context. In the course of this development it would also be of interest to incorporate further characteristics of each user category beyond the social embeddedness (e.g., demographics) in order to get a more comprehensive picture.

6 Conclusion

Ever more organisations have been adopting ESN to foster collaboration, communication, and knowledge sharing among their employees (Aral et al., 2013; von Krogh, 2012). While there is a growing body of literature on ESN in general and knowledge sharing in ESN in particular, we still observe a lack of research on employees' knowledge exchange practices in ESN, for instance how users share and seek knowledge in ESN. Thus, the aim of this paper is to investigate how users can be classified based on their knowledge exchanging behaviour and how users in each category are characterised with respect to their structural characteristics as well as their position in the organisational hierarchy. Our analysis is enabled by a plethora of data generated when users interact and connect with others (Giles, 2012). Against this background, we analyse a large scale dataset of ESN usage.

First, we show how users can be classified based on their participation in the knowledge sharing process in ESN. Here, we were able to show that most users in the ESN can be classified as takers and therefore, acquire disproportionately much knowledge compared to the amount of knowledge they contribute for others. Second, by applying SNA (Wasserman and Faust, 2009) we found that givers, who share more knowledge in the ESN than they acquire from it, are characterised by a high number of written direct messages and social relationships in the ESN. Moreover, they are also well connected both in the social and the activity graph, giving them, from a structural perspective, a central position in the ESN. Therefore, organisations are well recommended to identify and address their givers for an effective knowledge management within the organisation.

With our results, we hope to contribute to a better understanding of ESN and the online knowledge exchange within organisations in particular. Summing up, we believe that our study is a first but indispensable step with regard to studying users' knowledge exchanging behaviour in ESN. We hope that our present results will stimulate further research on that fascinating topic and support practitioners to better understand and use ESN for knowledge management.

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3.3 Conclusion to Chapter 3

The research questions addressed in this chapter are:

RQ. 5 *How can value adding key users be distinguished with respect to their structural characteristics like for example the number of followers, group memberships, or the centrality in ESN?*

RQ. 6 *How can users be classified with respect to their knowledge exchanging behaviour in ESN?*

RQ. 7 *How can users in the different categories be distinguished with respect to their structural position in the ESN and in the organizational hierarchy?*

The research in this chapter consists of two parts, addressing on the one hand the identification and definition of different actor roles and on the other hand the structural characteristics of these actor roles. To begin with, in Paper 2, value adding key users, who contribute and communicate their knowledge in the ESN, were identified based on the value add of their messages. Therefore, those users that received most likes were regarded as value adding, as most liked messages have a professional background. For the definition of givers, takers, and matchers (cf. Paper 3), the amount of users' write and read accesses on articles in a wiki in the ESN was used. Hence, the actor roles can be distinguished with respect to their context as well as the information that is required for their identification.

For all actor roles, the respective structural characteristics were analyzed. This investigation found huge similarities for the structural characteristics of those actor roles that actively share their knowledge in the ESN (i.e. value adding key users and givers).

Both papers were presented and discussed at the European Conference on Information Systems (ECIS), a prestigious IS conferences (i.e. ECIS 2014 and ECIS 2016), where their ideas and results found general approval. Paper 2 has been cited more than 20 times in conference or journal papers (Helms et al. 2016; Riemer et al. 2015; Viol et al; Wehner et al. 2017). Here, Viol et al. (2016) use the results and insights to motivate and to substantiate their own research on actor roles in ESN, while Helms et al. (2016) focused on the method for the creation of the activity graph for their research on the creation of networks. Although Paper 3 was published as recently as June 2016, it already has been cited (Hacker et al. 2017).

Summing up, both papers in this chapter contribute to the growing body of research on knowledge management in ESN. The insights are also of interest for practitioners as they offer organisations the opportunity to distinguish different actor roles and thus, to support an effective knowledge management.

As a final remark, it should be noted that Paper 2 sometimes uses the phrase social link as a reference social relationship (cf. Paper 3). Nevertheless, both terms can be used similarly and equally refer to the edges of the social graph.

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4 Role of Formal Hierarchies in Enterprise Social Networks

In this chapter, RQ. 8 and RQ. 9 are addressed by investigating the effects of formal hierarchies on user behaviour in ESN. As already mentioned before, ESN are said to transform power relations and hierarchies (Bobsin and Hoppen 2013) to more networked ones, as they have the potential of letting persons in an organisation interact as equals (McAfee 2009). To address this issue, two case studies are conducted at the GAF.

First, using data from an ESN used by the medical service unit of the GAF and data from 13 interviews the impact of formal hierarchical effects on three types of relations (i.e. social relationships, 1:1 communication and 1:n communication) are investigated and compared (RQ. 8). The second subsection addresses whether and how the formal hierarchical effects inside and outside ESN differ (RQ. 9). For this purpose insights from an online survey and data from the ESN are used.

4.1 Paper 4: The Impact of Formal Hierarchies on Enterprise Social Networking Behaviour

Status	Published	Full Citation
Accepted	12/2015	Behrendt, S., Klier, J., Klier, M., Richter, A., and Wiesneth, K. 2015. "The Impact of Formal Hierarchies on Enterprise Social Networking Behavior," in *Proceedings of the Thirty-sixth International Conference on Information Systems (ICIS)*, Fort Worth, TX.
Annotation: This paper is written in American English		

Abstract

With more and more companies using enterprise social networks (ESN) for employee communication and collaboration, the influence of ESN on organizational hierarchies has been subject of countless discussions in practice-oriented media and first academic studies. Conversely, the question whether and how formal organizational hierarchies influence ESN usage behavior has not yet been addressed. Drawing on a rich data set comprising 2.5 years of relationship building via direct messages, confirmed contact requests, and group messages, we are able to show that formal hierarchies have an important impact on social networking behavior. By applying means of social network analysis and supported by statements from interviews, we illustrate how deeply formal hierarchy impacts the three examined types of relationships. Our results motivate academics to further study the interrelation between hierarchy und ESN and hierarchy's effects regarding the sociotechnical design and implementation of related systems.

Keywords: Enterprise social networking, formal hierarchies, social networking behavior

1 Motivation

In the last couple of years many companies have begun to implement enterprise social networks (ESN) to foster collaboration, communication, and knowledge-sharing among employees (Aral et al. 2013; von Krogh 2012). ESN can support employees in terms of information seeking, dissemination and sharing, easier expert finding, ideation or team coordination (Guy et al. 2013; Richter et al. 2011) and thus enable an easy corporation-wide exchange without being subject to departmental or geographic boundaries (Aoun and Vatanasakdakul 2012). As they have shown to support the creation of social capital within organizations and to serve as a driving force to build effective and efficient business and create competitive advantage (Turban et al. 2011), ESN play an increasingly crucial role for companies (Aral et al. 2013). In addition to influencing information dissemination (Chau and Xu 2012), contribution behavior (Zhang and Wang 2012), or employee and organizational performance (Wu 2013; Zhang and Venkatesh 2013; Zhang and Wang 2012), the emergent network structures are also said to transform power relations and hierarchies (Bobsin and Hoppen 2013). As McAfee (2009, p. 207) notes, ESN have the potential of "giving many [...] within the organization a voice, letting them interact as equals...". This seems to be in contradiction with existing (formal) hierarchical structures.

Formal hierarchy[1] is as an essential and pervasive organizational characteristic which heavily influences informal social relations and strongly limits the variety of potential network structures (Corominas-Murtra et al. 2013; West et al. 1999). Notwithstanding, the interplay of formal organizational hierarchies and users' social networking behavior in ESN, i.e. how users communicate and connect, is still widely unexplored. More specifically, the question whether and how formal organizational hierarchies influence ESN usage behavior or users' position in the network has not yet been subject of academic discussion. However, there are calls to research the role of formal hierarchies in ESN (Howison et al. 2011; Kane et al. 2014) and to better understand the potential of ESN for delayering and changing organizational network structures that influence, for instance, information dissemination (Chau and Xu 2012) and contribution behavior (Zhang and Wang 2012).

By triangulating multiple sources of evidence in form of a case study, we acknowledge that the influence of formal hierarchy cannot be seen as a mere phenomenon without considering the context (Yin 2009). We use both qualitative data from interviews to understand the context and quantitative data extracted from the ESN to analyze social networking behavior on

[1] We distinguish formal and informal hierarchy. The former is inferred by official structures that are allocated by formal roles and ranking positions Diefenbach and Sillince (2011). These formal hierarchical structures can be represented, for instance, in an "org chart". Opposed to this, informal hierarchy is formed by conscious or unconscious social processes Diefenbach and Sillince (2011).

different hierarchical levels. Our case is the medical service unit of the German Armed Forces (*Deutsche Bundeswehr*). Formal hierarchy is represented by military ranks in this context. Military ranks describe a chain of command with superior and subordinate officers and may therefore be compared to organizational concepts like upper, middle and lower management. In doing so, we contribute to answering the following research question: *What is the impact of formal organizational hierarchy on social networking behavior in ESN?* Our study was conducted with respect to the theory of networks, which is about how ties and network properties come to be (Borgatti et al 2013). The theory of networks focuses amongst others on antecedents for nodes' positions in the network (i.e. who is central in the network) and antecedents for the creation of ties (i.e. who forms ties with whom). Therefore we address the following sub-questions: 1) *What is the impact of formal organizational hierarchy on users' network position in ESN?* 2) *What is the impact of formal organizational hierarchy on the creation of ties in ESN?* Our study does not only show that formal organizational hierarchy has a significant impact on the social networking behavior in ESN. We are also able to trace more distinct effects of formal hierarchy, i.e. we were able to identify and illustrate different roles and according behavior. For instance, our results reveal that the exchange of (group) messages mostly happens on the same hierarchical level. This effect even increases with the visibility and intensity of the organizational communication. Our results motivate further studies on how hierarchy should be considered in the sociotechnical design and implementation of related systems. Moreover, by analyzing different information exchange mechanisms and by showing how formal hierarchy is transformed into different types of network, which in turn are affected differently by organizational hierarchy, our study also contributes to a more diversified view on information (Aral et al. 2007).

The remainder of this paper is structured as follows. We first give an overview about hierarchy in networks in general and hierarchy in ESN in particular. We then describe the context of our case study as well as the analyzed data and the used research method. Afterwards, we present our findings, followed by a discussion of the results. We conclude with our contribution and an outlook on future research.

2 Theoretical Foundations

To lay the theoretical basis for our study, we will now show how formal hierarchy has direct and indirect effects on various aspects of offline and online social networks. We will elaborate on relevant studies in the context of formal hierarchy in organizations and their interplay with network structures. We furthermore show how the aspect of hierarchy has been analyzed in the context of IS in general and ESN in particular.

2.1 Organizational Structures: Between Hierarchy and Networks

Formal hierarchy has a long history in organizational research. In 1922, Max Weber described hierarchy as a "vertical formal integration of official positions within one explicit organizational structure" (Weber 2005). Other authors define formal hierarchy as an "ordered set of entities that can be classified as being inferior, superior or on the same level as one other" (Putzke et al. 2010, p. 3). Thus, in an organization with a well-marked formal hierarchy "each position or office is under the control and supervision of a higher one" (Diefenbach and Sillince 2011). Therefore, all roles and positions within the hierarchical structure are unambiguously defined and enable a clear differentiation between each other (Zeitlin 1974).

Social groups contain different types of power which in turn can establish hierarchical structures (French and Raven 1959). Formal decision-making structures, whether in terms of "authority", "command", or "control", are integral features within modern organizations (Marcum et al. 2012). In an organizational hierarchy, individuals act under a regime of administrative procedures and job roles defined by higher level superiors (Powell 1990; Putzke et al. 2010). Hence, formal hierarchy is an essential and also pervasive organizational characteristic (Corominas-Murtra et al. 2013), which is represented in formal relations, for example an "org chart" in organizations. Next to these formal relations, employees also establish different types of informal relations which can be distinguished into four types, namely: *similarities*, *social relations*, *interactions,* and *flows of goods* (Borgatti et al. 2009). However, existing formal structures like hierarchy heavily influence these informal structures (West et al. 1999) and hence strongly limit the variety of future informal network structures (Corominas-Murtra et al. 2013). The effect of hierarchy on social relations was evaluated for example in British hospitals among groups of doctors and nurses. The results show that nurses are more likely to discuss important matters with juniors than with doctors and hence form a distinct network structure (West et al. 1999). These network structures in turn have an influence on information dissemination (Chau and Xu 2012), contribution behavior (Zhang and Wang 2012), employee performance (Wu 2013; Zhang and Wang 2012), and stability of organizational networks (Quintane et al. 2013).

Both organizations with a well-marked formal hierarchy and organizations with a less marked formal hierarchy, have their own strengths and weaknesses. The strength of well-marked hierarchical organizations lies in their reliability, they are best suited for producing large quantities of standardized products or services (Powell 1990). Hence, organizations with mechanistic structures, that is organizations with a well-marked formal hierarchy, are most appropriate under conditions of high task certainty (Tichy et al. 1979). Today, companies are facing greater uncertainty due to technological changes, knowledge intense tasks, and higher per-

formance expectations. With increasing uncertainty, hierarchy is only exceptionally employed since the number of exceptions increases until hierarchy becomes overloaded (Galbraith 1974). The aspect of information sharing illustrates the differences between network and hierarchy. When information is passed along the formal hierarchy, no new meanings or interpretations are generated. Formal hierarchy only structures the flow of information (Johnson et al. 1994). In contrast, as information passes through a network, new connections and meanings are generated and evaluated (Powell 1990). Hence, network forms of organizations are better suited for knowledge workers who possess fungible knowledge that is not limited to a specific task but applicable to a wide range of activities (Powell 1990).

2.2 Hierarchy in Information Systems

There are only few studies that systematically analyze formal hierarchy in the context of IS. In one of these, hierarchy is considered in the context of IS and company culture, indicating that IS usage influences company culture and consequently hierarchical structures (Leidner and Kayworth 2006).

Other scholars focus on the identification of hierarchies in computer supported communication. Different approaches have been applied: an entropy-based method to rank employees based on personal communication patterns (Shetty and Adibi 2005), a method that uses topological features such as the degree of the nodes to rank employees (Rowe et al. 2007), and even an adapted algorithm called *HumanRank* based on Google's PageRank to assess the hierarchy of a person within a network of communication interactions (Wang et al. 2013). Formal hierarchy can also be used as a point of orientation to show the dissemination of different types of information (Aral et al. 2007). Discussions are more likely to diffuse vertically up and down the organizational hierarchy, but news is more likely to diffuse laterally as well as vertically, regardless of organizational roles and their connections (Aral et al. 2007).

In the last years, both research and practice have argued that many hierarchical organizations may be transformed into more networked patterns or flatter hierarchies (McAfee 2009; Tapscott and Williams 2006). This transformation is supported and accelerated by new IS technologies, which provide opportunities to improve communication and interaction within organizational boundaries, like ESN. ESN can be described as web-based platforms, which offer employees new ways of communication and collaboration in both public enterprise-wide communication streams and private groups with restricted memberships (Riemer and Richter 2010). ESN allow users to contribute content to a shared pool, which enables public responses to these objects, allow profile information to be presented, and connects users through features like 'friend requests' and 'following' (Wasko and Faraj 2005; Richter and Koch 2008), which similarly leads to a high degree of interconnectedness (Agarwal et al. 2008). Examples of ESN platforms are Yammer, IBM Connections and Jive.

Studies have shown that certain IS like ESN particularly catalyze this delayering, because they heavily support the required flexibility in communication (boyd and Ellison 2007; Turban et al. 2011). Following Turban et al. (2011), ESN support all types of possible social relations (Borgatti and Foster 2003), as they can facilitate one or more of six major applications: Information Dissemination and Sharing, Communication, Collaboration and Innovation, Training and Learning, Knowledge Management, as well as Management Activities and Problem Solving.

The increasing usage of ESN also led to an increasing scholarly interest. Indeed, ESN allow for a new research domain (Watts 2007), which analyzes and builds theories of large social systems by using their representations in large datasets (Kleinberg 2008). For example, different studies analyze the effect of network structures on dissemination of information, ideas or sentiments (Chau and Xu 2012; Ciriello et al. 2013; Hillmann and Trier 2012; Lerman and Ghosh 2010). However, the effect of organizational hierarchies on social networking behavior in ESN has received only little attention so far.

On the one hand, persons from different hierarchical levels employ ESN in different ways and organizational roles and hierarchical structures (with their role-typical behavior) are reproduced on such platforms (Riemer and Richter 2010). While employees seek feedback more often from colleagues in their own department (van der Rijt et al. 2013), executives tend to occupy positions with a high brokering aspect (Burt and Ronchi 2007). On the other hand, ESN can enable new social structures and thus alter the notion of hierarchy (Bobsin and Hoppen 2013), while communication activities have greater influence on responses than hierarchy (Stieglitz et al. 2014). ESN allow a greater visibility of other users' involvement, which in turn can affect users' behavior (Majchrzak et al. 2013), because it allows users to access information resources without contacting or knowing the author. As a consequence, informational hierarchies can be overcome because informal relationships established through an ESN can reinforce or interfere formal organizational processes based on hierarchy (Ellwardt et al. 2012).

Furthermore, ESN facilitate the development of non-hierarchical spaces, because they enable new relational structures which can decrease organizational distance and hence alter the notion of hierarchy (Bobsin and Hoppen 2013). They can also transform the network position of individuals, because they can disrupt the existing inertia inside an organizational network (Wu 2013). Technical features provide users with a high degree of transparency about the network structure and their network position, which allows them to use, or even change, these structures in their own interests (Kane et al. 2014). Summing up, ESN differ from offline networks in terms of available data (Howison et al. 2011), interaction mechanisms (Kane et

al. 2014), and power structures (Bobsin and Hoppen 2013), and therefore have to be considered differently in various aspects. At the same time, the question is still largely unanswered whether and how organizational hierarchies influence social networking behavior in ESN.

3 Research Method

A certain hierarchical level goes along with role inherent tasks incorporated as communication practices (Powell 1990; Putzke et al. 2010). Against this background, users' hierarchy may constitute an important factor with respect to users' social networking behavior as well. To get deeper insights, we conducted case study research to analyze to which extend formal organizational hierarchy actually affects social networking behavior of ESN users. According to (Yin 2009, p. 18), a case study "investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident". In our opinion, case study research is well-suited for our analysis for three reasons. First, case study research allows investigating networking and communication behavior among users in a natural setting, without exerting any control on the ESN and its users. Second, a "holistic, in-depth investigation" is required, which can be provided by case study research (Dubé and Paré 2003, p. 598). To ensure that our research question is not explored through one lens only, we triangle evidence from multiple sources (Yin 2009; Yin 2012), as we use both quantitative data extracted from the ESN and qualitative data from interviews. Third, the influence of formal hierarchy cannot be seen as a mere phenomenon without considering the context. In this respect case study research seems appropriate as it allows to investigate both phenomenon and context (Yin 2009).

In the following, we provide an overview of the case setting and the data collection. Then we describe the data analysis process and how we have applied SNA as a primary analysis method and interviews as means to reflect our findings.

3.1 Setting

The selected case organization is the medical service unit of the German Armed Forces. The medical service unit employs, amongst others, 2,700 medical officers and 1,600 trainee medical officers assigned to military medicine, military pharmacy, veterinary medicine, or dental medicine. The workforce (medical officers and trainee medical officers) is distributed over five hospitals (all major military hospitals in Germany), 37 universities (i.e. all universities in Germany which offer medical studies), and 200 other facilities. We selected this organization for the high transparency of its hierarchical structures (see Table 1), a fact that allows us to thoroughly analyze enterprise social networking across hierarchies. The medical service follows the formal organizational hierarchies of the GAF. Therefore in our case the military hi-

erarchies are divided into six levels. To make our results transferable to a non-military organizational setting, we describe each level briefly and try to compare them to common organizational roles. The description of each level is based on the *Administrative Order on the Position of the Military Superior* (Bundesministerium der Verteidigung 1956).

- **Level 1** is the lowest level. These persons have no authority over others.
- **Level 2** can be compared to team leaders. They can give commands to level 1 employees and lead small teams and delegate tasks accordingly. They have decision making power only in their own team.
- **Level 3** can be compared to managers. They can lead a collection of teams (e.g., a department) and coordinate their subordinates. They have decision making power to a certain degree.
- **Level 4** can be compared to business unit managers. They are responsible for the management, training and staffing of a business unit or sub-division. They are involved in the daily business in a consulting role and have authority over all lower levels of hierarchy.
- **Level 5** can be compared to executive directors. They are typically not involved in the daily business but lead divisions. They have authority over all lower levels and coordinate their subordinates by deciding on strategic aspects.
- **Level 6** can be compared to board members. They are the top management and have authority over all lower levels. Typically, they are not involved in the daily business, but fulfill representative and strategic tasks covering the entire organization.

From a network perspective, organizations in general can be perceived as small-world networks. In contrast to other network types like random networks or scale free networks, small-world networks consist of formally defined groups that execute tasks related to a common goal (Riketta and Nienaber 2007). Its members are mostly unrelated at the individual level, but are connected by a few members, linking the different groups (Shirky 2008). This also holds true for the medical service of the German armed forces. Most of its members are not directly related to one another as they work across more than 200 facilities. However, they are structured in groups like platoons, commandos which share the same goals. These groups are connected by group leaders with a higher military rank. Therefore, each member can reach another member by a small number of steps, which is also a characteristic of small-world networks (Barrat and Weigt 2000). This makes our findings applicable to other organizational settings with the same properties.

Considering the five typical types of hierarchical organizations as summarized by (Diefenbach and Sillince 2011), the German Armed Forces can also be seen as a classical *bureaucratic/orthodox organization*. All positions are placed along official lines of top-down command and control. Formal authority is closely related to the rank of a position, independent of the actual person holding this position (Diefenbach and Sillince 2011). Therefore, the results of this paper are applicable to other organizations of this type (small-world networks, bureaucratic/orthodox organizations).

In 2009, the department decided to implement an ESN – in the following referred to as Med-Net. The main goals of Med-Net were described as (1) fostering knowledge transfer and collaborative learning among staff, (2) improving the quality of education and the in-service training of new employees, (3) strengthening the corporate identity and the networking of staff, and (4) creating a collaborative knowledge base. To participate in the ESN, each user has to state his or her real name and military rank. Both are publically available parts of a user's profile. Even though the German Armed Forces is heavily regulated and has a very complex formal structure, Med-Net does not incorporate any pre-defined structure. Its use is voluntary and the user guidelines allow a self-regulated communication and usage of all features for any purpose. The ESN was launched in November 2010 as a pilot, which was developed and maintained by our research group. This gave us exclusive access to an otherwise inaccessible data set.

3.2 Data Collection and Preparation

The dataset was provided in MS Excel format, ranging from 2011-06-01 to 2013-09-30. To ensure confidentiality, all personal information (e.g., user names) was removed during data export. For 1,097 unique users the dataset contains information about the military hierarchical level. When referring to hierarchy in this context, we refer to the military ranks of the Med-Net users. For international consistency we use the NATO ranking code (NATO 1996) for military ranks. The grouping of the ranks (e.g., OF3-5) represents the common German Armed Forces structure (general, staff officer, officer, officer candidate, non-commissioned officer (NCO) and enlisted soldiers (in descending order)). In the following, we refer to the military ranks as *hierarchical levels* according to the column "level" in Table 1.

884 of the 1,097 users have at least one confirmed contact request ("social relationship") to another user (total number of social relationships: 3,849). Moreover, the data contain 4,096 direct messages exchanged between two users (1:1 communication) and 1,523 group messages (1:n communication) with 1,443 comments. In Med-Net, a group message is publicly visible for members of a group only. Particularly interesting group messages can also be published by users in a so called "knowledge base", which is used as an enterprise wiki.

The network data are the result of user interactions and were saved by the Med-Net system itself. The data were not produced explicitly for our research, but can rather be seen as a by-product of using the system (Howison et al. 2011). To better understand the data, their possibilities and limitations and to interpret the results, additional context information is needed. Therefore, after analyzing the data in compliance with a transformative mixed method design (Creswell and Plano Clark 2011), we conducted 13 semi-structured interviews with staff on different military levels and from different locations, to get insights into people's experiential life (Schultze and Avital 2011). The interviews were conducted between August and September 2013. To support the conversation with the interviewees, we developed an interview guide (Bryman and Bell 2011) and tested it with a pilot group of Med-Net users. In its final form, it contains 13 questions in four different categories including questions about the persons and their role in the medical service, about the experiences with ESN in general, about experiences with Med-Net in particular and about the influence of military hierarchies on their behavior in Med-Net. The interview guide can be found in the appendix. The interviews were conducted by the authors via telephone as well as in person and had an average length of 60 minutes. The interviews were recorded and transcribed. Since the interviews were conducted in German, the quotations used in this paper were translated from German into English (Regmi et al. 2010).

Military rank (NATO)	**Rank (GAF)**	**Level**	**No. of unique users in the ESN**		**No. of users in regard to social relationships**		**No. of users in regard to 1:1 communication**		**No. of users in regard to 1:n communication**	
OF 6-9	General	6	3	0%	2	0%	2	0%	1	0%
OF 3-5	Staff officer	5	117	11%	78	9%	72	13%	35	10%
OF 1-2	Officer	4	549	50%	455	51%	310	55%	193	54%
OF-D	Off. Cand.	3	309	28%	264	30%	135	24%	95	27%
OR 5-9	NCO	2	28	3%	22	3%	18	3%	16	4%
OR 1-4	Enlist. soldier	1	91	8%	63	7%	29	5%	18	5%
Sum			**1,097**		**884**		**566**		**358**	

Table 1: Number and Share of Users of Different Hierarchical Levels

3.3 Data Analysis

To investigate the role of hierarchy and particularly to analyze a user's social networking behavior in the ESN in dependence of his or her hierarchical level, we applied certain means of SNA (Wasserman and Faust 2009). SNA has been intensively used in IS research, for example to investigate users' network creation behavior (Krasnova et al. 2010) or social capital as a result of the usage of an online social network (Ellison et al. 2007). According to Freeman (2000, p. 350), SNA "involves theorizing, model building, and empirical research focused on uncovering the patterning of links among actors". In this context, we focus on centrality

measures to get insights into the users' position in the network (Freeman 1979). The most common centrality measures are degree centrality, closeness centrality, and betweenness centrality (Freeman 1979). A social network can be represented as a graph with a set of nodes (users) and a set of edges (ties) linking pairs of nodes (Wasserman and Faust 2009). The edges may be directed or undirected and can represent either social links like friendship relationships (social graph) or communication activities (activity graph) like messages amongst users (Adamic and Adar 2003; Bampo et al. 2008; Heidemann et al. 2010). To get profound insights into a user's social networking behavior in the ESN, we distinguish the possible relations users can create into *relational states* (continuously persistent relationships) and *relational events* (multiple discrete events) (Borgatti et al. 2013). Relational states are represented in Med-Net by the feature (confirmed) contact requests. In the context of this paper, we call these (1) *social relationship.* Relational events are technically possible by either private or public communication. The corresponding Med-Net features are private messages and comments to group content which we call group messages. These two types correspond to (2) *1:1 communication* (direct messages) and to (3) *1:n communication* (group messages). These three system features are also the only features by which users can interact directly with one another. They furthermore represent the most common features in ESN or SNS in general (Leonardi et al. 2013). The resulting networks are illustrated in Figure 1. Here, a node represents a Med-Net user. The node size depends on the amount of ties a node has. The more ties, the bigger a node. The connections between the nodes represent the respective relations. The strength of a tie represents the amount of interactions between two nodes. The thicker a tie, the more interactions. We used the Force Atlas layout algorithm in *Gephi*[2] to visualize the graphs.

In the case of social relationships, the social graph contains 884 nodes (users) and 3,849 undirected edges. Figure 1 (left) shows this whole network. In the network picture nodes are senders and recipients of contact requests, while edges comprise confirmed contact requests. When 1:1 communication is examined, nodes are senders and recipients of direct messages, and edges are created by sending a direct message to a user via the Med-Net. The corresponding activity graph (Figure 1, middle) contains 566 users and 4,096 directed edges. In addition, we also analyzed the hierarchical level of the participants for each type of relationship, respectively. Next to social relationships and 1:1 communication we also conducted analyses for group messages (1:n communication). On that level (Figure 1, right), nodes are defined as users who create an initial group message or a comment. Edges were defined as comments on initial content. To assess the influence of hierarchy on different types of rela-

[2] http://gephi.github.io/

tionships and to avoid biased results, these three relationship types were considered separately. For our analyses, we used the igraph package for R[3] to calculate the centrality measures degree centrality, closeness centrality, and betweenness centrality for each node of the social as well as of the activity graph. To gain further insights into the dataset, we also analyzed descriptive user statistics. In particular, we calculated the participation of Med-Net users with respect to their hierarchical level.

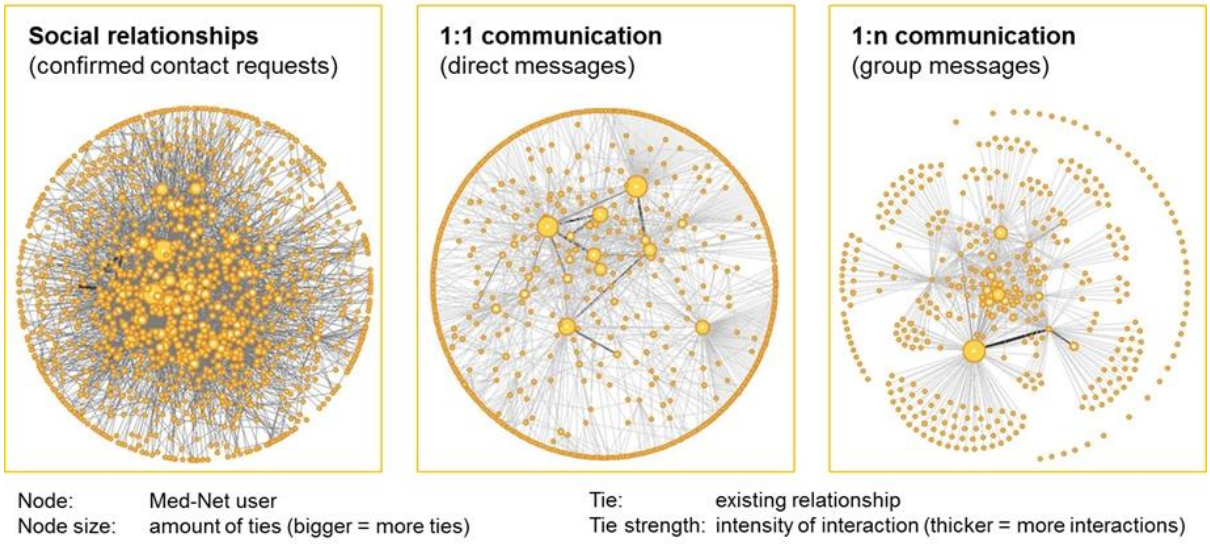

Figure 1. Visualization of the Three Types of Relationships

As Table 1 shows, all hierarchical levels are represented in the data, from enlisted soldier (level 1) or officer candidate (level 3) up to staff officer (level 5) and general (level 6). Most of the users are related to level 3 (28%) and level 4 (50%), both representing the middle levels of the military hierarchy. In addition, as provided in Table 1, we also calculated the number and share of users for the social relationships (confirmed contact requests), the 1:1 communication (direct messages), and the 1:n communication (users posting group messages) with respect to the six hierarchical levels. While nearly 81% of all users have at least one social relationship, 52% of all users have written or received a direct message and 33% have posted a group message, indicating that most of the users are related to level 3 and level 4.

4 Results

This section is dedicated to the findings of our study. Our analysis of users' networking behavior was conducted with respect to the theory of networks, which is about how ties and networks properties come to be (Borgatti et al 2003). The theory of networks focuses amongst others on antecedents for nodes position in the network (i.e. who is central in the

[3] http://cran.r-project.org/web/packages/igraph/index.html

network) and antecedents for the creation of ties (i.e. who forms ties with whom). First, we focus on the users' position in the network depending on their hierarchical level (i.e. is formal hierarchy an antecedent for a user's position in the ESN). The second part concentrates on the effect of hierarchy on the creation of the three types of relationships (i.e. is formal hierarchy an antecedent for the creation of links in the ESN). Finally, the third part focuses on the interview results to reflect on our findings, while the last part gives first insights into the role of time.

4.1 Network Positions and Hierarchy

In a first step we aimed to investigate if formal hierarchy is a possible antecedent for users' positions in the network, we use network centrality, which is a most common way to determine the position in the network. To analyze a user's position in the network, we calculated degree centrality, closeness centrality, and betweenness centrality for each node of the social graph (i.e. social relationships based on confirmed contact requests) and the activity graph (i.e. 1:1 communication based on direct messages). Table 2 shows the average values for the centrality measures depending on the users' hierarchical levels.

The results for the social graph indicate that users on middle hierarchical levels (i.e. levels 2-4) are very well connected resulting in the highest average values for degree centrality and betweenness centrality. This means that, on average, users on middle hierarchical levels have the highest number of social relationships (degree centrality). Moreover, they are most often included in the shortest paths between two other users (betweenness centrality) and may therefore bridge structural holes and foster information exchange connecting pairs of other users who do not have a direct social relationship. Focusing on 1:1 communication represented by the activity graph, the results show that users on upper middle hierarchical levels (i.e. levels 4, 5) are most active while users on the lowest hierarchical level (i.e. level 1) barely participate in the communication. This holds for both receiving (in-degree centrality) and writing (out-degree centrality) direct messages.

Hierarchical level	Social graph			Activity graph			
	Degree centrality	Closeness centrality	Betweenness centrality	In-degree centrality	Out-degree centrality	Closeness centrality	Betweenness Centrality
Level 6	0.40%	6.10%	0.01%	0.71%	0.44%	**1.24%**	**0.00%**
Level 5	0.67%	6.00%	0.21%	**1.96%**	**1.78%**	0.70%	0.35%
Level 4	**1.15%**	6.01%	**0.34%**	**1.71%**	**1.69%**	0.97%	0.37%
Level 3	**0.92%**	6.02%	**0.21%**	0.70%	0.74%	0.89%	0.08%
Level 2	**1.22%**	6.08%	**0.45%**	1.18%	1.76%	1.00%	0.48%
Level 1	0.39%	5.76%	0.08%	0.31%	0.38%	0.83%	0.02%

Table 2. Values for Centrality Measures Depending on Users' Hierarchical Levels

Further, Table 2 shows that users on the highest hierarchical level (i.e. level 6) are characterized by the highest average closeness, but the lowest average betweenness centrality for the activity graph. The result for closeness centrality indicates that these users are generally close to all other users in the activity graph (note that closeness centrality is based on a user's shortest paths to all other users) and that their messages may therefore reach a large number of users in a relatively short time (via 1:1 communication between users). However, at the same time these users are not included in the shortest paths between two other users in the activity graph of the ESN (cf. betweenness centrality) and are hence not able to control or even listen to the information exchange between other users.

4.2 Relationships Between Users and Hierarchy

The descriptive user statistics reveal that, depending on the hierarchical level, the number of users varies greatly in size (cf. Table 1). This so called population bias (Howison et al. 2011) in our dataset could skew the results. When analyzing our dataset with respect to the influence of hierarchy on the relationships between users in the ESN, the number of users in the single hierarchical levels has to be taken into account accordingly. This is due to the fact that the relationships between users may not only be subject to the influence of hierarchy, but also to the sheer number of users on the respective hierarchical level: for example, a higher number of social relationships between users on level 2 and level 4, compared to the number of relationships between users on level 2 and level 5 may – to a certain extent – be attributable to the fact that in the ESN the number of users on level 4 (549) is about 4.7 times higher than the number of users on level 5 (117).

If hierarchy had no influence on the relationships between users, the number of a user's relationships to users of a certain hierarchical level would be proportional to the number of ESN users on the respective hierarchical level. Referring to the above example, it would be expected that a user on level 2 has about 4.7 times more relationships to users on level 4 than to users on level 5. In the following, to account for this fact in our analyses, we compare the observed distribution of the relationships in our dataset to the expected distribution of the relationships if hierarchy had no influence on the relationships between users. The underlying theoretical basis of the expected distribution of a user's relationships if hierarchy had no influence is illustrated in Figure 2.

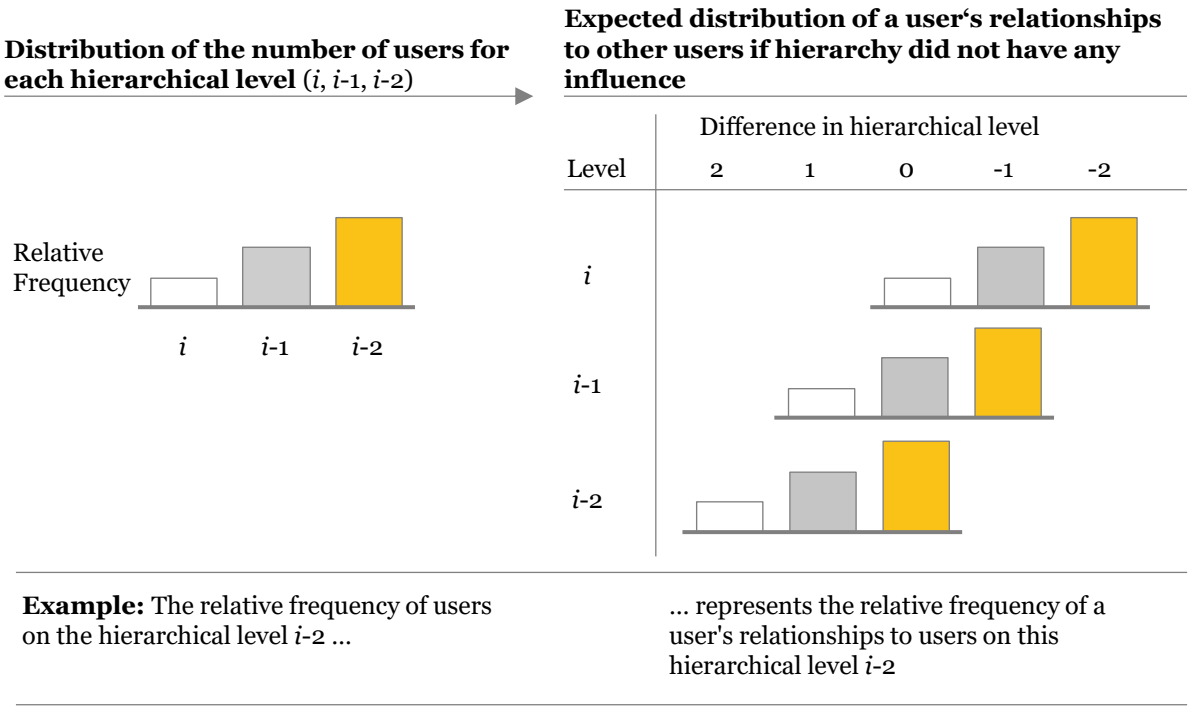

Figure 2. Expected Distribution of a User's Relationships if Hierarchy had no Influence

For reasons of clarity and comprehensibility, Figure 2 only comprises three general hierarchical levels (*i*, *i-1*, and *i-2*), where *i* is the highest and *i-2* is the lowest level. The left-hand side of Figure 2 shows the distribution of the number of users with respect to the hierarchical levels. This distribution is used to represent the expected distribution of a user's relationships to other users depending on the hierarchical levels, respectively the differences in the users' hierarchical levels (cf. right-hand side of Figure 2). Positive differences in the hierarchical levels refer to a user's relationships to other users on higher levels, while negative differences indicate relationships to users on lower hierarchical levels. For the example in Figure 2, for a user on level *i-1* the difference is 1 for relationships to users on level *i* and -1 for relationships to users on level *i-2*. In Figure 2, for example, due to the high number of users on the hierarchical level *i-2*, users of all levels are expected to have the highest number of relationships to users on level *i-2* and the smallest number of relationships to users on level *i* (if hierarchy had no influence).

Based on the theoretical basis described above, Table 3 shows the percentage differences (indicating hierarchical effects) of the values of the observed distribution of the social relationships compared to the values of the expected distribution of the social relationships if hierarchy had no influence. For reasons of readability, higher values are shaded dark.

Hence, the relative frequency of social relationships among users on hierarchical level 5 (i.e. the difference in hierarchical level equals 0), for example, is 385% higher than it would be expected if hierarchy had no influence. In contrast, focusing on users on the hierarchical level

4, the relative frequency of social relationships to users on level 5 (i.e. the difference in hierarchical level equals 1) is 51% smaller than expected.

	Difference in hierarchical level										
Hierarchical level	5	4	3	2	1	0	-1	-2	-3	-4	-5
Level 6						-100%	871%	-72%	-100%	-100%	-100%
Level 5					477%	385%	-16%	-71%	48%	-100%	
Level 4				-90%	-51%	42%	-37%	13%	-85%		
Level 3			-100%	-78%	-17%	63%	-1%	-41%			
Level 2		-100%	-19%	5%	-24%	341%	-29%				
Level 1	-100%	-100%	-52%	33%	104%	327%					

Table 3. Observed vs. Expected Distribution of Social Relationships

According to the results in Table 3, hierarchies seem to have an influence on the social relationships between users in the ESN. Indeed, for all hierarchical levels the observed distribution of the users' social relationships significantly (for α=0.05) differs from the expected distribution of the social relationships if hierarchy had no influence. It is particularly remarkable that users primarily tend to connect with their peers resulting in strongly over-proportional numbers of social relationships to users on the same hierarchical level (i.e. the difference in hierarchical level equals 0). This holds except for the users on the highest hierarchical level (i.e. level 6) for which it has to be noted that our dataset only contains very few users on this level (cf. Table 1). However, it is noticeable that there are no social relationships among the users on the highest hierarchical level. Rather, they (i.e. level 6) are primarily connected with users on the next lower level (i.e. level 5).

The first line of Table 4 (cf. social relationships) contains the aggregated values for all users of the ESN. The results highlight that, overall, the relative frequency of social relationships among users on the same hierarchical level is 267% higher than it would be expected if hierarchy had no influence. Further, it becomes evident that the respective percentage differences decrease with the number of hierarchical levels that are bridged. This means that users tend to have less social relationships the higher the absolute value of the difference in the respective hierarchical levels are. Indeed, our analysis reveals that there is not a single social relationship that connects users who are more than three hierarchical levels apart.

Analogously, we analyzed users' 1:1 communication in terms of direct messages sent to other users (cf. second line of Table 4) and users' 1:n communication in terms of (comments on) group messages (cf. third line of Table 4) with respect to the users' difference in hierarchical level. In contrast to direct messages, (comments on) group messages do not have a single receiver, but are visible for all users of the group or the whole ESN, respectively. Therefore, when analyzing the influence of hierarchy on 1:n communication we focused on the comments on group messages and the difference in hierarchical level between the commenter of a group message and its initiator.

All users	Difference in hierarchical level										
	5	4	3	2	1	0	-1	-2	-3	-4	-5
Social relationships	-100%	-100%	-86%	-78%	-7%	267%	-4%	-77%	-91%	-100%	-100%
1:1 communication	-100%	-95%	-65%	-76%	15%	231%	5%	-83%	-90%	-95%	-100%
1:n communication	-100%	-93%	-80%	-91%	15%	301%	-37%	-89%	-99%	-100%	-100%

Table 4. Observed vs. Expected Distributions of Relationships (Percentage Differences)

The results for 1:1 and 1:n communication are to some extent similar to those observed for the social relationships: The users tend to primarily write direct messages to and comment on group messages of users on the same hierarchical level (percentage difference with respect to the expected value if hierarchy had no influence: 231% and 301%, respectively) and do barely bridge different hierarchical levels. We found that for all three relationship types contained in Table 4 the observed distribution of the users' relationships significantly (for α=0.01) differs from the expected one if the ESN was free of hierarchical effects. Hence, hierarchies do indeed influence relationships between users in ESN significantly. It is, however, remarkable that not all types of relationships are affected to the same extent.

The results in Table 4 indicate a stronger hierarchical influence on social relationships and especially 1:n communication as compared to 1:1 communication. Actually, the users' barrier to bridge hierarchical levels seems to be lower for writing private direct messages as compared to establishing publicly visible social relationships or commenting group messages. In addition, while there is not a single social relationship that connects users who are more than three hierarchical levels apart, in 1:1 communication users indeed relate to other users who are four hierarchical levels apart.

In the course of 1:n communication, users have the possibility to additionally publish their group message in the "knowledge base", which is used as an internal wiki. With respect to these messages we found that a big majority of 85% were initiated by users of upper hierarchical levels (i.e. levels 4 and 5). However, compared to all group messages included in the analysis, users tend to comment more on group messages of users on higher hierarchical levels which are included in the "knowledge base".

4.3 Interview Results

Through the interviews we were able to get a better understanding of the underlying context which influences the user behavior and becomes visible in the data analysis. For example several interviewees stated that they needed some time to get acquainted with this new form of communication: "*In the beginning [of a communication] it is a little difficult because everybody is very distanced/impersonal until the discussion was really going on."* (*i*13).

Furthermore, the users explained that they see a huge difference between the three different types of possible interactions and the influence of hierarchy within each of them. Social relationships for example, in the form of confirmed contact requests are more important than 1:1 communication (direct messages) and hierarchy plays a bigger role here: "*A friend is a friend. If a friend of mine was a medical director and I was connected with him on Facebook, I would connect with him in Med-Net as well. But if I don't know him, I would not add him."* (*i*1).

In general, the interviewees realized the potential of Med-Net to reduce hierarchies and the resulting possibilities such as better knowledge exchange or faster task coordination. "*I see the advantages of flat hierarchies are much bigger than the disadvantage of directly bothering e.g., a general. The platform allows you to get information and contacts that you could not access otherwise."* (*i*4). They also stated that a delayering to a certain degree was desired in some situations and would make life easier. "*It is a possibility not to bypass the official channels, but to ask for information in a different way."* (*i*2).

On the other hand, some interviewees do not want a hierarchy free structure and see a threat in such communication, especially in terms of respect. "*Communication on* Med-Net *complements the hierarchical processes. […] It must not be mistaken as the common way of communication."* (*i*5). They also state that military hierarchies still play a role in Med-Net. One reason is the pure knowledge about the other person's rank and the official character that comes with it: "*Additionally, the official background is bigger because you see the rank. This causes some inhibitions. So in* [Med-Net] *you feel more in the Bundeswehr than in Facebook."* (*i*9).

Others say that military ranks have a huge influence on open communication because they feel watched and because a written statement is easy to copy and could be used against them. This prevents critical but helpful comments: "*In general you say your opinion* [in a discussion]*. But the disadvantage is that in* [Med-Net] *everything is documented. This makes you think about what you write. […] And if this goes round, there would be a risk. This makes it difficult in some situations to express your real opinion."* (*i*7). The interviews also showed that an exchange happens more often with persons within the same rank. "*We often use the [Med-Net] group "supervising officers". In this group, we share news which are relevant only for us." (i3).*

These results clarify that the low degree of cross hierarchical interaction in Med-Net is due to a mix of social factors (feeling of being watched), organizational culture (Med-Net complements offline communication) and platform features (prominent display of user's military rank). Without the interviews, the underlying reasons for the data results would be purely speculative and would not allow such a nuanced view.

4.4 Influence of Hierarchy over Time

The interviews indicate that users need time to get acquainted to this new form of communication in the organizational context. This leads to the assumption that the influence of hierarchy will change in time the more the users get used to communicating via Med-Net. To get first insights into how the impact of formal hierarchies on enterprise networking behavior changes over time we divided our dataset into two time frames ranging from 2011-06-01 to 2012-09-30 (time frame 1) and from 2012-10-1 to 2013-09-30 (time frame 2), respectively. We chose these two time frames because the roll-out of Med-Net took place in a two stage pilot phase, a development phase lasting until May 2011, followed by a trial period until September 2011. During this period, more and more users joined Med-Net as the registration process was rolled out step by step. From October 2011, Med-Net was open for everybody in the medical service. Hence, time frame 1 consists of the trial period and the first year of regular operation. Time frame 2 refers to the second year of regular operation of Med-Net. Conducting the analyses described above separately for each of these time frames, we aimed to find out whether the influence of hierarchy changes over time and makes, for example, users more likely to bridge hierarchical levels and therefore connect with users on different hierarchical levels. Table 5 shows the percentage differences of the values of the observed distribution of the social relationships compared to the values of the expected distribution of the social relationships if hierarchy had no influence for each of the two time frames.

	Difference in hierarchical level										
	5	**4**	**3**	**2**	**1**	**0**	**-1**	**-2**	**-3**	**-4**	**-5**
Time frame 1	-100%	-100%	-94%	-83%	-15%	296%	-9%	-83%	-96%	-100%	-100%
Time frame 2	-100%	-100%	-76%	-69%	-6%	237%	1%	-69%	-84%	-100%	-100%

Table 5. Observed vs. Expected Distributions of Social Relationships over Time (Percentage)

Again, for both time frames the observed distribution of the users' relationships significantly (for α=0.01) differs from the expected one if the ESN was free of hierarchical effects. Nevertheless, it is salient that the hierarchy's influence seems to decrease over time. Indeed, the absolute value of the percentage differences (indicating hierarchical effects) decreases for all values of the difference in the respective hierarchical levels. For example, in the first time frame the relative frequency of social relationships among users on the same hierarchical level is still 296% higher than it would be expected if hierarchy had no influence; for the second time frame we observe a much smaller value of 237%. Moreover, within the second time frame users increasingly tend to connect with other users on different hierarchical levels as well. Hence, it may be argued that over time ESN contribute to reducing hierarchical effects in an organization and lead to flatter hierarchies.

5 Discussion

5.1 Implications for Theory

Our study shows a significant effect of hierarchy on social networking behavior in ESN.

First of all, we found that the users' position in the network depends on their hierarchical level and were able to identify and illustrate different roles and according behavior. As the analysis of the social graph shows, the core in terms of dense interconnectedness is constituted by users on middle hierarchical levels (level 2, 3, and 4). This middle layer has the highest number of social relationships in terms of confirmed contact requests to other users in the network (high degree centrality) and acts as boundary spanner (x for other users who do not have a direct social relationship (high betweenness centrality)). At the same time, the upper middle hierarchical levels (i.e. levels 4, 5) communicate more actively in terms of 1:1 communication (direct messages) while users on the lowest hierarchical level (i.e. level 1) barely participate in the communication. Furthermore, users on the highest hierarchical level (level 6) play a special role in communication: On the one hand, the high closeness centrality indicates that they are very close to all other users in the network which means that their messages may reach a large number of users in a relatively short time which may be very important. On the other hand, their betweenness centrality is very low so that they are not able to listen to the information exchange between other users. Thus, the way in which users on the highest hierarchical level communicate could be characterized as strict top-down communication. However, the role of a leader communicating in an ESN is supposed to be quite the opposite namely "from command and control to facilitate and aggregate" (Cook 2008).

Second, our results indicate that formal hierarchical levels influence the three different types of relationships between users in ESN significantly. Users generally tend to connect and communicate more with users on the same hierarchical level but rarely bridge different hierarchical levels. However, the effect of formal hierarchy is weakest in 1:1 communication (direct messages), followed by social relationships (confirmed contact requests). The strongest effect is observed in 1:n communication (group messages). This may be due to the fact that direct messages cannot be seen by anyone else except by the sender and the receiver. People in users' contact lists, however, can be seen by every connected user and group messages by everybody within the respective group or the entire ESN. This means that the more visible and intense the communication gets, the more it is affected by formal hierarchy. Our interview results support this finding as the interviewees state that they are very careful in terms of criticism and politeness. Furthermore, they try to minimize communication with higher levels as they try to avoid being perceived as a careerist or sycophant. Our results are also in

line with a study that showed that the related communication types capture different behavioral properties within an organization and that these communication types may even have a stronger effect than hierarchical positions (Stieglitz et al. 2014).

Consequently, further studies should research in more detail how hierarchy should be considered in the sociotechnical design of related systems.

The behavior of users on all hierarchical levels may be explained by the fact that the users have appropriated Med-Net as it best produces personal benefits. People within the same hierarchical level are more likely to share similar communication practices. Our results are also in line with a study by Zhang and Venkatesh (2013) who state that online communication rather complements than replaces offline communication. Our interviews confirmed the users' tendency towards interacting more within the same hierarchical level due to their role in the organization. So even in virtual space, users feel more comfortable with people who are in the same situation or share similar communication practices.

Finally, the results of our analysis show that relationships across hierarchies are growing as time passes. This means that the strong and persisting impact of hierarchy on ESN usage may slightly decrease over time. Or in other words: it may be argued that over time ESN contribute to reducing hierarchical effects. This is in line with the interview results that indicated that users need time to get used to this new form of open communication, especially within the studied organization that can be characterized as heavily regulated, where communication has to pass through proper channels.

According to our results, we expect that the Med-Net users will continue to inspect the platform and identify new use cases that will contribute to decreasing organizational hierarchies.

5.2 Implications for Practice

Whereas hierarchy is an essential concept in the military domain, hierarchical structures can also be found in other organizational contexts outside the military domain (Corominas-Murtra et al. 2013), for example in large organizations or in the consulting business (Stieglitz et al. 2014). Even though we analyzed just one case with a well-marked formal hierarchy, the results may also hold for other organizations with a less marked formal hierarchy.

Even though users on the highest hierarchical level (i.e. level 6) only have a low degree centrality, their closeness is very high. This may be an advantage when it is necessary to spread messages fast and effectively throughout the whole network. This confirms the findings of Burt and Ronchi (2007) according to which executives tend to occupy positions with a high brokering impact. On the other hand, due to the low betweenness, these users are in a bad position to get to know what "is going on" in the organization. The activity in terms of in-degree and out-degree is the highest in the middle hierarchical levels (i.e. level 4 and 5). These

are the users who drive the knowledge exchange which is accompanied by a high degree of connectedness.

Contrary to all group messages in general, users rather tend to comment group messages of higher hierarchical levels in the "knowledge base", which clearly shows the demand to discuss certain topics. The least active users are on the lowest hierarchical level (i.e. level 1). However, these users are relatively new to the organization and hence cannot contribute that much. But it seems that the higher hierarchical levels have either no time or other reasons for not contributing and supporting the knowledge exchange. In fact, knowledge is produced by the middle and upper, not the top hierarchical levels. These aspects are good starting points for managerial decision makers who want to improve organizational communication, knowledge exchange, or structural weaknesses.

5.3 Limitations and Future Research

Our findings have to be seen in the light of some limitations. First, we only considered one single institution which provided us with the data needed. Nevertheless, we selected this organization for its high transparency of the hierarchical structures which allows us to clearly differentiate between hierarchical levels and to thoroughly analyze enterprise social networking across hierarchies. Whereas military organizations might differ from business organizations in some points, we do not think (and there is no existing study that shows different results) that the communication hierarchies are much different. Second, we have not analyzed the content exchanged in Med-Net so far. However, in a first step and to reflect our findings, we have enriched the findings of the SNA with insights from the interviews. This seems to be a promising starting point for future research. Third, although we considered different time frames, the network dynamics were not our focus. This leaves room for future research considering the investigated effects over time. Fourth, we did not consider individual attributes like age, gender and experience (e.g., years of service) explicitly. While, the rank already partly reflects age and experience, this leaves room for further studies. Finally, our analysis investigates how the formal organizational hierarchy effects the communication and networking behavior of the users in the ESN. Future research could complement our study by analyzing and comparing the social relationships and communication relationships of the users within the ESN and beyond in an offline-context.

6 Conclusion

Ever more organizations have been adopting ESN to foster collaboration, communication, and knowledge sharing among employees (Aral et al. 2013; von Krogh 2012). While there is a growing body of literature in the emerging field of ESN, we still observe a lack of research focusing on the interplay of formal organizational hierarchies and users' behavior in ESN.

Thus, the aim of this paper was to investigate how formal organizational hierarchy affects users' network structures and communication behavior in ESN. Our research is spurred by a plethora of data generated in ESN when users connect and communicate with one another (Giles 2012). This data wealth allows for great opportunities to investigate and understand the interplay of formal organizational hierarchies and users' behavior in ESN. We analyzed a large scale dataset of the ESN Med-Net provided by the medical branch of the German Armed Forces – an organization which is by nature clearly hierarchically structured and therefore seemed particularly appropriate for our work. The dataset contains information about the users' social relationships, communication activities, and military rank (hierarchical level).

Applying SNA (Wasserman and Faust 2009) accompanied by user interviews to get insights into people's experiential life (Schultze and Avital 2011), we found that the users' position in the ESN depends on the hierarchical level. Concerning their social relationships in the ESN, users on middle hierarchical levels are particularly well connected and may bridge structural holes and foster information exchange in the organization. In addition, we showed that formal hierarchical levels influence the relationships between users significantly. This holds for users' 1:1 communication via direct messages, social relationships in terms of confirmed contact requests, and 1:n communication via group messages (in ascending order). Users tend to connect and communicate with users on the same hierarchical level but barely bridge different hierarchical levels. However, returning to the statement made at the beginning that ESN have the potential to make people within organizations interact as equals: Indeed, first analyses with respect to the role of time revealed that after a certain time hierarchy's influence on social relationships seems to decrease slightly and that users increasingly tend to connect with users on other hierarchical levels. This is in line with the user interviews conducted to critically reflect our results.

With our paper, we hope to contribute to a better understanding of the emerging phenomenon of ESN. Summing up, we believe that our work is a first but important step towards understanding the interplay of formal organizational hierarchies and users' behavior in ESN. We hope that our paper will stimulate further research on this fascinating topic and will serve as a proper starting point for future works. In this context, for example time series analyses to better understand temporal effects may constitute a promising next step.

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Appendix

A – Interview guide

1. Please introduce yourself and describe your job role.
2. Which social networking services do you use in private and for business purpose? Please also state why you use it and how strong it is integrated in your daily routine.
3. Where in your daily routine do you use Med-Net?
4. Why do you use Med-Net? (and no other service)
5. What are benefits of Med-Net compared to other systems?
6. In which situations was Med-Net especially helpful?
7. Can you describe a humorous situation you experienced with Med-Net?
8. Did you experience some unpleasant situations with Med-Net? If so, please elaborate further.
9. Did you discover more possible applications / use cases than the ones already described?
10. What else do you want to do in Med-Net?
11. How do military hierarchies influence your usage of Med-Net?
12. Would you recommend Med-Net to your colleagues?
13. Which benefits do you see in Med-Net for the medical department of the German Armed Forces?

4.2 Paper 5: Two Sides of the Same Coin? – Distinguishing Formal Hierarchical Effects Inside and Outside Enterprise Social Networks

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Abstract

With more and more companies using Enterprise Social Networks (ESN) for employee communication and collaboration, the influence of ESN on organizational hierarchies has been subject of numerous discussions in practice-oriented media and first academic studies. Conversely, the question if formal hierarchies affect interaction inside and outside ESN (i.e., personal interaction or interaction via traditional media such as email or telephone) in the same way has not yet been addressed. Therefore, the aim of our research is to analyse whether and how the hierarchical effects inside and outside ESN differ. The analysis of data from an online survey as well as a rich dataset comprising two years of communication and collaboration inside an ESN shows significant differences between the hierarchical effects inside and outside the ESN. Triangulating both datasets allows us to illustrate how the effects impact the two examined types of interaction (communication and collaboration). Although our findings indicate significant impact of formal hierarchy on both – interaction inside and outside the ESN – we found it to be weaker inside the ESN.

Keywords: *Enterprise Social Networking, Formal Hierarchies, Communication Behaviour, Collaboration Behaviour*.

1 Motivation

Today, employees interact with each other in person or via different types of media. Recently, Enterprise Social Networks (ESN) have been playing an increasingly crucial role for organizations when it comes to online communication (Aral et al., 2013; von Krogh, 2012). ESN have shown to be able to support employees in terms of information seeking, dissemination and knowledge sharing, easier expert finding, ideation, or team coordination (Guy et al., 2013; Richter et al., 2011) and thus enable an easy corporation-wide exchange of knowledge without being subject to departmental and geographic boundaries (Aoun and Vatanasakdakul, 2012).

Depending on the type of organization, the respective activities are formalized to a certain degree in terms of who to interact with. Whereas in a bureaucratic/orthodox organization the chain of command is very strict, in a network organization formal functions emerge due to the given tasks (Diefenbach and Sillince, 2011). In either case, formal organizational hierarchy, which is inferred by official structures that are allocated by formal roles and ranking positions, is an essential and pervasive organizational characteristic (Diefenbach and Sillince, 2011). It heavily influences social relations and the resulting network structures (Corominas-Murtra et al., 2013; West et al., 1999) and therefore the way employees communicate and collaborate.

When it comes to digital media, with ESN being the most prominent example, the interplay of formal organizational hierarchies and users' communication and collaboration behaviour is still widely unexplored. There is a number of calls to research the role of formal hierarchies in ESN (Howison et al., 2011; Kane et al., 2014) and to better understand the potential of ESN for delayering and changing organizational network structures (Chau and Xu, 2012). We react to these calls by exploring the effect of organizational hierarchy on employees' interaction (i.e. communication and collaboration). More specifically, we research if the effects of hierarchies on employees' interaction inside an ESN differ from the hierarchical effects on employees' interaction outside an ESN. Here, interaction outside ESN comprises all kinds of professional interaction that is done personally or via the use of traditional media such as telephone or email between two or more persons. Comparing employees' interaction inside and outside the ESN allows us to answer the following question: *How do the effects of formal hierarchies on employees' interaction inside and outside an ESN differ?*

Our results contribute to existing research in various ways: First of all, we show that formal hierarchy strongly affects interaction inside and outside ESN. For instance, our results reveal that most interaction happens on the same hierarchical level. Most importantly, our study is the first to show that the effect of hierarchy on communication and collaboration differs in-

side and outside the ESN in several aspects. We do not only find a weaker impact of hierarchies in ESN, but are also able to show that the chain of command is erupted inside the ESN. These findings have important implications for theory and practice. They contribute to a better theoretical understanding of the role of ESN in the communication repertoire of an employee. Moreover, they help people responsible for implementing ESN in organizations as they get insights on how ESN impact the formal relations and thus, the transformation of organizations. From a managerial perspective our results are also of interest for organizations that use ESN to foster collaboration across hierarchies, for instance, for generating new innovations.

The remainder of this paper is structured as follows: In Section 2, we provide an overview of the relevant literature on hierarchy in Information Systems (IS) in general and ESN in particular. Section 3 describes the research method, the case setting, and the data collection and analysis process. In Section 4, we present the findings of our analysis. Afterwards, in Section 5 we discuss implications and limitations of our work and provide directions for further research. Finally, we conclude with a brief summary.

2 Theoretical Foundations

To lay the theoretical basis for our study, we discuss direct and indirect effects of formal hierarchy on various aspects of offline and online social networks. We furthermore show how the aspect of hierarchy has been analysed in the context of IS in general and ESN in particular.

2.1 Organizational hierarchies and structures

Formal hierarchy has a long history in organizational research. Max Weber describes hierarchy as a "vertical formal integration of official positions within one explicit organizational structure" (Weber, 2005). Other authors define formal hierarchy as an "ordered set of entities that can be classified as being inferior, superior or on the same level as one other" (Putzke et al., 2010, p. 3). Thus, in an organization with a well-marked formal hierarchy "each position or office is under the control and supervision of a higher one" (Diefenbach and Sillince, 2011). Therefore, all roles and positions within the hierarchical structure are unambiguously defined and enable a clear differentiation between each other (Zeitlin, 1974). Social groups contain different types of power which in turn can establish hierarchical structures (French and Raven, 1959). Formal decision-making structures, whether in terms of "authority", "command", or "control", are integral features within modern organizations (Marcum et al., 2012). In an organizational hierarchy, individuals act under a regime of administrative procedures and job roles defined by higher level superiors (Powell, 1990; Putzke et al., 2010). Hence, formal hierarchy is an essential and also pervasive organizational characteristic (Corominas-Murtra et

al., 2013), which is represented in formal relations, for example an "org chart" in organizations. According to Diefenbach and Sillince (2011), different types of hierarchical organizations can be distinguished by how strict the chain of order is regulated. Here, in a *bureaucratic/orthodox organization* all roles are placed along a given line of top-down control, where orders are transmitted downwards. In contrast, in a *network organization* the hierarchy is ordered via the emergence of formal functions due to given tasks and not a strict chain of command.

Next to these formal relations, employees also establish different types of informal relations which can be distinguished into four types, namely: similarities (i.e., two persons sharing similar characteristics such as location or gender), social relations (i.e., the kind of relation between two persons such as kinship or affection), interaction (i.e., the kind of interaction that invoked the relation between two persons such as communication or collaboration), and flows (i.e., the kind of "good" that is transferred from one person to another such as information or resources) (Borgatti et al., 2009). However, existing formal structures heavily influence these informal structures (West et al., 1999) and hence limit the variety of future informal network structures (Corominas-Murtra et al., 2013). The effect of hierarchy on social relations was evaluated for example in British hospitals among groups of doctors and nurses. The results show that nurses are more likely to discuss important matters with juniors than with doctors and hence form a distinct network structure (West et al., 1999). These network structures in turn have an influence on information dissemination (Chau and Xu, 2012), contribution behaviour (Zhang and Wang, 2012), employee performance (Wu, 2013; Zhang and Wang, 2012), and stability of organizational networks (Quintane et al., 2013).

Both organizations with a well-marked formal hierarchy and organizations with a less marked formal hierarchy, have their own strengths and weaknesses. The strength of well-marked hierarchical organizations lies in their reliability, they are best suited for producing large quantities of standardized products or services (Powell, 1990). Hence, organizations with mechanistic structures, that is organizations with a well-marked formal hierarchy, are most appropriate under conditions of high task certainty (Tichy et al., 1979). Today, companies are facing greater uncertainty due to technological changes, knowledge intense tasks, and higher performance expectations. With increasing uncertainty, hierarchy is only exceptionally employed since the number of exceptions increases until hierarchy becomes overloaded (Galbraith, 1974). The aspect of information sharing illustrates the differences between network and hierarchy. When information is passed along the formal hierarchy, new meanings or interpretations are only rarely generated. Formal hierarchy only structures the flow of information (Johnson et al., 1994). In contrast, as information passes through a network, new connections and meanings are generated and evaluated (Powell, 1990). Hence, network forms

of organizations seem better suited for knowledge workers who possess fungible knowledge that is not limited to a specific task but applicable to a wide range of activities (Powell, 1990).

2.2 Hierarchies and Enterprise Social Networks

There are only few studies that investigate the interplay of formal organizational hierarchy and IS in general and ESN in particular. Nevertheless, it is indicated that IS usage influences company culture and consequently hierarchical structures (Leidner and Kayworth, 2006). Within this strand of research scholars focus on the role of hierarchy in computer-supported communication. Here different approaches have been applied (cf. e.g., Rowe et al., 2007; Shetty and Adibi, 2005). In this context, Wang et al. (2013) for instance, propose an algorithm called HumanRank that, based on the idea of Google's PageRank, allows to assess the formal hierarchical position of a person based on his or her communication interactions. Other research with respect to the dissemination of information found that discussions are more likely to diffuse vertically up and down the organizational hierarchy, but news is more likely to diffuse laterally as well as vertically, regardless of organizational roles and their connections (Aral et al., 2007).

In the last years, both research and practice have argued that many hierarchical organizations may be transformed into more networked patterns or flatter hierarchies (McAfee, 2009; Tapscott and Williams, 2006). This transformation is supported and accelerated by new IS such as ESN, which provide opportunities to improve communication and collaboration within organizational boundaries. ESN transfer concepts of social network sites, like uniquely identifiable user profiles or the consume, produce, and interaction with streams of user generated data (cf. boyd and Ellison, 2007; Ellison and boyd, 2013), in the organizational context. They offer employees new ways for informal networking through communicating and collaborating in both, public enterprise-wide communication streams and private groups with restricted membership (Riemer et al., 2010). Examples of ESN platforms are Microsoft Yammer, IBM Connections, Tibbr or Jive SBS. An important reason for organizations to adopt dedicated workplace ESN services is to mitigate the risk related to confidentiality and information security of using public social networks such as Facebook for workplace communication (DiMicco et al., 2008).

ESN are said to transform power relations and hierarchies (Bobsin and Hoppen, 2013) and to have the potential to let all employees interact as equals (McAfee, 2009). However, the effect of organizational hierarchies on social networking behaviour in ESN has received only little attention so far. On the one hand, persons from different hierarchical levels employ ESN in different ways and hierarchical structures (with their role-typical behaviour) are reproduced on such platforms (Riemer and Richter, 2010). On the other hand, ESN can enable new social

structures and thus alter the notion of hierarchy (Bobsin and Hoppen, 2013), while communication activities have greater influence on responses than hierarchy (Stieglitz et al., 2014). ESN increase the visibility of other users' involvement, which in turn can affect users' behaviour (Majchrzak et al., 2013), because it allows users to access information resources without contacting or knowing the author. As a consequence, informational hierarchies can be overcome, because informal relationships established through an ESN can reinforce or interfere formal organizational processes based on hierarchy (Ellwardt et al., 2012). At the same time, it is still unanswered whether and how the effects of formal hierarchies inside and outside ESN differ.

3 Research Method

To be able to analyse the role of formal organizational hierarchies in-depth, we study a case at the German Armed Forces. Since we are specifically interested in if the hierarchical effects inside ESN differ from those outside the ESN, we use communication and collaboration behaviour as examples for interaction behaviour. Thereby, we focus on the hierarchical levels of the respective communication and collaboration partners. This allows us to analyse how formal hierarchies actually affect communication and collaboration. To get deeper insights on the effects of formal organizational hierarchies, we triangle evidence from multiple sources, i.e. we use both data extracted from the ESN and data from an online survey (Yin, 2009, 2012).

3.1 Case

In the following, we focus on the medical service unit of the German Armed Forces. It has a strictly defined and highly transparent hierarchical organizational structure. Considering the five typical types of hierarchical organizations as summarized by Diefenbach and Sillince (2011), the German Armed Forces can be seen as a classical bureaucratic/orthodox organization. All positions are placed along official lines of top-down command and control. Formal authority is closely related to the rank of a position, independent of the actual person holding this position (Diefenbach and Sillince, 2011). Therefore, our results seem particularly applicable to organizations of this type (i.e., bureaucratic/orthodox organizations).

The medical service unit employs amongst others, 2,700 medical officers and 1,600 trainee medical officers assigned to military medicine, military pharmacy, veterinary medicine, or dental medicine. The workforce (medical officers and trainee medical officers) is distributed over five hospitals (all major military hospitals in Germany), 37 universities (i.e., all German universities which offer medical studies), and 200 other facilities. The medical service unit follows the formal organizational hierarchies of the German Armed Forces as described in the

Administrative Order on the Position of the Military Superior (Bundesministerium der Verteidigung, 1956) in which the military hierarchies are divided into seven levels: general, staff officer, captain, lieutenant, non-commissioned officer (NCO), enlisted soldier and civilians who are employed within the medical service unit. To make our results transferable to non-military organizational settings, we briefly describe each level and try to compare them to common organizational roles (cf. Table 1).

Level	Rank	Description	Common organizational role
7	General	Generals are the top management and have authority over all lower levels. Typically, they are not involved in the daily business, but fulfil representative and strategic tasks covering the entire organization.	Board member
6	Staff officer	Staff officers are typically not involved in the daily business but lead divisions. They have authority over all lower levels and coordinate their subordinates by deciding on strategic aspects.	Executive director
5	Captain	Captains are responsible for the management, training and staffing of a business unit or sub-division. They are involved in the daily business in a consulting role and have authority over all lower levels.	Business unit manager
4	Lieutenant	Lieutenants can lead a collection of teams (e.g., a department) and coordinate their subordinates. They have decision making power to a certain degree.	Manager
3	NCO	Non-commissioned officers (NCOs) can lead small teams and delegate tasks accordingly. They have decision making power only in their own team.	Team leader
2	Enlisted soldier	Enlisted soldiers have no authority over others.	Employee
1	Civilian	Civilians who are employed by the German Armed Forces.	Employee

Table 1. Description of the hierarchical levels.

In 2009, the department decided to implement an ESN – in the following referred to as Med-Net. By introducing Med-Net, the German Armed Forces aimed to foster communication, collaboration and knowledge sharing among its employees since they are geographically spread across Germany. The main goals of Med-Net were described as 1) fostering knowledge transfer and collaborative learning among staff, 2) improving the quality of education and the in-service training of new employees, 3) strengthening the corporate identity and the networking of staff, and 4) creating a collaborative knowledge base. To participate in the ESN, each user has to state his or her real name and military rank. Both are publicly available parts of a user's profile. Even though the German Armed Forces is heavily regulated and has a very complex formal structure, Med-Net does not incorporate any pre-defined structure. Its use is voluntary and the user guidelines allow a self-regulated communication and usage of all features for any purpose. The ESN was launched in November 2010 as a pilot, which was developed and maintained by our research group. This gave us exclusive access to an otherwise inaccessible dataset.

3.2 Data collection

To investigate the effects of formal hierarchies on interaction inside and outside the ESN, we consider respective information regarding communication and collaboration in both settings. This allows us to better understand the different hierarchical effects. Indeed, we can draw conclusions on 1) whether the effects of hierarchies inside the ESN are the same as outside the ESN and 2) how the hierarchies influence communication and collaboration behaviour inside and outside the ESN. We base on data from two different sources. By conducting an online survey among the employees of the medical service unit of the German Armed Forces, we retrieved data about to which extent people communicate and collaborate with other people on the different hierarchical levels outside the ESN. Respective data regarding the interaction inside the ESN was ascertained via a dataset exported from Med-Net. Basis of our analysis is that the effects of hierarchies can be observed in communication and collaboration behaviour and in consequence with whom (i.e. hierarchical levels) people communicate or collaborate.

3.2.1 Data collection via online survey

To gain insights with respect to the effects of hierarchies on interaction (communication and collaboration) in the daily work outside the ESN (i.e., interaction that is done personally or via traditional media such as email or telephone), we employed an online survey. The target group of the survey were members of the medical service unit. We created a questionnaire in which we retrieved for an exemplary workweek 1) the average number of persons a person has communicated or collaborated with outside the ESN in his or her daily work and 2) the respective distribution of communication partners and collaboration partners among the hierarchical levels. Thus, we do not only know with how many persons an employee interacted, but also to which extent he or she interacted with the different hierarchical levels. Both was surveyed for the years 2013 and 2014, respectively. Our questionnaire was attached to an online survey commissioned by the administration of the medical service unit. An invitation to the survey was sent via email to all members of the medical service unit. Moreover, a link to the survey was posted to the cover page of Med-Net. In total, the online survey ran for 82 days.

As a result, we were able to collect a sample of 127 complete and valid responses. Whereas not all participants of the survey have joined the medical service unit prior to 2014 or preferred not to answer to some questions the sample size might differ between the years 2013 and 2014 as well as between communication and collaboration. Table 2 provides information about the respondents' hierarchical level as well as the share of each hierarchical level in the medical service unit in 2013 and 2014. In addition, it also comprises information about the

sample size for communication and collaboration in each year. For instance, 125 persons provided valid responses regarding their communication behaviour in 2014. Since no generals (i.e., level 7) participated in the survey, we do not consider the behaviour of persons on level 7 in our further analysis.

Based on the information provided by the participants of the survey, for each year and each hierarchical level, respectively, we derived the average distributions of an employee's communication partners and collaboration partners among the hierarchical levels. Hence, we can for instance state, to what extent a person on level 4 on average communicated outside the ESN with persons on the same hierarchical level (i.e., level 4) or with persons on any other level of the organizational hierarchy in 2014.

Hierarchical level	**Share of persons in the medical service unit**[5]		**Number of respondents in the online survey**			
			Communication		**Collaboration**	
	2013	2014	2013	2014	2013	2014
Level 7	0%	0%	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Level 6	13%	14%	46 (43%)	46 (37%)	43 (46%)	44 (41%)
Level 5	7%	7%	5 (5%)	7 (6%)	5 (5%)	5 (5%)
Level 4	3%	3%	27 (25%)	30 (24%)	19 (20%)	23(21%)
Level 3	36%	38%	22 (20%)	25 (20%)	18 (19%)	20 (19%)
Level 2	11%	13%	1 (1%)	9 (7%)	1 (1%)	7 (7%)
Level 1	30%	25%	7 (6%)	7 (6%)	8 (7%)	8 (9%)
Sum	100%	100%	108 (100%)	125 (100%)	97 (100%)	107 (100%)

Table 2. Number and share of persons and respondents on the different hierarchical levels.

3.3 Data collection via log file from Med-Net

The medical service unit of the German Armed Forces provided us with a dataset ranging from January 2013 to December 2014. To ensure confidentiality, all personal information (e.g., user names) was removed during data export. The dataset contains, amongst others, information regarding 3,273 unique users of the ESN including their military hierarchical level, direct messages exchanged with other users as well as written, modified, and read articles in the knowledge base. For our research we can draw on 942 direct messages to represent communication inside the ESN. Moreover, in the knowledge base a total of 485 articles were authored and 752 modifications were undertaken in the time period under observation. Hence, we can draw on which users worked together on an article in the knowledge base to investigate collaboration inside the ESN. Summing up, we analyse users' communication in terms

[5] We are not allowed to provide information on the absolute number of persons on each hierarchical level.

of direct messages sent to other users and collaboration in terms of working together on articles in the knowledge base inside the ESN. Depending on the hierarchical level, Table 3 shows the number and share of users in the ESN as well as the respective sample sizes for communication and collaboration inside the ESN for the years 2013 and 2014. On this basis, for each year and each hierarchical level, respectively, we calculated the average distributions of an employee's communication partners and collaboration partners among the hierarchical levels – i.e., to what extent users on a specific hierarchical level on average interacted with other users in the ESN depending on the hierarchical levels.

Hierarchical level	**Number of unique users in the ESN**		**Number of users included in our dataset (sample)**			
			Communication		**Collaboration**	
	2013	2014	2013	2014	2013	2014
Level 7	7 (0%)	8 (0%)	2 (1%)	3 (1%)	0 (0%)	1 (1%)
Level 6	278 (16%)	686 (24%)	62 (16%)	84 (16%)	23 (15%)	27 (29%)
Level 5	171 (10%)	239 (8%)	41 (10%)	40 (8%)	18 (12%)	12 (13%)
Level 4	699 (39%)	761 (27%)	173 (44%)	188 (37%)	78 (51%)	34 (36%)
Level 3	438 (24%)	616 (21%)	88 (22%)	127 (25%)	24 (16%)	11 (12%)
Level 2	86 (5%)	316 (11%)	10 (3%)	29 (5%)	1 (1%)	0 (0%)
Level 1	116 (6%)	257 (9%)	15 (4%)	41 (8%)	8 (5%)	9 (9%)
Sum	1,795	2,883	391 (100%)	512 (100%)	152 (100%)	94 (100%)

Table 3. Number and share of ESN users on the different hierarchical levels.

4 Results

This section is dedicated to the findings of our study. First, we analyse whether the effects of hierarchies on communication and collaboration generally differ inside and outside the ESN. Then, we focus on how hierarchies influence communication and collaboration behaviour inside and outside the ESN.

4.2 Differences in the effects of hierarchies inside and outside the ESN

In a first step, we aimed to investigate if the effects of hierarchies on communication and collaboration inside the ESN are the same as outside the ESN. These effects are recognizable in with whom (resp. hierarchical level) persons communicate and collaborate. Therefore, for each year and each hierarchical level, respectively, we calculated the distribution of communication partners as well as collaboration partners among the different hierarchical levels. Then, we applied a chi-squared test for homogeneity (Pearson, 1900) to compare the respective distributions inside and outside the ESN.

Table 4 shows the results of the chi-squared test for each hierarchical level. For level 6 for instance, we observe a test value of 53.76 for communication in 2013. For this test value, we have to reject the hypothesis that for this year and hierarchical level, communication partners

inside and outside the ESN share the same distribution (for α=0.01). Thus, we found evidence that for level 6 and 2013 the effects of hierarchies on communication inside and outside the ESN differ significantly.

Hierarchical level	Communication		Collaboration	
	2013	2014	2013	2014
Level 6	53.76***	30.00***	66.97***	40.84***
Level 5	11.32*	18.75***	14.72**	10.74*
Level 4	15.81**	4.79	33.11***	30.72***
Level 3	64.67***	38.25***	83.82***	96.89***
Level 2	101.59***	56.36***	125.00***	100.00***
Level 1	16.74**	11.02*	100.00***	35.07***
*** α=0.01 ** α=0.05 * α=0.1				

Table 4. Results of the chi-squared test for homogeneity (including level of significance α).

The results (cf. Table 4) further indicate that this holds true not only for level 6 and communication in 2013 but also for all other hierarchical levels and communication in both years (except for level 4 in 2014). In addition, similar results can be observed for collaboration in the years 2013 and 2014. Hence, we found evidence that the effects of formal hierarchies inside and outside the ESN do not only differ with respect to communication but also with respect to collaboration.

Summing up, the results show that a person's behaviour inside the ESN significantly differs from his or her behaviour outside the ESN with respect to whom the person communicates and with whom the person collaborates. This means that inside the ESN persons interact with persons from other hierarchical levels than they do outside the ESN.

4.2 Impact of hierarchies on employees' interaction

Further, we aim to analyse how the hierarchical effects influence communication and collaboration inside and outside the ESN. Since the number of persons in each hierarchical level varies greatly in size (cf. Table 2 and Table 3), a population bias (Howison et al., 2011) could skew the results. Thus, when analysing our data with respect to the effects of hierarchy on communication and collaboration between persons, the number of persons on each hierarchical level has to be considered accordingly. This is due to the fact that communication and collaboration may not only be subject to the influence of hierarchy, but also to the sheer number of persons on the respective hierarchical level.

If hierarchy had no influence on the interaction between persons, the number of a person's interaction partners on a certain hierarchical level would be proportional to the number of persons on the respective hierarchical level. If, for instance, the number of persons on level 1 is as four times as the number of persons on level 3, it would be expected that a person has four times more interaction partners among persons on level 1 than among persons on

level 3. In the following, to account for this fact, we compare the observed distributions of communication partners and collaboration partners inside and outside the ESN to the respective expected distributions if hierarchy had no influence. The underlying idea of using the expected distribution if hierarchy had no influence is illustrated in Figure 1.

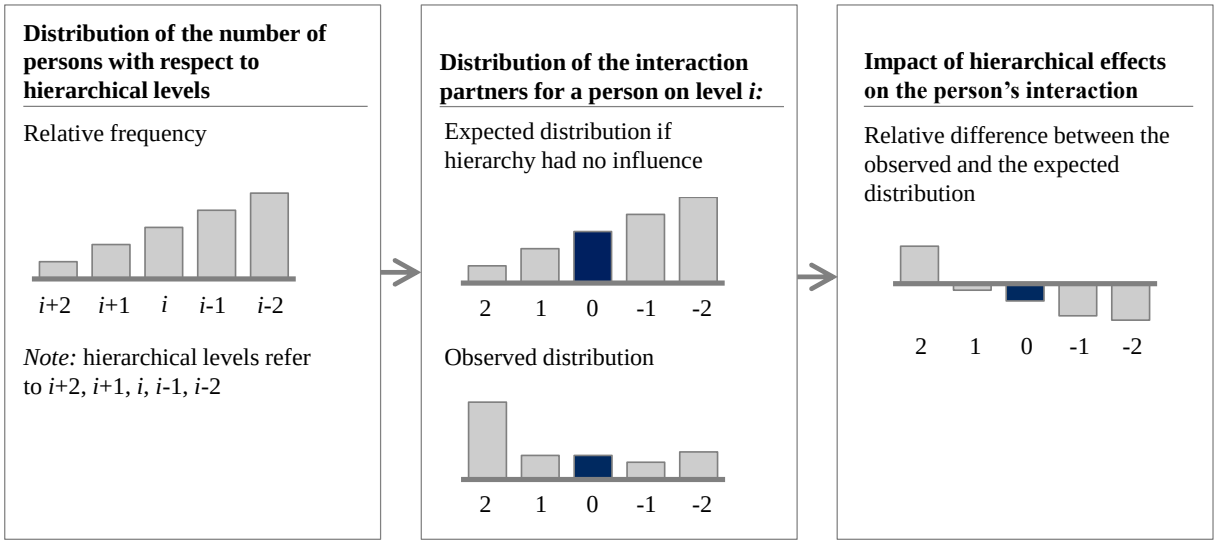

Figure 1. Basic idea to determine the impact of hierarchical effects on employees' interaction.

For reasons of simplicity, Figure 1 only comprises five hierarchical levels (*i*+2, *i*+1, *i*, *i*-1, and *i*-2), where *i*+2 is the highest and *i*-2 is the lowest level. The left-hand side of Figure 1Figure illustrates the distribution of the number of persons with respect to the hierarchical levels. This distribution is used to represent the expected distribution if hierarchy had no influence of a person's interaction (i.e. communication or collaboration) partners depending on the hierarchical levels, respectively the differences in hierarchical levels. Positive differences in hierarchical levels refer to interaction with persons on higher levels, while negative differences indicate interaction with persons on lower hierarchical levels. Regarding the example in Figure 1, for a person on level *i* the difference is 2 for interaction with persons on level *i*+2 and -2 for interaction with persons on level *i*-2. Due to the smallest number of persons on level *i*+2 and the highest number of persons on level *i*-2, a person on *level i* is expected to have the smallest number of interactions with persons who are two levels higher and the highest number of interactions with persons who are two levels lower. The actually observed distribution of interaction partners may differ from this expected distribution (cf. centre of Figure 1). In the following, to determine the impact of hierarchical effects on employees' interaction, we calculate the relative differences between the values of the actually observed distribution and the respective values of the expected distribution if hierarchy had no influence (cf. right-hand side of Figure 1). In Figure 1, this results in a positive relative difference for a difference in hierarchical levels of 2 while the other relative differences are negative. Indeed, the relative

frequencies of interaction partners on all other hierarchical levels (*i*+1, *i*, *i*-1, and *i*-2) are lower than expected if hierarchy had no influence.

Based on these theoretical considerations, for each person we calculated the relative differences between the values of the actually observed distributions of the interaction partners and the respective values of the expected distributions of the interaction partners if hierarchy had no influence. Figure 2 shows the aggregated results depending on the respective differences in hierarchical levels. Thereby, as introduced above, positive differences in hierarchical levels represent interaction with persons on higher hierarchical levels and vice versa. Moreover, for reasons of clarity and comprehensibility all communication and collaboration that bridges at least two hierarchical levels was aggregated.

The upper part of Figure 2 refers to communication (cf. diagram a)) and collaboration (cf. diagram b)) outside the ESN. Here, for instance, the relative frequencies of communication partners on the same hierarchical level (i.e., difference in hierarchical levels of 0) are 208% (for 2013) respectively 232% (for 2014) higher than it would be expected if hierarchy had no influence. In contrast, the relative frequencies of communication partners on the next higher level are 66% (for 2013) respectively 41% (for 2014) lower than expected. According to our results, hierarchy seems to have a strong influence on communication outside the ESN. Indeed, it is particular remarkable that persons primarily tend to communicate with their peers resulting in strongly over proportional numbers of communication partners on the same level (for communication the observed distributions significantly (for α=0.01) differ from the expected distributions if hierarchy had no influence). Further, it becomes evident that there is much less communication with persons on higher hierarchical levels. This also holds for collaboration outside the ESN. While people tend to collaborate with their peers and subordinates, less collaboration than expected is observed with superiors. Here, the distributions differ significantly (for α=0.01), too.

The lower part of Figure 2 refers to communication (cf. diagram c)) and collaboration (cf. diagram d)) in the ESN. The results reveal that in the ESN persons also primarily communicate with their peers: we found that the observed distributions for communication significantly (for α=0.01) differ from the expected ones if hierarchy had no influence. Moreover, the more hierarchical levels communication has to bridge, the less persons actually communicate with each other (cf. decreasing relative differences). For collaboration in the ESN, we observed a strong hierarchical influence for 2013 (observed distribution significantly (for α=0.01) differs from the expected one). However, collaboration behaviour within the ESN obviously changed in 2014. Indeed, for this year the results indicate a reduced impact of hierarchical effects and the observed distribution does not significantly (for α=0.01) differ from the expected one if hierarchy had no influence.

Summing up, we found that hierarchy significantly influences communication and collaboration inside and outside the ESN. Persons primarily tend to interact with their peers and barely bridge multiple hierarchical levels. However, the effects of hierarchies inside and outside the ESN differ to some extent. Within the ESN the hierarchical effects seem not as strong as outside the ESN. While outside the ESN communication and collaboration with superiors seems to be heavily limited, interaction inside the ESN seems to be more open. Here, persons communicate and collaborate more with superiors than outside the ESN. In contrast, inside the ESN persons tend to less interact with their subordinates. Thus, in the ESN interaction seems not to be limited by a clear line of control and command while outside the ESN a top-down line can be observed. Finally, while hierarchical effects outside the ESN seem to barely change over time, comparing interaction inside the ESN for the years 2013 and 2014, we observe a decrease of hierarchical effects on collaboration. Hence, it may be argued that over time ESN can contribute to reducing hierarchical effects in an organization and can lead to flatter hierarchies.

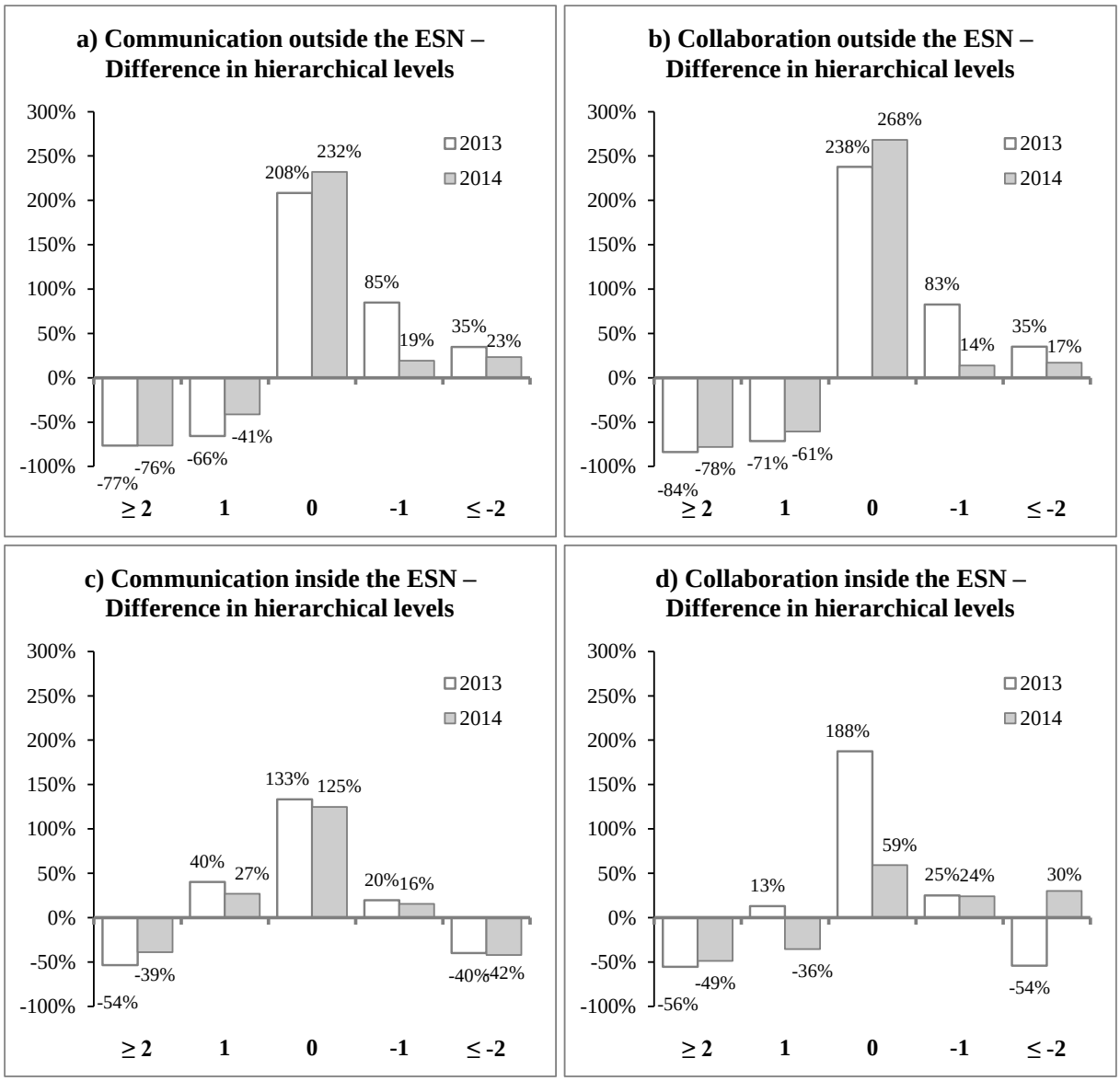

Figure 2. Impact of hierarchical effects on interaction as indicated by relative differences between observed and expected distributions if hierarchy had no influence.

5 Discussion

5.1 Implications for theory and practice

We aimed to investigate if the effects of hierarchies on employees' interaction (i.e., communication and collaboration) inside an ESN differ from the hierarchical effects on employees' interaction outside ESN. The findings contribute to theory and practice in different ways.

Overall, our results provide insights into how people behave regarding their communication and collaboration partners inside and outside ESN with respect to the influence of formal organizational hierarchy. The hierarchical effects can be recognized by the amount of interaction between the different hierarchical levels – i.e., how much interaction takes part between a person and other persons on the same level (peers), on higher levels (superiors), or on lower

levels (subordinates). First of all, our findings show that the hierarchical effects, i.e. a person's behaviour with respect to whom to interact, inside and outside the ESN, differ significantly (cf. Table 4). Inside an ESN people communicate and collaborate more with persons from other hierarchical levels than they do outside the ESN. From a management perspective, this is of special interest for those responsible for introducing ESN. Here, the employees seem to have recognized the benefits of the ESN and use the ESN beyond their interactions regarding their tasks in their daily work. For instance, they use the ESN to extend their knowledge by collaborating with others in the knowledge base or actively communicating experiences and knowledge with other users apart their usual professional environment. Our results are also supported by a prior study that found that in organizations where the employees are geographically spread, like in the German Armed Forces, an ESN can be seen as networking and crowdsourcing space which is basically used for discussion, input generation, idea generation as well as informal talk beyond formal professional guidelines (Richter and Riemer, 2013).

Second, our study sheds light into how the impact of hierarchy on interaction, i.e. communication and collaboration, varies whether it takes part inside or outside ESN. Although the effects of formal hierarchies inside and outside the ESN differ, we could observe that employees generally tend to communicate and collaborate more with their peers – i.e. colleagues on the same hierarchical level (cf. Figure 2). While communication and collaboration behaviour outside the ESN seems to be more controlled by a regime of administrative procedures and job roles defined by higher level superiors (Powell, 1990; Putzke et al., 2010), also inside the ESN people seem to bear in mind the hierarchal level of others for their interactions (also see Riemer and Richter, 2010). Thus, hierarchies play a decisive and significant role not only outside but also inside the ESN. This might be due to different reasons. One is that the employees have appropriated Med-Net in a way that it best produces personal benefits. People within the same hierarchical level are more likely to share similar interests as well as communication practices (West et al., 1999). Another reason is that people might try to minimize communication with higher levels beyond their daily work as they try for instance to avoid being perceived as a careerist or sycophant. Or they expect professional disadvantages if superiors consider their behaviour in the ESN to be disrespectful or inappropriate.

Third, nevertheless the most interesting result is that the effect of hierarchy seems to be weaker inside the ESN than outside the ESN (cf. Figure 2). Hierarchy is clearly recognizable for interactions outside the ESN, i.e. employees tend to interact with their subordinates in preference and hesitate to interact with superiors. In contrast, inside the ESN these strict hierarchical structures seem to be erupted. Here, the differences between the observed distributions of communication and collaboration partners on the one hand, and the respective expected distributions if hierarchy had no influence on the other hand, are smaller than outside the ESN. Inside the ESN employees do communicate less with their subordinates and

more with superiors than outside the ESN. A reason for the shift from communication with subordinates to superiors can be that employees are less hesitant to interact with superiors than they would be outside the ESN as they use the ESN, for instance, for seeking advice and additional knowledge. Further, we showed that initially the impact of formal hierarchies was higher for collaboration than for communication but changed over time. In 2014, the formerly high impact of hierarchy on collaboration nearly vanished. Hence, users need time to get used to this new form of open communication and collaboration, especially within the studied organization that can be characterized as heavily regulated. This means that the strong and persisting impact of hierarchy on communication and collaboration may slightly decrease over time. Or in other words: it may be argued that over time ESN contribute to reducing hierarchical effects and may lead to flatter hierarchies.

5.2 Limitations and further research

Although our findings provide first and interesting insights into the differences of hierarchical effects inside and outside ESN, they have to be seen in the light of several limitations. First, we only studied one single institution. Nevertheless, the case of Med-Net was selected for its high transparency of the hierarchical structures which allows us to clearly differentiate between hierarchical levels and to thoroughly analyse the hierarchical effects. Whereas military organizations might differ from business organizations in some points, comparable hierarchical structures (i.e. bureaucratic/orthodox organizations), where all positions are placed along official lines of top-down command and control, can also be found in other organizational contexts outside the military domain (Corominas-Murtra et al., 2013), for example in large organizations or in the consulting business (Stieglitz et al., 2014). Further studies can support to confirm the findings of this study. Second, we only analysed two types of interaction. Obviously, communication and collaboration cannot completely reflect users' behaviour in ESN, which also takes part in the creation of social relationships. However, it might be assumed that the selected kinds of interactions are important and well-used functionalities of ESN. While in a first step it seemed appropriate to use communication and collaboration as examples for users' behaviour inside ESN, further studies are needed to analyse other types of relations such as social relationships. Third, we did not consider individual attributes like age, gender, and experience (e.g., years of service) explicitly. While, the hierarchical levels may already partly reflect age and experience, this leaves room for further studies. Finally, although we considered different time frames, the network dynamics were not the focus of this study. This leaves room for future research considering the investigated effects over longer periods of time in more detail.

6 Conclusion

Ever more organizations have been adopting ESN to foster collaboration, communication, and knowledge sharing among employees (Aral et al., 2013; von Krogh, 2012). While there is a growing body of literature in the emerging field of ESN, we still observe a lack of research focusing on the interplay of formal organizational hierarchies and users' behaviour in ESN. Thus, the aim of this paper was to investigate how formal organizational hierarchy affects employees' interaction inside and outside ESN and how these effects differ. Our research is spurred by a plethora of data generated in ESN when users connect and communicate with one another (Giles, 2012) as well as data from an online survey. This data wealth allows for great opportunities to investigate and understand the interplay of formal organizational hierarchies and employees' behaviour.

We could show that formal organizational hierarchies significantly affect the way employees interact with each other inside and outside the ESN. Thereby, employees generally tend to communicate and collaborate with persons on the same hierarchical level but barely bridge different hierarchical levels. However, it has to be noted that hierarchical effects on employees' interaction inside and outside ESN differ to certain extent. While people tend to interact along a top-down line of command outside the ESN, interaction inside the ESN seems to be more open and not as limited. Moreover, we observed first indications that hierarchical effects on collaboration in the ESN tend to decrease over time. Thus, it might be assumed that ESN can contribute to reducing hierarchical effects in organizations and can lead to flatter hierarchies.

With our paper, we hope to contribute to a better understanding of the emerging phenomenon of ESN. Summing up, we believe that our work is an important step towards better understanding the interplay of formal organizational hierarchies and users' behaviour in ESN. We hope that our paper will stimulate further research on this fascinating topic and will serve as a proper starting point for future work.

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4.3 Conclusion to Chapter 4

The research questions addressed in this chapter are:

RQ. 8 What is the impact of formal organizational hierarchy on users' network position in ESN?

RQ. 9 How do the effects of formal hierarchies on employees' interaction inside and outside an ESN differ?

In a first step, it was analysed, if and how the formal hierarchies in an organisation affect users' networking behaviour in ESN. Here, a significant impact on different kinds of relations could be found. This research based on the statement that ESN can lead to flatter hierarchies (McAfee 2009). Nevertheless, this first analyses sparsely allowed to draw conclusions on the statement, as only small information about the impact of formal organisational hierarchies outside the ESN was known. Thus, in a second step, the hierarchical effects inside and outside ESN were compared for different kinds of relations. The results revealed that the impacts largely differed. Moreover, the impact is smaller inside the ESN.

Both papers used the same case (i.e. GAF) and build on the same theoretical base for measuring the impact of hierarchies. However, they differ with respect to the investigated kinds of relations. While in Paper 4 three different relations are analysed (i.e. 1:1 communication, 1:n communication, and social relationships), the analyses in Paper 5 were conducted for two kinds of relations only (i.e. communication and collaboration). Here, 1:1 communication in Paper 4 and communication in Paper 5 are the same as they base on the messages that are exchanged among the users. For Paper 5 it was forwent to investigate social relations due to difficulties to transfer the concept of social relationships in social media to a suitable offline context.

These papers are not the first to investigate the role of formal hierarchies in ESN. This topic was prior addressed by Riemer et al. (2015) and Stieglitz et al. (2014). However, their research differs with respect to the considered kinds of relations as well as the specific research objective. Both papers compare the impact of formal and informal hierarchies on communication inside ESN. Thus, their research does not consider the impact on social relationships (cf. Paper 4) as well as hierarchical effects outside the ESN (cf. Paper 5).

Paper 4 was presented at the International Conference on Information Systems 2015 (ICIS) one of the most presitigious IS conference. At the moment, Paper 5 is under revision at the ECIS.

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5 Structure and Evolution of Enterprise Social Networks

This chapter addresses RQ. 10 and RQ. 11, by investigating the evolution of ESN. The structure of ESN is not static but evolves dynamically as more and more users join the ESN and create new links to other users (Ghosh and Ganguly 2014). Here, prior research for many other real world networks has found, that the creation of new links is not random but follows certain drivers such as users' degree centrality (Albert and Barabási 2002; Barabási and Albert 1999; Jin et al. 2001). To get deeper insights on the patterns and drives for the evolution of ESN, a real world data set comprising the temporal development of an ESN is used. For this, different measures for topological characteristics of the ESN's structure are applied to different periods to investigate how the structure of ESN changes in time (RQ. 10). Moreover, the drivers behind users' attachment behaviour (i.e. the creation of new links to other users) are analysed (RQ. 11).

5.1 Paper 6: Evolution, Structure and Users' Attachment Behavior in Enterprise Social Networks

Status	Published	Full Citation
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Annotation: This paper is written in American English		

Abstract

Due to the increasing number of organizations who have started to implement Enterprise Social Networks (ESN), their network structure, which is invoked by the users and interactions among them, has gained increasing attention, both by practitioners and researchers. However, prior research has not considered how the network structure of ESN evolves over time through interactions among users. To address this lack in research we investigated two research questions: 1) How do the topological characteristics of ESN evolve in time? 2) How is users' attachment behavior characterized with respect to the creation of social relationships during the evolution of ESN? Drawing on a rich dataset comprising more than 4 years of networking and interactions, we are able to show that ESN do not evolve randomly but follow preferential attachment. Rather, our findings indicate a significant, positive correlation between users' centrality in the network and their number of new social relationships.

1. Introduction

In the last couple of years, more and more companies have started to implement so called Enterprise Social Networks (ESN) to foster collaboration, communication, and knowledge-sharing among employees [8, 55]. According to a study by Deloitte [23], more than 90% of all Fortune 500 companies had used ESN by the end of 2013. Due to the growing importance of ESN and its use in daily work practices of employees, there is an increasing demand to better understand the role and impact of these social technologies in and on knowledge-intensive corporate work [14, 48]. First studies have shown that ESN can, for instance, support expert finding, information seeking, idea sharing, or team coordination [24, 51]. ESN can be defined as web-based platforms, which offer employees new ways of communication and collaboration in both public enterprise-wide communication streams and private groups with restricted memberships [49]. ESN allow users to contribute content to a shared pool, allow profile information to be presented, and connects users through features like 'friend requests' [12].

Prior studies have shown [e.g., 31, 56] that the structure of ESN is of great importance. On the one hand, the network structure of ESN plays a decisive role for the explanation of user behavior [56]. On the other hand, topological characteristics like transitivity and mutuality are significant predictors of the desire to form new ties [31]. As the network structure of an ESN is invoked by the connections among its users, it changes in time as more employees are participating and creating new links. Social networks in general and ESN in particular are typical examples of dynamic networks which evolve with respect to a growing number of users and interactions among them [30]. With our research on the evolution of ESN, we aimed to investigate patterns in users' networking behavior and interaction in the ESN that lead to a dynamic network structure. Accordingly to studies with a similar research focus for social media networks [cf. e.g., 30, 40], we did not consider how the platform emerges in the organization and how it is adopted by the employees (for information on the emergence of ESN see [50]).

Especially for organizations that plan to implement an ESN it seems important to gain indications of how the users connect and interact in the ESN. These insights in the dynamic of the structure allow, for instance, to support the avoidance of isolated subnets. Rather, knowledge of the patterns in users' attachment behavior might be helpful with respect to the identification of potential future key users [cf. e.g., 13], since users' importance is inferred by their structural position in the network [36].

In this context, the structure and evolution of many real world networks [e.g., 38, 46] have been studied before. To explain and illustrate their dynamics, models for the evolution of net-

works have been proposed. These models can be found for a large variety of real world networks such as communication networks, information networks, and social networks [22, 38]. First network evolution models for social media networks can be found as well [e.g., 41, 30] due to the growing popularity and importance of social media. However, it is unclear, if these models can be applied to ESN. Whereas ESN are available to employees of an organization only and are mainly thought to support communication and collaboration [49], social media networks are available for the mass and differ in their main focus [see 39]. Rather, ESN differ from other social media networks with respect to some of their topological characteristics [cf. 18].

Today, there is still a lack of research on the evolution of ESN (i.e., how does the network structure change in time). In this paper, we aim to address this issue. Based on a dataset of an ESN used by the German Armed Forces (Deutsche Bundeswehr), we investigate how the topological characteristics evolve in time. In a second step, we analyze users' attachment behavior to other users, i.e., the creation of new social relationships, with respect to these users' position in the network. Therefore, we address the following research questions:

1) How do the topological characteristics of ESN evolve in time?

2) How is users' attachment behavior characterized with respect to the creation of social relationships during the evolution of ESN?

Our results indicate that the structure of ESN does not evolve randomly, but follows preferential attachment due to its power-law degree distribution. Rather, we are able to illustrate that new users (i.e., users who join the ESN in the current period) mainly attach to users who have joined the ESN in prior periods. In addition, we found that a user's position in the social graph influences his or her attractiveness of creating social relationships to other users. Whereas many organizations hesitate to introduce ESN for the fear of failure to support active networking and interaction among all employees to benefit from the positive effects of the ESN, our results may help them, since they contribute to a better understanding of the dynamics in the creation of social relationships in ESN. Given that social technologies like ESN are a core phenomenon of the 21st century, our findings contribute to a more refined understanding of ESN in general.

The remainder of this paper is structured as follows: In Section 2, we give an overview of the theoretical background of our research. In Section 3, we describe the case setting as well as the data collection and preparation process, followed by a short introduction of measures and methods used during our analysis. Our findings are presented in Section 5. Finally, in Section 6, we critically discuss implications and limitations of our research and provide directions for further research. We conclude with a brief summary.

2. Theoretical background

This section is dedicated to a brief overview on the theoretical foundations of our research. We elaborate on the structure of ESN and how it can be quantified. We furthermore show how network evolution has been analyzed in general and for social media networks in particular.

2.1 Enterprise Social Networks and their structure

Prior research has shown that the network structure of ESN play a decisive role in understanding and explaining user behaviour in ESN [56]. Here, for example, Golder and Yardi [31] found that the topological characteristics transitivity and mutuality are significant predictors of the desire to form new ties. The structure of an ESN is invoked by the binary connections among users. It can be mostly perceived as "a set of actors connected by a set of ties. The actors (often called 'nodes') can be persons, teams, organizations, concepts, etc. ties connect pairs of actors (…)" [17, p. 922]. The edges may be directed or undirected and can represent either social links, like friendship relationships (social graph), or communication activities (activity graph), like messages amongst users [e.g., 2, 10, 32]. A well-known method to analyse the network structure is Social Network Analysis (SNA) [57] that can form the theoretical basis for understanding the network structure of social networks in general and ESN in particular.

SNA offers both measures with respect to the topological characteristics of a network represented as a graph and measures that quantify the position of a user in the network by means of user centrality [16, 57]. Most common topological characteristics are, for instance, the global clustering coefficient, shortest average path distance, and density as well as the graph's degree distribution [5, 30, 57]. These characteristics were, amongst others, studied for a variety of social media networks [e.g., 4, 27, 45, 54]. The first research on the topological characteristics on ESN was conducted by Chelmis and Prasanna [18], who studied the network structure using the activity graph of an ESN called @replies. They found that for some topological characteristics, like small world characteristics, ESN differ from social media networks. However, they did not consider network evolution.

Next to the characteristics of the graph, the structural characteristics of the single users can be measured. Here, a well-known method is node centrality [57]. The most common centrality measures include degree centrality, closeness centrality, and betweenness centrality [28]. In the context of social media networks in general and ESN in particular, there are first articles using these centrality measures to identify influential users, for example to foster more effective advertising or marketing strategies [e.g., 32, 33, 53] or to characterize central users on academic networking platform [34] and value adding users in ESN [12].

To sum up, researchers have emphasized the importance of the network structure and central nodes. But, to the best of our knowledge, research lacks on considering both the structure of an ESN and its evolution. Therefore, the aim of our paper is to investigate how the topological characteristics change in time and how users' centrality influences the creation of new social relationships.

2.2 Evolution of networks

Many real-world systems take the form of networks, as they can be represented by a set of nodes connected by a set of edges. Popular examples are, for instance, the World Wide Web (WWW) or social networks [38]. Some of these networks are static, for example blood vessels. Others, like social networks, are dynamic since their structure changes in time [11, 38]. However, in recent years, this topic has been subject to an increasing amount of attention [cf. e.g., 5]. Whereas the evolution of networks has initially been thought to be random [25, 26], research found increasing evidence for a number of non-random characteristics [15]. Many real world networks obey unexpected scaling laws [6, 11] and differ from randomness [37].

Hence, there has been research resulting in models that treat networks as evolving dynamical systems. In prior research, models have been proposed [e.g., 10, 30, 38] being able to capture and reproduce properties observed on various kinds of real world networks [7]. Most of these models consider 1) a continual addition of new nodes and links and 2) preferential attachment that is mostly to nodes that have a high degree centrality (i.e., lots of ties to other nodes) [31]. One of the best-known and most applied preferential attachment models was proposed by Barabasi and Albert [11] (also known as BA model), who used node's degree centrality as driver for the creation of new links. Initially, it was applied to the WWW [11], but later the BA model was also adapted for other kinds of networks [e.g., 40]. Other models consider the nodes' heterogeneity as the main predictor for attachment of new nodes [15] or focus on triadic closure [58].

First network evolution models for different social media networks can be found as well [e.g., 30, 41, 42]. Among the most studied networks are Twitter [e.g., 30] and Flickr [41, 42, 44]. The models mainly differ in the considered driver for preferential attachment behavior. Kumar et al. [41], for instance, found preferential attachment biased by the cost of creating a connection to an isolated community and the ease of connecting with a large single component, while Leskovec et al. [42] stated that users create links with users they have already been close to before. Other drivers that were observed are triadic closure [e.g., 44] and degree centrality with a cut-off (i.e., restriction on degree centrality) [30]. While all the previous studies considered logical time steps [30], Gaito et al. [29] investigated bursts in users' creation of links.

Although the BA model is among the most applied models for network evolution and first models on OSN use degree centrality as driver for the attachment process [e.g., 30], some authors question its applicability on social networks [38, 47]. However, the use of other measures was proposed. Abbasi et al. [1], for instance, suggested betweenness centrality. In this paper, we aim to address the evolution of the structure of ESN and to analyze the drivers for users' attachment behavior due to the lack of research on this theme.

3. Research method

In this section, we provide an overview of the setting of the case and the data collection. Then, we discuss the analysis process and the applied methods.

3.1 Setting

We use the case of the medical service of the German Armed Forces to gain first insights into the evolution of ESN. The medical service employs amongst others nearly 3,000 medical officers and 1,600 trainee medical officers who are distributed among five major military hospitals, 37 public universities that offer medical studies, and 200 other facilities. In 2010, the German Armed Forces started to implement an ESN for its medical service employees – in the following referred to as Med-Net. The main goals of Med-Net were described as (1) fostering knowledge transfer and collaboration, (2) improving the quality of education and the in-service training of new employees, and (3) creating a collaborative knowledge base. In the ESN, all users are represented by a user profile. After joining the network, the users can send contact requests, which have to be confirmed, or write direct messages. The case of Med-Net was selected because of the large dataset including information on users and links (i.e., social links and activity links) from Med-Net's launch in 2010 till February 2015. Timestamps for users' accession date and the creation of links among the users allow us to analyze the evolution of the ESN.

3.2 Data collection and preparation

We were provided with the dataset ranging from November 2010 to February 2015. To investigate the evolution of Med-Net, we aggregated the data on a quarterly basis. Whereas, the ESN was only available to a very small number of users as part of a testing phase in the months after its launch, our analysis were not conducted for earlier times than 2nd quarter 2011. The dataset was provided in MS Excel format, and to ensure confidentiality, all personal information (e.g., user names and the messages' content) was removed during data export.

In the following, we provide a few descriptive statistics on our dataset. The dataset contains information about 2,826 unique users as well as the month and year they have joined Med-Net. 1,645 of the users have at least one confirmed contact request ("social relationship") to

another user (total number of social relationships: 7,390). Moreover, the data include 18,418 direct messages written by a total of 830 users. In Med-Net, the number of users and social relationships increased steadily. Hence, in 2nd quarter of 2011, 142 users were part of the ESN, but in the 1st quarter of 2015, the ESN was used by 2,826 users. This means an average annual growth rate of nearly 21%. In addition, Med-Net shows a continual addition of social relationships (average annual growth 23%) and messages (average annual growth 37%). Altogether more than 70% of all users can be considered as active users of the ESN, because they are involved in the communication activity or social networking.

4. Data analysis

To investigate the evolution of ESN we calculated topological characteristics of the social graph of the ESN and applied the most common centrality measures to the social graph (i.e., social relationship) and the activity graph (i.e., communication activity in terms of messages exchanged among the users).

A network and its structure can be described using topological characteristics. Some of the most common measures are degree distribution, global clustering coefficient, density, and small world characteristics in terms of the average shortest path [46, 57]. Degree distribution $P(k)$ measures the fraction of nodes having degree k. In the context of Med-Net k represents the number of a user's social relationships. The degree distribution of social networks and social media networks is often found to show power-law characteristics (i.e., broad distribution with a heavy tail) [30]. Thus, there are a large number of users having a small number of social relationships and a small number of users having many social relationships. To investigate whether Med-Net shows such characteristics, we fitted a power-law degree distribution [cf. 20] and tested its suitability by using a Kolmogorov-Smirnov test [35]. We further considered the global clustering coefficient C, which can be described as the ratio of three times the number of closed triples to the number of connected triples in the network [46]. A connected triple is a set of three nodes sharing at least two edges while a closed triple shares at least three edges. In the context of Med-Net, a high clustering coefficient indicates that users are more likely to create a social relationship with users they have mutual social contacts with. Moreover, we also calculated the network density, which describes the portion of potential ties that actually can be found [30]. Another well-known topological characteristic is the average shortest path, which is quantified by the average geodesic distance between any pair of nodes in the network [46]. Prior studies [e.g., 43] have found it to be small even for very large networks in general and also for social media networks in particular [9]. The calculation of these topological characteristics for the social graph of the ESN for each quarter respectively allows us to analyze how the structure evolves over time. Moreover, we are able to compare its evolvement with dynamics known for other real world networks.

Finally, this analysis are also a prerequisite for the investigation of users' attachment behavior which leads to the observed network structure of the ESN. To investigate the attachment behavior of users in the ESN, we applied the most common centrality measures, degree centrality, closeness centrality, and betweenness centrality [28] to each node in the social graph and activity graph of the ESN. This analysis was conducted for each of the observed periods. In a next step, we used the results as a basis to investigate drivers in users' attachment behavior. Therefore, we used Spearman rank correlation [51] and measured the correlations between users' centrality and the number of new contact requests in the next quarter. Altogether, the results of the correlation analysis allow us to get first and interesting insights in the patterns in users' attachment behavior. In addition, they allow conclusions about the role of central users for fostering networking and interaction among the users (e.g., how are they characterized with respect to their structural position in the network?)

5. Findings

This section is dedicated to the results of our study. First, we focus on the topological characteristics of the ESN's social graph. The second part concentrates on the analysis of users' attachment behavior and potential drivers for preferential attachment of social relationships.

5.1 Topological characteristics

In a first step, we analyzed the topological characteristics of the social graph of the ESN, which is based on social relationships. We calculated the global clustering coefficient, the average shortest path length, and the density for each quarter. Due to the closed testing phase, our analysis started with 2nd quarter 2011.

The results indicate that the ESN is characterized by a low global clustering coefficient. While in 2nd quarter 2011 the clustering coefficient was 0.32, it decreased over time and was 0.17 in 1st quarter 2015. The average quarterly decrease of the clustering coefficient is about 4%. Our results further indicate that the ESN is getting less dense over time. In 2nd quarter of 2011, we observed a density of 0.03, but in 1st quarter 2015, the density was 0.002. This results in an average decrease of 15% per quarter. Moreover, our analysis indicates that the average shortest path length increased in time. Med-Net had an average shortest path length of 3.1 in the 2nd quarter of 2011, and of 3.8 in 1st quarter 2015. Finally, our analysis showed that for all observed quarters, nearly all users with at least one social relationship are connected in a large single-component.

In a second step, we analyzed the degree distribution $P(k)$ of the social graph of Med-Net for each quarter. A power-law distribution was fitted for each quarter to analyze if the distribution shows power-law characteristics. The liability of the fitted distributions was tested using

a Kolmogorov-Smirnov test [35]. For each quarter, a continuous power-law distribution could be fitted with values for the exponent α between 1.72 and 2.67. The values for k_{min} (i.e., the smallest value of k the distribution was fitted for) are nearly 0. This indicates that the fitted power-law distributions are suitable for all values $k \geq 1$. Hence, the distributions were fitted for all nodes with at least one confirmed social relationship. The p-values of the Kolmogorov-Smirnov test are nearly 1 for all distributions. Hence, we can assume that the degree distribution of the ESN is power-law.

Altogether we found that the structure of the ESN can be considered as dynamic, as the topological characteristics change in time. Although the ESN mainly consisted of a large single component, this component seems to get less dense in time. Moreover, the already low clustering coefficient decreases which indicates that friends are not very likely to share mutual social relationships. In addition, the power-law degree distribution indicates that the networks evolvement is not random, but follows preferential attachment.

5.2 Attachment behavior of users

Whereas our previous analysis showed that the evolution of ESN follows a preferential attachment, we wanted to investigate potential drivers. Hence, in a further step, we analyzed the attachment behavior of users. For our analysis, we partly followed Abbasi et al. [1] who analyzed the attachment behavior in a co-authorship network of publications. In a first step, we investigated the attachment behavior of new and existing users in each quarter. Existing users are defined as those users of the ESN who already have joined the network at least one quarter ago, while a new user is defined as a user who joined the network in the current quarter. Table 1 shows the results. For each quarter it includes the number of existing users as well as the number of new users. Further, the table contains the total number and share of new users who created at least one new social relationship to a new or an existing user, respectively. This analysis was also conducted for old users. For example, in 2nd quarter 2012, 91 new users joined the ESN and 7 (8%) of them created a social relationship to at least one other new user, and 26 (29%) of them created a social relationship to at least one of the 880 users who had joined the ESN previously. In the same quarter, 32 (4%) existing users built a social relationship with at least one new user and 102 (12%) with at least one other old user. These results indicate that except for year 2011, only a small share of the new users created social relationships to another new user. Instead new users tended to befriend existing users. Inverted attachment behaviors can be observed in the 3rd quarter or 4th quarter of the sole years. In these quarters new users are more likely to connect with other new users than with existing users. Similar results are yielded when investigating the attachment behavior of existing users. Here, the share of existing users who created at least one social relationship to other existing users is higher than the share of existing users who created a social relationship

to at least one new user. In 4th quarter 2013, for instance, 47 (3%) existing users created at least one new social relationship to a new user and 158 (10%) of them to an existing user. Moreover, we found that the share of users who created a social relationship decreased in time.

Quarter	No. of users	No. of new users	No. of new users creating at least one social relationship to				No. of existing users creating at least one social relationship to			
			a new user		an existing user		a new user		an existing user	
2nd Quarter 2011	142	138	64	(46%)	13	(9%)	2	(50%)	1	(25%)
3rd Quarter 2011	472	330	86	(26%)	84	(25%)	49	(35%)	81	(57%)
4th Quarter 2011	775	303	54	(18%)	78	(26%)	58	(12%)	150	(32%)
1st Quarter 2012	880	105	2	(2%)	17	(16%)	26	(3%)	106	(14%)
2nd Quarter 2012	971	91	7	(8%)	26	(29%)	32	(4%)	102	(12%)
3rd Quarter 2012	1025	54	4	(7%)	8	(15%)	27	(3%)	71	(7%)
4th Quarter 2012	1170	145	14	(10%)	27	(19%)	37	(4%)	137	(13%)
1st Quarter 2013	1302	132	5	(4%)	19	(14%)	28	(2%)	116	(10%)
2nd Quarter 2013	1376	74	3	(4%)	20	(27%)	27	(2%)	105	(8%)
3rd Quarter 2013	1544	168	8	(5%)	27	(16%)	24	(2%)	104	(8%)
4th Quarter 2013	1726	182	16	(9%)	36	(20%)	47	(3%)	158	(10%)
1st Quarter 2014	1988	262	9	(3%)	22	(8%)	34	(2%)	153	(9%)
2nd Quarter 2014	2103	115	3	(3%)	15	(13%)	19	(1%)	107	(5%)
3rd Quarter 2014	2510	407	42	(10%)	19	(5%)	11	(1%)	120	(6%)
4th Quarter 2014	2713	203	3	(1%)	19	(9%)	19	(1%)	140	(6%)
1st Quarter 2015	2826	113	1	(1%)	11	(10%)	10	(0%)	43	(2%)

Table 1. Creation of social relationships between users in Med-Net

While in 4th quarter 2011, 18% of all new users created at least one social relationship to a new user and 26% of them to at least one existing user, in 4th quarter 2014 only 1% created a relationship to at least one new user and only 9% to at least one old user.

Summing up the results, only a minority of the new and the old users created new social relationships. Especially in later quarters, there seems to be a group of users who are responsible for the creation of social relationships. With respect to users' attachment behavior, we found that both new users and existing users tend to create social relationships to existing users, while only a small number of users create social relationships to users who have joined the ESN in the current quarter. Moreover, the preference of social relationships to existing users appears to be responsible for the existence of the large single component. The inverted attachment behavior of new users in some quarters might be due to new trainee medical officers joining the medical service unit mostly in September (3rd quarter) and October (4th quarter). Initially, these new members are mainly in contact among themselves. Therefore, they connect primarily with each other in the ESN.

In a second step, we aimed to investigate potential drivers for preferential attachment. Hence, we analyzed how a user's position in the network and his or her communication activity influences the attachment behavior of other users. Therefore, we do not only focus on a user's degree centrality in the social graph and in the activity graph of the ESN, but also calculated closeness centrality and betweenness centrality for the social graph as well as the

activity graph of the ESN. We used Spearman rank correlation to measure the correlation between existing users' centrality and the number of users who attach to them in the following quarter. For instance, we look at the correlation of a user's centrality in 1st quarter 2014 and the number of contact requests he or she received and confirmed in 2nd quarter 2014. The results of our analysis are presented in Table 2. The significance of the results was tested by the use of a 2-tailed t-test [21]. All results were found to be significant at the 0.01 level.

The results in Table 2 indicate that users' attachment behavior is positively correlated to user centrality. Hence, users tended to attach to well-connected users of the social graph as well as the activity graph. Table 2 also shows that a user's activity (centrality in the activity graph) seems not as important as his or her social relationships. Here, users tended to create social relationships to users who already had a large number of friends (i.e., degree centrality) or are close to all other users in the network (i.e., closeness centrality). In addition, the most attractive users are also able to control information flows (i.e., betweennness centrality) in terms of their position in the social graph. This holds for all quarters that were analyzed.

Altogether we found that users' degree centrality in the social graph seems to be the best predictor of preferential attachment for new social relationships in the ESN. The results further indicate that also closeness centrality and betweenness centrality in the social graph can be seen as drivers for preferential attachment, while users who take part in the most part of the ESN's communication (cf. out-degree centrality) and who control communication flows (cf. betweenness centrality in the activity graph) seem not to be preferred for the creation of a social relationships.

Quarter (Q)	Social Graph			Activity Graph		
	C_D	C_C	C_B	C_{Out-D}	C_C	C_B
2nd Q 2011	0.58	0.51	0.50	0.26	0.30	0.28
3rd Q 2011	0.43	0.40	0.41	0.16	0.12	0.22
4th Q 2011	0.32	0.30	0.31	0.21	0.20	0.17
1st Q 2012	0.40	0.41	0.41	0.23	0.22	0.28
2nd Q 2012	0.26	0.25	0.23	0.18	0.17	0.19
3rd Q 2012	0.38	0.37	0.38	0.28	0.29	0.27
4th Q 2012	0.44	0.44	0.55	0.36	0.37	0.31
1st Q 2013	0.37	0.37	0.34	0.25	0.28	0.23
2nd Q 2013	0.36	0.33	0.34	0.25	0.28	0.26
3rd Q 2013	0.23	0.21	0.23	0.18	0.17	0.19
4th Q 2013	0.15	0.12	0.15	0.11	0.12	0.11
1st Q 2014	0.20	0.16	0.19	0.12	0.06	0.10
2nd Q 2014	0.20	0.17	0.19	0.15	0.17	0.18
3rd Q 2014	0.39	0.38	0.48	0.09	0.06	0.11
4th Q 2014	0.29	0.22	0.30	0.11	0.07	0.12

All correlations are significant at the 0.01 level

C_D: Degree Centrality
C_C: Closeness Centrality
C_B: Betweenness Centrality
C_{Out-D}: Out-degree Centrality

Table 2. Correlation between users' centrality and new contact requests in each quarter

6. Discussion and conclusion

In this section, we discuss the contribution of our research and its implications for theory and practice. We also consider the limitations of our study as starting points for future research. Finally, we will conclude with a short summary of our research.

6.1 Implications for research and practice

In this study, we investigated the evolution of the network structure of ESN. In doing so, we considered how topological characteristics change in time and how the users behave with respect to the attachment process for the creation of new social relationships. First, in our paper, we considered the structure of an ESN as well as the aspect of time. Prior studies mostly focused on the investigation of topological characteristics of the graph [e.g., 18] or the structural characteristics of the single users [e.g., 13], without investigating the dynamics in their structure. In this context, we found that the evolution of the ESN led to a single giant component containing nearly all users with at least on social relationship. With respect to the decreasing density and low clustering coefficient, we found that there must be a small group of users connecting the users in the ESN. This result is of special interest for practitioners for two reasons. 1) It shows that networking and interaction in the ESN are not subject to local boundaries within the organization. Rather, they help to connect employees with various characteristics, like different locations. 2) These connective users are of special interest with

respect to supporting and governing networking and interaction in terms of communication and collaboration in the ESN.

Second, our results indicate that the formation of the social graph in ESN is not random. Rather; we observed a power-law degree distribution. This result is of special interest since studies [e.g., 53] found that not all social media networks exhibit power-law degree distributions. The power-law degree distribution further indicates the existence of preferential attachment. We found that new users tend to befriend existing users instead of other new users. In contrast, the attachment of the new users to the single giant component of the graph is mainly radiated from the existing users. Hence, most users with at least one social relationship are interested in being part of the community. Therefore, they take an active part in the networking process. Moreover, practitioners need not hesitate that the ESN consists of just sparely connected components. Indeed, the structure of the ESN, which depends on how users are connected, allows an easy diffusion of news and ideas [19]. This is of great relevance when information has to be disseminated across the entire organization in a short time.

Third, alongside with this, we were also able to show that users' position in the network influences the attachment behavior. We found that users tend to attach central users in the ESN' social graph and activity graph. More detailed, users create social relationships with users that already have many friends (cf. degree centrality in the social graph). We observed the so-called rich-get-richer phenomenon [59]. Thus, from a practical perspective, organizations do not have to constantly identify key users [e.g., 13], since users with a central position in the ESN are very likely to keep it. For practitioners, it is important to involve these users in fostering networking and interaction in the ESN. This might ensure that all users are connected in relative short time, after joining the network.

6.2 Limitations and future research directions

Although our study is the first one to consider the structure of an ESN and its evolution and the results of our analyses provide interesting insights, there are several limitations which can serve as starting points for future research. First, we only considered one single organization, which provided us with the relevant data needed to conduct this research. Nevertheless, the ESN of the German Armed Forces has a large number of users. Thus, we assume that our results may also hold for other organizations using ESN. Second, we focused on the creation of social relationships only. However, it may well be assumed that also the creation of activity links (i.e., messages) is an important part of the ESN's evolution. While in a first step it seemed appropriate to focus on social relationships, further studies are needed to analyze the role of user activity for network evolution in-depth (e.g.,. does the evolution of the social graph differ from the activity graph?). Third, military organizations might differ from business organizations in some points. But according to the work descriptions in the Administrative

Order on the Position of the Military Superior [3] military ranks can be seen as equivalent to formal job titles in organizations like upper, middle and lower management. Hence, we do not think that ESN in non-military organizations evolve different. Fourth, we considered only a selection of potential aspects and drivers for the creation of social relationships in ESN. Nevertheless, we considered both a user's centrality in the social graph and in the activity graph as potential drivers of preferential attachment. However, further research is needed to analyze more aspects of preferential attachment (e.g., need to consider a fitness parameter like, for instance, users' role in the organization's hierarchy?). In addition, we believe that also a user's offline social network (i.e., colleagues and friends) might affect his or her attachment behavior. Finally, our research approach is mostly exploratory and data driven. Nevertheless, we were able to gain first and interesting insights on this topic which can be used as a basis for further research. Based on further in-depth insights in the dynamics and evolution of ESN, we aim to propose a model for the evolution of ESN in the future.

6.3 Conclusion

There is a growing body of literature in the emerging field of ESN, as more and more organizations have started to use ESN, for example, to foster collaboration and communication among their employees [8, 55]. However, we still observe a lack of research focusing on the evolution in the structure of these networks. The dynamic was not considered in prior studies on the structure of ESN [e.g., 12, 13], and even less research was conducted with respect to the topological characteristics of the social graph of ESN (for research on the activity graph see [18]). Thus, with this paper, we aimed at analyzing how the characteristics that describe how the structure of an ESN evolve in time as well as at identifying drivers in users' attachment behavior. Our analysis was enabled by the use of a large-scale dataset of the German Armed Forces. This dataset contains all information regarding the addition of users and links from over a long period of time since the implementation of the ESN. By calculating the most common topological characteristics, we were able to show how ESN are in some aspects comparable to other real world networks and in particular social media networks, but also differ in terms of their clustering coefficient. Rather, the attachment of new links is not random, but significantly and positively correlates with users' centrality in the social graph.

With our paper we hope to contribute to a better understanding of the emerging phenomenon ESN. We believe that our research is a first but interesting step towards understanding the evolution of the structure of ESN and its drivers. We also hope that our paper will stimulate further research on this interesting topic and will be used as a starting point for further research. In addition, it will contribute to a better understanding on the structure of ESN and help organizations to support and govern networking and interaction in terms of communication and collaboration in the ESN.

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5.2 Conclusion to Chapter 5

Chapter 5 addresses the following research questions:

RQ. 10 How do the topological characteristics of ESN evolve in time?

RQ. 11 How is users' attachment behaviour characterised with respect to the creation of social relationships during the evolution of ESN?

The research in this chapter build on the discovery that for many real world networks the creation of links is not random but is subject to different drivers (cf. e.g., Barabási and Albert 1999). Paper 6 gives interesting insights on the evolution of ESN, by investigating and comparing the structure of an ESN in different periods as well as a selection of possible drivers for user attachment.

Unlike other research on ESN within this dissertation, Paper 6 is not motivated by a specific case of application such as knowledge management or networking behaviour. Although Papers 2 - 5 consider the network structure for their analyses, too, it is only used as means to an end to investigate different aspects, such as structural characteristics of actor roles, in the respective context. Instead, Paper 6 focusses merely on the network structure and thus, contributes to better understanding of its dynamics. These insights can be applied to various cases of application. Here, for instance, they could be used for the prediction of actor roles in future periods.

Paper 6 was presented and discussed at the Hawaii International Conference on Systems Sciences (HICSS) in 2016. Although the short time since its publication, it has already been cited (cf. Laumer et al. 2017).

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6 Conclusion

In the first subsection, the major findings of this dissertation are discussed. In the second part, its limitations, which serve as starting points for future research, are considered. The points that are identified within this chapter do not address sole papers but address the dissertation as a whole.

6.1 Major Findings

1) *This dissertation found five research fields that were predominantly addressed by IS research on OSN based on a comprehensive structured literature review. Moreover, for each field research gaps that should be addressed by future research were shown.*

In Chapter 2 five main research fields were identified based on an analysis of more than 500 papers about OSN, that were published in major IS journals or presented at major IS conferences. Here, the first research area contains paper that deal with the elementary characteristics and the structure of OSN. The second research area is about users' behaviour in OSN, while the third area contains papers about privacy concerns and the protection of privacy in OSN. The fourth area addresses the usage of OSN by organisations and its impact on society (e.g., politics and education). Finally, the fifth research area focuses on the (technical) design of OSN and their features. The results show the thematic and methodical diversity of the existing research contributions on OSN. In addition, ten research gaps were identified that have not been considered by IS research yet and can be addressed in future research. These include amongst others, challenges for organisations induced by the usage of ESN. The identified research gaps were used as a basis, for further research within the scope of this dissertation. They allowed identifying business needs that are addressed. Thus, the relevance of this dissertation's research objectives for research and practice is assured (Hevner et al. 2004).

2) *Users' position in the network structure of an ESN heavily influences user behaviour.*

First, users' position in an ESN as quantified by means of centrality measures plays an important role and strongly influences users' knowledge sharing behaviour (cf. Paper 2 - 3). The results reveal the outstanding position of users who actively contribute to the knowledge exchange process in ESN. Users, who actively communicate and share their knowledge and thus are helping other users to get their daily work done in a better way, have a central position in the network and are therefore very active users. Next to being among the users with the most social relationships, they are also responsible for major parts of the ESNs' communication activity. Thus, to a large part they can be found among the users who wrote the most messages as well as received the most messages. In addition, they are also among the best-

connected users of the ESN with respect to all centrality measures. This holds for both, the social graph as well as the activity graph.

Second, a central position in the ESN is a main driver for the creation of new ties (cf. Paper 6). The findings indicate that users in an ESN tend to create new social relationships with other users who already have a central position in the network. Here, the strongest impact can be observed for degree centrality, but there is also a recognisable impact of all other common centrality measures. Thus, users who already are central in the network are very likely to keep this position.

From a practical perspective, these insights help organisations to better understand how users act, communicate, and connect with others. Their central position in the network allows an easy identification of influential and important users. Here, this dissertation is also able to show that, contrary to prior studies (cf. e.g., Chun et al. 2008; Heidemann et al. 2010; Xu et al. 2008), the social graph is at least as appropriate to identify these users as the activity graph. Moreover, simple centrality measures like degree centrality have proved to be as beneficial as complex measures like eigenvector centrality (cf. Paper 2).

3) Formal organisational hierarchy plays an important role for users' behaviour in ESN.

A significant effect of formal organisational hierarchies on users' networking and interaction behaviour (i.e. who forms ties with whom) in ESN was found. In particular, triangulating data from multiple sources (i.e. network data and data from an online survey or interviews) the significant impact of formal hierarchies on networking behaviour in ESN using the examples of social relationships, communication, and collaboration could be shown. Here, for instance, the results reveal that users generally tend to create ties with their peers and barely bridge different hierarchical levels. This effect even increases with the visibility and intensity of the respective interaction. These results seem contrary to prior studies, claiming that ESN have the potential to make people within an organisation to interact as equals (cf. Paper 4).

Although, hierarchical effects are clearly recognizable inside the ESN, the effects seem to be weaker inside the ESN than outside the ESN (cf. Paper 5). The results regarding temporary changes reveal that after a certain time hierarchies' influence seems to decrease slightly (cf. Papers 4 - 5).

However, formal organisational hierarchies do not only affect with whom users in an ESN interact but also how they behave with respect to their contribution in the knowledge sharing process. The higher the position in the formal organisational hierarchy, the higher is the amount of persons on this level who actively share their knowledge. This might be due to the fact that at the beginning, they are careful and uncertain about the competitive situation and thus aim at gaining knowledge themselves without caring about others yet as they want to

prove themselves in a first step. But the longer they are within a hierarchical level, the more confident they become to post relevant knowledge and the more they give to others.

4) *Users' role in the knowledge sharing process in ESN can be determined by their amount of shared and sought knowledge.*

In Chapter 3.2, two measures for the classification of users to one of three actor roles (i.e. givers, takers, and matchers (cf. Grant (2013))), based on their reciprocities in terms of seeking and sharing knowledge, were developed. Both measures determine the actor role of a user based on his or her amount of sharing knowledge as well as his or her amount of seeking knowledge. Thereby, the "Absolute Distance Measure" allows classifying a user independent from other users, while the "Relative Distance Measure" also considers the knowledge sharing behaviour of other users of the ESN in comparison. Using a dataset of an ESN used by the medical service unit of the GAF, the applicability of both measures was demonstrated. Here, both measures lead to very similar results (i.e. no statistically significant change in the assignment of users to the categories) and showed that most users in the ESN can be classified as takers and therefore, acquire disproportional much knowledge compared to the amount of knowledge they contribute for others (cf. Paper 3).

5) *Users' behaviour in ESN is comparable to their behaviour in other social media services.*

First, as users transfer their habits and demands regarding the usage of social media services into their work place (van Zyl 2009), they also seem to transfer their behaviour into ESN. Prior research on online communities has found that only a small share of users actively participate in a community and create most of its content while the large majority of users can be described as lurkers (i.e. rather passive users) (Katz 1998; Muller et al. 2010; Nielsen 2006). The results indicate that this also holds for ESN as only a small amount of users actively contributes to the ESN by sharing knowledge, writing messages, or creating new social relationships (cf. Papers 2 - 3).

Second, the results reveal that users' attachment behaviour (i.e. to whom they create new relationships to) is comparable to those in other social media services. The creation of new nodes and the creation of ties are not random, but significantly correlate with users' position in the network in terms of network centrality (cf. Paper 6). While for instance, users' degree centrality heavily influences the creation of social relationships for Twitter (Ghosh and Ganguly 2014) similar results are found for ESN. The results further reveal that the most common topological characteristics (e.g., average path length and density) of the observed ESN are comparable to those of other social media services, but also differ in terms of their lower clustering coefficient.

6.2 Limitations and Future Research

This work has focussed on selected aspects regarding OSN and ESN. Thus, interesting results and insights were found. Nevertheless, this dissertation is also subject to some limitations which can serve as starting points for future research. The limitations concerning sole papers in particular are discussed in the respective chapters of this dissertation. Next to them, there are also some limitations concerning the dissertation as a whole:

First, within this dissertation two research topics in the scope of social media were addressed. The findings contribute to a better understanding of OSN as well as ESN. However, the large and comprehensive field of social media services does not only consist of these two kinds of services. Moreover, it also includes content-oriented sites or messaging services such as Twitter, YouTube, Instagram, Snapchat, or Wikipedia. Nevertheless, OSN and ESN are of great importance and special interest for both, research and practice, because of their popularity and their essential role in the life of people as well as organisations. In addition, it might be argued that the results of this dissertation may also hold for other social media services and the methods of this dissertation can to a certain extend be applied to them.

Here, for instance, the measures and concepts for the classification and investigation of different actor roles also might be adopted and applied for other social media services, like Wikipedia or online forums. In the case of Wikipedia, there are on the one hand a great number of users using the platform to gain knowledge and on the other hand a small proportion of users sharing their knowledge by actively collaborating on articles. Thus, the roles of givers, takers, and matchers (cf. Paper 3) also seem to be applicable. Investigating the role of different users in Wikipedia with respect to their reciprocities in terms of seeking and sharing knowledge could help to better understand their behaviour and motivations. Here, for instance, users that have been characterized as givers can be considered as especially important to the platform. Knowing who these users are could help Wikipedia to better engage with them and therefore promote their loyalty. This might also hold for providers of help forums that base on social engagement such as O2 guru, Telekom hilft, and open collaboration platforms such as GitHub.

The analysis for the investigation of network evolution (cf. Paper 6) could also be transferred to other social media services. Prior research on the evolution of social media services did not compare and investigate multiple drivers in detail, but only proposed models where just one possible driver was considered. Especially with respect to relatively new social media services like Snapchat or services that rapidly grow in number of users such as Instagram, it seems important to understand their dynamics. Regarding social media marketing, marketers have started to focus on so-called influencers to promote their products and services as well as to spread information and messages. A large number of users they are connected with as well

as their great reach often characterizes these influencers. Thus, for marketers it is important to know how the personal network of the influencers changes over time and what drivers have the most impact on its evolution. In addition, such insights are also of great interest for the provider of social media services as they help them to understand and predict the growth and evolution of their service.

Second, most of this dissertation's research on ESN focusses on the network structures that are invoked by the binary relationships among the users. Amongst others, the network structures were used to investigate structural characteristics of users as well as users' networking behaviour. Although, the investigation of network structures in ESN plays a decisive role in understanding and explaining ESN (Katona et al. 2011; Wang et al. 2013) it cannot completely reflect all aspects. Here, it seems especially promising to make use of further approaches in the emerging field of Social Media Analysis (Stieglitz et al. 2014) to extend the research objectives of this dissertation. Here, the analysis of so-called structured attributes (i.e. e.g., answering behaviour or position of nodes in a network) by means of statistical analysis or SNA is an important part of social media analysis. In addition, social media analysis also comprises the approaches for the analysis of opinions (e.g., sentiment analysis) and topics (i.e. content analysis or trend analysis) (Stieglitz et al. 2014). Here, for instance, advanced text mining and sentiment analysis techniques (cf. e.g., Gamon et al. 2005; Hu and Liu 2004; Pang and Lee 2008) make it possible to effectively and automatically analyse huge amounts of text messages and user generated content in an automated way (cf. e.g., He 2013). Hence, it is not only possible to analyse if users have communicated with each other, but also to gain insights on the messages' content and intention. This allows, for instance, to state if a message is used to share or to request knowledge or if a post is rather positive or negative.

Although, in Chapter 3.1 qualitative text analysis was used to determine a message as professional or non-professional, the manual coding process took a long time and the involvement of at least two people to ensure the variability of the results (Hayes and Krippendorff 2007; Krippendorff 2004). Thus, manual analysis is only hardly applicable to large amounts of data. In contrast, automated text analysis could be applied to large amounts of messages content as well as user-generated content in ESN. Thus, combining statistical analysis with automated text analysis methods will help to achieve a more sophisticated method for the classification of givers and takers. Such an approach would not only focus on users' amount of seeking and sharing knowledge by taking into account the number of written and read articles, but also enables to consider the content of messages as well as the extent of write accesses.

In addition, an analysis of the style of communication (i.e. sentiment, wording, as well as the formality of messages) that is exchanged in ESN, could add complementary insights on the

effects of formal organisational hierarchy in ESN. Here it seems to be promising to investigate users' style of communication with respect to the differences in the hierarchical levels of the involved communication partners. It might be assumed, that users' style differs when communicating whether with superiors or with subordinates.

Finally, the research investigating users' behaviour in ESN with respect to knowledge management (cf. Papers 2 - 3) and the role of formal hierarchies (cf. Papers 4 - 5) did not consider all aspects of user behaviour, possible relations as well as dynamics in the network.

On the one hand, some analyses did not take into account the dynamics in the user behaviour. Research on actor roles in the knowledge management did not investigate, if the role of a user changes in time. Here, for instance, in one period a user might be classified as a value adding key user while in the following period he or she is not a key user anymore. The same holds for the roles identified in Paper 3. Hence, it might be assumed that investigating the transition of actor roles in the ESN bears great potential. In a next step, a model could be developed that, based on users' behaviour in prior periods as well as based on other characteristics, predicts the actor role of users in the following periods. This will help organisations to better understand the behaviour of their employees and allows a better and more efficient support and governance of knowledge management in ESN.

On the other hand, some analyses focused merely on selected aspects of ESN (cf. Paper 2 – 6). For the classification of users based on their behaviour with respect to sharing and seeking knowledge (cf. Paper 3), all activities of the knowledge sharing process that did not take part within the knowledge base were excluded from the analysis. The same holds for the identification of value adding key users (cf. Paper 2) since likes and bookmarks do not fully reflect the value add of a message or a user for the organisation. In addition, the analyses of the effects of formal hierarchies were not done for all kinds of social relations (cf. Borgatti et al. 2009) that can occur among people (cf. Papers 4 - 5). While in a first step it seems appropriate to focus on selected aspects, further studies are needed to analyse the research objectives more in-depth: How can value add be measured in ESN? How can users be classified based on the content of their messages with respect to the knowledge sharing process? How differs the creation of social relationships inside and outside the ESN?

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