

# **The Impact of Formal Hierarchies on Enterprise Social Networking Behavior**

*Completed Research Paper*

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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 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

## 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<sup>1</sup> 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 layering 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 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).

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<sup>1</sup> 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).

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.

## **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.

### ***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 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, 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).

## ***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.

## 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.

## 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 hierarchies 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.

### **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).

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

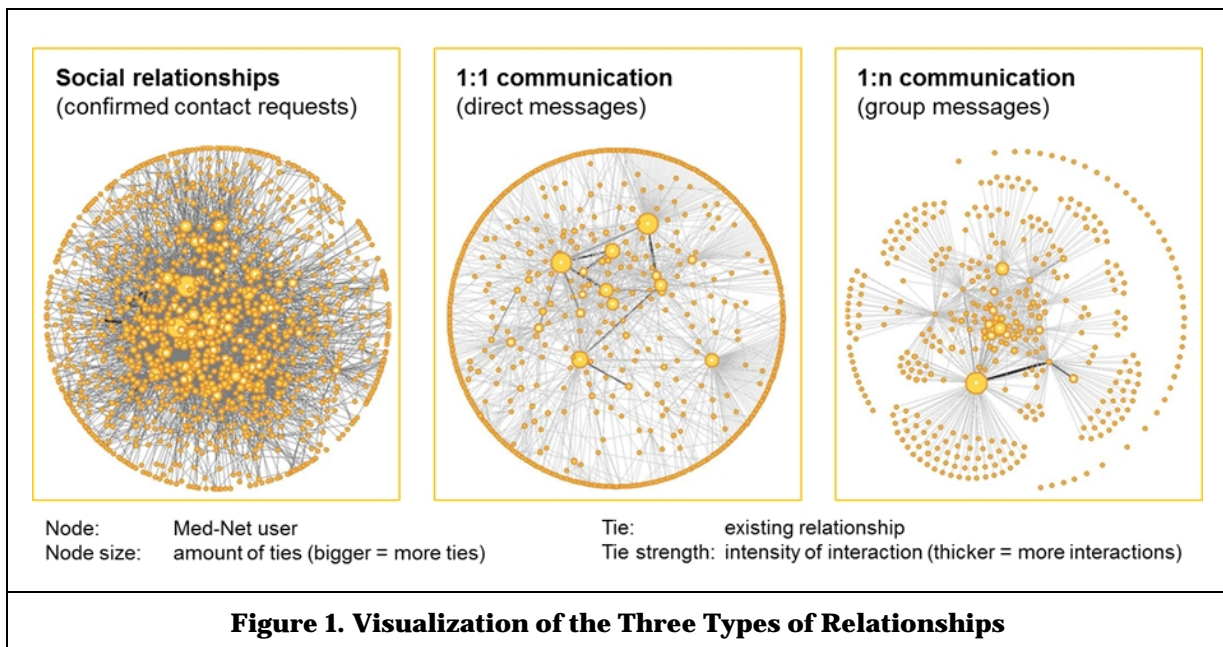
Military rank (NATO)	Rank (GAF)	Level	No. of unique users in the ESN		No. of users in regard to social relationships		No. of users in regard to 1:1 communication		No. of users in regard to 1:n communication	
OF 6-9	General	<b>6</b>	3	0%	2	0%	2	0%	1	0%
OF 3-5	Staff officer	<b>5</b>	117	11%	78	9%	72	13%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

## 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*<sup>2</sup> 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 relationships and to avoid biased results, these three relationship types were considered separately. For our analyses, we used the *igraph* package for R<sup>3</sup> 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.



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.

<sup>2</sup> <http://gephi.github.io/>

<sup>3</sup> <http://cran.r-project.org/web/packages/igraph/index.html>



## 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 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.

### 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.

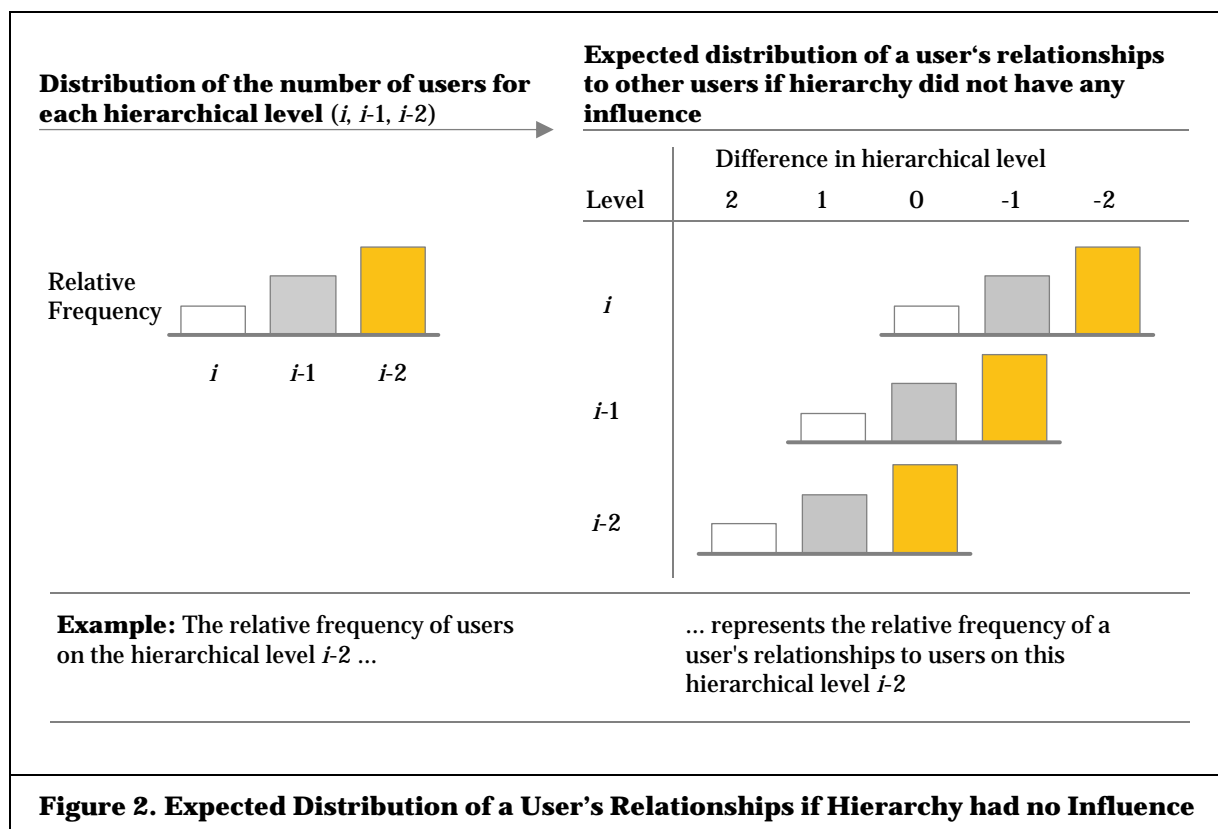
<b>Table 2. Values for Centrality Measures Depending on Users' Hierarchical Levels</b>							
Hierarchical level	Social graph			Activity graph			
	Degree centrality	Closeness centrality	Betweenness centrality	In-degree centrality	Out-degree centrality	Closeness centrality	Betweenness Centrality
Level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

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.

### 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.



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.

<b>Table 3. Observed vs. Expected Distribution of Social Relationships (Percentage Differences)</b>											
Hierarchical level	Difference in 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%					

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  $\alpha=0.05$ ) 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.

<b>Table 4. Observed vs. Expected Distributions of Relationships (Percentage Differences)</b>											
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%

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  $\alpha=0.01$ ) 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".

## 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."* (i13).

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."* (i1).

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."* (i4). 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."* (i2).

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.” (i5). 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.” (i9).*

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.” (i7).* 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.

### ***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.

<b>Table 5. Observed vs. Expected Distributions of Social Relationships over Time (Percentage Differences)</b>											
	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%

Again, for both time frames the observed distribution of the users’ relationships significantly (for  $\alpha=0.01$ ) 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.

## **Discussion**

### ***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.

### ***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.

### ***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.

### ***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?