Collective Dynamics of Digitally Enabled Social Networks

Oliver Posegga

University of Bamberg

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Erstgutachter: Prof. Dr. Kai Fischbach
Zweitgutachter: Prof. Dr. Detlef Schoder
Mitglied der Promotionskommission: Prof. Dr. Tim Weitzel

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To my father, Günter.

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Abstract

This thesis investigates the role of technology in the collective dynamics of digitally enabled social networks. Based on a review of the historical foundation of research on crowds, collective behaviour, and collective dynamics in the social sciences and in research on complex systems, it develops a conceptualisation of collective dynamics in the context of digitally enabled social networks. This conceptualisation provides the foundation for one overarching and three subordinate research questions dedicated to different aspects of the role technology plays in understanding and managing the collective dynamics of digitally enabled social networks. The body of work comprising this dissertation is distributed across fifteen papers that contribute to these research questions.

Introduction

Research on the collective dynamics of human interaction has gained a considerable amount of interdisciplinary attention over the past decades and has even been described as a twenty-first century science (Kleinberg, 2008; Watts, 2007). One reason is the growing success and pervasiveness of interactive information and communication technologies, which play an important role in organisations, everyday life, and society in general (Agarwal et al., 2008; Oinas-Kukkonen et al., 2010; Winter et al., 2014). These technologies provide the foundation for digitally enabled social networks, which—in contrast to many social networks that have been subject to earlier research on collective dynamics—are not exclusively comprised of social actors and their interactions, but also of the technological artefacts that afford and mediate their access to other actors and information (Kane et al., 2014). The role technology plays in the emergent phenomena arising from the collective dynamics of such systems is not well understood—it is increasingly difficult to distinguish social interactions from interactions between individuals and technology (Contractor et al., 2011; Lyytinen & Yoo, 2002).

The goal of this thesis is to contribute to the understanding of the role technology plays in managing and understanding collective dynamics of digitally enabled social networks. It is structured as follows: In the next section, I provide a theoretical background on collective dynamics and digitally enabled social networks. In the section dedicated to the background on collective dynamics, I summarise three lines of research that provide the foundation of our conceptualization of collective dynamics, namely, research on collective behaviour, research on complex systems, and research on network dynamics. While all three approaches can be traced back to different origins and differ in their methodological and theoretical foundations, they share in common that they address emergent phenomena arising from the collective dynamics of networked systems. I synthesise the results of our review and provide a general definition of collective dynamics. In the second part of the next section, I introduce the concept of digitally enabled social networks. Based on this conceptualization, I identify three aspects of the role technology plays with respect to the collective dynamics emerging from digitally enabled social networks, which serve as the foundation for the three research questions that guide the presentation of the work comprising this thesis. In the subsequent section, I provide a classification of the fifteen articles presented in this dissertation based on the research questions and the four interdisciplinary domains in which the studies comprising this thesis have been conducted. Following this section, I present the fifteen

articles and their contributions to the research goals of this thesis in a summarising section. The conclusion in final section of this dissertation is a summary of these contributions.[1]

Theoretical Background and Related Research

The subject of this dissertation is the role of technology in understanding and managing the collective dynamics of digitally enabled social networks. The papers presented in this thesis are grounded in interdisciplinary theory that can be organised as two primary streams of research. The first stream is related to research on collective dynamics in complex social systems and the emergent phenomena arising from them. This line of investigation includes theories of collective behaviour, collective action, group dynamics, and research on crowds, all of which originate in sociology and psychology. The second stream comprises research on digitally enabled social networks and their role in enabling and constraining social interaction, originating from research in the fields of information systems, organisations, and human-computer interaction. In the following sections, we elaborate on both research streams and review influential contributions made to each of them before synthesising them to lay the foundation for the papers presented in this dissertation.

Collective Dynamics

The first part of this review summarises research on *collective dynamics* and establishes an interdisciplinary understanding of the concept. In the context of research on social interaction, the term has been used ambiguously to refer to phenomena emerging from complex systems comprised of social actors and their interactions. The origins of research on collective dynamics, however, can be traced back to two primary lines of research, both relevant to this work: the term has been used in relation to collective behaviour and related phenomena studied in sociology and psychology (Lang & Lang, 1961); and the term has been used in research on complex systems, specifically the dynamics of networked systems and the structural dynamics of networks modelled from them (Watts & Strogatz, 1998). Both lines of research share in common that they aim to analyse and explain emergent phenomena arising in the context of social interaction.

Collective Dynamics in Research on Collective Behaviour

The first line of research can be traced at least back to the seminal work of Gustave Le Bon (1896), who studied the behaviour of crowds in the late nineteenth century. His interest in research on crowds stemmed from the social movements and unrests of the time. He witnessed the fall of the French Second Empire in 1870 and its aftermath, including the Paris Commune in 1871, in which crowds of revolutionaries rioted in the streets of Paris. This experience had a lasting impact on his understanding of crowds, which he described as "only powerful for destruction" (Le Bon, 1896, p. 19). He differentiated between crowds in a colloquial sense, which are nothing more than a gathering of individuals, and in a psychological sense, that is, when those individuals form a collective mind and a unified entity. One of the defining properties of crowds, according to Le Bon, is that they are more than just the sum of the individuals gathered together. He writes:

[1] Some of the material discussed in this paper have, in part, been introduced in the research articles comprising this dissertation, which can be found in Appendix A.

> The psychological crowd is a provisional being formed of heterogeneous elements, which for a moment are combined, exactly as the cells which constitute a living body form by their reunion a new being which displays characteristics very different from those possessed by each of the cells singly. ... [T]he aggregate which constitutes a crowd there is in no sort a summing-up of or an average struck between its elements. What really takes place is a combination followed by the creation of new characteristics, just as in chemistry certain elements, when brought into contact—bases and acids, for example—combine to form a new body possessing properties quite different from those of the bodies that have served to form it. (Le Bon, 1896, pp. 30-31)

With this early depiction of the emergent nature of crowds, Le Bon provided an important foundation for research on collective behaviour. The field was later defined through the work of Park and Burgess (1921), Blumer (1951), Turner and Killian (1957), Smelser (1965), and Park (1967). Collective behaviour, in general, refers to social processes that contradict social structures, values, and norms. It differs from ordinary social interactions in its spontaneous and volatile occurrences in response to collective events and impulses (Park & Burgess, 1921). Phenomena that have been studied in this context include panics, crazes, disasters, mass hysteria & delusion, riots, fads, fashion, revolutions, sects, and religious cults (cf. Blumer, 1951; Lang & Lang, 1961; Le Bon, 1896; Smelser, 1965; Turner & Killian, 1957).

Research on collective behaviour can be classified according to the different types of collectivity studied in the field. Blumer (1951) distinguished between research on the crowd, the public, the mass, and the social movement. Le Bon (1896) characterised the crowd as a collective of individuals who act in unity, based on a common emotion and irrationally in response to a stimulus or collective event. The concept of the public differs from the crowd in that it is defined by a single issue discussed by a collective of individuals. As described by Lang and Lang (1961), the public is defined by the issue and exists as long as the issue itself persists. Individuals can belong to as many publics as there are issues in which they are interested. Further, the public lacks the irrationality of the crowd in the sense that the discussion adheres to rules and reason (Lang & Lang, 1961). Similar to the public, the mass is defined as a collective of individuals who share an interest in a single issue or stimulus; it differs, however, in terms of the communication between those individuals, which is not necessarily defined for masses (Lang & Lang, 1961). Masses can act collectively without a direct form of interaction among their members. Social movements can take on various forms and are defined by their intent to change society or its members (Blumer, 1951).

The field has produced several theories on the emergence of collective behaviour and its nature, most notably the Contagion Theory (Blumer, 1951; Le Bon, 1896), the Emergent-Norm Theory (Turner & Killian, 1957), and the Value-added Theory (Smelser, 1965). These theories are based on different assumptions regarding the social processes and the nature of the actors involved in phenomena of collective behaviour. Most importantly, they differ with respect to the assumption of irrationality, which is at the core of Le Bon's understanding of crowds and which has since been subject to criticism, and regarding what should and what should not be considered as collective behaviour. In this context and with respect to the classification of collectivity, the boundaries of the field remain vague (Smelser, 2015). To find a more inclusive term for the various approaches to understand collective behaviour, Lang and Lang (1961) sought to summarise the field under the phrase 'collective dynamics':

> The field of collective dynamics is a subdivision of sociology. Its subject matter includes a variety of transitory social phenomena. In part it is concerned with the formation of crowds, masses, and publics—all of them collectives in constant flux. Also included for study are the kinds of interaction within groups and societies

> which give rise to flurries of rumors, scapegoating, the selection of victims, the succession of leaders; or which radically transform a group, as in panic. Finally, the field includes some social psychological processes that may unite individuals casually thrown together into more permanent groups: the gang, the sect, or the active nucleus of a social movement. Whether the phenomenon to be analyzed consists of some short-lived convergence of individuals' interest and behavior (as in the crowd or a public controversy) or the disruption of and strain against organized patterns (as in panic) or whether it involves the spontaneous emergence of new group enterprises, in every case it grows out of social interaction: the phenomena are collective. (Lang & Lang, 1961, p. 3)

Lang and Lang provided a more technical and concise definition of collective dynamics:

> [Collective dynamics] refers to those patterns of social action that are spontaneous and unstructured inasmuch as they are not organized and are not reducible to social structure. (Lang & Lang, 1961, p. 4)

Their definition emphasises the importance of social interaction as the foundation of collective phenomena and the role of social structure in their emergence. The social structure, comprising actors, their relationships, the networks emerging from them, and the roles and statuses held by actors, serves as a reference point for social interaction. In this, it provides boundaries that organise social interaction. Patterns of collective dynamics are not completely independent of those boundaries, as actors participating in phenomena of collective dynamics typically still hold some position in the social structures in which they are embedded (Lang & Lang, 1961, p. 14). In contrast to the organised patterns within the boundaries of social structure, (Lang & Lang, 1961) describe four characteristics of unorganised collective patterns: they are spontaneous and emerge in contrast to social structure; they manifest themselves as the expression of an aspect (e.g., an impulse, hope, or promise) that is not recognised by the social structure; participation is dynamic in that partaking in the social action makes an actor part of the emergent pattern; and leadership emerges only on demand and based on the needs of the participants (Lang & Lang, 1961, p. 14).

While the work of Lang and Lang was well received and highly influential, the term collective dynamics never gained sufficient traction to take over the field. In his discussion of the phrase collective behaviour, Smelser commented on this as follows:

> A more neutral, but equally misleading, term has been coined recently by Lang and Lang—"collective dynamics." Although collective behavior bears an intimate relation to social change, it seems wise to reserve the term "dynamics" for a field more inclusive than collective behavior alone. (Smelser, 1965, p. 2)

Collective Dynamics in Research on Complex Systems

The second line of research on collective dynamics is related to the study of complex systems and their dynamics. While both lines of research bear many similarities and overlap in certain areas, the complex systems approach to collective dynamics is more inclusive and concerned with systems that come from diverse and sometimes strikingly different domains. Complex systems have been subject to research in a variety of disciplines, including physics, biology, chemistry, mathematics, computer science, economics, psychology, and sociology (Bar-Yam, 1997). The complex systems approach provides a comprehensive and universal perspective on systems and has proven successful in unveiling and conceptualising the processes that govern the characteristics of systems as diverse as neural networks, power grids, and social networks (Watts & Strogatz, 1998).

The shared properties of complex systems are complexity and emergence (Bar-Yam, 1997; Page, 2010). Complexity is notoriously difficult to conceptualise, and definitions vary widely (Arthur, 1999). Scott Page provides a rough but fitting explanation of complexity as not 'easily described, evolved, engineered, or predicted' and defines it as lying 'between order and randomness' (Page, 2010, p. 32). His definition emphasises that complex systems are not completely random; rather, their characteristics are based on intricate patterns of interactions between their parts, which while potentially subject to randomness follow at least some sort of rule. Emergence, the second property of complex systems, refers to the outcomes of those interaction patterns. Complex systems tend to have unexpected properties that cannot be explained by mere analysis of the system as a whole (i.e., at the macro level) or by the composition of its components (i.e., the micro level). They can be explained only by understanding the patterns of collective interaction among the system's elements, which are often governed by nonlinear and self-organizing processes that unfold over time (Goldstein, 1999). In this sense, understanding the collective dynamics of complex systems means understanding the collective and dynamic patterns of interaction among the system's elements in relation to their aggregated outcomes over time.

A standard approach to modelling collective dynamics is grounded in graph theory and network analysis. Complex systems are networked systems—that is, complex networks—in the sense that the interactions among their elements play a central role in their behaviour and characteristics at the system level. Network analysis is an approach based on representing those systems by modelling their elements as nodes and their interactions as edges. The work of Watts and Strogatz (1998) is a notable example of research investigating the collective dynamics of complex systems; they examine the collective dynamics of small-world networks, and in particular the emergent phenomenon of the small-world property that has been found in many networked systems in the natural and social sciences. Systems that show this property are characterised by unexpectedly short path lengths between their elements. If they are modelled as networks, the shortest path from one node to another is significantly shorter than a random network of the same size would suggest.

In most systems, there is no explanation for this phenomenon, which can be derived from a mere analysis of the system and its structure as a whole. Travers and Milgram (1969) first investigated the small-world problem in a large-scale experiment. They asked randomly chosen individuals to forward a letter to an individual they did not know personally. The participants were allowed to forward the message only by asking an acquaintance to pass it on to its destination. Thus, the messages travelled along the paths of their social relationships to the final recipients. The surprising finding of the study was that more messages than expected reached their target and did so in very few steps. Travers and Milgram (1969) had anticipated it might take a message more than 100 steps on its route from the starting points to the targets, but instead found that the messages reached their destination after being passed on an average of only 5.2 times. Watts and Strogatz (1998) discussed this phenomenon and designed a generative model that makes simple assumptions regarding how the nodes of a network form relationships; they succeeded in developing an algorithm capable of generating small-world networks.

Another emergent property that has been researched from this perspective is the 'scale-free' property of complex networks. Many complex systems, including social, technological, business, and transportation networks, show a degree distribution that follows a power law throughout the growth of the network (Barabasi & Albert, 1999). Similar to Watts and Strogatz (1998), Barabasi and Albert (1999) aim at a mechanistic explanation for this property by investigating the collective dynamics of complex networks. They provide a simple model based on assumptions regarding the network's formation and growth. In their model, individual nodes constantly enter the network and establish a connection with another node. This link formation process is

biased towards nodes that have already have high number of connections. They refer to this mechanism as 'preferential attachment' and provide a minimal model capable of producing scale-free network structures that resemble those of real-world networks.

The goal of this line of research is often to identify simple laws and governing principles that define the emergent phenomena arising from complex systems (Borgatti et al., 2009). It thus follows the reductionist approach of the natural sciences, which often neglects the particular context and background of a system in favour of finding minimalistic and powerful explanations for complex phenomena. Newman (2003) summarises the goal of the body of work relevant to this line of research as follows:

> First, it aims to find and highlight statistical properties, such as path lengths and degree distributions, that characterise the structure and behaviour of networked systems, and to suggest appropriate ways to measure these properties. Second, it aims to create models of networks that can help us to understand the meaning of these properties—how they came to be as they are, and how they interact with one another. Third, it aims to predict what the behavior of networked systems will be on the basis of measured structural properties and the local rules governing individual vertices. (Newman, 2003, p. 171)

Dynamics of Social Networks

Both lines of research outlined above overlap in that they are concerned with similar emergent phenomena that are grounded in the collective dynamics of the networked systems from which they arise. While the first line of research is grounded in the social sciences and heavily invested in social and psychological theories on crowds and other forms of social collectivity, the second is rooted in the natural sciences, is more inclusive, and has a stronger focus on the structural properties of systems. Research on social networks in the form of the body of interdisciplinary work comprising the field of network analysis and network theory lies between both lines of research and has been subject to both the social and natural sciences for a long time. Borgatti et al. (2009) traces the origins of network research back to the work of Auguste Comte, the French philosopher who suggested modelling social systems similar to physical systems and aspired to establish the field of social physics, and French sociologist Émile Durkheim, who compared social systems to biological systems. Those pioneering interdisciplinary approaches found their way into the groundbreaking work of Jacob L. Moreno, the Austrian-American psychiatrist and group psychotherapy pioneer who used graphs to study the social structure of small groups, which lead to the emergence of sociometry and eventually social network analysis and network theory (Borgatti et al., 2009; Freeman, 2004).

The work presented in this dissertation is grounded in both lines of research and draws on social network analysis and network theory in the context of social and organisational systems. To provide a background for the following section, which is dedicated to the role of technology in digitally enabled social networks and this dissertation's overarching research question, the remainder of this section briefly introduces the essential terminology and concepts needed to discuss the study of collective dynamics from a network perspective.

Social network analysis is a collection of methods and techniques (Howison et al., 2011; Wasserman & Faust, 1994) accompanied by a vast and growing body of interdisciplinary network theory that has emerged from network-based research in various domains (Borgatti & Halgin, 2011; Watts, 2004). The fundamental idea behind social network analysis is to model social relationships and interactions between individuals as graphs comprised of nodes representing individual actors and edges representing their relationships (Butts, 2009; Mitchell, 1969; Wasserman & Faust, 1994; Watts, 2004). The goal of social network analysis is to analyse

the structure of such graphs to gain insights into the complex social systems they represent. As indicated above, the origins of the methods and techniques comprising social network analysis lie within sociology, social psychology, mathematics, graph theory, and anthropology, with many of the fundamental ideas and assumptions of network analysis dating back to the 1970s (Freeman, 2004; Galaskiewicz & Wasserman, 1993; Wasserman & Faust, 1994). With its increasing popularity as a tool and subject of research, social network analysis has grown beyond the domain of social systems and has been applied to a wide variety of networked systems, including organisational, biological, technological, and socio-technical systems (Borgatti et al., 2009; Contractor et al., 2011; Newman, 2003).

In the context of studying the collective dynamics of networked systems using social network analysis, it is important to note that scholars have been studying small networks from a primarily static point of view for decades (Lazer et al., 2009). The differentiation between a static and dynamic approach to network analysis is a very general dichotomy that refers to the temporal nature of the underlying dataset and the degree to which time is incorporated into both the research questions posed and the methodologies applied. If a network study is based on cross-sectional data—that is, a snapshot of a network representing it at a single point in time—it is referred to as static. From this perspective, temporal information about the relationships and interactions used to model the network is missing or neglected, and the study is limited to research questions and methodologies that do not account for the temporal nature of networks. In the light of the background established above, it is evident that this approach is insufficient for understanding the collective dynamics of networked systems. A dynamic approach, in contrast, is based on longitudinal data describing the network at multiple points in time. Depending on the available quantity of observations over time, such a dynamic approach allows for consideration of time-related research questions (Stokman & Doreian, 1997), which requires a different set of methodologies with which to analyse a network's development over time (Snijders & Doreian, 2010, 2012). Dynamic approaches to network analysis, in contrast to static approaches, are well suited to analyse the collective dynamics of networked systems, and in particular their structural dynamics.

Dynamic approaches can be broken down further, depending on whether the emphasis lies on analysing change, dynamics, or evolution. While the three terms are often used interchangeably without further distinction, Stokman and Doreian (1997) describe them as distinct concepts. Given at least two snapshots of a network at two distinct points in time, change can be observed if the snapshots differ with a sufficient statistical significance. Since a network is only a metaphor representing a complex system of individuals and their relationships, change is a social phenomenon, which can be highly complex and difficult to explain; this is especially true for social networks, in which such phenomena are the result of interdependent decisions of multiple actors over time (Watts, 2007). According to Stokman and Doreian (1997), subsequent changes observed over time are called the dynamics of a network. While change and dynamics are directly observable and measurable phenomena, their underlying mechanisms—that is, social processes—are usually invisible, not directly measurable, and highly complex. Stokman and Doreian describe dynamics of networks as symptoms of such processes and contend that the evolution of a network cannot be understood by an exclusively structural understanding of the observed dynamics. The evolution of a network is more than just change through time: it is defined by the underlying social processes that govern the observable patterns of change in a network's structure. Accordingly, understanding the evolution of networks implies understanding the processes underlying structural dynamics, that is, the coherent sequences of events that are their cause.

In addition to the early work of Stokman and Doreian (1997) in the field of mathematical sociology, Ahuja et al. (2012) more recently proposed a framework to study network dynamics based on microfoundations and

microdynamics of networks. The concept of microfoundations captures endogenous and exogenous factors responsible for structural change at the ego-network level and, in sum, affect properties of the overall network. By introducing the concept of microdynamics, Ahuja et al. relate those factors to mechanisms that affect the formation and contents of ties as well as the change of nodal attributes throughout the network. For example, an actor might engage a relationship to maximise the utility of his ego-network. His choice of a partner might then be biased towards actors who are similar to him. According to the framework of Ahuja et al., the actor in this scenario would modify his ego-network based on the microfoundation 'agency' while his choice of a partner would be explained by the 'homophily' mechanism, which falls into the microdynamics category. As a consequence of the interplay between microdynamics and microfoundations, the structural properties of the networks and the contents flowing through them change. This, in turn, is what we can observe as change and dynamics of networks as described by Stokman and Doreian. Hence, understanding repeatedly observed patterns of change based on the concept of microfoundations and microdynamics resembles the notion of understanding the underlying processes of networks and, therefore, network evolution as introduced by Stokman and Doreian (1997).

The concept of network evolution bears strong similarities to the complex systems approach to analysing collective dynamics in emphasising the role of structural patterns and their dynamics, which unfold over time, and the methods used in their analysis. In focusing on the processes operating in the system and the context in which they are embedded, however, it is similar to the contextualised approach of research on collective dynamics regarding crowds and collective behaviour. In summary, the collective dynamics of social networks can be defined as the emergent structural patterns arising from complex networked systems of social actors as well as their outcomes, which are the aggregated results of the processes governing the interactions and relationships between those actors and the context in which they are embedded. This minimal definition serves as a foundation for the following section, in which I discuss the role of technology in understanding and managing the collective dynamics of social networks.

Digitally Enabled Social Networks

With the growing success and pervasiveness of interactive information and communication technologies, which play a major role in organisations, everyday life, and society in general (Agarwal et al., 2008; Oinas-Kukkonen et al., 2010; Winter et al., 2014), research on collective dynamics, in particular from a network perspective, has flourished and gained a considerable amount of interdisciplinary attention over the past few decades (Kleinberg, 2008; Watts, 2007). Watts (2007) describes the profound opportunities internet-based communication and interaction afford for research on human social behaviour and describes the 'science of networks' as a twenty-first-century science:

> For the first time, we can begin to observe the real-time interactions of millions of people at a resolution that is sensitive to effects at the level of the individual. Meanwhile, ever-faster computers permit us to simulate large networks of social interactions. The result has been tremendous interest in social networks: thousands of papers and a growing number of books have been published in less than a decade, leading some to herald the arrival of a "science of networks". (Watts, 2007, p. p.489)

In the same vein, Kleinberg (2008) points out that the popularity of social media networks and the convergence of social and technical networks give rise to a measurement revolution:

> The past decade has witnessed a coming-together of the technological networks that connect computers on the Internet and the social networks that have linked humans for millennia. ... [W]e are witnessing a revolution in the measurement of collective human behavior and the beginnings of a new research area—one that analyzes and builds theories of large social systems by using their reflections in massive datasets. (Kleinberg, 2008, pp. p.66-67)

Today, data related to social phenomena is available at a scale difficult to imagine before the rise of social media platforms such as Facebook, Twitter, and Wikipedia. This has transformed traditional research in various disciplines and has prompted the emergence of new interdisciplinary fields such as computational social science (Lazer et al., 2009). The impact of such technologies and their associated sociotechnical systems, however, goes beyond the mere ability to log the traces of digital interactions among their users. Technologies such as social media (Kaplan & Haenlein, 2010), social media networks (Kane et al., 2014), and enterprise social media (Kane, 2015; Leonardi et al., 2013) have proven to be significant drivers of change in organisational environments and beyond. They enable novel patterns of social interaction, affect existing ones, and enable new forms of organising (Kane et al., 2014; Leonardi et al., 2013; Leonardi & Vaast, 2017). Understanding the phenomena that arise from the interplay between such technologies and their users is a promising and challenging opportunity for interdisciplinary research, as it frequently requires scholars to revisit their theoretical and methodological foundations, which have often been developed in the absence of comparable technologies (Lazer et al., 2009; Watts, 2007). However, despite the strong interdisciplinary interest, this line of research is still in its infancy, and neither the social processes that have been subject to research in the social sciences for decades nor the role of technology in those processes are well understood:

> Some of the ideas are not as new as sometimes advertised; many of the popular models are too simplistic to stand up to scrutiny; and even the more sober-looking empirical studies tend to use data that happen to be available, rather than obtained with a specific research question in mind. As a result, despite the avalanche of publications and breathless headlines, it is probably true that little has been learned about real social processes. (Watts, 2007, p. p.489)

In contrast to traditional approaches, modern research on the collective dynamics of social networks is concerned not with what might be called conventional social networks but specifically with digitally enabled social networks. Such systems are not exclusively comprised of social actors and their interactions, but also of the technological artefacts that afford and mediate their access to other actors and information (Kane et al., 2014). Social network analysis, most network theories, and the vast body of work on collective dynamics have not been developed for such systems, as is indicated by the fact that the fundamental introduction to social network analysis provided by Wasserman and Faust (1994) does not even mention the role of technology in network research beyond its capability to enable computational analysis of networks. The ubiquity of modern information and communication technologies, however, makes it increasingly difficult to distinguish social interactions from interactions between individuals and technology (Contractor et al., 2011; Lyytinen & Yoo, 2002). With the increasing maturity of theoretical foundations and methodological approaches that account for the entanglement of social interactions and technological artefacts, scholars have begun to revisit the foundations of network research on sociotechnical systems (Contractor et al., 2011; Howison et al., 2011; Kane et al., 2014).

In this context, it is important to note that the term 'social network' is often used interchangeably in reference to two different things. First, the term is used to refer to specific technologies. For example, in research on online social networks (Garton et al., 1997), social network sites (Boyd & Ellison, 2007), digitally enabled social networks (Agarwal et al., 2008), and social media networks (Kane et al., 2014), and supersets

of such technologies (e.g., Cao et al., 2015), the term is used to describe the systems comprised of the aforementioned technologies, their users, interactions, and the contexts in which they are embedded. Second, in social network analysis, the term refers to graphs modelled from networked systems. Thus, the first use of the term typically refers to the systems scholars seek to understand, whereas the second refers to models of such systems.

To emphasise the conceptual distinction between the studied systems and their models, I refer to the former as digitally enabled social networks and to the latter simply as networks, structures, or graphs. Similar to Agarwal et al. (2008), I define digitally enabled social networks as sociotechnical systems comprised of social actors and their relationships that are at least partially enabled or extended based on interactive information and communication technologies and the affordances they provide. This definition is more inclusive than the one above in that it captures a broad variety of systems of interest to information systems research. Further, it emphasises the sociotechnical nature of such systems, which is not adequately reflected by the term 'social network'. This aspect of the definition is important in the context of research on collective dynamics from a network perspective, as most theories and methods used in this context have been developed with an emphasis on social systems rather than on technical or sociotechnical systems (Contractor et al., 2011).

In the light of the above, the overarching research question of this dissertation is:

> What role does technology play in the collective dynamics of digitally enabled social networks?

This question can be broken down into three subsequent questions, which I discuss in the following section and which serve as guiding questions for the work presented in this dissertation. They are derived from three focal characteristics of digitally enabled social networks. First, digitally enabled social networks give rise to novel emergent phenomena that are characterised by the collective dynamics of the underlying sociotechnical systems. Second, digitally enabled social networks introduce the subject of technology design to research on collective dynamics. Third, digitally enabled social networks generate constant streams of digital trace data, which describe the detailed interactions among their users and the technological features of the underlying platforms over time.

The ability of digitally enabled social networks to enable novel emergent phenomena, is based on their defining characteristic, that is, their sociotechnical nature. As so adequately described by Watts (2007), the plethora of work published in research on digitally enabled social networks shows no shortage of innovative labels for seemingly new and astonishing phenomena that often reveal little novelty upon closer examination. Many of the topics discussed by scholars in the context of traditional research on collective dynamics and collective behaviour, such as the spread of rumours and the emergence of social movements (Lang & Lang, 1961; Le Bon, 1896), have resurfaced in research on digitally enabled social networks. The question is: What has changed with the advent of digitally enabled social networks? For one, digitally enabled social networks are novel phenomena, which require scholars to ask different research questions that address the role technology plays in the context of research on their collective dynamics (Kane et al., 2014). In their discussion of social media networks, Kane et al. (2014) point out that the design and affordances offered by the technologies underlying social media networks are likely to affect the formation and performance of the social networks arising from them. Social media affect how their users can perceive, access, and navigate through social structures and the contents available to them. Kane et al. (2014) discuss that the focus of traditional research on social networks does not necessarily account for the effects of technology in this regard, and that very little is

known about the effect technology plays in this context. The majority of theories on collective dynamics of networked systems have not been devised for digitally enabled social networks.

In this context, Kane et al. (2014) point out that the technologies underlying such networks are subject to the design of their developers, who define how users can present themselves, create and consume content, and engage in various types of social interaction. Further, the features of such technologies offer affordances that are often novel in that they have not been available in traditional settings. Social media platforms, for example, enable their users to bypass relational constraints in the search for new contacts by making it possible for them to explore, search for, and quickly build relationships with other users. Similarly, features of such technologies enable access to available content without requiring individuals to rely on their relationship to others, potentially diminishing the value of those relationships with respect to their ability to grant access to desirable content. Kane et al. (2014) argue that affordances such as these are likely to cause dynamics not explained by traditional network theory. Thus, the simplistic application of social network analysis and network theory without its adaption to the specific characteristics of the analysed system is unlikely to reveal novel phenomena of digitally enabled social networks. In the past, such simplistic approaches have led scholars to question the value of network research in other disciplines (Kilduff, Tsai, & Hanke, 2006). Rather than simply revisiting and adapting core network theories, scholars have called for the extension of known and the development of new theories that will account for the unique characteristics of the systems studied in their respective disciplines (Kilduff et al., 2006; O'Donnell, 2014; Parkhe, Wasserman, & Ralston, 2006). In this vein, the first guiding question for the work presented in this thesis is:

> What role does technology play in enabling novel phenomena that emerge from the collective dynamics of digitally enabled social networks?

The second aspect of the role technology plays in the collective dynamics of digitally enabled social networks is closely related to what has been mentioned in the previous paragraphs regarding the role of technology design. Digitally enabled social networks are based on technologies that are designed for a specific purpose. While some of the design aspects of a technological platform might lead to unintended collective dynamics that give rise to emergent phenomena, they can be used as an instrument to promote actively some specific types of collective behaviour. This is perhaps most evident in organisational settings, where the introduction of interactive technologies such as enterprise social media follows specific organisational goals (Kane, 2015). In this context, technologies can be implemented explicitly to promote digitally enabled social networks that contradict organisational structures, hierarchies, and norms (Behrendt et al., 2014; Kane, 2015; Leonardi et al., 2013). In enabling social processes that are difficult to implement in traditional organisational settings, such technologies can increase employee and organisational performance, especially of tasks that require a high degree of innovation and creativity (Kane, 2015). Digitally enabled social networks have shown promise in helping resolve problems that are complex and difficult to define (Schoder et al., 2014) and in enabling novel forms of providing innovative and creative solutions through crowdsourcing (Zuchowski et al., 2016).

Outside of organisational settings, digitally enabled social networks have shown promise in helping to cope with crisis and disaster situations. Social media have been used to acquire and disseminate crisis-related information and to coordinate relief activities, which has led to the emergence of group dynamics (Eismann et al., 2016). The collective dynamics arising in this context depend on the design of the enabling technologies (Eismann et al., 2016) and can help overcome social, technological, and organisational communication barriers

that would otherwise hamper crisis management activities (Fischer et al. 2016). While platforms such as Twitter and Facebook have not been designed intentionally to support crisis management processes, platform providers have recognised the role their technologies play in this context. In response, some platform providers have implemented features that are activated only during crises and disasters. Facebook, for example, provides a disaster response program, including a safety check feature that allows users to announce publicly that they are safe during disaster situations (Facebook, 2017). Similarly, Airbnb's disaster response program provides features to encourage its users to provide emergency accommodations to those in need during disasters (Airbnb, 2017).

In both examples, the design of the enabling technologies contributes to the emergence of collective dynamics that are disruptive in the sense that they operate outside of conventional social and organisational structures and norms, but are constructive in their positive outcome. In this, they differ from the negative image of collective dynamics, which is well established in early research on collective behaviour and crowds (Le Bon, 1896; Smelser, 1965). While by definition it is notoriously difficult to manage the emergent phenomena arising from complex systems (Ottino, 2004), understanding enabling technologies as instruments to encourage and manage collective dynamics in specific contexts provides a novel and promising perspective for research on collective dynamics. In this vein, I pose the following question:

> What role does technology play in managing the collective dynamics of digitally enabled social networks?

The third aspect of digitally enabled social networks is the constant stream of data generated by their underlying technologies. These data are also referred to as digital trace data, defined by Howison et al. (2011) as follows:

> We define digital trace data as records of activity (trace data) undertaken through an online information system (thus, digital). A trace is a mark left as a sign of passage; it is recorded evidence that something has occurred in the past. (Howison et al., 2011, p. p.769)

They further describe the characteristics of digital trace data in contrast to traditional data as found rather than reported, event-based rather than summarised, and longitudinal rather than cross-sectional. Digital trace data are the byproduct of information systems, which continuously log the activity of their users as part of their operational routines. Those logged activities and events form time series of sociotechnical interactions between users and technological artefacts, which allow scholars to infer social relationships among users. The increasing availability of this type of data is what Kleinberg (2008) described as the foundation of a measurement revolution in research on social networks and what has led, at least in part, to the emergence of the field of computational social science (D. Lazer et al., 2009). While traditional research on social networks has provided a multitude of instruments to collect network data (e.g., interviews, name generators, rosters, archives), it has always been subject to limitations (Marsden, 1990). The data provided by digitally enabled networks help overcome some of those constraints, especially with regards to the completeness, depth, and temporal information that digital trace data provide. Further, the availability of this type of data represents a unique opportunity to study the complex dynamics of social interaction and human behaviour without introducing biasing measurement effects to the systems from which they emerge.

Digital trace data, however, have several shortcomings, which require scholars to make crucial assumptions when using them in the context of social network analysis (Howison et al., 2011). One major deficit of digital trace data is their lack of contextual and contentual information. Network data that are collected by traditional

means are acquired based on methods tailored towards a specific system in a specific social, cultural, and organisational context. For example, asking the employees of an organisation to list their most trusted colleagues or name who they seek advice from in a specific subject matter requires scholars to understand the organisational context in which the actors are embedded. Further, it requires the employees to think about a specific type of relationship they share with others, which in turn allows scholars to make grounded assumptions about those relationships, their value, and the content that can be assumed to flow through them. This lack of contextual information has led to innovative solutions that can be used in conjunction with digital trace data to provide a more comprehensive view of social networks. Some authors have proposed to combine digital trace data with traditional data in mixed methods approaches (Behrendt et al., 2014; Trier & Richter, 2014), while others have proposed more elaborate forms of measuring social relationships using sociometric badges, that is, portable sensor platforms that can be used to track informal communication between and among individuals (Fischbach et al., 2009; Gloor et al., 2011; Gloor et al., 2012).

Other approaches to using digital trace data in the context of research on collective dynamics of digitally enabled social networks can be found in examples of predictive studies, which aim to forecast trends and outcomes of social processes. Digital trace data have, for example, been used successfully to predict the success of movies (Krauss et al., 2008), stock market trends (Zhang et al., 2011), and election outcomes (Tumasjan et al., 2010). While there is no doubt that this type of data bears impressive predictive power, we still lack a thorough understanding of the sociotechnical processes that generate said data (Lazer et al., 2009; Watts, 2007). Thus, research that aims to explain the complex phenomena arising from the collective dynamics of digitally enabled social networks requires a careful consideration of the assumptions made about those processes and their alignment with the assumptions underlying the theories used in the explanation. The otherwise simplistic use of digital trace data is prone to validity issues and flawed conclusions (Howison et al., 2011; Jungherr et al., 2012; Lazer et al., 2014).

In the light of the opportunities provided by digital trace data, their limitations, and the lack of critical research that acknowledges their unique characteristics and the generating processes from which they emerge, the third guiding question of the work presented in this dissertation is:

> How can digital trace data be used to understand and explain the collective dynamics of digitally enabled social networks?

Classification of Articles

The three questions developed above serve as guiding questions for the work presented in this dissertation. They point to three major areas of research on the collective dynamics of digitally enabled social networks and emphasise three different roles of technology in that context. The first area focuses on understanding the phenomena emerging from the collective dynamics of digitally enabled networks and the potential role technology plays in their formation. The second aims to understand the role technology plays in managing such phenomena. The third area is dedicated to further understanding of digital trace data and the challenges and opportunities they provide for research on the collective dynamics of digitally enabled social networks. The three areas, which overlap to some degree, are equally important in understanding the collective dynamics of digitally enabled social networks.

The articles comprising this dissertation can be categorised according to the three areas and the corresponding research questions. Table 1 lists the individual articles, their current publication status, and the research question to which they make their primary contribution. Articles I-VII contribute primarily to the understanding of specific phenomena arising from the collective dynamics of digitally enabled social networks (RQ1); articles VIII-X aim to establish how technology can be used to manage and utilise such phenomena (RQ2); and articles XI-XV provide methodological contributions to the use of digital trace data in research on collective dynamics of digitally enabled social networks (RQ3). Within the last group, articles XI, XII, XIV, and XV reflect critically upon the use of digital trace data, while article XIII provides an innovative methodological approach to using digital trace data.

RQ	No.	Article
1	I	Posegga, O., Fischbach, K., & Donath, M. (2014). Using Weighted Interaction Metrics for Link Prediction in a Large Online Social Network. In K. A. Zweig, W. Neuser, V. Pipkek, M. Rohde, & I. Scholtes (Eds.), Socioinformatics - The Social Impact of Interactions between Humans and IT. Cham, Switzerland: Springer International Publishing.
1	II	Tilly, R., Posegga, O., Fischbach, K., & Schoder, D. (2015). What is Quality of Data and Information in Social Information Systems? Towards a Definition and Ontology. Proceedings of the International Conference on Information Systems.
1	III	Tilly, R., Posegga, O., Fischbach, K., & Schoder, D. (2017). Towards a Conceptualization of Data and Information Quality in Social Information Systems. Business & Information Systems Engineering, 59(1), 3–21.
1	IV	Posegga, O., Zylka, M., & Fischbach, K. (2015). Collective Dynamics of Crowdfunding Networks. Proceedings of the Hawaii International Conference on System Sciences.
1	V	Volkmann, G., Putzke, J., Posegga, O., Fischbach, K., & Schoder, D. (2015). Out-Group-Tie Centralization and the Performance of Work Groups. Proceedings of the Jahrestagung der Wirtschaftsinformatik.
1	VI	Eismann, K., Posegga, O., & Fischbach, K. (2016). Collective Behaviour, Social Media, and Disasters: A Systematic Literature Review. Proceedings of the European Conference on Information Systems
1	VII	Fischer, D., Posegga, O., & Fischbach, K. (2016). Communication Barriers in Crisis Management: A Literature Review. Proceedings of the European Conference on Information Systems.
2	VIII	Zuchowski, O., Posegga, O., Schlagwein, D., & Fischbach, K. (2016). Internal crowdsourcing: conceptual framework, structured review, and research agenda. Journal of Information Technology, 31(2), 166–184.
2	IX	Sobiegalla, F., Posegga, O., & Fischbach, K. (2016). Connecting Disaster Volunteers and Relief Organizations: A Design Science Approach. Proceedings of the International Conference on Information Systems
2	X	Sobiegalla, F., Posegga, O., & Fischbach, K. (2017). Evaluating a Mobile Crisis Response System for the Management of Disaster Volunteers. Proceedings of the International Conference on Design Science Research in Information Systems and Technology.
3	XI	Posegga, O., & Fischbach, K. (2017). Soziotechnische Netzwerke und Digitale Spurendaten. Soziologie, 46(1), 54–57.
3	XII	Posegga, O. (2017). Social Network Analysis in Information Systems Research. Working Paper.
3	XIII	Spiegel, O., Abbassi, P., Zylka, M. P., Posegga, O., Fischbach, K., Schlagwein, D., & Schoder, D. (2014). Getting Boundary Conditions Right: Towards a Classification of the Information Economy Sectors. Proceedings of the Academy of Management Proceedings.
3	XIV	Jungherr, A., Posegga, O., Schoen, H., & Jürgens, P. (2017). Characterizing Political Talk on Twitter: A Comparison Between Public Agenda, Media Agendas, and the Twitter Agenda with Regard to Topics and Dynamics. Working Paper.
3	XV	Jungherr, A., Schoen, H., Posegga, O., & Jürgens, P. (2017). Digital Trace Data in the Study of Public Opinion. Social Science Computer Review, 35(3), 336–356.

Table 1. Article overview.

Research on the collective dynamics of digitally enabled social networks is, as established in the preceding sections, an interdisciplinary endeavour that involves the social and natural sciences alike. Consequently, the work presented in this dissertation is distributed across the social sciences, computer sciences, organisation sciences, and information systems communities. The articles fall into four broad areas: fundamental contributions to the topic; contributions in the context of organisational research; research on crisis management; and

research in the domain of politics and public opinion. Table 2 classifies the 15 articles based on the research questions and the four areas.

	Fundamentals	Organisations	Crisis Management	Public Opinion
RQ 1: Understanding Collective Dynamics	I, II, III	IV, V	VI, VII	
RQ 2: Managing Collective Dynamics		VIII	IX, X	
RQ 3: Using Digital Trace Data in Research on Collective Dynamics	XI, XII	XIII		XIV, XV

Table 2. Classification Framework.

Articles I, II, III, XI, and XII contribute to the fundamental understanding of the collective dynamics of digitally enabled social networks. Article I investigates the structural dynamics of digitally enabled social networks from a link prediction perspective. Articles II and III investigate the emergence of data and information quality in digitally enabled social networks. Articles XI and XII critically reflect upon the use of network analysis and network theory in digitally enabled social networks. Articles IV, V, VIII, and XIII are concerned with the collective dynamics of digitally enabled social networks in organisational settings.

In Article IV, my co-authors and I investigate the collective dynamics of digitally enabled crowdfunding networks. Article V investigates the group dynamics of digitally enabled social networks in organisational settings and their effect on business unit performance. In article VIII, we propose internal crowdsourcing as a digitally enabled form of organising that can be used to motivate and manage collective dynamics among employees to solve intelligence, design, and decision problems. The contribution of article XIII lies in the development of a method to derive industry classifications from digital trace data collected from a large social media platform.

Articles VI, VII, IX, and X address the context of crisis management. In VI and VII, we review the state of the art in research into collective behaviour on social media and communication barriers in disaster and crisis management. Articles IX and X are two parts of an on-going design science project dedicated to developing a solution to manage the collective dynamics of disaster volunteers with a technological artefact that connects disaster volunteers and relief organisations.

The last two articles, XIV and XV, fall into the category of research on politics and public opinion. In article XIV, we compare public and mass media agendas with public agendas generated from digital trace data and evaluate critically their differences with respect to underlying data generating processes. Article XV investigates critically the explanatory power of digital trace data in the study of public opinion.

In the following section, I summarise the individual contributions of these articles in terms of the three research questions introduced earlier.

Contributions

Research Question 1

The articles summarised in this section contribute to the first research question: What role does technology play in enabling novel phenomena that emerge from the collective dynamics of digitally enabled social networks? Articles I, II, and III investigate fundamental topics in this context; articles IV and V investigate collective dynamics of digital enabled social networks in organisational settings; and articles VI and VII provide contributions to the research question in the context of crisis management.

Article II and III are the results of a single study and so are presented together.

Contribution of Article I

Article I is the result of an empirical study conducted in cooperation with the provider of a large German social media network and was presented at the Jahrestagung der Gesellschaft für Informatik in 2014. It contributes to the first research question by investigating the collective dynamics of digitally enabled social networks from a link prediction perspective. It offers insights into the formation of digitally enabled social networks and the role digital trace data play in predicting the formation of relationships between the members of the network.

Article I. Posegga, O., Fischbach, K., & Donath, M. (2014). *Using Weighted Interaction Metrics for Link Prediction in a Large Online Social Network.* In K. A. Zweig, W. Neuser, V. Pipkek, M. Rohde, & I. Scholtes (Eds.), Socioinformatics - The Social Impact of Interactions between Humans and IT. Cham, Switzerland: Springer International Publishing.

Motivation. Research on the link prediction problem represents one of the approaches to studying the structural dynamics of digitally enabled social networks. In general, it can be described as the problem of predicting the likelihood of occurrence for all as yet non-existent or unknown edges in a network. Liben-Nowell and Kleinberg have defined the problem for social networks as follows: 'Given a snapshot of a social network at time t, we seek to accurately predict the edges that will be added to the network during the interval from time t to a given future time t'.' (Liben-Nowell & Kleinberg, 2007). Finding good solutions to the problem requires a proper understanding of the process of link formation, which reflects the decision of individuals to engage in social interactions.

In this work, we focus on improving local similarity metrics used in neighbour-based link prediction approaches that have been discussed by Liben-Nowell and Kleinberg (2007) and Lü and Zhou (2011). Neighbour-based metrics exhibit a limited perspective on the network. When used for link prediction, such metrics neglect pairs of actors separated by a path with a length greater than 2. In other words, they consider only pairs of actors with at least one mutual friend. The set of mutual friends is also referred to as neighbourhood. While the restriction to this minimal distance seems strong, many studies show that a major portion of newly established links connects actors who have been sharing at least one mutual friend (Leskovec et al., 2008). In fact, the phenomenon behind this observation, called triadic closure, is well known and has been studied in many networks (Kossinets & Watts, 2006; Newman, 2003). We argue, however, that traditional versions of such metrics are designed only for unweighted networks and hence are typically applied to simple social graphs (comprised of actors and their static 'friendship' relationships that can generally be established in social media networks), ignoring a large portion of the data provided by the technologies underlying digitally enabled social

networks (especially temporal interaction data, which refers, for example, to private and public communication events involving both actors).

Goal. The goal of this paper is to understand how different forms of relational activity taking place between pairs of actors in digitally enabled social networks contribute to their link formation behaviour. Thus, the study aims to contribute to the understanding of the emergence of the complex structures exhibited by digitally enabled social networks.

Approach. In our approach, we focus on link prediction using structural similarity-based algorithms (Liben-Nowell & Kleinberg, 2007; Lü & Zhou, 2011) and neighbour-based similarity metrics largely because of their high computational efficiency and the low volume of information they require to make valuable predictions. More important, this approach gives us full control over the volume of information used for the prediction, thus allowing us to compare the quality of predictions derived from different types of information about the network structure and interaction data. We modify the volume of information used in this context by adjusting how we model the network structures from the data available on the digitally enabled social network. We model three different types of graphs: the social graph, which is comprised of static 'friendship' relationships established by the actors at a single point in time; the interaction graph, which is comprised of actors and their relationships representing various types of private and public communication; and a combined graph, which uses contains weighted edges representing both types of information. To compare different neighbour-based metrics in these different graphs we designed, we use similarity-based prediction algorithms, which follow the basic assumption that two nodes of a network are more likely to establish a future connection if they are close or, regarding their structural properties, similar to each other. Such similarity, or proximity, can be quantified using proximity metrics, which can be used to assign a score to each pair of unconnected nodes in a network. Pairs of nodes can be sorted and ranked based on such scores. Furthermore, the top-k (where k is typically a number between 10 and 100) ranked pairs can be classified as the most similar actors, which are assumed to be most likely to share a future connection and, hence, are predicted to be future acquaintances. As many of the standard neighbourhood-based metrics are designed for simple (i.e., undirected, unweighted) graphs, we modify those metrics to be comply with the more complex (weighted and directed) interaction and combined graphs. We tested the performance of the most common neighbour-based metrics—that is, common neighbourhood, Adamic/Adar, resource allocation, preferential attachment, and Jaccard's coefficient—which have been discussed previously by Liben-Nowell and Kleinberg (2007) and Lü and Zhou (2011). We used data obtained through cooperation with the provider of a German social network site that had, at the time of the study, approximately 9.38 million users.

Results. The initial social graph we constructed from the data on the digitally enabled social network we investigated comprises 513,419,650 edges between 7.4 million unique actors. In total, the graph contains 9.38 million actors. During the entire observation period, we logged 521,583,014 interactions. Within the 60 days of observation, 4 million users took part in at least one interaction and 2.7 million of those sent at least one private message. Thus, 42.64% of all users were responsible for all interactions observed in those 60 days, and 25.33% produced all outgoing private messages during that period. Among the logged interactions, 11,690,430 friendships were established and 2,789,371 friendships were deleted. Some 87% of all friendships created were formed between users who already existed in the initial snapshot of the social graph. We took a random sample of 1,000 recently established friendships from the test period and found that 84% of all new friendships are formed between actors with one or more common neighbours. Moreover, 80% of all those new friendships are established between actors with a minimum of three common neighbours. The users in our sample established

241 friendships among 71,715 previously unconnected pairs of actors; that is, they befriended 0.336% of all considered candidates within the 30-day test period.

The results of the comparison between the different metrics computed on the different graphs show that traditional metrics applied to the social graph exhibit the highest prediction quality. As the social graph contains the most information on static social relationships and the interaction graph the most recent and detailed information on interactions, our findings suggest that the platform's users prefer quantity over quality when it comes to establishing new connections. This results in the simplest metrics performing best. They outclass more complex metrics that rely exclusively on interaction-related information.

Our findings are consistent with existing studies. Furthermore, we find that despite the low performance of the modified metrics, a user's recent activity has a significant effect on his/her establishment of friendships in the near future. This is an important insight that highlights the relevance of previous interactions in the process of link formation.

Contribution of Articles II and III

Articles II and III are dedicated to understanding the emergence of data and information quality in social information systems. Article II provides a systematic review of different conceptualisations of data and information quality and compares it to the characteristics of social information systems, while Article III builds on that review and provides a more comprehensive conceptualisation of data and information quality in this context. The first article was presented at the International Conference on Information Systems in 2015 and the second article is published in the journal *Business & Information Systems Engineering*. By investigating the sociotechnical processes that led to the emergence of data and information quality in social information systems, both articles contribute to the understanding of the collective dynamics of digitally enabled social networks related to the content produced and consumed by their members.

Article II. Tilly, R., Posegga, O., Fischbach, K., & Schoder, D. (2015). *What is Quality of Data and Information in Social Information Systems? Towards a Definition and Ontology.* In: Proceedings of the International Conference on Information Systems (ICIS), Fort Worth, TX.

Article III. Tilly, R., Posegga, O., Fischbach, K., & Schoder, D. (2017). *Towards a Conceptualization of Data and Information Quality in Social Information Systems.* Business & Information Systems Engineering, 59(1), 3-21.

Motivation. Data and information quality (DIQ) have been defined traditionally in an organisational context and with respect to traditional information systems (IS). Numerous frameworks have been developed to operationalise traditional DIQ accordingly. However, over the last decade, social information systems (SocIS) such as social media have emerged that enable social interaction and open collaboration of voluntary prosumers rather than supporting specific tasks as do traditional IS in organisations. Traditional conceptualisations of DIQ such as 'fitness for use' or 'intrinsic' DIQ do not adequately reflect the unique characteristics of SocIS. Such systems can be defined as ''information systems based on social technologies and open collaboration'' (Schlagwein, Schoder, & Fischbach, 2011). Thus, they are still covered by the broader definition of IS as being sociotechnical systems that acquire information (in this case, from humans/groups), store and process data, and present information to humans. However, applications of social IS expand beyond organisational contexts and use cases of traditional IS (M. Parameswaran & A. B. Whinston, 2007; Manoj Parameswaran & Andrew

B. Whinston, 2007). Schlagwein et al. (2011) describe six characteristics that differentiate SocIS from traditional IS. First, their affordances are social interactions such as 'friending', 'liking', 'sharing', and 'commenting', while those of traditional IS are information and business processing (i.e., sociability). Second, SocIS are typically open in terms of membership and usage, while traditional IS typically have predefined user groups, at least to a certain degree, that must use the traditional IS either because they need information for their tasks or because they are required to enter certain information (i.e., openness). Third, social information systems are typically open to co-development by their users, who can take on the roles of user and developer; this is not the case in traditional IS, which are typically developed and maintained by dedicated professionals (i.e., user role). Fourth, users of SocIS typically create and consume user-generated content, whereas traditional IS, in part due to predefined roles and purposes as well as rules governing their use, exhibit higher levels of structuring and homogeneity of content. Fifth, SocIS are enabled by interactive technologies that provide online features to enable and encourage different forms of social interaction, while traditional IS are typically designed to solve specific organisational tasks and thus require less interactive (and sometimes offline) technologies (i.e., technology). Sixth, SocIS are inherently Internet-based online systems, accessed conveniently through, for example, a Web browser on various devices, and (almost) ubiquitously available to their users, whereas traditional IS are often only accessible within the local network of an organisation (i.e., location). We argue that traditional definitions of DIQ are insufficient for capturing these characteristics, presumably because they have been developed for traditional IS in an organisational context. Traditional definitions make assumptions about, for instance, users, user behaviour, tasks, contexts, governance, and the relationship of data/information production to consumption that conflict with the characteristics of SocIS, which afford social interactions to an open, heterogeneous, virtual community of users who function both as producers and consumers of content, interact in different social subsets, and distribute IS governance amongst themselves.

Goal. The goal of the study underlying the two articles summarised here is to establish how DIQ is conceptualised in IS with respect to the characteristics of SocIS and to provide a conceptualisation of DIQ that accounts for those characteristics.

Approach. Our methodology comprises two steps, namely, the identification DIQ conceptualisations prevalent IS research and the analysis of their applicability to SocIS. Both steps are conceptual in nature, but have different goals. In the first step, we build a taxonomy of existing DIQ conceptualisations. The conceptual contribution is what MacInnis (2011) calls a differentiation. It aims at adding clarity by distinguishing entities through, for instance, a taxonomy or typology. We build the taxonomy using a structured literature review in which we identify DIQ definitions in IS research studies and group them to distinct conceptualisations in an inductive way. The resulting taxonomy of DIQ conceptualisations provides the input for the second step of our methodology, in which we analyse critically the applicability of these conceptualisations to SocIS. The type of conceptual contribution in this step is revising, that is, ''taking a novel perspective on something that has already been identified'' (MacInnis, 2011). The literature review we conducted to derive a taxonomy of DIQ conceptualisations follows the state of the art in the IS discipline (Kitchenham, 2004; Webster & Watson, 2002). We conducted a keyword-based search using the following keyword combinations: 'information AND quality' and 'data AND quality'. The scope of our review was limited to the Senior Scholars' Basket (Lowry et al., 2013) and the AIS Electronic Library. In the latter database, we searched the titles, keywords, and abstracts of all archived papers for the keywords 'information quality' and 'data quality'. The review as initially conducted in the first paper and updated for the second paper to include all matching articles published before 20 April 2015. The results of our search process were processed manually (i.e., screening for relevance, removal

of duplicates). We evaluated the contents of all papers manually with regards to their conceptualisation of DIQ and derived a taxonomy according to the guidelines of Nickerson et al. (2013).

Results. In our systematic review, we identified 730 papers, of which we found 249 that matched our inclusion criteria. We used those articles as the foundation for our taxonomy of DIQ conceptualisations, which comprises nine dimensions (i.e., DIQ as correspondence, fitness for use, semiotic, conformance, perceived, organisational, user-generated content, hybrid, and only dimensions; these have several shortcomings when applied to SocIS.

The general problems of existing conceptualisations can be summarised under three major themes, all rooted in specific assumptions about (traditional) IS. First, when human IS users are considered in conceptualising DIQ, their role as information consumers is prioritised over their role as information producers. This conflicts with the prosumer role in SocIS, that is, that both user roles—as producers and consumers of content—are equally important and mutually dependent for (digital) social interaction and collaboration. We conclude that DIQ in SocIS needs to be conceptualised as reciprocal between prosumers because DIQ in SocIS is inherently an interplay of different individual DIQ perceptions. Second, existing conceptualisations often assume that data/information and DIQ perceptions are homogeneous and static. Such is not the case for SocIS, in which perceptions of DIQ and, hence, contribution and consumption of data/information may vary across heterogeneous (groups of) prosumers, time, and contexts. DIQ in SocIS is, hence, inherently dynamic. Third, specific aspects of IS use are assumed to be explicit so that DIQ management can be purposefully designed and evaluated. For example, context, task, and real-world reference systems of IS use are derived from functional roles, business processes, and organisational goals. Such is not the case for SocIS, in which many aspects of IS use by often unknown, heterogeneous, and changing users are instead implicit but nevertheless shape human information behaviour and DIQ perceptions.

Following from this, we propose to conceptualise DIQ in SocIS as a reciprocal, dynamic, and implicit sociotechnical process that enables the matching of individual information supply by some prosumers and information demand by others. The perspective of individual prosumers is important because whether and how they participate in SocIS and contribute or consume content is driven by their (information) behaviour. However, when conceptualising DIQ in SocIS, the individual level is not sufficient because social interaction and collaboration include multiple individuals. Hence, we propose to conceptualise DIQ in SocIS as a process of matching information supply and demand between multiple prosumers. This matching is reciprocal because DIQ perceptions of one prosumer that shape data/information during production are evaluated by other prosumers and their respective DIQ perceptions during consumption. It is dynamic because DIQ perceptions change across users, contexts, and time. It is also implicit because which DIQ perceptions and evaluations become effective during individual production and consumption can usually not be observed directly for other prosumers. Further, we conceptualise DIQ in SocIS as a process and speak of 'information supply and demand' rather than 'contributed and consumed content' because DIQ in SocIS is not restricted to data/information that have already been contributed and consumed at a given time. Rather, in interactive and collaborative SocIS, DIQ also includes the potential for future contribution and consumption given the prosumers of the SocIS, their perceptions of certain phenomena, their perceptions of DIQ, and their motivation and interest to participate in the SocIS. In other words, if one prosumer cannot find certain information in existing user-generated content or finds it to be lacking certain dimensions of quality, she can interact instantaneously with other prosumers and ask for contribution or improvement of that piece of information. The observable and measurable state of

DIQ of some user-generated content in some SocIS as evaluated by some prosumers at a specific time can at best be indicative of the larger DIQ process of matching information supply and demand.

Finally, the process is sociotechnical: as it involves human prosumers engaging with technical features of an IT artefact. We propose to view the larger sociotechnical process of matching information supply and demand as being composed of different sociotechnical mechanisms that are actualised repeatedly by the prosumers, whether consciously or subconsciously. For instance, a prosumer may be brought into contact with other prosumers who match or produce content that matches her individual DIQ definition (allocation). A group of prosumers within the larger community may compare and discuss individual DIQ definitions and negotiate some compromise (negotiation), resulting in a locally accepted definition of target levels, actual levels, and quality dimensions (consensus). New prosumers may learn accepted DIQ definitions from veterans in the community and explicitly formulated norms (socialisation). Taking part in these activities and using such sociotechnical mechanisms to mediate and arbitrate data/information and DIQ is part of collective information behaviour in SocIS and hence should be considered when conceptualising DIQ in SocIS.

Contribution of Article IV

Article IV reports an empirical study to investigate the collective dynamics of crowdfunding networks. It was presented at the Hawaii International Conference on System Sciences in 2015 and contributes to the understanding of the collective dynamics arising in the context of entrepreneurs that seek crowdfunding through digitally enabled social networks.

Article IV. Posegga, O., Zylka, M., & Fischbach, K. (2015). *Collective Dynamics of Crowdfunding Networks.* In: Proceedings of the Hawaii International Conference on System Sciences (HICSS), Kauai, HI.

Motivation. Crowdfunding is a phenomenon that has garnered considerable of attention in recent years. Belleflamme et al. define crowdfunding as 'an open call, mostly through the Internet, for the provision of financial resources either in form of donation or in exchange for the future product or some form of reward and/or voting rights' (Belleflamme et al., 2014). Crowdfunding initially appeared in 2006 (Lawton & Marom, 2010) and has its roots in crowdsourcing (Howe, 2006), in which the 'crowd' works together collaboratively on a common goal. In crowdfunding, the crowd collectively provides financial resources for products and services to be developed. Thus, crowdfunding is its own unique category of fundraising (Mollick, 2014).

Crowdfunding has become a popular phenomenon, at least in part due to the growing availability of digital platforms (e.g., Kickstarter and Indigogo) that provide a technological infrastructure for individuals to create and maintain their own crowdfunding campaigns online. Those platforms often exhibit additional features that resemble those of social media platforms (e.g., profile pages, communication, search, and privacy-related features). Thus, crowdfunding platforms allow for forming digitally enabled social networks in an organisational context.

Crowdfunding—particularly through Kickstarter—has caught the attention not only of consumers and startups but also researchers. Recent research on crowdfunding has focused on dynamics (Mollick, 2014), geography (Agrawal et al., 2011), and economic characteristics (Agrawal et al., 2014) of crowdfunding markets. Scholars have also analysed the motivators and deterrents of participation (Gerber & Hui, 2013), and examined social influence in crowdfunding markets (Burtch et al., 2013). These studies investigate the coherence between these aspects and funding success. They typically distinguish between two types of users: supporters and project creators. However, crowdfunding platforms allow users to play both sides of the market, that is, both to create

and support projects. Hence, crowdfunding markets can be characterised as two-sided markets (Eisenmann et al., 2006) in which users can act both as entrepreneurs and investors. Recent research reveals initial insights into the dynamics and characteristics of crowdfunding networks arising from such marketplaces. This research, though, is restricted primarily to the analysis of static network snapshots and the investigation of the dyadic level of the emerging network structures. As outlined in the theoretical background of this thesis, this perspective is limited in understanding the collective dynamics of such networks.

Goal. The goal of this study is to overcome the limitations of previous network research on the collective dynamics of digitally enabled social networks in the context of crowdfunding by investigating the mechanisms governing those dynamics with respect to project creators who play both sides of such markets.

Approach. We collected data from the crowdfunding platform Kickstarter, at the time of this study the most popular online crowdfunding platform. We used a self-written Web crawler to collect the properties of all Kickstarter projects, their creators, and their supporters between April 2009 and April 2014. For each project, we collected the status (i.e., failed, successful, cancelled, suspended, or live), funding goal, launch date, deadline, creator, and a list of other project creators supporting the project. In addition, we collected the nickname, first name, origin, and date of platform entry for each creator on our list. The resulting dataset contains 128,841 projects launched by 111,617 project creators. Further, we restricted the overall dataset to the Kickstarter creator network by removing outlier projects with extremely low or high funding goals. In addition, since Kickstarter was restricted to U.S.-based crowdfunding campaigns, we removed all non-U.S. projects from our dataset. Finally, we focused on the top 200 most-active project creators and drew a snowball sample from the processed dataset, resulting in a final sample of 2,241 projects, 1,477 active creators, and 6,394 support relationships between those. We used these data to generate six network snapshots, each spanning a period of six months, with nodes representing platform members and edges representing the support relationships that occurred in the respective timeframe of the snapshot. In addition to the data already collected, we determined the geographical distance between the actors as well as their gender. The resulting networks allowed us to examine the collective dynamics of the crowdfunding network.

We formulated thirteen hypotheses regarding network mechanisms related to reciprocal, transitive and hierarchical link formation; exogenous attributes such as homophily, gender, and geographic distance; the experience of actors in terms of their previous crowdfunding activity on the platform; and their popularity in terms of their previous success and network position. To test the proposed hypotheses, we use stochastic actor-based models (ABM) as introduced by Snijders (Snijders & van Duijn, 1997; Snijders, 1996, 2001) and discussed in detail by Ripley and Snijders (2009) and Snijders et al. (2010). ABMs have been developed to analyse network changes over time, with the goal of understanding collective behaviour using statistical models that are based on assumptions regarding the link formation behaviour of individual actors in the context of endogenous and exogenous variables. Following a forward selection approach, we estimated thirteen models in total. Beginning with endogenous effects, we included exogenous and interaction effects in a stepwise procedure and then validated our results by performing a backward selection procedure.

Results. Of the 1,477 project creators in our sample, we identified 24.17% as female and 75.83% as male. The mean (median) of projects created per user at the end of our observation period is 1.54 (1.0). Project creators are separated by an average distance of 1,235 miles; the median is 1,215 miles. We find a positive tendency towards the creation of hierarchical network structures and a tendency to increased funding towards prominent project creators. Thus, the support among project creators seems to be highly concentrated in a

subgroup of popular actors. In crowdfunding networks, this could also promote a concentration of experience and knowledge—especially when a funding relationship might also indicate an increased likelihood for additional support (e.g., advice). Hierarchical network structures such as this can be found in many complex systems (Ravasz & Barabási, 2003). In this regard, it is interesting to observe that experienced project creators tend to support fewer projects than do inexperienced creators. Similarly, popular creators provide less support than unpopular ones. Thus, we find evidence that project creators do not have a long-term motivation to support others. Once they reach a certain status, their supporting activity diminishes. Others have established a preference for reciprocity in crowdfunding networks as well as a positive correlation between reciprocity and project success (Zvilichovsky et al., 2015).

In analysing triadic relationships between actors and their effect on the network level, we extend the scope of previous research on similar networks, which has been limited to the dyadic level of analysis. Our findings confirm a strong preference for the direct reciprocation of project support (i.e., restricted support). Moreover, we observe a negative preference for the indirect reciprocation of project support (i.e., generalised exchange). As described by Bearman (1997), restricted exchange systems are often separated into dense subgroups (or clusters) of well-connected individuals. Absent generalised exchange mechanisms, such subgroups form self-sufficient subsystems. Thus, successful strategies and behaviours emerging from one subgroup may remain in that group rather than spreading through the entire network. Further, Agrawal et al. (2011) found there is no effect of geographic distance between projects and potential supporters on the likelihood of actual project support. In contrast, traditional investors prefer to invest in founders close to them (Sorenson & Stuart, 2001). Moreover, there is evidence that traditional investors show a preference for gender homophily (Sorenson & Stuart, 2008).

Our own findings provide additional evidence for the missing effect of geographic distance on project support. Further, our crowdfunding results suggest that there is no evidence of gender homophily among project creators. Hence, compared to traditional investors, project creators in crowdfunding markets show different behaviour in this regard. At the same time, female project creators do receive a higher amount of support from other creators than do male creators. Male project creators have a higher tendency to provide support in general.

Contribution of Article V

Article V reports on the results an empirical study of the collective dynamics of intra-organisational group dynamics and group performance. It was presented at the Jahrestagung der Wirtschaftsinformatik in 2015. In contributes to the understanding of performance-related phenomena emerging from intra-organisational digitally enabled social networks and is based on a dynamic social network analysis approach using digital trace data.

Article V. Volkmann, G., Putzke, J., Posegga, O., Fischbach, K., & Schoder, D. (2015). *Out-Group-Tie Centralization and the Performance of Work Groups*. In: Proceedings of the Jahrestagung der Wirtschaftsinformatik (WI), Osnabrück, Germany.

Motivation. In growing numbers, organisations have responded to this erratic and complex environment with group-based organisational structures that decentralise decision making and allow them to react more quickly and innovatively (Hargadon, 1998; Mohrman et al., 1995). Increased task complexity associated with

knowledge work and flatter work structures created by group-based structures lead to an increase in interdependence between work groups. Because of this, work groups are increasingly responsible for coordinating and performing complex cross-functional tasks and bridging organisational workgroups to create and transfer valuable resources of knowledge and know-how (Ancona & Caldwell, 1992).

In the literature, establishing these out-group ties with other work groups and managing these cross-group interactions are often referred to as team boundary spanning (Ancona, 1990; Ancona & Caldwell, 1992; Marrone, 2010). However, no clear picture has yet emerged regarding which group structures are most beneficial for internal work group management, that is, for how boundary spanning is best managed and distributed within the group and which internal work group network structure allows a group to perform best. More attention is needed to examine—at a finer-grained level—how member boundary spanning is combined at the group level (e.g., the use of a single focal boundary spanner vs. shared boundary-spanning responsibility across all members, or something in between) (Marrone, 2010) and whether a high or moderately dense internal work group network structure is better for performance.

Moreover, the findings of Hansen et al. (2001) show that the context in which those structures appear is highly relevant, because whether the tasks performed by a group are predominantly explorative or exploitative—that is, involving highly tacit knowledge or highly explicit knowledge, respectively—affects which kind of internal workgroup network structures allow a group to perform best. They identify exploitative tasks as, for example, daily work, routine work, continuous improvement, increasing production efficiency, and so on (Hansen et al., 2001). Therefore, much of the knowledge involved in exploitative tasks is likely to be explicit, because the expertise required is already available and the problem, possible solutions, and causal mechanisms among the parameters involved in the task are known (Hansen et al., 2001). Groups and group members benefit from obtaining existing, complementary knowledge through their network that avoids duplication of effort and, typically, group members know well when and how frequently they need to consult contacts to obtain needed and valuable knowledge (Hansen et al., 2001). Thus, exploitative tasks can often be split easily into a number of subtasks that can be completed by individual group members.

In sum, prior research has suggested the need to refine the understanding of how structural properties of internal and external work group network relations affect group performance while simultaneously considering whether the tasks performed are predominantly exploitative or exploratory and whether the knowledge required is predominantly tacit or explicit.

Goal. The purpose of this study is to refine the understanding of both internal and external work group structures that are beneficial for internal work group management. Therefore this study examines work groups performing predominantly exploitative tasks and analyses which internal group network structures influence work group performance positively, while at the same time examining how boundary spanning activities are best managed at the group level by analysing which internal distribution structure of boundary spanning ties influences group performance positively.

Approach. In pursuit of this goal, we follow a social network analysis approach and focus on analysing the structure of an organisation's digitally enabled social network. An organisation's informal social network relies not only on direct face-to-face communication but also on information system components (e.g., videoconferences, teleconferences, telephone, e- mail) designed to support more unstructured group interactions. Hence, this study focuses on the informal network of work groups in the organisation built by social relations

constructed of interaction ties of the work group members gathered via information system components. We investigate the effect of work group network density—that is, the internal density of a digitally enabled social network emerging from interactions within the work group—and the effect of out-group tie centralisation. We develop the concept of out-group tie centralisation to investigate the effects of boundary-spanning mechanisms and define it as the variation in the group members' network ties to other social actors who are not members of the group itself. When the variation in the number of network ties per group member is low, no group member enjoys substantially more ties to social actors outside the group than does any other group member. In contrast, when the variation in the number of network ties per group member is high, some members have proportionately more ties to social actors who are not members of the group itself.

We test our hypothesis based on a data set provided by a medium-size German bank with approximately 4,000 employees and some 389 work groups. The data set includes the formal group membership of each employee, as well as all emails (without content) sent or received by bank employees (n=3,653) during 2010. In total, the email archive comprised 4,950,801 emails belonging to 142,858 dyads. After processing the data set, our final sample contains 120 work groups (i.e., sales groups) ranging in size from 4 to 66 members; the average group size is 15.12 members. The average age of employees in the sample is 37.66 years, and 43.7% of employees are men. The tasks performed by these 120 groups in the final sample are exploitative tasks that involve banking services such as construction financing for private households, high-net-worth individuals, and companies; retail banking services for private households; private banking services for high-net-worth individuals; corporate banking services for companies; and funding and financial services for startups and new ventures. These tasks can be completed directly by an individual group member or can be split into subtasks to be completed by an individual group member. For all groups, we obtained the group performance, that is, the degree to which they achieve their contribution margin targets based on their sales.

We estimate the effect of group network density, out-group tie centralisation, and gender distribution on group performance using series of panel data models (e.g., Woolley, Chabris, Pentland, Hashmi, & Malone, 2010) in R (v. 3.0.2) using the packages lme4 (v. 1.1-7) and plm (v. 1.4-0). Panel data models can be estimated when data are collected from the same subjects over multiple periods. As illustrated above, our balanced panel comprised 1440 observations (i.e., 12 months of observations for each of the 120 work groups).

Results. We hypothesised and tested whether a high density of the internal work group communication network influences work group performance positively. We also hypothesised and tested whether there is an inverted u-shaped relationship between out-group tie centralisation and group performance to support our proposed work group boundary spanning management approach, which states that the best way to manage boundary spanning at the work group level is to assign boundary spanning tasks to a small number of selected group members suited to the task.

Our data do not support our first hypothesis, which is perhaps explainable by the fact that there may also be negative effects on performance from high-grade dense interaction structures within a group. Based on an in-depth discussion of the adverse effects of group density on performance, we re-estimated our models, adding a squared density effect to the equation. However, we found neither the squared density effect nor the ordinary density effect to be statistically significant at a .1 level of significance. Hence, we also cannot conclude that there is a reversed u-shaped relationship between density and performance. Apparently, there is no (linear or reversed u-shaped) relationship between density and group performance.

With regards to the effect of out-group-tie centralisation, the data confirm our hypothesis. These findings indicate that work groups should pay attention not only to managing their interactions within the group, but that it is necessary as well to manage actively the ties to out-group members. An organisation should not encourage its group members to leave out-group interactions to a central person within the team, nor should it encourage all group members to have an equal level of out-group interactions. Rather, a medium level of variance in the amount of out-group interaction among group members is beneficial for work group performance.

Contribution of Article VI

Article VI is the result of a systematic literature review dedicated to classifying and discussing collective behaviour emerging from social media networks in disaster and crisis situations. The paper was presented at the European Conference on Information Systems 2016 and contributes to the understanding of phenomena arising from the collective dynamics of digitally enabled social networks in the context of crises and disasters.

Article VI. Eismann, K., Posegga, O., & Fischbach, K. (2016). *Collective Behaviour, Social Media, and Disasters: A Systematic Literature Review.* In: Proceedings of the European Conference on Information Systems (ECIS), Istanbul, Turkey.

Motivation. There can be little doubt that the late twentieth century has seen a rapid increase in both human-made and natural disasters (Coleman, 2006; Eshghi & Larson, 2008). The emergence of new information and communication technologies and particularly social media has significantly altered disaster response in recent years (Veil et al., 2011). It has also attracted the attention of the information systems discipline. Beginning with the seminal paper of Palen and Liu (2007), a new focus on using information technologies in disaster response has evolved in IS and the social sciences. Investigating social phenomena in the social media environment is exceedingly promising, as these technologies allow for exploring behavioural patterns that were once invisible (Kleinberg, 2008). The pervasiveness of such technologies and the convergence of digital and social networks enable scholars to adopt new perspectives on well-established theories and assumptions that emerged when the world was more analogue (Agarwal et al., 2008; Lazer et al., 2009). Although social media are often used simply as information dissemination tools in disasters (Lindsay, 2011), there is evidence that they also promote distinct social phenomena such as digital convergence (Hughes et al., 2008), digital commemoration (Liu, 2011; Walter, 2015), and the emergence of digital volunteers (Hughes & Tapia, 2015; Reuter et al., 2013).

Goal. The popularity and relevance of the topic have led to a large number of publications focusing on the interplay between social media and emergent phenomena in this context, which are often dedicated to specific topics. The purpose of our research is to gain a more general view of collective behaviour in social media in disasters and establish what disaster-related collective behavioural phenomena have been observed in social media.

Approach. We develop an analytical framework that guides our review and an adaption of the model provided by Kreps (1984), who describes four structural dimensions of disasters along which their features can be classified: the disaster event, its impacts, the social units affected by these impacts, and the responses taken up by the affected social units. As we aim for an overview of collective behaviour in social media, we restrict our argument to behaviours that can be observed in the respective environment. Social media platforms are defined in terms of technology as Web 2.0 platforms open to modification, participation, and collaboration by all users, and in terms of usage as providing a forum for user-generated content created by non-professional

contributors (Kaplan & Haenlein, 2010). At present, various social media platforms are used in disaster-related communication, including popular platforms such as Facebook, Twitter, and Flickr (Briones et al., 2011; Liu et al., 2008), but also disaster-specific applications (Ludwig et al., 2015; Reuter et al., 2015).

Because specific social media platforms are subject to frequent conceptual and technological changes (Oinas-Kukkonen et al., 2010), we focus instead on their general features. According to Kane et al. (2014), social media platforms can be described meaningfully in terms of four stable features, namely whether and to what degree a platform: provides unique user profiles ('digital profile'); allows users to access digital content through and protect it from various search mechanisms provided by the platform ('search and privacy'); provides mechanisms for users to articulate a list of other users with whom they share a connection ('relational ties'); and allows users to view and traverse their connections and those of others on the platform ('network transparency').

We investigate the knowledge base on disaster-related collective behaviour in social media in disasters using a systematic literature review. This method provides the means to identify, evaluate, and interpret the available research on collective behaviour in social media in disasters (Kitchenham & Charters, 2007). The goal of our review is explanatory in nature, as we seek to expose how findings on social media usage in disasters relate to the theory of collective behaviour in those situations. In pursuing this goal, we follow the recommendations and guidelines described by Vom Brocke et al. (2009) and summarise research outcomes and particular findings of existing work around our analytical framework. We derive our keyword-based search from the context of our study and search for articles matching the following keywords in their title, keywords, or abstracts: (disaster* OR cris*s) AND ('social media' OR 'social network' OR 'social networks'). The scope of our review is restricted to research indexed in the following databases: ACM Digital Library, AIS Electronic Library, EBSCOhost online research databases, IEEE Xplore Digital Library, JSTOR, ScienceDirect, and the Social Science Citation Index. Our final search, conducted on 29 October 2015, yielded 3,746 hits across all databases, including 3,311 unique hits, of which we identify 78 to be relevant to our review.

Results. We inferred seven key findings from the literature that illustrate the state of knowledge regarding the relationship between disaster characteristics and collective behaviour in social media in response to these very characteristics. We organise our findings according to the dimensions of our analytical framework, that is, disaster events, their impact, the social units affected by them, and the response of such units.

With respect to disaster events, we find that sharing and obtaining factual information is the primary function of social media usage consistently across all disaster types, but the secondary functions vary. The impact of crises on collective behaviour on social media can be characterised by two findings from the literature. First, disaster management activities are not restricted to individual phases of the disaster management lifecycle in social media. They spread across the all elements of the lifecycle, including the pre-crisis phases 'mitigation' and 'preparedness', as well as the post-crisis phases 'response' and 'recovery'. Second, the duration, scope, and magnitude of disasters influence the extent of social media usage in a disaster, but not necessarily the structure and function of usage. With regards to the social units, we identify three common themes in the literature: different actor types make use of social media in similar ways but perceive different conditions and restrictions for social media usage in disaster situations; social media enable members of the population to reach formerly inaccessible actors but do not ensure two-way communication; and social media integrate unspecified and wider audiences into disaster communication, which can lead to group emergence. Finally, with regards to the response of those individuals, we find that the features of social media platforms determine the

structure and function of collective behaviour on these platforms in disasters. The various types of responses afforded to users of social media heavily depend upon the features provided by such platforms.

Our findings show that social media have the potential to diminish established relationships between collective behaviour and disaster characteristics. On the one hand, we see that traditional functions are detached from specified actors and disaster impact phases. Disaster-related activities can be performed by anyone and at any time in social media. On the other hand, structural patterns of interaction between social units tend to resolve in social media. There is evidence that social media platforms connect audiences that are affected directly by a disaster with others that are at most concerned indirectly. At the same time, it has become possible to disseminate messages to whomever might be interested, rather than having to address any particular audience. Finally, although there is considerable empirical evidence that social media affect collective behaviour in disasters, to the best of our knowledge the underlying causal mechanisms remain unexplored.

Contribution of Article VII

Article VIII is the result of a systematic literature review dedicated to establishing the state of the art in research on communication barriers in crisis management, with an emphasis on the role technology plays in this context. The study was conducted along with the one that led to article VI and was presented at the European Conference on Information Systems in 2016. It contributes to revealing the role technology plays in crisis-related phenomena, in particular by enabling and constraining interaction patterns that emerge within and between relief organisations and the public.

Article VII. Fischer, D., Posegga, O., & Fischbach, K. (2016). *Communication Barriers in Crisis Management: A Literature Review.* In: Proceedings of the European Conference on Information Systems (ECIS), Istanbul, Turkey.

Motivation. To address natural or human-made crises, it is crucial to distribute relevant information and expertise promptly to all crisis response organisations (i.e., fire and rescue services, medical assistance, government agencies, public organisations, police) to save lives and minimise damage. For instance, during 9/11, responding organisations could not rely on contingency plans due to the scale and uniqueness of the attack. Multiple organisations were involved in the crisis response (Kapucu, 2006a, 2006b); the public (i.e., victims, volunteers, others affected) reacted in unforeseeable ways (Kapucu, 2006a); communications technology failed (Comfort & Kapucu, 2006; Kapucu, 2006a); and information flowed too slowly and at insufficient levels of detail (Bruijn, 2006). Moreover, coordination between the various responding organisations failed because they had not established communications with other crisis responders in advance of the event (Bruijn, 2006; Comfort & Kapucu, 2006; Kapucu, 2006b).

It has been established that communication among all crisis responders is a key factor that positively affects preparedness, mitigation, coordination, and cooperation; empowers communities; and limits harm (van Gorp et al., 2015). Hence, barrier-free communication is crucial for successfully managing a crisis. Given the catastrophic failures crisis responders have faced due to the many communication-related challenges, scholars have dedicated a considerable amount of attention to the role of communication in crisis management (Allen et al., 2014; Dawes et al., 2004; Kapucu, 2006b; Manoj & Baker, 2007; Netten & van Someren, 2011). Reliable and effective communication during a crisis response is difficult to achieve because it must be established within and between organisations and with the public. Despite multiple advances in crisis communication and related technology (Ahmed, 2011; Amailef & Lu, 2011; Chen et al., 2008; Currion et al., 2007; Fruhling, 2006), crisis

communication is often experienced as ineffective (Allen et al., 2014; Bharosa et al., 2010; Day et al., 2009). In addition, the research has seemed to lack a comprehensive overview about communication during crisis management and the barriers hindering communication.

Goal. To address this issue, we conducted a systematic literature review to synthesise existing literature on crisis communication and communication barriers between and within crisis response organisations and the public. The review suggests several avenues for future research.

Approach. We first develop an analytical framework to guide our literature review on communication barriers in crisis management. We adopt the crisis definition of (Kreps, 1984, pp. author-year), who defines crises as 'events, observable in time and space, in which societies or their larger subunits (e.g., communities, regions) incur physical damages and losses and/or disruption of their routine functioning' (Kreps, 1984, p. p.312). This review focuses in particular on natural and human-made crises, such as hurricanes or terror attacks (Eshghi & Larson, 2008).

Our framework comprises three central elements: the crisis management phases, communication among crisis responders, and the types of communication barriers that can arise in this context. We distinguish between four phases of crisis management, as suggested by Lettieri et al. (2009). The first two are the pre-crisis phases mitigation and preparedness. The aim of the mitigation phase is to prevent a crisis and mitigate the vulnerability of environmental and social systems, while the aim of the preparedness phase is to enable crisis managers and other potential crisis responders to respond effectively should a crisis happen (McLoughlin, 1985). The remaining two phases are crisis response and recovery. During the response phase, all responders react to prevent further loss and damage, while the aim of the recovery phase is restoration and rehabilitation of the crisis environment (McLoughlin, 1985).

For the second element, communication among responders, we distinguish between two groups. Response organisations include all organisations involved, such as relief organisations, government agencies, medical assistance, fire and rescue services, and the police. The second group is the public, comprising victims, volunteers, and other people affected by the event. We include the public and its role because increased access to and use of social media has resulted in the public taking an active part in crisis management (Leong et al., 2015). Crisis communication takes place within and between response organisations as well as among the public, and the public also communicates with organisations during crisis management (Quarantelli, 1988; Quarantelli, 1997).

With respect to communication barriers, we adopt the classification of Manoj and Baker (2007), who define three categories of communication barriers: technological barriers, which correspond to problems based on the technology used for crisis management; social barriers, which arise because of differences among individuals in the various crisis response organisations or the public involved during the crisis phases; and organisational barriers between and within organisations during crisis management.

The study's aim is to synthesise highly relevant literature on communication and communication barriers during crisis management using a systematic literature review (Schwarz et al., 2007). We follow the recommendations of Okoli and Schabram (2010) as well as Webster and Watson (2002) in structuring the review. We derive the keywords used as the foundation of our search process from the framework and identify articles matching the following search phrase in their titles, keywords, or abstracts: (cris*s OR disaster OR catastrophe

OR emergenc*) AND (mitigation OR preparedness OR response OR recovery) AND (communication OR information). Taking into account the interdisciplinary nature of the topic, we conducted the keyword-based search in five information systems and social sciences literature databases: AIS Electronic Library, EBSCO Business Source Complete, ACM Digital Library, Science Direct, and IEEE Xplore Digital Library. The search yielded 11,719 articles. After processing the resulting articles (i.e., removing duplicates, quality assessment, manual screening for relevance), we identified 76 relevant articles, which we synthesised according to the three communication barriers.

Results. We identify four central types of communication barriers related to technology. First, infrastructure failure occurring during a crisis has been found to disrupt communication between physically separated crisis responders (e.g., due to radio and cellphone blackouts, general loss and failure of communication systems, the absence of backup networks, and the disruption of infrastructure support). Second, the non-acceptance of available technology can hamper the communication of physically separated crisis responders. Third, the heterogeneity of different technologies used in crisis response can lead to inconsistencies and interoperability issues, adversely affecting communication among responding actors. Fourth, communication barriers between the public and relief organisations can result from the use of social media, that is, due to the spread of rumours that interfere with decision making, information overload, inadequate levels of information quality, and the lack of social media usage by relief organisations. Technological barriers not addressed and eliminated during the pre-crisis phases can hinder communication between all crisis responders during response and recovery.

Further, we identify three types of organisational barriers: intra-organisational communication is hampered by differences in organisational cultures, norms, rules, and goals; intra-organisational communication can be negatively affected by intra-organisational networks not having been sufficiently developed before a crisis (e.g., resulting in a lack of trust and an unwillingness to cooperate); and location and resource issues can cause a lack of intra-organisational communication during crises, such as when resources are too limited to connect all crisis responders, information is available only at the local level, or crisis responders are not well trained in the use of communication systems.

Finally, we identify three major social barriers. First, the diversity between responders can hinder communication due to language barriers, a lack of trust, or religious, ideological, political, ethnic, cultural, and/or nationality differences, any of which can complicate cooperation. Second, communication often fails to meet the requirements of the situation due to an inadequate presentation, filtering, or interpretation of the sender and receiver, adversely affecting decision-making. Third, information-related problems can hinder decision makers due to information overload, insufficient information, a lack of information quality, incorrect data coordination and integration, low information priority, unreliability and a low level of confidence in data, inconsistent data from different sources, and incomplete or conflicting interpretations of data. Social barriers are closely related to technological barriers, as they often result from the way social units produce and consume content that is distributed via digitally enabled social networks.

Research Question 2

The articles summarised in the following contribute to the second research question: What role does technology play in managing the collective dynamics of digitally enabled social networks? Article VIII investigates the phenomenon of crowdsourcing as an inter-organisational approach (i.e., internal crowdsourcing) to enable and manage the collective dynamics of digitally enabled social networks to resolve design, intelligence, and decision problems. Articles IX and X are part of an on-going design science research project that aims to provide a

technical artefact for connecting and managing the collective behaviour of unaffiliated disaster volunteers. Both articles are presented together, as they are part of the same study and cover the design (article IX) and planned evaluation (article X) of the artefact.

Contribution of Article VIII

Article VIII is the result of a systematic literature review dedicated to understanding and explaining the phenomenon of internal crowdsourcing. The paper, which was published in the *Journal of Information Technology*, contributes to the understanding of how digitally enabled social networks and inter-organisational crowds can be managed to resolve design, intelligence, and decision problems.

Article VIII. Zuchowski, O., Posegga, O., Schlagwein, D., & Fischbach, K. (2016). *Internal crowdsourcing: conceptual framework, structured review, and research agenda.* Journal of Information Technology, 31(2), 166-184.

Motivation. The use of 'social' information technology in enterprises (and other organisations) has increased substantially in recent years. This increased use, and the enterprise social systems social IT enable, are gradually transforming organisational processes and structures (e.g. Bughin et al., 2013; Leonardi et al., 2013; McAfee, 2009). Social IT changes how enterprises interact externally with their customers and internally with employees (organisational members) (Aral et al., 2013). In a recent study, 82% of enterprises surveyed systematically used social IT (Bughin et al., 2013). At the same time, very few enterprises are able to unlock the full potential of social IT, which several analyses suggest lies in its internal rather than external use (Aral et al., 2013; Hu & Schlagwein, 2013; Koch et al., 2012).

Even more recently, 'internal crowdsourcing' with employees has seen a substantial uptake in practice and has attracted a first wave of research papers and dedicated studies. The alternative term 'enterprise crowdsourcing' can be misleading because it has been used both for internal crowdsourcing and for crowdsourcing by an enterprise in general (internal or external) (Hetmank, 2014). Forms of internal crowdsourcing with employees have been documented at enterprises including Deloitte (Riemer & Scifleet, 2012), Deutsche Telekom (Rohrbeck et al., 2015), and IBM (Bailey & Horvitz, 2010; Muller et al., 2013). Despite the popularity of the concept, it lacks a clear conceptualisation and is not well defined, especially in comparison to other forms of crowdsourcing.

Goal. The goal of this paper is to provide an overarching conceptualisation of internal crowdsourcing in contrast to traditional crowdsourcing and other forms of organising. The guiding questions of this paper are: What exactly is internal crowdsourcing? What do we know about internal crowdsourcing? Where are we lacking knowledge about internal crowdsourcing?

Approach. In pursuit of this goal, we develop a conceptual framework of internal crowdsourcing and conduct a comprehensive literature review, structured with the aim of better describing the domain of internal crowdsourcing and synthesise the relevant knowledge available in peer-reviewed published research (one of the review genres described in Rowe, 2014). For the structured literature review, we followed best practices for literature reviews accepted in the IS discipline (Schryen, 2012; Webster & Watson, 2002). First, we performed a keyword-based search (Kitchenham & Charters, 2007; Kitchenham, 2004) to find papers that self-identified as being concerned with internal crowdsourcing. Second, we performed a concept-centred search (Webster &

Watson, 2002) to identify papers that did not use the term but nonetheless were about the internal crowdsourcing concept. In addition, we used other (non-systematic) methods of identifying relevant papers (e.g., our knowledge of internal crowdsourcing in research and practice). The keywords and concepts used in the search process were derived from an iterative set of probing searches and extensive discussions in the research team in the light of the conceptual framework. We used the academic databases Academic OneFile, EBSCO BusinessHost, Science Direct, and Scopus for the keyword-based search. We conducted the final keyword-based search on 15 August 2015. This step resulted in a total of 20,974 hits across all databases—a high number of hits that is not unusual for keyword-based searches (Boell & Cecez-Kecmanovic, 2015). After processing the identified papers (application of inclusion and exclusion criteria, manual assessment of relevance), the resulting set of relevant papers comprises 74 research articles, which we evaluate and synthesise along the dimensions of our framework.

The foundation of our framework is the working definition of internal crowdsourcing we developed after evaluating the relevant literature: Internal crowdsourcing is an IT-enabled group activity based on an open call for participation in an enterprise. Our corresponding framework has six main components: problems, which covers insights into the problems suitable for internal crowdsourcing (i.e., (collective) intelligence, design, and decision problems); governance, which cuts through the internal crowdsourcing phenomenon in terms of governance and management tasks (i.e., corporate culture and change, incentive design, task definition and decomposition, quality assurance, community management, and regulations and legal implications); people, which encompasses insights regarding those involved with internal crowdsourcing (i.e., requesters and solvers); information technology, which concerns the types of IT used for internal crowdsourcing (i.e., general social and specific crowdsourcing IT); processes, which are the phenomena along the internal crowdsourcing timeline (i.e., preparation, execution, evaluation/aggregation, resolution); and outcomes, which covers the outputs from internal crowdsourcing that correspond to the problems that serve as input for a given crowdsourcing effort (i.e., integration, innovation, choice). The framework serves as a guiding structure to synthesise the literature and organise our findings.

Results. A detailed presentation of the findings along the dimensions of the framework is beyond the scope here; instead, this summary is of some of the key findings from of our results. We found that internal crowdsourcing can be used to solve several types of problems (i.e., intelligence, design, choice). To address such problems effectively, several major design and governance parameters (i.e., criteria, duration, rewards, etc.) must be established. Research informing such design decisions will be useful as it helps organisers and requestors with better design of internal crowdsourcing.

We found that several of the governance tasks performed in internal crowdsourcing are not sufficiently understood. For example, we lack knowledge, theories, and frameworks with which to answer basic questions such as what qualifications (if any) an enterprise should require of solvers or how long an internal crowdsourcing initiative should last. Further, while incentives and motivations in internal crowdsourcing have been a specific focus in substantial research (e.g. Kugler et al., 2013; Lopez et al., 2010; Simula & Vuori, 2012), no general model has been agreed upon regarding what motivates solvers in internal crowdsourcing. The contradictory conclusions regarding the effectiveness of monetary incentives (El-Ella, et al., 2013; Bailey & Horvitz, 2010; Benbya & Alstyne, 2011; Soukhoroukova & Spann, 2012) suggest the need for a deeper investigation of the relationship between, for example, different purposes of internal crowdsourcing and solvers' motivations.

People and their roles in internal crowdsourcing also require further research. Although we were able to describe basic types of participants, we do not know which type of manager pushes for internal crowdsourcing or which type of employee is eager to participate. Both would be useful to know, for example, to identify early adopters and build a critical mass of participants. Related to this, research should also explore further how to put together an effective crowd. In addition, while the evidence shows that IT plays an enabling role in crowdsourcing, little is known about the interactions and relationships between people and IT for crowdsourcing. To understand better the uses and consequences of IT platforms for crowdsourcing, further research on dynamic interactions between employees, the enterprise, and the IT they use for internal crowdsourcing is necessary. Theories of technology affordance and constraints (a theory seeking to understand the action potential of IT relative to a human/animal actor) might provide fruitful ground for future research in this direction (e.g. Leonardi et al., 2013; Majchrzak & Markus, 2012; Volkoff & Strong, 2013). Another relevant but underexplored question is the measurement of 'success', that is, the achievement of the goals of internal crowdsourcing and its short-, mid-, and long-term impacts.

Contribution of Articles IX and X

Articles IX and X contribute to research question 2 by providing an approach to managing the collective dynamics of volunteer helpers during crisis and disaster situations. Both articles are part of an on-going design science study aimed at providing a technical artefact to connect unaffiliated disaster volunteers and official relief organisations in disaster relief activities. Thus, the articles provide a design-oriented approach to manage the collective dynamics of digitally enabled social networks. Article IX presents the design of the artefact, while Article X is dedicated to its planned evaluation. The first article was presented as a research-in-progress paper at the International Conference on Information Systems in 2016. The second was presented at the International Conference on Design Science Research in Information Systems and Technology in 2017, where it received the award for best research-in-progress paper. This summary presents the results of both papers together.

Article IX. Sobiegalla, F., Posegga, O., & Fischbach, K. (2016). *Connecting Disaster Volunteers and Relief Organizations: A Design Science Approach*. In: Proceedings of the International Conference on Information Systems (ICIS), Dublin, Ireland.

Article X. Sobiegalla, F., Posegga, O., & Fischbach, K. (2017). *Evaluating a Mobile Crisis Response System for the Management of Disaster Volunteers*. In: Proceedings of the International Conference on Design Science Research in Information Systems and Technology (DESRIST), Karlsruhe, Germany

Motivation. Disaster relief organisations increasingly find themselves confronted by the growing frequency of man-made crises (Coleman, 2006) and with a scarcity of paid relief workers (Sargisson et al., 2012). Disaster volunteers who participate voluntarily in disaster relief activities play an important role in coping with crisis situations. However, along with the benefits comes the challenge of managing efficiently volunteers not officially associated with relief organisations. We refer to these individuals as unaffiliated disaster volunteers; they are autonomous and erratic in nature and form self-organised, ad-hoc groups. Relief organisations involved in our study observed an increasing occurrence of this type of disaster volunteering during long-term crises.

Several communication, coordination, and organisational issues hamper the deployment of disaster volunteers (Sargisson et al., 2012). For example, poor communication is likely to lead to counterproductive relief

attempts. In addition, a lack of information about existing social structures and organisational processes interferes with and hinders the efforts of relief organisations. Furthermore, a high degree of volatility in the availability of disaster volunteers sometimes results in work being left undone without notice. Thus, there is room to improve cooperation between professionals and volunteers with respect to effectiveness and efficiency.

Goal. The goal of this research project is to resolve some of the issues that arise from unaffiliated disaster volunteers by connecting them to official relief organisations through a technical platform—namely, a mobile crisis response system (MCRS) that will enable organising and managing these volunteers during crisis response and disaster relief activities. This study aims to not only provide a technical solution but to understand how the design of the solution affects the collective dynamics emerging between official relief organisations and unaffiliated volunteers.

Approach. In developing the MCRS, we followed the design science approach (Peffers et al., 2007; Von Alan et al., 2004) and generated a conceptual design based on knowledge drawn from theoretical and practical sources. The first research-in-progress paper (article IX) covers the first four phases introduced by Peffers et al. (2007): problem identification and motivation, objectives of a solution, design and development, and demonstration. The second research-in-progress paper (article X) covers the preparation for the evaluation phase, which will, after completion, be followed by the communication phase.

The goal of the problem identification and motivation phase is to formulate a motivation to justify the value of a solution, provide a clear definition of the problem, and limit the study's scope. In this phase, we primarily followed a problem-driven approach and conducted open interviews (King & Horrocks, 2010) and expert workshops (Alexander & Beus-Dukic, 2009, p.476) with official representatives from three of the largest relief organisations in Germany (German Red Cross, Johanniter-Unfall-Hilfe, Arbeiter-Samariter-Bund) to investigate the challenges that arise in coordinating volunteer helpers in the context of the refugee crisis in Germany. This approach has enabled us to develop a clear understanding of the problem and secure stakeholder support throughout the design process in an early stage of the research project. As a result, we defined the problem addressed in this research as follows: There is neither an organisational nor a technological nexus between unaffiliated disaster volunteers and relief organisations, which leads to several challenges with respect to information management, coordination, and motivation.

In the second phase, we aim to determine the objectives of a solution for the specified problem to define what is necessary, possible, and feasible. To achieve this goal, we have followed a theory-driven approach and conducted a thoroughly reviewed related literature. In addition, we adopted a problem-driven approach and conducted a second round of interviews with stakeholders. In our literature review, we analysed research on existing crisis response system solutions to identify their limitations and potential challenges for our own approach. We used the results and findings to refine the idea of an adequate software solution. We next conducted semi-structured telephone interviews using open-ended questions to develop the conceptual MCRS design (King & Horrocks, 2010). We invited participants from three stakeholder groups: relief organisation employees, divided into management and field experts, and unaffiliated disaster volunteers. The interviews provided us with practical expert knowledge and supplementary insights about users' motivations to adopt a corresponding software solution, and also identified potential obstacles that might prevent its use.

Based on these results, we entered the design and development phase, in which we derived design requirements from the previously collected material by means of descriptive and interpretive coding, which resulted

in the definition of overarching themes that provided the foundation for defining functional and non-functional requirements (King & Horrocks, 2010). Based on these requirements, we developed a functional prototype, which we presented to a diverse audience in the demonstration phase to prove its suitability to solve one or more aspects of the problem. Feedback from several prototype demonstrations of our design laid the foundation for the remaining phases: a rigorous demonstration and evaluation of our design and the communication of our findings, planned in Article X and briefly described along with the other results below.

Results. We derived seven design requirements by integrating the overarching themes identified. We then translated these requirements into three general design principles that describe the main functions of the conceptualised system in a generic and abstract manner: improve information management, improve coordination, and maintain engagement. We mapped these principles to thirteen concrete design features—eight functional design features (FDFs) and five non-functional design features (NFDFs)—that would eventually constitute specific ways to implement a design principle in an actual artefact. The FDFs are: collect unaffiliated disaster volunteers' data (FDF 1); provide crisis-related information to unaffiliated disaster volunteers (FDF 2); provide key performance indicators on volunteer activities to relief organisations (FDF 3); enable data aggregation for analysis (FDF 4); enable the creation of tasks for relief workers to call for support (FDF 5); provide a matching process to recommend tasks to unaffiliated disaster volunteers depending on their skills and qualifications (FDF 6); enable directed communication in the form of task-related message boards (FDF 7); and enable broadcast communication in the form of mission-wide notifications and news provided by heads of operations (FDF 8). The NFDFs are: establish different levels of unaffiliated disaster volunteer participation (NFDF 1); enable data privacy (NFDF 2); minimise complexity (NFDF 3); facilitate the provision of insurance to unaffiliated volunteers (NFDF 4); and utilise a personal approach (NFDF 5).

The core functions of the artefact to address the most important specified design features comprise: a simple registration process; a management interface to create, update, and delete crisis response activities offered to unaffiliated disaster volunteers; message boards to provide a central communication nexus for response activities; and news feeds to distribute official information provided by relief organisations. To improve the coordination of tasks and helpers, we further specify design features for an appropriate matching process that presents available crisis response activities to unaffiliated volunteers who meet potential requirements (e.g., possess a driver's license; have first aid skills). The matching system provides unaffiliated disaster volunteers access to crisis response activities based on their preferences and qualifications. Further, it enables relief workers to prioritise specific activities by recommending them manually to individual volunteers. In addition, we propose features to motivate unaffiliated disaster volunteers during their involvement, such as a low entry threshold for new users, data privacy, and low complexity. We implemented the MCRS prototype as a responsive web application and went through several refining iterations based on feedback obtained during the demonstration phase.

To design the evaluation, we applied the four-step DSR (Design Science Research) evaluation research design method proposed by Venable et al. (2012). We plan to conduct a field experiment (Gerber & Green, 2012) to assess the system's quality. The experiment is based on a joint mission exercise that will be performed by the relief organisations involved. During the exercise, the relief organisations will simulate a crisis scenario, under realistic conditions, derived from a real natural disaster that took place in a medium-size German city in 2013. Within the limits of this mission exercise, we suggest an adjusted post-test only/control group design (Field & Hole, 2002). Accordingly, we will divide the experiment between two independent groups: the control group and the treatment group. Both will perform the same tasks with the same resources. The control group

will manage unaffiliated disaster volunteers based on the traditional approach—oral communication—while the treatment group will use the MCRS prototype. We use an adaption of the Enterprise Systems Success Model (Sedera & Gable, 2004) to evaluate the success of our MCRS based a survey and guided interviews, both of which will be conducted immediately after the mission exercise. If we can successfully test the appropriateness of the artefact for the problem identified, we can move to the last step of the design study—that is, the communication of our results.

Research Question 3

The articles summarised in the following contribute to the third research question: How can digital trace data be used to understand and explain the collective dynamics of digitally enabled social networks? While they differ in their research design, the five articles comprising this section share in common that they provide methodological contributions. The first two articles discussed here, articles XI and XII, provide a critical perspective on the use of digital trace data using methodological approaches grounded in social network analysis and network theory. Article XIII provides an empirical contribution and explores a novel method grounded in social network analysis based on digital trace data from a large social media network to derive an industry classification. The last two articles provide empirical contributions that reflect critically upon the use of digital trace data in public opinion research. Both studies were conducted in a larger project in the context of the 2013 German federal election campaign. Article XIV investigates how the public and the mass media agenda observed before the election diverge from the salient topics discussed in social media networks at the same time. Article XV investigates critically the relationship between traditional methods of public opinion research (i.e., opinion polls) and more recent approaches based on digital trace data and discusses the challenges and opportunities that arise in this context.

Contributions of Article XI and XII

The Articles XI and XII contribute to the third research question by investigating methodological approaches to research on the collective dynamics of digitally enabled social networks. Article XI is a brief commentary on the challenges and opportunities of using digital trace data in network analysis, which emphasizes the sociotechnical nature of digitally enabled social networks. Article XII follows the line of argument summarised in the first paper and provides a critical review of information systems research on digitally enabled social networks with regards to their characteristics as outlined at the beginning of this article. The first article has been published along with a series of commentaries on the state of the art of social network research in the journal Soziologie and has been presented at the annual meeting of the Deutsche Gesellschaft für Soziologie in 2016. The second article is an unpublished working paper, which is planned to be submitted to the Journal of the Association for Information Systems in Fall 2017. Both articles are presented together, as they are part of the same study and highlight different aspects of the same line of argument.

Article XI. Posegga, O., & Fischbach, K. (2017). *Soziotechnische Netzwerke und Digitale Spurendaten.* Soziologie, 46(1), 54-57.

Article XII. Posegga, O. (2017). *Social Network Analysis in Information Systems Research.* Working Paper.

Motivation. Research on social networks has gained a considerable amount of interdisciplinary attention over the past decades and has even been described as a twenty-first-century science (Kleinberg, 2008; D. J.

Watts, 2007). One of the reasons for this is the growing success and pervasiveness of interactive information and communication technologies, which play an important role in organisations, everyday life, and society in general (Agarwal et al., 2008; Oinas-Kukkonen et al., 2010; Winter et al., 2014). While research on social networks has been subject to information systems research long before the rise of social media (e.g. Aydin & Rice, 1991; Rice, 1994; Stein, 1992), the impact of social media has led information systems scholars to develop a growing interest in the topic (Berger, Klier, Klier, & Probst, 2014; Cao et al., 2015; Kane et al., 2014). In contrast to the disciplines social network analysis emerged from, however, information systems research is concerned with digitally enabled social networks rather than social networks. Such systems are not exclusively comprised of social actors and their interactions, but also of the technological artefacts that afford and mediate their access to other actors and information (Kane et al., 2014). Social network analysis and most network theories have not been developed for such systems, as is indicated by the fact that fundamental introduction to social network analysis provided by Wasserman and Faust (1994) does not even mention the role of technology in network research beyond its capability of enabling the computational analysis of networks. The ubiquity of modern information and communication technologies, however, makes it increasingly difficult to distinguish social interactions from interactions between individuals and technology (N. S. Contractor et al., 2011; Lyytinen & Yoo, 2002). With the increasing maturity of theoretical foundations and methodological approaches that account for the entanglement of social interactions and technological artefacts, scholars have begun to revisit the foundations of network research on sociotechnical systems (N. S. Contractor et al., 2011; Howison et al., 2011; Kane et al., 2014).

Goal. In the light of the above, we aim to investigate how information systems research has used social network analysis and how it has adapted its methods and techniques to account for the specific characteristics of digitally enabled social networks with an emphasis on their sociotechnical nature. Thus, we pose the following research question: *"What role does technology play in social network analysis in information systems research?"*

Approach. To answer the question posed above, we develop an analytical based on the work of Sarker et al. (2013), who introduce the notion of a study's anatomical components, which they describe in terms of its research focus, up-front theory, methodology, and contributions. The first component, i.e. the research focus, refers to the fundamental research questions raised by a study as well as to its general goal and the causal mechanisms investigated in its pursuit. We rely on the framework provided by Borgatti and Foster (2003) to guide our investigation of the goals and mechanisms social network analysis studies in information research focus on and thus distinguish between the explanatory goals and the explanatory mechanisms investigated in network research. The second component, i.e. up-front theory, refers to network theories that are used in conjunction with methods, techniques, and measures borrowed from social network analysis. The third component, i.e. methodology, refers to a study's general research strategy. In network research, this involves a chain of interdependent assumptions ranging from the collection of network data over the modelling of network structures to their analysis and interpretation. The last anatomical component refers to the contribution of a study. For each component, we discuss how the role of technology and the sociotechnical nature of digitally enabled social networks are considered.

Results. We summarise the findings of our analysis in four key points. First, we find that contemporary approaches to social network analysis and network theory do not necessarily account for the specific characteristics of digitally enabled social networks. The theories and methods of traditional network research have often been devised for social systems and do not account for the characteristics of digitally enabled social

networks, which are sociotechnical systems. Thus, novel theorising and the development of methods that account for the characteristics of sociotechnical systems are interesting starting points for future research. Second, traditional social network analysis is based on an ontology that has been devised for social systems and is thus limited in its capability to represent sociotechnical systems. Accordingly, following contemporary approaches to revisit the ontological foundations of network research on digitally enabled social networks are promising avenues for future research. Third, we point out a need for future research on the dynamics of digitally enabled social networks that accounts for the sociotechnical processes governing such systems. Finally, we discuss some of the shortcomings of digital trace data, which provide unprecedented opportunities for network research, but might require the development of novel methods to fully realise their potential.

Contribution of Article XIII

Article XIII is the result of an empirical study that exploits digital trace data on employee turnover in an explorative approach to derive an industry classification system. The paper was presented at the Annual Meeting of the Academy of Management in 2014 and contributes to the third research question by exploring the capabilities of digital trace data, resulting in a novel approach to industry classification.

Article XIII. Spiegel, O., Abbassi, P., Zylka, M. P., Posegga, O., Fischbach, K., Schlagwein, D., & Schoder, D. (2014). *Getting Boundary Conditions Right: Towards a Classification of the Information Economy Sectors*. In: Proceedings of the Academy of Management Proceedings.

Motivation. Chiasson and Davidson (2005) reviewed research articles published in *MIS Quarterly* (MISQ) and *Information Systems Research* (ISR) between 1997 and 2004 and found that most (58%) of the studies they analysed did not identify the industry in which the study was conducted. They noted: '[I]ndustry provides an important contextual "space" to build new IS theory and to evaluate the boundaries of existing IS theory' (Chiasson & Davidson, 2005). A review a few years later by Seddon and Scheepers (2012) of all articles published in *MISQ* and *ISR* in 2007 and 2008 found that only 24% of the empirical papers discussed the boundary conditions that applied to their results.

Neglecting industry context can have a serious effect on research results by underspecifying theory or by leading to general explanations that do not hold in other contexts (Chiasson & Davidson, 2005). 'Identifying individuals, groups, and organisations that are members of an industry is an empirical, as well as a conceptual, issue' (Chiasson & Davidson, 2005). While high-level industry categories such as 'manufacturing' or 'service sector' are more appropriate for meta-analyses, more granular government classification schemes may be useful to define industry boundaries (Chiasson & Davidson, 2005). For instance, Xue et al. (2011) use the North American Industry Classification System (NAICS) to measure business unrelatedness between headquarters and business units as a function of differences in industry codes. The statistical tests in these sorts of studies, which rely on classification systems such as International Standard Industrial Classification (ISIC) or NAICS, are, however, valid only to the degree the underlying classification system is valid. Industry classifications such as ISIC define industries by similar production processes, similar products, or similar behaviour in financial markets. These approaches are imperfect, and companies get lumped into sectors as though they do only one thing (Karmarkar & Apte, 2007). The challenge of coming up with a narrow definition of IS-based industries is complicated by the pervasiveness of Information and Communication Technology (ICT) in other industries and the so-called 'convergence' of technology and industries (e.g. Garcia-Murillo & MacInnes, 2003).

Goal. The goal of this paper is to explore a classification approach by combining employee mobility data and social network analysis to overcome some of the issues outlined above.

Approach. According to Crowston and Myers (2004) industries can be analysed from three different yet complementary research perspectives: economic, institutional, and social/cultural. While the economic perspective is most commonly taken in IS research, the other two offer several advantages. For instance, the social/cultural perspective focuses on social relationships, networks, and structures that can be built by patterns of interaction among people and organisations within an industry (Crowston & Myers, 2004). It includes employee mobility, recently identified as an interesting point of research from a social network analysis perspective: Collet and Hedström (2013) show that tie formation in inter-organisational networks generated by employee mobility are contingent upon the direction of past ties and that most of the knowledge exchange stemming from this mobility occurs on short sociometric distances. Employee mobility, furthermore, can be used to determine the existence of a cluster and the degree to which it functions as an industrial cluster.

Other than certain case-based economic geographical studies (A. Agrawal, Cockburn, & McHale, 2006; Martin & Sunley, 2003), no systematic attempts have been made to define industrial systems based on turnover flows (Eriksson & Lindgren, 2008). We use data on turnover flows collected from the social media platform LinkedIn, which offers such data in terms of the employment histories provided by its members. At the time of this study, LinkedIn provided this information in terms of aggregated flows of employees from one organisation to another. We used a snowball sampling approach to identify IS-related organisations and collected the turnover flows between 29,419 organisations. The data collection was completed in June 2012. We used this data to construct a network in which nodes represent organisations and the directed edges between them represent flows of employees weighted with the number of employees moving from one organisation to the other. To identify industry clusters based on this network structure, we used the community detection algorithm developed by Rosvall and Bergstrom (2008). It especially suited for large networks with weighted and directed ties and has performed very well in several benchmarking studies (Lancichinetti & Fortunato, 2009). By applying the algorithm to the turnover network, we are able to identify a hierarchy of clusters based on turnover flows. Since the algorithm tries to maximise the internal cohesion of those clusters, we expect them to reflect adequately the dynamics of employee movements, as described by Collet and Hedström (2013). We manually reviewed the resulting industry clusters at the two highest level of the revealed hierarchy and labelled them according to their composition.

Results. Overall, the algorithm identified 135 clusters on the first (root) level. However, the distribution has a long tail. The first 10 clusters account for 97.42% of the companies. The top 3 clusters show distinct patterns in the underlying classification. Cluster 1 consists primarily of companies in ICT-related classifications, and there are some companies related to the Internet sector. However, there is almost no trace of companies belonging to the Content and Media sector. On the contrary, Clusters 2 and 3 are almost purely characterised by the Content and Media sector. Surprisingly, in Cluster 3 there are also some companies related to the ICT sector. We investigated this further and found that this cluster also comprises companies at the interface with the Content and Media sector. For instance, there are companies that provide information services and access to content databases, as well as some computer software providers.

From a top-down perspective of characteristics of the Information Economy sectors based on OECD definitions and ISIC classification, we find there is much greater turnover within the Information Economy than with industries outside. In addition, the inbound and outbound flow of employees is almost balanced. Taking a closer look at industries and companies that exchange employees with the Information Economy, we find

there are considerable differences between the three sectors. Most interesting, the analysis of the top 10 sources for employees reveals some characteristics: the ICT sector receives employees from outsourcing partners and the military; the Content and Media sector primarily from financial companies; and the Internet sector from universities and consulting firms. These differences between the sectors are found as well when looking at company size, type, and age. The Internet sector, for instance, has much smaller and younger companies that are predominantly privately held. Conversely, the ICT and Content and Media sectors have many more companies with more than 10,000 employees and significantly more public companies. Again, this reflects the different maturity levels of those sectors.

Looking more closely at the Information Economy sectors, we find that the industry is not as homogeneous as one might think, at least from a turnover perspective. First, in absolute terms, there is much more turnover within than across each of these sectors. This results in distinct industry clusters that are also visible in a network graph. The Internet sector is closely related to the ICT sector, but still clearly distinguishable, while the Content and Media sector is more an adjacent neighbour of the other two sectors. These clusters exist not only on a sector level, but some unique sub-sectors can also be identified and located. The ICT sector itself consists of some local clusters, including network equipment, semiconductors, services (consulting and outsourcing), and software and platforms. The video game industry subsection plays an interesting role in connecting companies in the Content and Media sector with companies in the ICT sector.

Another important finding is that we can identify companies that bridge several subsections. Thomson Reuters and Electronic Arts are prominent examples. Thomson Reuters links four different subsections. It is essential for multinational information and media firms to attract employees from different sectors to gain competitive advantages over its rivals. The detailed analysis of the composition of the sub-clusters and the flows between them is presented in the paper.

In summary, our approach provides promising insights into the structure of the network emerging from the analysed organisations and their turnover relationships, illustrating a novel approach to using digital trace data in IS research.

Contribution of Article XIV

Article XIV is the result of an empirical study that contributes to Research Question 3 by investigating how the public and the mass media agenda observed before the election diverges from the salient topics discussed in social media networks at the same time. The study was conducted in the context of the 2013 German federal election campaign. The resulting paper was submitted to the *International Journal of Public Opinion Research* in 2015 and dropped out of the peer review process after two rounds in 2017. While it is currently under revision and being prepared for a submission to the journal *New Media & Society*, the version included here is the working paper, which represents the final version submitted to the *International Journal of Public Opinion Research*.

Article XIV. Jungherr, A., Posegga, O., Schoen, H., & Jürgens, P. (2017). *Characterizing Political Talk on Twitter: A Comparison Between Public Agenda, Media Agendas, and the Twitter Agenda with Regard to Topics and Dynamics.* Unpublished working paper in preparation for resubmission after two rounds of review in the International Journal of Public Opinion Research.

Motivation. The microblogging service Twitter has developed into a very prominent space for political discourse. Since the 2008 U.S. presidential election, political campaigns all over the world have found an uptick in Twitter messages commenting on candidates, parties, campaigns, and politics in general (see Jungherr, 2015). The same holds for collective action (e.g. Bastos et al. 2015; Theocharis et al., 2015). This development has made Twitter a new space in which public political discourse in the form of tweets posted by users referring to politics affords insights which topics, actors, content, or arguments to which politically vocal Twitter users pay attention, with which they interact, and on which they comment. As a text-based online service, Twitter permits researchers to measure these objects of political attention and thereby develop a ranked list of topics and actors that were at any given time the focus of politically vocal Twitter-users—a Twitter agenda, if you like.

While the availability of Twitter data makes it trivially easy to determine a Twitter agenda, it is much more difficult to interpret such an agenda. Traditionally, communication research has considered an agenda to be an ordered list of 'topics the media and public are paying attention to and regard as important', but also has been interested in and 'how the media and public perceive and understand the details of these topics' (McCombs, 2014, p. xiii). Twitter's skewed user base—unrepresentative of the general population—and its data generating process as a microblogging service make it highly unlikely for Twitter data to offer a valid approach for identifying public or media agendas. Instead, it appears more likely that Twitter allows a specific view of political topics, actors, or content that politically vocal Twitter users want to be publicly perceived as interacting with. As such, measuring and analysing Twitter agendas potentially enables us to get more detailed insights into the hybrid media system (Chadwick, 2013)—the increasingly complicated interactions between public opinion, political media coverage, and online content—than traditional, survey-based research allows.

In this paper, we lay the groundwork for such a deeper analysis by examining closely the agenda emerging from political discourse on Twitter. We posit three potential scenarios: (1) The Twitter agenda may mirror the public agenda; (2) the Twitter agenda may reflect the media agenda; and/or (3) the Twitter agenda may follow channel-specific patterns, interconnected with but not determined by public and media agendas. In this paper, we argue that the last option is the most likely one.

Goal. The goal of the paper is to establish how a Twitter agenda could be modelled from digital trace data obtained from Twitter and to establish which of the three scenarios outlined above is the one to which that agenda corresponds.

Approach. Before we can compare issue agendas across media, we have to identify salient topics in the public's mind, in mainstream media, and on Twitter. This study was conducted in the context of the 2013 German federal election campaign. More specifically, we focused on the last stages of the campaigning phase, that is, the last two months before the election. We used panel data from the German Longitudinal Election Study (GLES) to establish the public and mass media agendas. With respect to the former, the GLES provides the results of a CATI survey (Rattinger et al., 2014) in which respondents were asked to identify the two most pressing political problems in Germany. To identify the media agenda, we used two publicly available datasets provided by the GLES documenting political coverage in newspapers and on television. Both datasets are offered in the same hand-coded format, which uses a four-digit coding scheme to classify salient topics.

To establish a Twitter agenda, we collected politically relevant messages posted during the campaign through the social-media data vendor Gnip. The complex data collection process, which is documented in the

paper, resulted in 1,390,571 messages posted by 98,149 German-speaking users during our observation period (July 8 to September 21, 2013). We identified salient topics connected to hashtags, which are widely used on Twitter to establish the topical context for a message (Jungherr, 2015), and focused on the top 1,000 most often used politically relevant hashtags. We coded the hashtags according to their political context based on the GLES coding scheme (i.e., aspects of the campaign, political issues, political television programs, or other topics). We then aggregated the usage count for the hashtags in each category and calculated its mention share to establish its relative salience.

Results. We find that 34.5% of all mentions of the identified hashtags are related to comments on political parties, while 17.5% referred to mass media, 16.5% referred to aspects of the campaign, and 11.2% mentioned candidates, while only 10.4% referred to political issues. This very rough sketch of political Twitter activity shows that politically relevant messages focused predominantly on parties and were reactions to political television programs. Political issues were much less prominent.

When directly comparing the 10 most prominent topics on all four agendas, we find much variance. The public agenda is dominated by worries about the financial and Euro crisis, unemployment, education, and labour policy. In contrast, the newspaper agenda is dominated by the coverage of the NSA spying scandal, various international crises, the financial and the Euro crisis, and Germany's energy supply after phasing out nuclear power. The television agenda is also dominated by the coverage of international crises and the NSA scandal. Transport policy and defence are next on the list. The Twitter agenda focuses on comments on the NSA scandal, issues of data retention by the state, data protection, and data privacy, transport policy, and interior policy in general. It is also important to note that the Twitter agenda appears to be much more focused on one topic than the other agendas. Examining the topics prominent on the Twitter agenda also shows that internet-related issues made up nearly half of all issue mentions. This pattern supports the notion that Twitter offers a view of political reality mediated by the interests of politically vocal Twitter users (Jungherr, 2015; Jungherr et al, 2016).

In total, 48 issues emerged in coding the four agendas in question. Calculating the correlations between the mention shares these 48 issue categories had on the respective agendas allows us to assess the interconnection between the public agenda, the newspaper agenda, the television agenda, and the Twitter agenda. The public agenda is only very weakly correlated with the newspaper agenda, the television agenda, and the Twitter agenda. Unsurprisingly, the newspaper and the television agendas are highly correlated. The Twitter agenda also appears to be correlated with the newspaper and television agendas, albeit weaker than both media agendas are correlated to each other.

These findings clearly support scenario three. The agenda emerging from political talk on Twitter shows hardly any relationship to the public agenda as measured by surveys. The Twitter agenda is moderately correlated with the newspaper and television agendas. This supports findings that show political talk on Twitter to be highly reactive to media coverage but also as following channel-specific patterns with respect to the topics emphasised and ignored on Twitter. In this case, the Twitter agenda was dominated by topics of specific interest to Twitter users (NSA, data retention, data protection, privacy, and internet policy) and topics allowing for controversy and ridicule (transport policy/infrastructure). We conclude that this raises serious concerns for attempts at using Twitter as a regular tool to assess public opinion (e.g., Murphy et al., 2014).

Contribution of Article XV

Article XV is the result of an empirical study that investigates the relationship between traditional methods of public opinion research (i.e., opinion polls) and similar approaches based on digital trace data and discusses the challenges and opportunities that arise in this context. It contributes to the third research question by investigating the opportunities and limitations provided by digital trace data emerging from digitally enabled social networks in the context of public opinion research. The paper was published in the *Social Science Computer Review*.

Article XV. Jungherr, A., Schoen, H., Posegga, O., & Jürgens, P. (2016). *Digital Trace Data in the Study of Public Opinion.* Social Science Computer Review, 35(3), 336-356.

Motivation. The use of digital tools in the context of a growing number of social activities has provided scientists with a new reservoir of data documenting various aspects of social life (e.g., D. Lazer et al., 2009). Recently, researchers have attempted to unlock the potential of digital trace data—data produced by people while interacting with digital services (e.g. Howison et al., 2011)—in the study of public opinion (e.g. Murphy et al., 2014). Here, researchers focused predominantly on using data collected on Twitter either to infer current levels of support toward political actors or to predict their support in upcoming elections (cf. Gayo-Avello, 2013). The seeming success in linking Twitter data to metrics of political support has even led some scholars to suggest replacing or supplementing traditional survey-based techniques with social media–based strategies (e.g. Bermingham & Smeaton, 2011; Ceron, Curini, & Iacus, 2015; Ceron et al., 2014; Franch, 2013; O'Connor et al., 2010; Sang & Bos, 2012; Thapen & Ghanem, 2013; Tumasjan et al., 2010).

In this article, we present evidence that the prospects of measuring political support through Twitter are highly unlikely to materialise and that the literature is very likely falling victim to a classic fallacy in the social sciences: using a quantitative indicator (Twitter-based metrics) to draw inferences on a latent target concept (political support) but instead measuring another concept (attention to politics) that sometimes, but far from always, may be correlated with the target concept of interest. This mistake arises through the insufficient testing of indicator validity (cf. Adcock, 2001; Hand, 2004).

Goal. In light of the above, the goal of this paper is to investigate the validity of Twitter-based metrics as indicators of political attention and political support of candidates and parties.

Approach. In this study, we focus on political support and Twitter mentions of political actors during the 2013 German federal election campaign. We investigate the relationship between popular Twitter metrics and two different target concepts of political support based on popular approaches—forecasting and nowcasting—in the field. The first approach aims at predicting future election results (e.g. Bermingham & Smeaton, 2011; Fink et al., 2013; Franch, 2013; Tumasjan et al., 2010). In the second approach, scholars focus on correlations between Twitter-based time series and opinion polls (e.g., Contractor & Faruquie, 2013; Fink et al., 2013; Thapen & Ghanem, 2013). Irrespective of target concepts, previous research utilised various Twitter metrics that are based on mentions of political actors and political parties as well as the sentiment of those mentions.

To investigate the validity of Twitter metrics in both approaches, we use data collected from Twitter and publicly available data on opinion polls and the actual election outcomes. With respect to Twitter data, we relied on the Gnip, a vendor of social media data. The complex data collection process, which is documented

in the paper, resulted in 1,390,571 messages posted by 98,149 German-speaking users during our observation period (July 8 to September 21, 2013). The dataset used in this study is identical to the one described in article XIV.

To compute Twitter-metrics that are frequently used in the two approaches described above, we extracted all mentions of eight political parties in Germany (CDU, CSU, SPD, Die LINKE, Bündnis 90/Die Grünen, FDP, AfD, and Piratenpartei). We then counted each message that included at least one character string related to a specific actor as one mention of that actor. We aggregated all mention counts of these concepts for each day between July 1 and September 22. Further, we decided to test three different measures of sentiment. First, we hand coded 1% of all party mentions in key words or hashtags, excluding retweets (6,479 tweets), with regards to their negative, neutral, or positive sentiment toward the mentioned party. Second, we used the Hopkins/King approach to automated content analysis (Hopkins & King, 2010), which has been used by earlier researchers to identify sentiment in political tweets (Ceron et al., 2015; Ceron et al., 2014). Third, we analysed hashtags that German Twitter users employed to identify the valence of a tweet toward a mentioned party. These hashtags consist of a party's name followed by a '+' or a '–' (e.g., #cdu+ or #cdu-). A comprehensive discussion of those decisions is provided in the article. One way to assess the validity of an indicator in measuring a latent concept is by comparing it with established measures (cf. Adcock, 2001).

With regard to political support, two comparative metrics offer themselves: official election results and results from opinion polls. To assess election results, we use the number of votes each party received, as reported by the Bundeswahlleiter (http://www.bundeswahlleiter.de). We collected results of opinion polls on the website Wahlen, Wahlrecht und Wahlsysteme (http://www.wahlrecht.de). We included polls with field times between July 1 and September 22 published by seven different institutes: Forsa, Forschungsgruppe Wahlen, Gesellschaft für Markt- und Sozialforschung (GMS), Infratest dimap, INSA-Consulere (INSA)-Meinungstrend, Institut für Demoskopie Allensbach, and TNS Emnid. As a baseline for nowcasting, we assigned the published results to the respective field periods.

Results. In our analysis of forecasting based on Twitter metrics, we compare seven Twitter metrics of parties with their respective vote shares. The results suggest that the overall validity of Twitter mentions as indicators of political support expressed in votes is rather poor. Using the share of users mentioning a party—as suggested, for example, by Sang and Bos (2012)—would have led researchers to overestimate the results for all parties. Users regularly mentioned more than one party in their tweets, thus rendering metrics based on comparing shares of users mentioning a party a dubious information source, as they tend to overestimate significantly the relative importance of political actors offline.

Measurements based on aggregates of mention or hashtag counts also performed poorly. As the differences between shares in keyword and hashtag mentions of all party mentions and actual vote share indicate, keyword mentions exaggerated the vote shares of the parties FDP, Die LINKE, Piratenpartei, and the AfD, while underestimating the vote shares of the CDU/CSU and the SPD'. Measurements based on positive sentiment toward a party fail as well. This is true for all three sentiment measures we tested. Again, this approach leads to a massive overestimation of support for the AfD and the Pirates while significantly underestimating levels of support for CDU and SPD. Thus, including various sentiment measures does not improve the Twitter-based measurement of the result of the 2013 election.

As for nowcasting, we compare daily levels in Twitter metrics with opinion poll results, an established indicator of political support. The analysis focuses on time series of mention shares (key words and hashtags). Given the overestimation of vote shares based on shares of users mentioning a party, we excluded these metrics from this analysis. Starting with the variance of the time series of Twitter metrics and opinion polls, we find a striking difference. The opinion polls vary mildly over time, whereas Twitter metrics exhibit considerable variation. Accordingly, the time series appear to follow different dynamics. This pattern suggests that the time series of Twitter metrics and opinion polls are unlikely to be strongly correlated. Our results suggest there is no systematic relationship between Twitter-based metrics and opinion polls, irrespective of the assumptions concerning the temporal and causal relationship. Hence, relying on Twitter as an indicator of the evolution of party support in the 2013 election campaign on a day-to-day basis would have led to flawed conclusions.

Further analyses suggest that mention levels of political parties were largely driven by public attention to politics; in particular, media appearances of leading candidates, controversies, and public debate seem to have played a considerable role. The evidence suggests that Twitter mention shares fluctuate because of various underlying phenomena that appear to be related to public attention toward politics but none of them related to political support.

Based on these dynamics, it is doubtful to expect that in the 2013 German federal election campaign Twitter metrics of political parties mirrored their electoral fortunes or trends in public opinion polls. If anything, Twitter metrics appear to have reflected public attention to a given party, though even in this respect they are not a perfect indicator. More generally, our analysis suggests that the debate about links between Twitter metrics and political phenomena revolves around theoretical issues concerning data-generating processes. Future research may be well advised to focus on theoretical underpinnings rather than exclusively on empirical findings.

Conclusion

This thesis contributes to the understanding of the role technology plays in understanding and managing the collective dynamics of digitally enabled social networks. I reviewed three different approaches to studying collective dynamics, which span the natural and social sciences. This review suggests that these approaches differ significantly in their conceptual understanding of collective dynamics, but share a common interest in understanding the emergent phenomena of networked systems. Building on this common ground, I have provided a conceptual foundation for the research on collective dynamics presented in this thesis. Further, I provided a conceptualisation of digitally enabled social networks, that is, social networks (partially) enabled by interactive technologies. I contrasted the characteristics of such networks with those typical for traditionally investigated social networks and derived three research questions from the findings:

RQ1 What role does technology play in enabling novel phenomena that emerge from the collective dynamics of digitally enabled social networks?

RQ2 What role does technology play in managing the collective dynamics of digitally enabled social networks?

RQ3 How can digital trace data be used to understand and explain the collective dynamics of digitally enabled social networks?

The fifteen papers presented in this dissertation offer interdisciplinary contributions to all three research questions. Five of the studies investigate collective dynamics of digitally enabled social networks on a fundamental level; four reside within the domain of organisational research; four studies are related to phenomena that arise in the context of crisis management; and two are concerned with public opinion research.

With respect to the first research question, we analysed the collective dynamics of digitally enabled social networks from a structural perspective by investigating the process of link formation in a large German social media network comprising more than 9 million users and their interactions (Article I). The research provides evidence that the link formation process is influenced by social features that allow the creation of static relationships rather than interaction-based features. Further, we find that some of the link formation processes assumed by reductionist approaches to modelling the emergence of complex systems (e.g., preferential attachment) cannot be confirmed by our data. Further, we investigated the emergence of data and information quality in digitally enabled social networks.

Based on a comprehensive literature review, we revealed that traditional conceptualisations of data and information quality are inadequate in the context of digitally enabled social networks, as they have not been designed with their characteristics in mind (Article II and III). Further, we investigate the collective dynamics of two organisational networks. First, in a comprehensive study on a crowdfunding platform, we characterise the digitally enabled network arising from it as a two-sided marketplace and reveal its structural mechanisms using stochastic actor-based modelling (Article IV). Second, we investigate the group dynamics of teams in a large financial institution in a longitudinal network study (Article V). Our results provide evidence for an inverted u-shaped relationship between group boundary spanning behaviour and group performance, which we discuss in the light of technology-enabled forms of organisation enabling such behaviour.

Two of the studies contributing to this research question were conducted in the context of crisis management. The first study provides a conceptual framework for collective behaviour in social media networks and establishes the state of the art with respect to this line of research (Article VI). The findings are summarised along seven key aspects and emphasise the role technology plays in enabling collective dynamics of digitally enabled social networks in the context of crisis situations. Similarly, the second article investigates social, organisational, and technological communication barriers in crisis situations based on a literature review. The results show several benefits of technologies enabling inter- and intra-organisational networks in crisis communication, but also point towards difficulties that arise in the case of failure.

As for the second research question, we provide contributions from two lines of research. The first paper in this category provides a framework and structured review of internal crowdsourcing (Article VIII). In this study, we provide a conceptualization of a novel form of inter-organisational organising based on the technology-driven formation and management of crowds that resolves specific types of organisational problems. The second line of research contributing to this research question is represented by a design science study that aims to develop and test a technical artefact to manage unaffiliated disaster volunteers. Early demonstrations of our design suggest that the technology provides for managing unaffiliated disaster volunteers with official relief organisations. Both lines of research emphasise the potential and value of the collective dynamics of crowds (in contrast to the negative image attributed to the phenomenon in historical research, e.g., Blumer, 1971; Le Bon, 1896) and discuss the importance of providing adequate environments and technologies to enable and manage them.

With respect to the third research question, the studies offer three different contributions. The first line of research investigates the methodological challenges of using network analysis and network theory in the context of digitally enabled social networks (Article XI and XII). The literature review conducted adopts a critical stance on network research conducted in the information systems community and offers guidelines to improve upon the current state of the art. The second line of research is represented by an empirical study that uses digital trace data on employee mobility and community detection algorithms to generate an industry classification of the information economy. This approach to using digital trace data emerging from digitally enabled social networks provides interesting insights into the information economy and represents an innovative and explorative approach to industry classification. The last line of research contributing to this research question resides within the domain of public opinion research. Research on public opinion, collective dynamics, and complex systems has a long history (cf. van Ginneken, 2003). With the success of social media platforms and other digitally enabled social networks that offer opportunities to observe the public mind, public opinion research has produced a plethora of approaches to utilise this digital trace data. Both papers dedicated to this line of research adopt a critical stance on some of those approaches. The first article investigates critically the use of digital trace data in research on public and mass media agendas (Article XIV). We compare salient topics in the public and mass media agenda as well as on Twitter during the 2013 German federal elections. Our findings support our hypotheses and provide evidence that issue salience on social media networks such as Twitter differs from issue salience in the mass media and public agenda. In the second study, we investigate the validity of metrics generated from digital trace data in now- and forecasting political support (Article XV). Based on an empirical investigation of polls and election forecasts during the 2013 German federal election using Twitter data, we find evidence that such metrics are indicators of political attention much more than they are indicators of political support. In conclusion, both studies highlight the opportunities provided by the availability of digital trace data, but point towards potential validity issues and other challenges arising from their use in the absence of a careful consideration of the underlying data generating processes, that is, the collective dynamics of digitally enabled social networks.

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Appendix

Appendix A.1: Paper I

Bibliographic data	Posegga, O., Fischbach, K., & Donath, M. (2014). Using Weighted Interaction Metrics for Link Prediction in a Large Online Social Network. In K. A. Zweig, W. Neuser, V. Pipkek, M. Rohde, & I. Scholtes (Eds.), *Socioinformatics - The Social Impact of Interactions between Humans and IT* (pp. 63-79). Cham, Switzerland: Springer International Publishing.
Abstract	There has been a considerable amount of recent research on the link prediction problem, that is, the problem of accurately predicting edges that will be established between actors in a social network in a future period. With the cooperation of the provider of a German social network site (SNS), we aim to contribute to this line of research by analyzing the link formation and interaction patterns of approximately 9.38 million members of one of the largest German online social networks (OSN). It is our goal to explore the value of users' interaction frequencies for link prediction based on metrics of local structural similarity. Analyzing a random sample of the network, we found that only a portion of the network is responsible for most of the activity observed: 42.64 % of the network's population account for all observed interactions and 25.33 % are responsible for all private communication. We have also established that the degree of recent interaction is positively correlated with imminent link formation – users with high interaction frequencies are more likely to establish new friendships. The evaluation of our link prediction approach yields results that are consistent with comparable studies. Traditional metrics seem to outperform weighted metrics that account for interaction frequencies. We conclude that while weighted metrics tend to predict strong ties, users of SNS establish both strong and weak ties. Our findings indicate that members of an SNS prefer quantity over quality in terms of establishing new connections. In our case, this causes the simplest metrics to perform best.
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Appendix A.2: Paper II

Bibliographic data	Tilly, R., Posegga, O., Fischbach, K., & Schoder, D. (2015). *What is Quality of Data and Information in Social Information Systems? Towards a Definition and Ontology.* In: Proceedings of the International Conference on Information Systems (ICIS). Fort Worth, TX.
Abstract	Data and information quality (DIQ) have been defined traditionally in an organizational context and with respect to traditional information systems (IS) as, for example, “fitness for use” of data or “intrinsic” DIQ. Numerous frameworks have been developed that operationalize traditional DIQ accordingly. However, over the last decade, social IS such as social media have emerged that enable social interaction and open collaboration of voluntary prosumers, rather than simply supporting specific tasks as do traditional IS in organizations. After reviewing the current definitions of DIQ, we conclude that these definitions do not capture DIQ in social IS well, nor how it is defined, maintained, and improved through social interaction. Hence, we propose a new definition of DIQ in social IS based on the notion of "matching" between dynamic, voluntary, and heterogeneous supply and demand of data/information. We illustrate our definition with an ontological framework and discuss its implications.
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What is Quality of Data and Information in Social Information Systems? Towards a Definition and Ontology

Completed Research Paper

Roman Tilly
University of Cologne
Pohligstraße 1
D-50969 Cologne
tilly@wim.uni-koeln.de

Oliver Posegga
University of Bamberg
An der Weberei 5
D-96052 Bamberg
oliver.posegga@uni-bamberg.de

Kai Fischbach
University of Bamberg
An der Weberei 5
D-96052 Bamberg
kai.fischbach@uni-bamberg.de

Detlef Schoder
University of Cologne
Pohligstraße 1
D-50969 Cologne
schoder@wim.uni-koeln.de

Abstract

Data and information quality (DIQ) have been defined traditionally in an organizational context and with respect to traditional information systems (IS) as, for example, "fitness for use" of data or "intrinsic" DIQ. Numerous frameworks have been developed that operationalize traditional DIQ accordingly. However, over the last decade, social IS such as social media have emerged that enable social interaction and open collaboration of voluntary prosumers, rather than simply supporting specific tasks as do traditional IS in organizations. After reviewing the current definitions of DIQ, we conclude that these definitions do not capture DIQ in social IS well, nor how it is defined, maintained, and improved through social interaction. Hence, we propose a new definition of DIQ in social IS based on the notion of "matching" between dynamic, voluntary, and heterogeneous supply and demand of data/information. We illustrate our definition with an ontological framework and discuss its implications.

Keywords: Social information systems; Social media; Data quality; Information quality; Ontology

Introduction

In 1992, *The Wall Street Journal* wrote, "Thanks to computers, huge databases brimming with information are at our fingertips, just waiting to be tapped. They can be mined to find sales prospects among existing customers; they can be analyzed to unearth costly corporate habits; they can be manipulated to divine future trends. Just one problem: Those huge databases may be full of junk." (cited after Wand and Wang (1996, pp. 86–87))

Replace "computers" with "social information systems" in the *Journal* quote, and it would sound quite familiar. This is especially the case now that social information systems (social IS) have become extremely successful in terms of user numbers and quantity of content, but are poorly understood with respect to data and information quality.

In essence, social IS "are information systems based on social technologies and open collaboration" (Schlagwein et al. 2011, p. 2). They include, for example, the various forms of social media. Many people use social IS to obtain and share general information, advice, or gossip, and for communication, entertainment, socializing, or political mobilizing (Kaplan and Haenlein 2010; Parameswaran and Whinston 2007a, 2007b; Schlagwein et al. 2011). Issues of data and information quality potentially affect all these aspects: Are users interested in and do they actually talk about the same phenomena? What motivates users to engage in social IS and to contribute content? Does the social medium allow producers of data to express their perceptions so consumers of data will understand what they meant? How can producers know what consumers are interested in so they can supply them with high-quality information? Who decides about data and information quality? These and other issues cannot necessarily be resolved successfully in social IS. For example, Denning and colleagues (2005) warned that developing an encyclopedia in an open and collaborative mode such as the Wikipedia project, rather than through the traditional editorial mode, might negatively affect quality of information. This has proven to be partly correct, depending the topic domains or dimensions of quality (Mesgari et al. 2015).

Given the past decades of research on data quality (DQ) and information quality (IQ) for traditional information systems (Lee et al. 2002; Madnick et al. 2009; Sadiq et al. 2011; Xiao et al. 2014)—including the important role of IQ for IS success (DeLone and McLean 1992, 2003; Petter et al. 2008)—one might assume that understanding issues of DQ/IQ in social IS is merely a question of transferring existing definitions, frameworks, and measures to a new domain. In fact, several approaches have aimed at applying traditional DQ/IQ concepts to social IS (for an overview, see Chai, Potdar, and Chang (2009); Chai, Potdar, and Dillon (2009); Mesgari et al. (2015)). Also, with respect to IS success, IQ has been included in applications of the DeLone-McLean-model (DeLone and McLean 1992, 2003) to explain the success of social IS such as corporate intranets (Barnes and Vidgen 2009), online communities (Lili and Rong 2013; Zheng et al. 2009), and social micro-blogging services (Ou et al. 2011).

However, in line with other scholars (Lukyanenko et al. 2014a; Lukyanenko and Parsons 2015), we argue that traditional definitions of DQ/IQ are inappropriate to capture fully the characteristics of social IS, presumably because those definitions have been developed for traditional IS in an organizational context. For example, traditional DQ and IQ are often defined in terms of "fitness for use," that is, whether data and information are fit to be used by data/information consumers (Ballou et al. 2003; Lukyanenko et al. 2014a; Madnick et al. 2009; Strong et al. 1997; Wang and Strong 1996; Zhu and Wu 2011). Since "use" of data/information is supposed to serve as a benchmark to assess the level of DQ/IQ, this conceptualization implies three aspects: (1) user, task, and context of data/information use are known; (2) data/information use is prioritized over data/information production; and (3) development and usage of the IS are controlled by an IS sponsor that can enforce prioritization according to use to achieve "fitness for use" of data/information. While "fitness for use" is thus well suited for an organizational, utilitarian context (Parsons and Wand 2014), we argue it is inappropriate for social IS with highly variable, non-enterprise, voluntary, informal uses; users that produce and consume data/information in social interaction; and a central sponsor with little (if any) control over content and how the social IS is used. Similar problems arise when confronting other DQ/IQ paradigms with the concept of social IS, namely, the "intrinsic" DQ paradigm (Orr 1998; Wand and Wang 1996), the semiotic framework of DIQ paradigms (Price and Shanks 2005; Shanks and Darke 1998), including its social DQ paradigm (Shanks and Corbitt 1999), or the strategic DIQ paradigm (van der Pijl 1994).

We use the distinctive characteristics of social IS as described by Schlagwein et al. (2011) to establish a comprehensive understanding of the issues that arise when applying the traditional DQ/IQ paradigms in the social IS context. We thereby identify quality issues related to data and information in social IS that need systematic examination. Hence, the aim of this study is first to develop definitions of DQ and IQ in social IS that abstract from specific uses (i.e., user, task, context) of data/information, and that equally include the perspectives of consumers and producers of information, henceforth referred to as "prosumers" (Toffler 1980). For that purpose, we propose to view DQ/IQ in social IS as "matching" demand and supply of information between prosumers. "Matching" is seen as a socio-technical process of interaction, communication, and negotiation between prosumers enabled and mediated by technological means through social software and data. Certain socio-technical mechanisms may help promote social interaction and matching. So, to increase matching is both a social and technological challenge. We discuss how DQ/IQ in social IS can be improved, based on the proposed notion of matching supply and demand. Further, our definition can provide a new angle to evaluate existing mechanisms and foster the design of new mechanisms. Hence, this study should improve the understanding of DQ/IQ in social IS and guide further systematic research into this and related topics such as social IS success.

The remainder of this article is organized as follows. In the next section we lay the groundwork for developing a new definition of social DQ/IQ by introducing definitions of traditional IS, traditional DQ/IQ, and social IS, and by contrasting traditional IS to social IS. In the third section, we describe the literature review we conducted to compile a comprehensive set of existing DQ/IQ paradigms. In the fourth section, we discuss and evaluate existing paradigms of DQ/IQ with respect to their applicability to social IS. Further, we present our new "matching" paradigm for DQ/IQ in social IS and propose the ontology of DQ/IQ in social IS. In the fifth section, we discuss how this new paradigm corresponds to the specific characteristics of social IS, and illustrate how the rather abstract paradigm can inform the design of mechanisms to promote DQ/IQ in social IS. The paper concludes with a short summary of our work as well as a discussion of limitations and areas for further research into DQ/IQ in social IS.

Related Work

Traditional IS, DQ, and IQ

Questions regarding the quality of data and information processed by IS are not new to IS research (Lee et al. 2002; Sadiq et al. 2011; Wand and Wang 1996; Wang and Strong 1996; Xiao et al. 2014). In fact, researchers and practitioners alike have undertaken several approaches to define, measure, and improve DQ and IQ (for an overview see, for example, Knight and Burn (2005); Lee et al. (2002); Madnick et al. (2009)). Hence, before we turn to a rather new family of IS—namely social IS—and propose a new definition of data and information quality specific to them, it is advisable to point out what we understand about traditional IS, DQ, and IQ.

We share the long-held view of IS as socio-technical systems (Boell and Cecez-Kecmanovic 2015; Lee 2010) comprising both social (humans and groups) and technical (hardware and software) parts that interact to generate, process, and store information and data. The "role of an information system is to provide a representation of an application domain (also termed the real-world system) as perceived by the user" (Wand and Wang 1996, pp. 87–88). With respect to traditional IS, we think of IS primarily in an organizational context in which the system is supposed to support certain users in performing certain tasks and thus "aim to provide instrumental value to the user" (van der Heijden 2004, p. 696). The nature of these IS are hence classified as utilitarian, in contrast to IS of a hedonic nature that "aim to provide self-fulfilling value to the user" (van der Heijden 2004, p. 696). Traditional IS entail various classes of IS such as transaction processing systems, management information systems, and decision support systems. Though these systems serve different purposes in an organization, they have in common that they retrieve, store, and process data that can be presented to human users (employees or customers) as information about real-world phenomena related to the organization, its activities, and its problems (Mason and Mitroff 1973).

The quality of data and information in traditional IS is an important aspect for organizations, especially with respect to their success (Lee et al. 2002; Madnick et al. 2009; Petter et al. 2008; Price and Shanks 2005). Though the ideas of DQ/IQ are intuitively comprehensible, defining them and establishing how they can be measured and managed has long been challenging and changing (Madnick et al. 2009; Wand

and Wang 1996). What makes it even more challenging and complicated is that studies dealing with DQ/IQ do not always differentiate between data and information and often do not share a similar understanding regarding these and other related terms (Kahn et al. 2002; Madnick et al. 2009; Price and Shanks 2005; Wand and Wang 1996). Hence, to advance the understanding of DQ/IQ to social IS requires first laying out our understanding of data and information as well as DQ and IQ in the context of traditional IS.

Basically, data are what are stored in a database and processed by an IS: signs that are used according to certain syntactical rules, are objective, and represent facts about relevant phenomena external to the IS, that is, in the real/physical world (English 1999; Price and Shanks 2005; Wand and Wang 1996). Data become information when a human user in an IS receives, perceives, and interprets data, puts them into context, and thus gives them a (subjective) meaning (English 1999; Glowalla and Sunyaev 2014; Price and Shanks 2005).

This distinction between data and information is also reflected in definitions of traditional DQ and IQ. A common definition of traditional DQ is the degree of integrity and correspondence of data to external phenomena, which comprises, for example, completeness, unambiguity, meaningfulness, and correctness (for example, in Orr (1998); Price and Shanks (2005); Wand and Wang (1996)). Conversely, a common definition of traditional IQ is "fitness for use," that is, the extent to which information can easily be perceived, interpreted, and applied to a task by the consumer of that information, based on data s/he receives (see, for example, Ballou et al. (2003); Madnick et al. (2009); Strong et al. (1997); Wang and Strong (1996)). This may include dimensions such as accessibility, suitability of presentation, understandability, security, and flexibility.

Both concepts, DQ and IQ, have a long history in IS research. IQ is an antecedent of use and user satisfaction (Doll and Torkzadeh 1988; Petter et al. 2008; Wixom and Todd 2005) and is included in the well-known DeLone-McLean-model of IS success (DeLone and McLean 1992, 2003). Further, several studies have taken on the idea of DQ and IQ as multidimensional concepts, yielding a plethora of DQ/IQ frameworks with overlapping sets of dimensions (for an overview, see Jayawardene et al. (2013); Knight and Burn (2005); Lee et al. (2002)). Corresponding to the "fitness for use" notion of DQ/IQ, which dimensions are relevant and which levels of quality should be attained depends on the use (Kahn et al. 2002; Lee et al. 2002). Also in line with "fitness for use" and the importance of DQ/IQ for IS success, development of traditional IS typically begins with an analysis of the users' information needs and other formal specifications (together referred to as "requirements") before an IS is designed and implemented to fulfill these requirements to the extent possible (Hirschheim et al. 1995; Lukyanenko et al. 2014a). Requirements are used in this process as benchmarks to define the required levels of DQ/IQ prior to IS development, and to evaluate DQ/IQ when the system is in use. Thus, a traditional IS is usually fitted to the users' requirements to achieve high levels of (traditional) DQ/IQ. While the focus of traditional IS is on the information consumer, humans are also involved in the production of information (Kahn et al. 2002).

Though DQ and IQ have a history in IS research, differentiations between both concepts in the literature are inconsistent. Some studies focus only on DQ, excluding the perceptional transformation of data to information (Glowalla and Sunyaev 2014; Wand and Wang 1996). Others define "data quality" to cover both DQ and IQ, as defined above (Madnick et al. 2009). In this article, we distinguish between data, information, DQ, and IQ as mentioned above. However, to avoid misunderstandings, we use "DIQ" ("data and information quality") in the remainder of this article when referring to both DQ and IQ.

Social IS

Since this article strives to develop a definition of DIQ for social IS, it must first be clear what a social IS is and how it differs from traditional IS. We build on an earlier definition, according to which a social IS is, essentially, an IS that is (1) based on social technologies and (2) enables or promotes open collaboration (Schlagwein et al. 2011, p. 2).[1] Social technologies include basic Web technologies that enable the dynamic

[1] The terminology in the domain of social IS is by no means consistent across the scientific community. Hence, we try to clarify—from our point of view—what is synonymous. What we call "social IS" may also be referred to as "social computing" (Parameswaran and Whinston 2007a, 2007b), "social-software

distribution, display, and (collaborative) creation of content, but also social software that more or less builds upon these technologies, such as wikis, social media/networking sites, platforms for content creation, and gaming (Kaplan and Haenlein 2010). Open collaboration enabled by these technologies can take various forms, such as socializing and communication (e.g., www.facebook.com), exchange of media content (e.g., www.youtube.com), collective creation of information repositories (e.g., www.wikipedia.org), or citizen science (e.g., www.galaxyzoo.org).

Social IS are still covered by the broader definition of IS as being socio-technical systems that acquire information (in this case, from humans/groups), store and process data, and present information to humans. However, applications of social IS expand beyond organizational contexts and use cases of traditional IS (Parameswaran and Whinston 2007a, 2007b). They "shift[s] computing to the edges of the network, and empower individual users … to manifest their creativity, engage in social interaction, contribute their expertise, share content, collectively build new tools, disseminate information and propaganda, and assimilate collective bargaining power" (Parameswaran and Whinston 2007b, p. 763). In other words, when moving from traditional IS to social IS, the focus widens from concrete task support to all kinds of social interaction. This means one cannot generally classify the nature of social IS as exclusively utilitarian or hedonic. Some social IS may be more utilitarian (e.g., social bookmarking sites), others more hedonic (e.g., video sharing platforms), and some a mixture (e.g., social networking sites). The dominant nature will also be subject to prosumers' perspective and usage of the social IS (Wang et al. 2009; Wu et al. 2011). Likewise, the widening from task support to social interaction should not be misunderstood as if social IS cannot be implemented and used in an organization; in fact, many companies already do so (Ellison et al. 2015; Leonardi et al. 2013; Wagner and Majchrzak 2006). But enterprise wikis, enterprise social media/networking sites, and other enterprise social IS still differ from traditional IS because they rely on social technologies and promotion of open collaboration, whereas traditional IS are designed to support specific tasks.

To illustrate how (enterprise and non-enterprise) social IS differ from traditional IS, we briefly summarize characteristics from Schlagwein et al. in which both IS types (ideally) differ from each other (for a more detailed discussion, see Schlagwein et al. (2011)).

Sociability. Central affordances of social IS are social interactions such as "friending," "liking," "sharing," and "commenting," while those of traditional IS are information and business processing. The user base of a social IS is often referred to as a "community" or "network" that has no predefined structures and roles. Instead, position, power, and control are distributed bottom-up, according to transparent social measures based on community interactions. In contrast, roles and credentials in traditional IS typically adhere to formal top-down, hierarchical structures of the organizational context (see Agarwal et al. 2008; Kohler et al. 2011; Xu et al. 2014).

Openness. Traditional IS typically have predefined user groups, at least to a certain degree, that must use the traditional IS either because they need information for their tasks (e.g., decision making) or because they are required to enter certain information (e.g., reporting). Traditional IS also explicitly exclude some people as users, whereas social IS, in contrast, are open participation systems with heterogeneous, voluntary, and possibly large user groups that are neither predefined nor restricted (see Howison and Crowston 2014; Parameswaran and Whinston 2007a, 2007b).

User role. For a traditional IS, there usually is a clear mapping of roles to people: developers (contractors or employees in the IT unit) create and maintain traditional IS; users (employees in functional units or customers) utilize it to enter or retrieve information. Social IS are also developed and maintained and capture and retrieve information, but users can engage in each of these activities and play the related roles voluntarily and based on motivation. Hence, social IS are "co-created" or "secondarily designed" by their users (see Germonprez et al. 2011; Millerand and Baker 2010).

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systems" (Germonprez et al. 2011), or "social media" (Kaplan and Haenlein 2010), though we view "social media" as a certain subclass of social IS. Our understanding of "social technologies" is comparable to what has also been called "Web 2.0 technologies" (O'Reilly 2005). What we term "social software" is similar to "social computing tools" (Ali-Hassan and Nevo 2009).

Content. Content (i.e., stored data) in social IS is often termed "user-generated content" (UGC). UGC is typically less structured and more heterogeneous than content in traditional IS because of the openness of social IS and the multifunctional role of its users. Traditional IS, with their predefined roles and purposes as well as rules governing their use, exhibit higher levels of structuring and homogeneity of content (see Fader and Winer 2012; Ghose et al. 2012).

Technology. Social IS build on the aforementioned social technologies that are typically easier to interact with, be a user of, adapt to, or develop than are traditional IS. The source code of social IS can be open (e.g., www.wikipedia.org, www.joindiaspora.com), while that of traditional IS is typically closed. Development and deployment of traditional IS typically follows staged lifecycle models, with major and minor releases, whereas social IS are often in a perpetual beta state and continuously deployed. Further, and related to openness in a technological sense, social IS often provide Web interfaces to connect to other IS (see Kane and Fichman 2009; Prasarnphanich and Wagner 2009; Vaast et al. 2013).

Location. Social IS are inherently Internet-based online systems, accessed conveniently through, for example, a Web browser on various devices, and (almost) ubiquitously available to their users. The online aspect of social IS also implies that its community is continuously connected. Though traditional IS can be made accessible over the Internet, online access is not typically among their integral features. Instead, they are understood as local systems, available in a local network or installed on a local computer (Hirschheim and Klein 2012). Continuously connecting a community is not typically among their objectives (see Parameswaran and Whinston 2007a, 2007b).

Since participation in social IS is mostly voluntary, prosumers' motivations to engage in social IS—for example, to use the social software and consume and produce content—play an important role. Though we cannot cover the wide array of literature on prosumer motivation in social IS, we offer a brief overview. Different motivations have been identified to affect engagement in various forms of social IS. Ridings and Gefen (2004) investigated prosumers' reasons for joining a virtual community across various online communities. They found information exchange and making/cultivating friendships to be most important, followed by exchanging social support, recreation, and technical features of the community website. Wasko and Faraj (2005) found that a desired increase in reputation was positively associated with content contribution to an electronic community of practice. In a field experiment in an online movie recommendation system, Chen and colleagues (2010) found that social comparison—that is, providing information about how one's level of contributions (in this case, movie ratings) compares to the median prosumer's contributions—motivates prosumers to increase content contribution. Following a uses and gratification perspective (Blumler et al. 1974) to explain why people choose certain media, Shao (2009) proposed structuring different motivations according to three basic types of interactions of users with user-generated media: consuming (e.g., reading/watching content); participating (e.g., rating/liking/commenting content; or liking/friending other users), and producing (e.g., substantively creating own content). He associated consuming with the needs for information and entertainment, participating with social interaction and community development, and production with self-expression and self-actualization. Further, though analytically distinct, interactions and motivations are interdependent in reality (Shao 2009). Heinonen (2011) took up this differentiation between consumption, participation, and production, and investigated empirically how three basic motivational factors (entertainment, social interaction, information) may drive activities in each of the three interactive types.

Structured Literature Review

To develop a definition and ontology of DIQ in social IS, we first conduct a structured literature review of the DIQ domain in general. We identify relevant DIQ paradigms and definitions that we use to develop a taxonomy. We build on our results to distinguish different understandings of the concept and discuss them in the context of social IS. Based on our findings, we develop and propose our own definition and ontology of DIQ in social IS that accounts for the unique characteristics of this specific type of IS. In this section, we first describe the structured literature review process and then develop the taxonomy and categorize extant work on DIQ.

Search Process

Our literature review follows the best-practice approaches of the IS discipline (Kitchenham and Charters 2007; Webster and Watson 2002). We identified relevant articles by systematically searching the titles, keywords, and abstracts of all articles published in the Senior Scholars' Basket ("Senior Scholars' Basket of Journals" 2011), that is, *European Journal of Information Systems*, *Information Systems Journal*, *Information Systems Research*, *Journal of AIS*, *Journal of Information Technology*, *Journal of MIS*, *Journal of Strategic Information Systems*, and *MIS Quarterly*. We conducted a keyword-based search (Kitchenham 2004; Kitchenham and Charters 2007) using two combinations of keywords: "information AND quality" and "data AND quality." We also searched the titles, keywords, and abstracts of all articles archived in the AIS Electronic Library (AISeL) for the keywords "information quality" and "data quality." We collected all papers that matched these keywords published before 20 April 2015. We manually screened the results, removed duplicates, and excluded articles that did not cover at least one of the concepts DQ, IQ, and DIQ. We included only articles that explicitly stated or referred to a definition of DQ and/or IQ.

Coding Scheme

From this screening of DIQ literature, we made two observations that guided the development of our taxonomy.

First, definitions of DIQ can exist on or comprise at least two different conceptual levels, namely, a DIQ paradigm and DIQ dimensions. The paradigm is a rather abstract and general statement about how quality should be conceptualized, while the dimensions detail the (most) relevant facets of quality according to and shaped by the paradigm. Three prominent examples of DIQ paradigms illustrate the paradigm-dimension distinction. The "intrinsic" DQ paradigm has been put forward by, among others, Orr (1998) and Wand and Wang (1996). These authors root their definition of DIQ in the "the role of an information system … to provide a representation of an application domain (also termed the real-world system) as perceived by the user" (Wand and Wang 1996, pp. 87–88), and hence define the DQ paradigm as "the measure of the agreement between the data views presented by an information system and that same data in the real world" (Orr 1998, p. 67). From this paradigm, Wand and Wang (1996) derive four dimensions of "intrinsic" DQ: completeness, unambiguity, meaningfulness, and correctness.

The well-known "fitness for use" paradigm by Wang and Strong (1996) provides another example. Acknowledging that product quality is ultimately based on consumers' evaluation (Juran 1989; Juran and Gryna 1980), they define high-quality data as "data that are fit for use by data consumer" (Wang and Strong 1996, p. 6). Guided by this paradigm, they survey empirically how data consumers define DQ on a more specific level. From their findings, they develop a framework of 15 "'data quality dimension' as a set of data quality attributes that represent a single aspect or construct of data quality" (Wang and Strong 1996, p. 6) and thus determine the "fitness for use" of data. Dimensions are, for example, accuracy, completeness, believability, relevancy, timeliness, ease of understanding, interpretability, and accessibility.

The paradigms in both definitions, while different, share several dimensions (e.g., completeness and correctness/accuracy). In fact, the comprehensive framework by Wang and Strong (1996) can be seen as *including* the intrinsic DQ definition and complementing it with aspects of data *and* information quality that are related to the use of data/information by consumers. This corresponds nicely to the distinction between data and information we made earlier: Since data are signs stored in a database that are supposed to represent external phenomena, data quality is determined by how good this representation is (in terms of, for example, the dimensions from Wand and Wang (1996)). Since information is data received and interpreted by humans, IQ is determined by the quality of the underlying data plus how well (in terms of the dimensions in the framework by Wang and Strong (1996)) data can be accessed, understood, and thus translated into information by humans. (Hence, it is more appropriate, in our terminology, to speak of "fitness for use" as a paradigm for DIQ.)

A last example is the integrated perspective on data, information, and their respective quality provided by the semiotic framework of DIQ by Shanks and Darke (1998) and Price and Shanks (2005). The framework builds upon the distinction between (1) the sign (e.g., a character, word, icon), (2) its referent or (intended) meaning (what the sign is supposed to refer to), and (3) its use or interpretation (how the sign

is understood and used by the interpreter). The authors borrow this from semiotics, which is the study of signs (Morris 1938; Peirce 1931; Price and Shanks 2005). Further, the relationships between these three components are termed syntactic (between multiple signs), semantic (between signs and their respective intended meanings), and pragmatic (between signs and their interpretation and use by a human receiver). Quality of data and information can then be mapped to these relationships. DQ includes syntactic quality ("conformance to database rules") and semantic quality ("correspondence to external phenomena") (Price and Shanks 2005, p. 91). IQ comprises the receivers' perception of syntactic and semantic quality (i.e., perception of DQ, since information is data received by humans) as well as pragmatic quality ("suitability for use" (Price and Shanks 2005, p. 91)).

For each of these three semiotic relations (or categories, as in Price and Shanks (2005)), quality may be defined and operationalized using various dimensions (criteria): for example, certain integrity rules (syntactic level); complete, unambiguous meaningful, correct mapping (semantic level); accessibility, suitable and flexible presentation, timeliness as well as perceptions of syntactic and semantic quality dimensions (pragmatic level) (Price and Shanks 2005). The work by Price and Shanks (2005) and Shanks and Darke (1998) underlines the importance of the paradigm-dimension distinction (category-criteria distinction), and how dimensions are shaped by and detail a paradigm. It also integrates three paradigms theoretically.

Our second observation from the screening of DIQ literature is that DIQ is typically seen as a multidimensional concept (Knight and Burn 2005; Lee et al. 2002; Zhang et al. 2014), that is, definitions include more than one dimension and the literature suggests a multitude of dimensions. Though we argued earlier that dimensions are shaped by and detail a rather abstract paradigm, it is also a common practice in the literature to define DIQ only in terms of its dimensions and not to follow a theoretical paradigm explicitly. Such studies typically combine several dimensions cited from the literature or developed *ad hoc* to define and operationalize DIQ. See, for example Blanco et al. (2010), McKinney et al. (2002), or Sanghoon et al. (2009), who used or combined existing DIQ scales (i.e., dimensions and items) from the literature to measure the construct of DIQ.

These observations informed the coding insofar as we focused on which paradigms were used in the studies, because the paradigm is what defines the perspective on DIQ, selection and definition of dimensions, and so forth. Further, the observations provided us with an initial set of categories, namely, intrinsic paradigm, fitness for use paradigm, semiotic framework, or no paradigm but only dimensions.

Analysis and Review

In this section, we present the results of our literature review process, apply the coding scheme to existing work on DIQ, and develop a taxonomy of DIQ definitions. We use the taxonomy to distinguish different understandings of DIQ and discuss them in the context of social IS. Finally, we develop our own definition of DIQ in the context of social IS, present a corresponding ontology of DIQ in social IS, and discuss implications of the new paradigm for socio-technical mechanisms to improve DIQ in social IS.

Review and Taxonomy of DIQ Definitions

Our search process resulted in a set of 730 articles. After removing duplicates and all articles that did match our exclusion criteria (see above), we identified 342 potentially relevant papers. We then screened each of these articles for their respective definitions of DIQ and decided to submit 249 articles to further analysis. In this section, we categorize and discuss the definitions and present our results as a taxonomy. Our observations from screening the literature provided an initial set of categories (see above), namely, definitions directly following the "intrinsic" paradigm; directly following the "fitness for use" paradigm; including both the "intrinsic" and "fitness for use" paradigms; employing the integrated semiotic framework; or using a combination of dimensions without referring to or defining a paradigm. We grouped articles not matching one of these categories into new categories, described below.

We assigned articles that do not cite one of the defined references (namely, Orr (1998) and Wand and Wang (1996)), but define a DIQ paradigm similar to the intrinsic to the new category "intrinsic—

indirect."[2] For example, Link and Memari (2013) define DIQ in terms of data meeting referential integrity constraints. Bardaki et al. (2013) define DIQ for an object tracking system in terms of correspondence of information to real-world objects, further defined by the dimensions of completeness and accuracy. Some of these articles cite the work of Ballou and Pazer (1985), who define DQ as "accuracy (the recorded value is in conformity with the actual value), timeliness (the recorded value is not out of date), completeness (all values for a certain variable are recorded), and consistency (the representation of the data value is the same in all cases)" (Ballou and Pazer 1985, p. 153). This definition reflects the "intrinsic" paradigm as defined by Wand and Wang (1996) and Orr (1998).

Some definitions do not cite one of the defined references for "fitness for use" but are similar to this paradigm because they state a similar paradigm (e.g., "information quality is mainly to be evaluated from the user's point of view" (Prestipino et al. 2006, p. 2), or "fitness for purpose" (Cheong and Chang 2007, p. 1000)), and/or because they cite similar paradigms (e.g., Bailey and Pearson (1983), who surveyed DIQ dimensions from managers, or the PSP/IQ model (Kahn et al. 2002), which builds on the "fitness for use" paradigm). We grouped these studies as "fitness for use—indirect."

We grouped studies that borrowed the definition and/or measurement instrument for DIQ from one of four studies in which DIQ has been investigated as an antecedent of user satisfaction (DeLone and McLean 1992, 2003; Doll and Torkzadeh 1988; Wixom and Todd 2005) into a new category "user satisfaction." One article (van der Pijl 1994) provides a paradigm of strategic DIQ in organizations and was assigned its own category ("strategic"). We grouped three articles into a new "social" category because they investigate social IS and provide DIQ definitions that do not fit into any of the other categories.

Table 1 is an overview of the categories, coding criteria, and number of articles in each category.

Category		**Criteria**	**Hits**
Intrinsic	Direct	Definition of DQ as integrity or correspondence to external phenomena and citing/referring to at least one of the definitions from Orr (1998) or Wand and Wang (1996).	6
	Indirect	Definition of DIQ similar to "intrinsic—direct," but no explicit reference to either Orr (1998) or Wand and Wang (1996).	11
Fitness for use	Direct	Definition of DIQ in relation to use (user, task, or context) and citing/referring to at least one of the definitions from Strong et al. (1997), Wang (1998), or Wang and Strong (1996).	72
	Indirect	Definition of DIQ similar to "fitness for use—direct," but no explicit reference to either Strong et al. (1997), Wang (1998), or Wang and Strong (1996).	17
Intrinsic and fitness for use		"intrinsic—direct" and "fitness for use—direct"	2
Semiotic		Explicitly citing the semiotic DIQ framework from Price and Shanks (2005) and Shanks and Darke (1998) (although some studies also cite Wand and Wang (1996) and/or Wang and Strong (1996)).	10
Multidimensional		Combining dimensions from frameworks to create *ad-hoc* constructs of DIQ, but without stating or referring to a higher-level paradigm.	102
User satisfaction		Borrowing the definition and/or measurement instrument of DIQ from one of four studies in which DIQ is investigated as an antecedent of user satisfaction, namely DeLone and McLean (1992, 2003), Doll and Torkzadeh (1988), or Wixom and Todd (2005).	25
Strategic		New paradigm of strategic DIQ in organizations (van der Pijl 1994).	1
Social		Investigating social IS (mostly, social media), and DIQ definition did not qualify for one of the categories above.	3

Table 1. Categories, Criteria, and Number of Articles

[2] Though integrity of data (syntactic quality) and correspondence of data to external phenomena (semantic quality) can be seen as two conceptually different paradigms (Price et al. 2008; Shanks and Darke 1998), we combine them in one category ("intrinsic") because they both concern the quality of stored data.

Existing DIQ Paradigms versus Social IS

In the following section, we assess the applicability of the paradigms we found in the literature to social IS, given its characteristics. We discuss the "indirect" categories with their respective "direct" categories. We omit discussion of the "intrinsic and fitness for use" category because it has no additional conceptual content beyond the separate categories "intrinsic" and "fitness for use." We also omit the "multidimensional" category from the discussion because studies in the category (by definition) do not employ a higher-level paradigm.

Intrinsic. The "intrinsic" category comprises two paradigms: integrity of data (syntactic level) and correspondence of data to external phenomena (semantic level). Part of the critique regarding definitions that restrict DQ to syntactic and semantic criteria has already been voiced earlier, and actually motivated the proposition of the use-centric "fitness for use" paradigm. As Wang and Strong argued, "it is the consumer who will judge whether or not a product is fit for use" (Wang and Strong 1996, p. 6). Strong, Lee, and Wang (while promoting "fitness for use") further urged that to "solve organizational DQ problems … one must consider DQ beyond the intrinsic view [and] move beyond stored data to include data in production and utilization processes" (Strong et al. 1997, p. 104). This argument underlies the insight that while necessary, syntactic and semantic quality alone are not sufficient to capture what data/information consumers who are supposed eventually to use the IS and data/information might think of DIQ.

Obviously, this argument still holds for social IS in which prosumers are supposed to participate. In fact, the problems when focusing only on intrinsic DQ are intensified (compared to traditional IS) because prosumers in social IS not only receive data but also produce them (*cf.* user role and content in social IS). Further, prosumers are typically not professionally trained to produce the content in social IS, and enforcement of syntactic and semantic quality on behalf of the producers is hard to achieve because content production is voluntary and outside of professional, predefined business routines (*cf.* openness and content).

Surely high levels of intrinsic DQ may also be, *ceteris paribus*, desirable in social IS. However, prioritizing only this paradigm could come at the cost of other dimensions of quality that are important for prosumers, or might even discourage production. For example, in the context of content production by users/customers (e.g., citizen science, open innovation, social media), Lukyanenko, Parsons, and Wiersma (2014b) argue that the conventional definition of the DIQ dimension completeness as "the ability of an information system to represent every meaningful state of the represented real world system" (Wand and Wang (1996, p. 93); as cited in Lukyanenko et al. (2014b, p. 4)) underrepresents the important role of the UGC producer. Specifically, completeness is typically determined with respect to data/information required by consumers, or with respect to a specific formal data model (which should, ideally, reflect the requirements). However, voluntary, heterogeneous UGC producers may not be willing or able to provide data that are complete in this sense. Nevertheless, consumers (e.g., companies, researchers, or a virtual community) may still be interested in what producers can provide. Thus, there is a tradeoff between completeness (complete representation of external phenomena) and, for example, accuracy (e.g., producers may provide dummy data only to complete their input), or even having any content at all (producers may be discouraged when faced with the required complete input). Hence, Lukyanenko and colleagues propose thinking of completeness in UGC contexts as "the extent to which a database captures all records of phenomena of potential interest to data consumers that data contributors are willing to provide" (Lukyanenko et al. 2014b, p. 4), and further propose using instance-based rather than class-based data models. They tested their proposition in a citizen science project on biodiversity in which voluntary users were asked to record observed species. They found that an IS that used an instance-based data model yielded significantly more contributions (observations) than one that used a traditional class-based data model (Lukyanenko et al. 2014b). Following these insights, in a different study (Lukyanenko et al. 2014a) the authors coined a new DIQ paradigm, "crowd IQ," for applications similar to citizen science (discussed here under the category "social").

Fitness for use. While the "fitness for use" paradigm is commonly applied to traditional IS, several studies also apply it to DIQ in social IS. For instance, Arazy and colleagues (2011), studying antecedents of IQ in Wikipedia articles, explicitly adapt the "fitness for use" perspective on IQ and employ the dimensions of accuracy, objectivity, completeness, and representation from Lee et al. (2002) to

conceptualize it further. Scholz and Dorner (2013), investigating antecedents of product reviews' helpfulness, motivate and structure textual features and meta-information of reviews along the consumer-centric IQ framework established by Wang and Strong (1996). Likewise, Urbach et al. (2010) operationalize IQ using traditional IQ dimensions when studying its impact on the use and success of employee portals.

We argue, however, that there are several problems when applying the "fitness for use" notion of DIQ to social IS. First, what "use" means is usually unknown *ex ante* because the prosumer group of a social IS is usually open, possibly large, heterogeneous, and changing (*cf.* sociability and openness of social IS). Hence, it is difficult to design the system according to specific information needs, tasks, and contexts given the variety of consumers, and to accommodate the best data production method for the different abilities, motivations, and knowledge among producers. In contrast, information needs in traditional IS are derived from and bound to specific business process tasks known throughout system development and use, and that are more stable. Further, the user base of a traditional IS is known and can be asked for quality criteria. Second, prioritization of consumption is inappropriate because production and consumption are mutually dependent in social IS with social interaction and open collaboration or prosumers (*cf.* user role). Further, content can be evaluated only when the system is in use, and adherence to requirements on behalf of the voluntary producers cannot be enforced as it can be in traditional IS by a central sponsor, who can purposefully select and design data/information sources and processes according to users' requirements during system development and adapt during system usage (*cf.* content). Third, since social IS are "located" online and, hence, potentially available ubiquitously, the use of a social IS is also subject to the users' changing contexts (i.e., observable features such as location and occupation) and situations (i.e., social and emotional). This is different from traditional IS in which the "use" is also rather stable because traditional IS are typically designed to be used locally/offline in an organizational context (*cf.* location). Finally, technology in social IS must accommodate data consumption by unknown/heterogeneous data consumers and hence provide more flexible or adaptable mechanisms to select and present data. It must further accommodate convenient, adaptable data production that relies on voluntary, self-motivated, non-professional producers. Hence, focusing only on "fitness for use" during consumption ignores the important role technology plays in social IS in capturing data and bringing together prosumers who wish to collaborate (*cf.* technology).

In summary, the "fitness for use" notion of DIQ is well suited for the organizational context in which users, tasks, and context are known and rather stable (at least to a certain degree); in which the prioritization of user requirements is justified by the purpose of IS to support users in accomplishing their tasks; and in which adherence to user requirements in IS development and use can be enforced by a sponsor (i.e., management). However, it does not capture characteristics of social IS and how DIQ is constituted in social interaction. One might apply the "fitness for use" paradigm in a descriptive/*ex-post* evaluation of existing social IS by certain prosumers, but it cannot, for example, guide the design of social IS.

Semiotic. With respect to the syntactic, semantic, and pragmatic level of the semiotic DIQ paradigm, most of what has been written above about the "intrinsic" and "fitness for use" paradigm applies, and hence does not need to be repeated here. Nevertheless, since the semiotic DIQ paradigm is explicitly theory-based (namely, in semiotics (Price and Shanks 2005; Shanks and Darke 1998)), it would be interesting to investigate how DIQ could be extended to social IS based on semiotics. In fact, Shanks and Corbitt (1999) proposed to add a social level of DQ "on top" of the other three levels (syntactic, semantic, pragmatic), building upon the semiotic DIQ definition by Shanks and Darke (1998) and an extended taxonomy of semiotic levels by Stamper (1992). Shanks and Corbitt thus define (semiotic) social DQ as "the *shared understanding* of the meaning of symbols. The goals for social data quality are an *understanding* of different stakeholder viewpoints and an *awareness* of any biases and other cultural and political issues involved" (Shanks and Corbitt 1999, p. 789; emphasis in original).

While shared understanding of the meaning of symbols (i.e., UGC) is an important aspect of DIQ in social IS as well, the definition does not capture that it is not defined *ex ante* in social IS which content there will be (*cf.* openness, user role, content, location). Further, assuming that one social IS might potentially have a very large number of prosumers, "shared understanding" need not mean that *all* prosumers must share the same understanding. Rather, people with shared understanding should be able to find each other in the population of prosumers. In other words, a definition of DIQ in social IS should incorporate the ideas

of a partially shared understanding between prosumers with respect to *which content* is or should be in the social IS, and what the *content means*.

User satisfaction. Articles in this category refer either to the IS success model by DeLone and McLean (1992, 2003), in which IQ is an antecedent of system use, user satisfaction, individual impact, and organizational impact; or the user computing satisfaction measurement instrument developed by Doll and Torkzadeh (1988), which covers many aspects similar to common DIQ dimensions (e.g., precise information, needed content, presentation format, timeliness of information); or the integrated model of user satisfaction and technology acceptance by Wixom and Todd (2005), which has confirmed IQ to be related to information satisfaction. However, none of these studies state or cite a higher-order paradigm for DIQ, but rather focus on developing measurement instruments. Hence, there are no paradigms to be discussed with respect to social IS.

Strategic. An article by van der Pijl (1994) is the only study in this category. He proposes a strategic paradigm of DIQ in which "quality of information in the organization is understood as the degree of fit between the goals and targets of the organization and the information systems supporting those" (van der Pijl 1994, p. 185). In other words, the information needed to achieve organizational goals, business process targets, users' and providers' targets, and personal interests (teleological perspective) and how information is produced by IS (design) and data processing (causal perspective) should correspond (van der Pijl 1994). Van der Pijl (1994) writes explicitly of "fitness for use" as one important perspective on DIQ, but has a broader view that reaches beyond individual use to include organizational goals. Further, DIQ conceptualized as the fit between teleological and causal perspectives on data/information can provide a new angle on how to assess and manage DIQ. However, this paradigm is also not well suited for application to social IS, partly because of what has already been said on "fitness for use" and partly because in social IS there is no hierarchy of organization and its goals, nor are there business processes and respective targets that could be fit to IS design and data processing.

Social. Finally, three studies are particularly interesting because they deal with DIQ in social IS and provide new approaches to DIQ. Valecha, Onook, and Rao (2013) study contributions and IQ in a collaborative crisis response IS (named "Ushahidi") during the aftermath of the 2010 Haiti earthquake. Using Ushahidi, victims could make requests for aid, which were then categorized, mapped, visualized, and made available to aid agencies and the public. Requests could also be discussed in threads. Valecha and colleagues (2013) focus on two IQ dimensions they deem to be of paramount importance in crisis response: uncertainty reduction and urgency. The study's empirical evaluation of Ushahidi aid-requesting threads with respect to these dimensions is reminiscent of the "fitness for use" paradigm, but the authors highlight explicitly the essential role of users/victims and their respective contributions (i.e., UGC) without which crisis response through Ushahidi would not have worked.

For such an application of DIQ in which content is primarily or exclusively user-generated, Lukyanenko, Parsons, and Wiersma (2014a) propose the DIQ paradigm of "crowd IQ" (their empirical work is situated in the area of citizen science; see above). Specifically, they define "crowd IQ" as "the extent to which stored information represents the phenomena of interest to data consumers (and project sponsors), as perceived by information contributors" (Lukyanenko et al. 2014a, p. 3). The crowd IQ paradigm highlights the importance of user contributions and the need for the IS to provide ways of information capturing suitable for the contributors, while acknowledging that this may come at the cost of fitness for use. More specifically, it is explicitly use-agnostic, that is, it allows for known as well as future uses of information. However, while crowd IQ explicitly acknowledges the important role of data/information producers and their perceptions, it is still specific to the crowd-sourcing context. It does not treat producers and consumers of data equally, since what are "phenomena of interest" are defined only by the consumers (and project sponsors). Data from producers may fit more or less with the interests of consumers. Further, the definition implies that the roles of producers and consumers are fixed. In fact, crowd IQ does not consider social interaction and open collaboration (at least not explicitly), which are essential for social IS (*cf.* sociability, openness, and user role). Hence, the definition of crowd IQ makes sense in the context of crowd-sourced data collection for flexible purposes (in which it has been proposed by Lukyanenko et al. (2014a)), but it cannot serve as a paradigm of DIQ in social IS.

An empirical study by Kane and Ransbotham (2012) investigates IQ of articles in Wikipedia's Medicine project and finds that quality is associated with the article-contributor-network's structure. As a measure of the dependent variable (i.e., IQ), Kane and Ransbotham (2012) use the quality rating that has been

assigned to each article by the Wikipedia community during a process of nomination, review, and voting of articles. In addition to its interesting empirical results, the study demonstrates a way in which prosumers of a social IS prosumers negotiate and define, but also improve, quality of content. Prosumers can contribute to the articles (by writing new parts or editing existing parts), discuss issues with other prosumers, and nominate and vote for articles they evaluate as being of high quality, thus defining what high quality is and should be. Though Kane and Ransbotham (2012) do not define a DIQ paradigm, one could say that in the case of Wikipedia, quality is what the community judges to be of quality.

From these three studies of DIQ in social IS we learn three things that should inform an explicit paradigm of DIQ in social IS. First, UGC contributions and producers are vital for social IS; they decide which data they actually (want to) contribute. Hence, second, the social IS (most important, the social software, including interfaces, algorithms, and storage) should be able to accept data/information in ways as flexible and adaptable to the contributors as possible, while expecting a variety of content. It must also provide means by which consumers can find and receive data/information they need. Third, to improve the match between what is produced and what is/would be consumed, the social IS should provide means by which its prosumers can negotiate what quality of data/information means to them, thus constituting a normative understanding of DIQ through a socio-technical process.

Definition of DIQ in Social IS

To resolve the issues the existing paradigms of DIQ raise when applied to social IS, we propose a new paradigm of DIQ based on the previous discussion of existing DIQ paradigms and that follows the notion of "matching" the demand for and supply of information about certain phenomena.

Recall that social IS are meant to be places where individuals meet and interact in a variety of heterogeneous contexts. Meeting and interaction take place through reciprocal production and consumption of data/information regarding specific phenomena, mediated by the social software. More precisely, information provided by the producers are transformed into data by human-computer interaction (HCI) with the social software; data are stored, processed, and transmitted by the social software; and data are requested, received, and interpreted by consumers (in HCI), thus becoming information. Since people may simultaneously take the roles of information consumers and producers, they are more appropriately characterized as being prosumers in the social IS.

Which information about which phenomena a prosumer could supply to the social IS (hereinafter termed "information potential") or might be searching for in the social IS ("information gap") will be determined by her/his individual interest in and subjective perception of phenomena. However, which information s/he actually supplies ("supply"), thus producing data, and which data s/he actually requests, receives, and interprets ("demand"), thus becoming information, will also depend on her/his individual motivation to participate in the social IS.

Based on this conceptualization, we propose to view a social IS as a place where demand for information by some prosumers meets the information supplied by others, and may be (more or less) satisfied through information exchange in social interaction and open collaboration. We argue further that the paradigm of social DIQ should be conceptualized as the matching of the demand for information by some prosumers and the information supplied by others, determined by interest, perception, motivation, and produced/consumed data, as described above. Since information exchange in social IS is mediated by the social software, the actual level of matching is also affected by HCI during production/consumption of data (e.g., how easy, flexible, intuitive is the interface), and technical issues of data storage and processing by the social software.

Specifically, we define *social IQ* as

> *the extent to which information supplied by prosumers (determined by their interest in and perception of phenomena as well as motivation and production of data) matches information demanded by other prosumers (likewise determined by interest in and perception of phenomena as well as motivation and consumption of data), mediated by social software and data through human-computer interaction;*

and *social DQ* as

> *the extent to which processing and storage of data by social software facilitates representation of information and matching of information supply and demand.*

Matching of information supply and demand has at least two facets: *allocation* and *negotiation*. Allocation means that matching can be achieved by finding appropriate content or counterparts for interaction for a given demand (or vice versa), given that social IS are characterized by heterogeneous content and a large, heterogeneous, changing user base. Negotiation means that the information supplied and demanded is not static in a social IS, but can be negotiated among its prosumers to increase the matching. Both allocation and negotiation involve prosumers and technical features of the social software. For example, recommendation algorithms may identify suitable content for consumers (allocation), or producers react and adopt their production to receive positive feedback from consumers (negotiation). Thus, defining, maintaining, and improving DIQ in social IS is essentially a socio-technical process enabled and supported by technical features of the social software as much as it relies on prosumers' motivation and activity.

Ontology of DIQ in Social IS

Approaching DQ or IQ from an ontological (or theoretical) perspective is seen as an alternative to empirical, intuitive/*ad-hoc*, or literature-based approaches (Price and Shanks 2005; Wand and Wang 1996; Wang and Strong 1996). Based on the definition of social DIQ, we identify five central entities relevant to social DIQ: (1) the user of the social IS who acts as information producer ("producer" for short); (2) the user of the social IS who acts as information consumer ("consumer"); (3) the social software; (4) data; and (5) the phenomena of interest ("phenomena"). With respect to the definition above of an IS as a representation of a real-world system to the user (Wand and Wang 1996, pp. 87–88), we view entities 1 through 4 as parts of the social IS, while entity 5—phenomena—is external to the social IS. The five entities are related to each other as follows:

1. Phenomena and producer — A producer is *interested* in certain phenomena, of which s/he has a subjective *perception*. Information thus mentally created by the producer constitutes her/his information potential.
2. Producer and social software — A producer is *motivated* to share her/his information with others who share her/his interest. S/he engages the social IS to share her/his information with a wider audience, using the interface of the social software. Thus, data are *produced* in HCI.
3. Social software and data — The social software retrieves and stores abstract data, processes and transforms them, and presents them through its user interface.
4. Consumer and phenomena — A consumer is *interested* in certain phenomena, of which s/he may already have a subjective *perception*. However, s/he has a demand for further information regarding the phenomena (information gap).
5. Consumer and social software — A consumer is *motivated* to engage in a social IS to fill her/his information gap by requesting, receiving, interpreting, and thus *consuming* data from the social software through HCI.

Figure 1 summarizes our ontology of social DIQ (relations are numbered according to the list above, and the names of entities are in bold).

Discussion

Confronted with the problem that traditional conceptualizations of quality of data and information are inappropriate for social IS, we develop a new paradigm of social DIQ based on the notion of "matching" information supply and demand. Our definition incorporates specifics of social IS as follows.

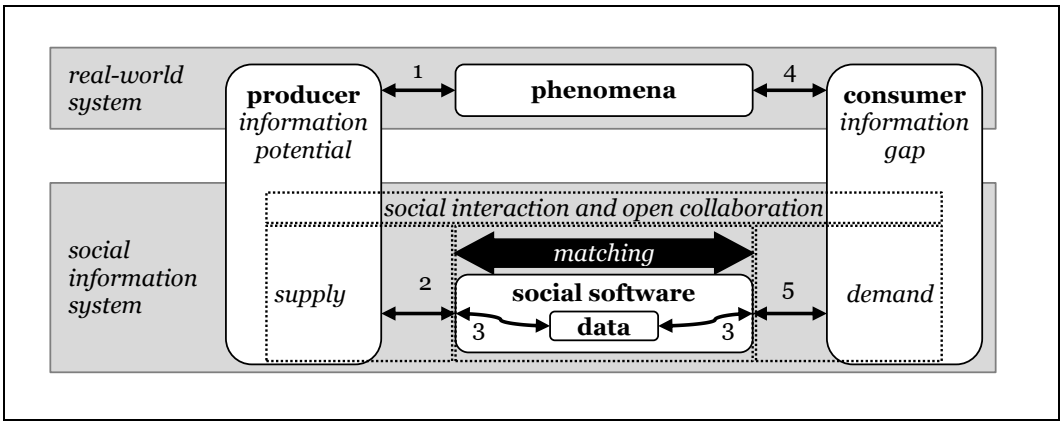

Figure 1. Ontology of social DIQ

Sociability. Our definition of social DIQ highlights the importance of matching prosumers' interests and respective exchanged information to each other, rather than supporting specific tasks. Specifically, the production of data suitable to the producer should match their consumption by a consumer with respective requirements, rather than focusing only on "fitness for use" by the consumer.

Openness. Since social IS are open and hence dynamic and somewhat unpredictable with respect to their user groups, the notion of matching in our definition of social DIQ has three implications. First, matching of production and consumption is something that can be assessed *ex post* rather than *ex ante*, but can probably be promoted by socio-technical means. Second, matching may change due to changes in the supply of information (i.e., different information) because the producers have changed, and changes in the demand for information because of a change in consumers. Third, it is less appropriate to assess matching on a global level than to do so partially, that is, whether subgroups of prosumers (and their respective supply and demand) match.

User role. The matching paradigm includes that prosumers of social IS can be producers and consumers at the same time. Hence, we use the term prosumer and mention both production and consumption to include that users of social IS can take different roles and that roles are interchangeable. Further, our definition speaks of a matching of supply and demand, which is meant to exclude any normative prioritization or hierarchy among the respective roles in a social IS with respect to DIQ. Specifically, we argue that while consumers want to find suitable content from producers, producers may also want to find an audience, depending on their motivation for engagement in the social IS. Our definition is thus different from "intrinsic" DQ, which excludes users' perspectives, or "fitness for use" DIQ, which prioritizes data consumption.

Content. Since data in social IS are mainly produced voluntarily and often by non-professionals, one must be aware that, unlike in traditional IS, social DIQ is subject to perception, motivation, abilities, knowledge, and interests of data producers and consumers—which our definition includes.

Technology. Social technologies (basic Web technologies as well as more complex social software) are the technical means for connecting prosumers and enabling open collaboration. They are different from technologies in traditional IS because they must accommodate not only data consumers but also data producers and their perceptions, motivations, abilities, knowledge, and interests. This would be ignored in a notion of DIQ that focuses primarily on the use of data/information. Therefore, similar to crowd IQ, our definition of social DIQ "recognizes the pivotal role of information contributors and motivates an effort to design systems sensitive to their points of view" (Lukyanenko et al. 2014a, p. 3). Further, social technologies are not only a means to convey data, but should also actively promote the matching of supply and demand in the social IS. This includes suitable and convenient mechanisms to gather, store, filter, transform, and present data, but also the possibility for prosumers to adapt social technologies to their preferences for a better human-computer interaction.

Location. The phenomena in which prosumers of social IS are interested, and how they perceive them, also includes questions of prosumer context and situation, which are important to social IS. Further, to match prosumers in a social IS appropriately also implies considering which contexts and situations match. Matching can be similarity, complementarity, or something else.

As already mentioned, defining, maintaining, and improving social DIQ (thus defined as matching) is a socio-technical process. This process can take the form of allocation (finding matching supply and demand) or negotiation (adopting supply and/or demand to match). Both forms can be supported by socio-technical mechanisms. Aggregation, filtering, search, and recommendation algorithms implemented in the social software can, for example, facilitate allocation. Meta-information (e.g., location) attached to stored data can even improve recommendations. Prosumers can be given the possibility to maintain digital profiles and allow tracking of activities in the social IS to enable improved personalized suggestions of content and other prosumers (Lu et al. 2015). Negotiation means prosumers voice their opinions about, for example, what is "good or bad" content, and which kinds of content they want to see in the social IS, but also that they listen to others' opinions. Successful negotiation can result in either adjustment of content or opinions, or both. A straightforward example is the common rating/linking of content from which prosumers can tell what the community evaluates as being "good" content (e.g., Chen et al. 2011). If altruism is an important motivation among prosumers, simply rating content would possibly be sufficient for making prospective producers adapt their production. However, if production is driven by the desire to gain reputation, negotiation could be improved by an additional mechanism in which a prosumer's reputation in terms of ratings is somehow signaled to others through her/his digital profile or avatar (e.g., Wasko and Faraj 2000, 2005). These and other mechanisms all rely on a combination of technical features as well as prosumers' motivation and activities. Implementing and evaluating mechanisms is the task of the provider of the social IS.[3] The matching paradigm of social DIQ can thus not only provide an analytical lens to understand better prosumer satisfaction and dissatisfaction, but also offer practical guidance through design, implementation, and operation of social software and social IS.

How can social DIQ be measured? Social DIQ is defined, maintained, and improved by the prosumers through social interaction. Hence, social DIQ is negotiated socially through social and technical mechanisms, and measuring social DIQ must therefore take into account the prosumers' understanding and perception of social DIQ. It will depend on which mechanisms are in place. Wikipedia's nomination, review, and voting process for articles, in which the community continuously measures social DIQ, provides a good example (see our section on "Existing DIQ Paradigms versus Social IS" and Kane and Ransbotham (2012)).

How are interaction and collaboration in a social *information* (meaning IT-supported) system different from direct (i.e., face to face) human-human interaction (HHI) in a social system? Actually, interaction and collaboration in both systems are similar with respect to our normative model of information potentials and gaps of actors constituted by their interest in and perception of phenomena, information supplied and demanded during interaction, and probably also with respect to the DIQ paradigm of matching. However, direct HHI and social IS differ with respect to their communication media characteristics. HHI has its advantages such as, for example, transmission of facial expressions, but limitations in terms of time (synchronous interaction), space (people have to come together, potentially traveling long distances), and reach (the number of people able to interact simultaneously is limited). The unique characteristics of social IS allow individuals to overcome some of these disadvantages. In enabling the collaborative and open generation, exchange, consumption, evaluation, and improvement of information in a self-organizing, socio-technical process, social IS can help increase the DIQ of information on phenomena that are of interest to their users. This, in turn, can affect the users' motivation to use the system (DeLone and McLean 1992, 2003; Petter et al. 2008).

[3] Ownership, development, and provision of a social IS can take different forms. Social IS may be owned, developed, and/or provided, for example, by a commercial provider to the public (e.g., www.facebook.com), by an organization and its IT department for internal use (e.g., enterprise social IS), or by the social IS' prosumers themselves (e.g., www.joindiaspora.com).

Is it possible to link traditional definitions of DIQ and social DIQ? If so, how? Consider, for example, a researcher investigating data in social IS, a provider of a public social media site, or a company using enterprise social media, all wanting to assess the quality of data/information in a social IS. In fact, these actors do have a certain use in mind when asking for DIQ in social IS. Hence, in this case, one may apply traditional definitions and frameworks of DIQ to data/information from social IS, for instance, "fitness for use" or "intrinsic." For example, one can assess empirically how accurately, timely, and comprehensively social media data on travel reviews reflect real-world travel and tourism (Tilly et al. 2015). Such an assessment of whether DIQ is sufficient for data from social IS to serve as observations in a research study explicitly takes care of the fact that these "digital trace data" (Howison et al. 2011) produced through a social IS are subject to perception, interest, motivation, social interaction, and other factors. Applying these data in "reality mining" (Eagle and Pentland 2006; Pentland 2009), "computational social science" (Lazer et al. 2009), or "big data analysis" (George et al. 2014) must be done with careful consideration of the social-IS context in which they have been produced (Howison et al. 2011; Kane et al. 2014) and should be accompanied by appropriate evaluations and tests (Ruths and Pfeffer 2014; Tufekci 2014).

Conclusion and Limitations

Starting from the observation that social IS are very different from traditional IS, we reviewed existing paradigms of DIQ with respect to their suitability to define DIQ in social IS. Since we identified several issues with existing DIQ paradigms when applied to social IS, we developed a new paradigm of social DIQ that incorporates the specific characteristics of social IS, namely, purpose of sociability, openness, users as prosumers, UGC, social technologies, and online availability. Basically, we define social DIQ as the matching of information supply and demand in a social IS. Further, our paradigm proposes to see DIQ in social IS as a socio-technical process in which DIQ is defined, maintained, and improved through social interaction and open collaboration. This process is enabled and supported by socio-technical mechanisms.

However, we could provide only a few examples to illustrate such mechanisms. Future research should conduct a comprehensive review of relevant literature and/or social IS in practice to get an overview of what kinds of mechanisms already exist and how these can be used to improve social DIQ. Further, mechanisms should be evaluated systematically.

Space limitations preclude us from discussing in more detail the possible settings in which social IS can occur and the implications those settings might have on the social IS, its data/information, and DIQ. For example, if social IS are used in organizations/enterprises (e.g., enterprise social media), prosumers' engagement could be driven by different motivations, and prosumers might be more cautious about what to contribute (DiMicco et al. 2008; e.g., Ellison et al. 2015). Further research should investigate how different settings affect social DIQ.

IS research has proven traditional DIQ to be an antecedent of IS success (DeLone and McLean 1992, 2003; Petter et al. 2008). It seems natural to assume a similar link between social DIQ and social IS success, although the concept of social IS success has yet to be established. Wagner et al. recently drafted the concept "online community *health*" (our emphasis) with a focus on the prosumers' evaluation of the online community. It is meant to "prioritize(s) effective inner workings … over targeted output for externals" (Wagner et al. 2014, p. 3). They explicitly reject applying traditional notions and models of IS success to online communities because "success implies that the online community somehow contributes to the performance of the host organization" (Wagner et al. 2014, p. 4). While we think that speaking of either "health" or "success" is actually a matter of terminology, we agree that success in online communities and social IS in general should be defined from the perspective of the prosumer. However, the concept of social IS success should be elaborated, and the proposed link between social DIQ and social IS success should be investigated.

Finally, several frameworks of traditional DIQ and respective dimensions have been long established, operationalized, and tested (Knight and Burn 2005; Lee et al. 2002). It was beyond the scope of this study to operationalize and test empirically the concept of social DIQ in these comprehensive ways. Further research is needed to develop measures of social DIQ according to our paradigm and evaluate them in social IS.

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Appendix A.3: Paper III

Bibliographic data	Tilly, R., Posegga, O., Fischbach, K., & Schoder, D. (2017). Towards a Conceptualization of Data and Information Quality in Social Information Systems. *Business & Information Systems Engineering, 59*(1), 3-21.
Abstract	Data and information quality (DIQ) have been defined traditionally in an organizational context and with respect to traditional information systems (IS). Numerous frameworks have been developed to operationalize traditional DIQ accordingly. However, over the last decade, social information systems (SocIS) such as social media have emerged that enable social interaction and open collaboration of voluntary prosumers, rather than supporting specific tasks as do traditional IS in organizations. Based on a systematic literature review, the paper identifies and categorizes prevalent DIQ conceptualizations. The authors differentiate the various understandings of DIQ in light of the unique characteristics of SocIS and conclude that they do not capture DIQ in SocIS well, nor how it is defined, maintained, and improved through social interaction. The paper proposes a new conceptualization of DIQ in SocIS that can explain the interplay of existing conceptualizations and provides the foundation for future research on DIQ in SocIS.
DOI	10.1007/s12599-016-0459-8

Appendix A.4: Paper IV

Bibliographic data	Posegga, O., Zylka, M., & Fischbach, K. (2015). *Collective Dynamics of Crowdfunding Networks.* In: Proceedings of the Hawaii International Conference on System Sciences (HICSS). Kauai, HI.
Abstract	The crowdfunding phenomenon has garnered a considerable amount of attention in recent years. Several online crowdfunding platforms have risen to prominence; they can be characterized as two-sided marketplaces. Recent research reveals initial insights into the dynamics and characteristics of crowdfunding networks arising from such marketplaces. This research, though, is restricted primarily to analyses of static network snapshots and at the dyadic level. In this study, we use a large longitudinal dataset to analyze the behavior of actors on both sides of the market who promote their own and fund others' projects. We investigate the influence of endogenous and exogenous effects on the dynamics of crowdfunding networks. Our results provide evidence for mechanisms promoting a hierarchical network organization and the absence of homophily-related mechanisms regarding gender or geographic distance. Moreover, we establish that experienced and popular project creators fund fewer projects.
DOI	10.1109/HICSS.2015.394

Appendix A.5: Paper V

Bibliographic data	Volkmann, G., Putzke, J., Posegga, O., Fischbach, K., & Schoder, D. (2015). *Out-Group-Tie Centralization and the Performance of Work Groups.* In: Proceedings of the Jahrestagung der Wirtschaftsinformatik (WI). Osnabrück, Germany.
Abstract	Organizations increasingly rely on group-based organizational structures to manage uncertain environments. However, at the group level there is still a limited understanding of how boundary-spanning activities should be managed to increase group performance. In this paper, we propose "out-group-tie centralization" as a concept that refers to the variation in the group members' network ties to other social actors who are not members of the group itself. When the out-group-tie centralization is low, no group member enjoys substantially more ties to other social actors outside the group than does any other group member. A panel analysis with 120 work groups from a medium-size German bank over a 12-month period reveals a reversed u-shaped relationship between out-group-tie centralization and group performance. However, the results indicate no association between the density of a work group communication network and that group's performance.
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Out-Group-Tie Centralization and the Performance of Work Groups

Gloria Volkmann[1], Johannes Putzke[1], Oliver Posegga[2], Kai Fischbach[2], and Detlef Schoder[1]

[1] Universität zu Köln, Seminar für Wirtschaftsinformatik und Informationsmanagement, Köln, Germany
{volkmann,putzke,schoder}@wim.uni-koeln.de
[2] Otto-Friedrich-Universität Bamberg, Lehrstuhl für Wirtschaftsinformatik insbes. Soziale Netzwerke, Bamberg, Germany
{oliver.posegga,kai.fischbach}@uni-bamberg.de

Abstract. Organizations increasingly rely on group-based organizational structures to manage uncertain environments. However, at the group level there is still a limited understanding of how boundary-spanning activities should be managed to increase group performance. In this paper, we propose "out-group-tie centralization" as a concept that refers to the variation in the group members' network ties to other social actors who are not members of the group itself. When the out-group-tie centralization is low, no group member enjoys substantially more ties to other social actors outside the group than does any other group member. A panel analysis with 120 work groups from a medium-size German bank over a 12-month period reveals a reversed u-shaped relationship between out-group-tie centralization and group performance. However, the results indicate no association between the density of a work group communication network and that group's performance.

Keywords: social network analysis, work group performance, boundary spanning

1 Introduction

Today's business environment has become more complex, subject to rapid changes, and uncertain as knowledge economies and greater global competition increase. In growing numbers, organizations have responded to this erratic and complex environment with group-based organizational structures that decentralize decision making and allow them to react more quickly and innovatively [1-2]. Increased task complexity associated with knowledge work and flatter work structures created by group-based structures lead to an increase in interdependence between work groups. Because of this, work groups are increasingly responsible for coordinating and performing complex cross-functional tasks and bridging organizational work groups to create and transfer valuable resources of knowledge and know-how [3]. In the literature, establishing these out-group-ties with other work groups and managing these cross-

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group interactions are often referred to as team boundary spanning [3-5]. This can assist an organization's work groups in meeting performance goals and task objectives [5] because the information and resources gained externally can be used internally to develop strategies and coordinate and complete work tasks. By engaging in boundary-spanning activities, work groups face the challenge of effectively integrating the external environment and transmitting external information and knowledge back into the work group itself, as well as effectively managing the internal work group environment [6]. Internal work group network structures are essential for effectively disseminating to group members information that already exists within the group as well as information obtained externally through boundary spanning [3-5]. Work groups must always balance potentially competing demands and objectives of internal and external group processes [7] and face choices about how to allocate limited attentional resources across various efforts [8].

From a social network perspective, work groups and these challenges can be represented as a network of relational ties established between various groups and within those groups between various group members to carry out these tasks [9]. This has prompted research on work groups and their network structures to analyze the impact of internal and external work group structures and their effect on work group performance outcomes, as well as to analyze which structures help work groups manage competing internal and external demands and therefore influence group performance positively. Prior research has shown that internal and external work group structures have both positive and negative consequences and that those consequences are further affected by contingencies in the task environment, such as the degree of exploration or exploitation inherent in the work tasks [5], [10-16]. However, no clear picture has yet emerged regarding which group structures are most beneficial for the internal work group management, that is, how boundary spanning is best managed and distributed within the group and which internal work group network structure allows a group to perform best. More attention is needed to examine – at a finer-grained level – how member boundary spanning is combined at the group level (e.g., the use of a single focal boundary spanner vs. shared boundary-spanning responsibility across all members, or something in between) [5] and whether a high or moderately dense internal work group network structure is better for work group performance.

Thus, the purpose of this study is to refine the understanding of both internal and external work group structures that are beneficial for the internal work group management. Therefore this study examines work groups performing predominantly exploitative tasks and analyzes which internal group network structures influence work group performance positively, while at the same time examining how boundary spanning activities are best managed at the group level by analyzing which internal distribution structure of boundary spanning ties influences group performance positively. Building on prior research, this study argues that there is a positive linear relationship between work group performance and work group density that results from the creation of a beneficial work atmosphere and group spirit and fast and flexible information diffusion within the group. Furthermore, this study argues that there is a reversed u-shaped relationship between out-group-tie centralization and group performance. At a moderate level of out-group-tie centralization, externally gained resources and infor-

mation can be disseminated quickly and efficiently to other group members, but at a higher level of out-group-tie centralization, boundary-spanning group members may become overstrained and a bottleneck may emerge that makes it difficult to transmit externally available resources and information efficiently to the rest of the group.

Results of an analysis of 120 work groups (performing predominantly exploitative work tasks) from a medium-size German bank over a 12-month period reveal no statistically relevant relationship between work group density and group performance. However, they show a reversed u-shaped relationship between out-group-tie centralization and group performance. Thus, this study contributes to existing literature by confirming the importance of the internal work group management of external work group ties as well as by suggesting that a moderate centralization (i.e., distribution) of out-group interaction among group members benefits the group performance of work groups involved in predominantly exploitative tasks.

The paper is structured as follows. We highlight the theoretical background of this research in section 2. We then develop two research hypotheses in section 3. Section 4 illustrates the method used for hypothesis testing. Section 5 provides the results. Finally, section 6 discusses our results and their theoretical and managerial implications, highlights some research limitations, and points out directions for further research.

2 Theoretical Background

In the social network analysis approach, an organization can be conceptualized as a network in which work groups are nodes that interact with each other. Such a representation of an organization makes abundantly clear that an organization's overall success depends on the success of its work groups. Work groups in an organization, as well as the organization itself, are multilevel constructs. Each work group comprises a network of its members and is simultaneously embedded in the network of all work groups in the organization. Hence, the success of a work group is affected by its external ties to other work groups, because the structure of the interconnectedness of work groups in an organizational network enhances or constrains the access of work groups to resources that are both necessary and valued in meeting performance goals and task objectives [9]. Further, the success of the work groups is affected by the structure of their internal ties, that is, network ties within the work groups. Internal group structures affect the work atmosphere and group spirit and thereby the inclination of group members to share information, help each other, and refrain from opportunistic behavior. In addition, internal group structures affect the speed and flexibility with which information diffuses within a group and how effective a group allocates its attentional resources to balance competing internal and external demands [3-5], [17].

Reagans and Zuckerman [10] found that organizational work groups with denser internal networks achieved a higher level of productivity than those with sparse internal networks. Hansen, Podolny, and Pfeffer [16] found that work teams with exploratory work tasks benefited from a network structure with many strong and non-redundant ties, whereas work groups pursuing tasks that exploited existing expertise

took less time to complete their projects if they had a network composed of weakly tied contacts that were moderately interconnected. In contrast, Sparrow and his colleagues [11] did not find that the density of internal group structures affect work group performance, but did find a negative relationship between work group network centralization and work group performance. In line with Reagans and Zuckerman [10], Mehra and his colleagues [14] found that the networks of high-performance work groups exhibit a higher internal density than those of low-performing work groups, and that work group leaders' network ties with peers and higher-level managers in an organization had a positive effect on work group performance. Furthermore Reagans, Zuckerman, and McEvily [12] found that work groups with a dense internal network structure and a large external range finished projects more quickly. In contrast, Oh and his colleagues [13] found that work groups performed best that had a moderately dense internal network structure and bridging ties to many other groups and formal leaders.

As the findings of previous research show, findings are inconsistent with respect to which forms of internal work group network structure allow a group to perform best. It is not absolutely clear whether a high- or moderately dense internal work group network structure is better for work group performance.

Moreover, the findings of Hansen and colleagues [16] show that the context in which those structures appear is highly relevant, because whether the tasks performed of a group are predominantly explorative – involving highly tacit knowledge – or predominantly exploitative –involving highly explicit knowledge – affects which kind of internal work group network structures allow a group to perform best. They identify exploitative tasks as, for example, daily work, routine work, continuous improvement, increasing production efficiency, and so on [16]. Therefore, much of the knowledge involved in exploitative tasks is likely to be explicit, because the expertise required is already available and the problem, possible solutions, and causal mechanisms among the parameters involved in the task are known [16]. Groups and group members benefit from obtaining existing, complementary knowledge through their network that avoids duplication of effort and, typically, group members know well when and how frequently they need to consult contacts to obtain needed and valuable knowledge [16]. Thus, exploitative tasks can often be split easily into a number of subtasks that can be completed by individual group members. In contrast, exploratory tasks involve problems that are novel to a group and its members and entail, for example, innovation, experimentation, one-time decisions, radical change, and so on [16]. Knowledge involved in exploratory tasks is likely to be tacit, which means it is difficult to articulate or can be acquired only through experience; further, the problem, solutions, and parameters involved in the task are often unknown [16]. Groups benefit from obtaining new ideas and large amount of knowledge through their network and may need to brainstorm the problems, discuss ideas, and exchange views often but irregularly [16]. Thus, exploratory tasks cannot be split easily into clearly defined subtasks that can be completed by individual group members. The entire groups may often need to develop and work on solutions together. Due to these differences in the types of tasks and the differences in the associated requirements of

interaction and exchange, the kind of group structures that are beneficial or disadvantageous for group performance differ according to the types of tasks.[16].

Previous research also has contradicting opinions and results regarding how boundary spanning is managed and distributed best within the group (e.g.,. shared boundary-spanning responsibility across all members vs. the use of a single focal boundary spanner, or something in between). On the one hand, Oh and his colleagues [15] argue that groups whose external relationships are distributed among more members within the group gain more and greater benefits from those relationships than groups in which those relationships are concentrated in a smaller number of group members. In addition, Marrone and colleagues [18] found that individual boundary spanning behavior did result in individual experience of role stress, but with increased boundary spanning at the work group level and with every work group member engaging in boundary spanning behavior, individual role stress was significantly diminished. One the other hand, Sherman and Keller [19] suggested, "When the volume of direct contact between two interdependent units increases with multiple personnel communicating, coordination problems can develop if a common point of contact does not exist in each unit […]. Boundary-spanning roles would minimize coordination problems caused by the increasing complexity of the network of communications spanning two interdependent units" (p. 248). Moreover, Davison and colleagues [20] found that groups that enact differentiated group roles as a mechanism to achieve coordination consistently outperform work groups that act like one large, undifferentiated group in which everyone is interacting with everyone else.

In sum, prior research has suggested the need to refine the understanding of how structural properties of internal and external work group network relations affect group performance while simultaneously considering whether the tasks performed are predominantly exploitative or exploratory and whether the knowledge required is predominantly tacit or explicit. In this study, we try to refine the understanding of how the structural properties of internal and external work group network relations at the group level (i.e., within the group) contribute to group performance for groups predominantly engaged in exploitative tasks. In doing so, this study focuses on the informal social networks in the workplace in and between work groups at the work group level, because the informal network makes work processes visual and shows how work in an organization is actually done. It shows how work groups and their members actually interact – giving and receiving needed resources such as information, know-how, feedback on progress, and support from key external parties – to accomplish tasks. [9].

Due to these particularities, an organization's informal social network relies not only on direct face-to-face communication, but also on permissive information system components (e.g., videoconferences, teleconferences, telephone, e- mail) designed to support more unstructured group interactions. Hence, this study focuses on the informal network of work groups in the organization built by social relations constructed of interaction ties of the work group members gathered via permissive information system components.

3 Hypotheses

3.1 Work Group Network Density

The density of a work group network is the intensity of interaction between all group members and is equivalent to the proportion of all possible interaction ties in a group that are actually present. This means the more ties each group member enjoys with other group members, the greater the density of the group-network. Previous research on groups in organizational systems suggests that the density of a group-network is associated with group performance (e.g. [11], [13]).

There are several theoretical reasons for a positive association between density and group performance. For example, Sparrowe and colleagues [11] argue that in groups with a dense interaction structure, one can expect a greater agreement on expectations, a stronger sense of accountability and thereby stronger reciprocity norms, greater awareness of each other's expertise, greater trust, and greater cooperation than in a group lacking such a dense interaction structure. Intense interaction among group members makes each group member aware of other group members' roles and responsibilities in the group and thereby also pinpoints the expectations and accountabilities of each group member. Hence, visibility of opportunistic behavior increases and thereby restricts opportunistic behavior within the group [11]. By counteracting opportunistic behavior, increased visibility and accountability also facilitate mutual trust and cooperation within a group [17]. Group members are more willing to share information and help each other because they know other members of the group will act alike and help and information given will ultimately be returned by another member of the group [13]. Moreover, interaction and exchange of information among group members develops, increases, and calibrates the awareness of each other's expertise. Therefore, one may have to seek out fewer group members to get required and sought-after information and help. This, in turn, leads to fewer chances of misinformation and less added workload for group members, because knowing how to get help and information directly reduces the need to go through the leader or other group members to get expertise and information [21]. Hence, in summary we hypothesize:

Hypothesis H1: The higher the density of a work group communication network, the higher the performance of the group.

3.2 Out-Group-Tie Centralization

"Out-Group-Tie Centralization" within a work group refers to the variation in the group members' network ties to other social actors who are not members of the group itself. When the variation in the number of network ties per group member is low, no group member enjoys substantially more ties to social actors outside the group than does any other group member. In contrast, when the variation in the number of network ties per group member is high, some members have proportionately more ties to social actors who are not members of the group itself.

Research on work group performance indicates that boundary-spanning activities are critical drivers of team performance because groups bridge otherwise diverse and

disconnected parties through out-group-ties with other groups as they pursue information transfer, knowledge creation, outside support, and feedback [3- 4], [13], [16]. Therefore, these groups may receive more diverse information, learn faster about developments in the organization, and be able to access a broad base of political support [12-13]. To be effective, work groups will need to manage group boundary-spanning interactions. Oh and colleagues [15] argue that an efficient way to manage group boundary spanning is by encouraging all group members to form network ties with members of other groups, because if a group's "external ties are more concentrated in a small number of group members, or just one group member, the remaining group members might become insulated from diverse information and opinions available externally. This insulation of the group from its environment invites more homogeneity of ideas and, thus, reduces its overall decision-making capacity" (p. 574). However, establishing and maintaining interaction ties across groups imposes additional demands on the group members above and beyond their own task-work and within-group interactions. Boundary spanning across groups is challenging and stressful for individuals because they face simultaneous and often conflicting pressures that require considerable time and effort [7-8], [18]. Therefore, given limited time, attention, and resources, groups need to develop and manage out-group-ties to other subgroups in the most efficient way. Because the volume of direct contact between two interdependent groups increases with multiple group members communicating, the development of coordination problems is more likely when all members of a group are interacting in an uncoordinated manner with all members of other groups in the organization. Therefore, information processing requirements argue for the restriction of direct interaction among each and every person [19]. Instead, a select number of group members will need to adopt integrating roles and maintain and manage out-group-ties for the entire group [20]. This will enable work groups to access and integrate various resources from other work groups quickly without being overwhelmed by having to manage excessive across-group interactions [22]. Hence, we hypothesize:

Hypothesis H2: There is an inverted u-shaped relationship between out-group-tie centralization and group performance.

4 Method

4.1 Sample

To test the proposed hypotheses, we analyzed a data set provided by a medium-size German bank with approximately 4,000 employees and some 389 work groups. The data set included the formal group membership of each employee, as well as all emails (without content) sent or received by bank employees (n=3,653) during 2010. In total, the email archive comprised 4,950,801 emails belonging to 142,858 dyads. Bank privacy regulations stipulated that our analyses be conducted anonymously. Therefore, the organization assigned a unique, randomly generated number to each employee and work group before handing the dataset to the researchers. Furthermore,

the organization excluded from the analysis work groups with fewer than 4 employees to prevent identification of employees through a unique combination of their attributes (e.g., gender and age), membership in such a small work group, the structure of their interactions within their work group, and the structure of interaction of their small work group with other work groups. This excluded 188 work groups from the analysis. From the remaining 201 groups, we identified 121 groups as profit centers with direct market contact ("sales groups"), for which the bank could provide us with comparable performance measures (see section 4.2). However, for the final analysis we had to exclude a single work group that was a severe outlier, because its performance was approximately 10 times the performance of the other work groups.

The 120 work groups in the final sample ranged in size from 4 to 66 members; the average group size was 15.12 members. The average age of the employees in the sample was 37.66 years, and 43.7 percent of employees were men. The tasks performed by these 120 sales groups in the final sample are exploitative tasks that involve banking services such as construction financing for private households, high-net-worth individuals, and companies; retail banking services for private households; private banking services for high-net-worth individuals; corporate banking services for companies; and funding and financial services for start-ups and new ventures. These tasks can be completed directly by an individual group member or can be split into subtasks that can be completed by an individual group member.

4.2 Measures

Dependent Variable.

Group Performance. The bank assesses the performance of its sales work groups based on the degree to which they achieve their contribution margin targets. These data were provided on a monthly level. Since these performance indicators are highly confidential, the bank rescaled them on a scale between 0 and 1 before providing them to us.

Independent Variables.

Work Group Network Density. The density of a group network g refers to the intensity of directed interaction between all n_g group members. It is calculated by dividing the number of the existing relational ties between all group members of a group e_g by the number of all possible relational ties between all group members of a group n_g (n_g -1):

$$density(g) = \frac{e_g}{n_g(n_g - 1)}$$

Out-Group-Tie Centralization. Graph centralizations are based on the differences between the centrality of the most central actors and the centrality of all others [23]. The out-group-tie centralization $C_o(g)$ of a work group g describes the variation in the group members' network ties to other social actors who are not members of the group

itself. It is calculated as the sum of the differences between the largest observed number out-group-ties $c_o(p^*)$ for group member p* and the number of out-group-ties $c_o(p_i)$ observed for each other actor p_i:

$$C_o(g) = \sum_{i=1}^{n_g} [c_o(p^*) - c_o(p_i)]$$

Dividing with the theoretical maximum sum of differences normalizes the centralization. This maximum value results for work groups whose ng members each share ties with all other $(n-n_g)$ members of the organization, where n is the total number of actors in the network. Thus, the normalized out-group-tie centralization is shown as:

$$C'_o(g) = \frac{\sum_{i=1}^{n_g} [c_o(p^*) - c_o(p_i)]}{n_g(n - n_g)}$$

Gender proportion. As previous research has shown that teams with a higher percentage of women have a higher collective intelligence and hence should perform better [24], we added the percentage of women in a work group as a control variable.

5 Results

For hypotheses testing, we estimated a series of panel data models (e.g., [24]) in R (v. 3.0.2) using the packages lme4 (v. 1.1-7) and plm (v. 1.4-0). Panel data models can be estimated when data are collected from the same subjects over multiple periods. As illustrated above, our balanced panel comprised 1440 observations (i.e., 12 months of observations for each of the 120 work groups). Table 2 shows the results for a model that includes fixed effects for only the 120 work groups. "Fixed effects" for the 120 work groups mean that we estimated a model with the following functional form

$$\begin{aligned} Group\ Performance_{it} &= \beta_0 + \beta_1 gender\ proportion_{it} + \beta_2 density_{it} \\ &+ \beta_3 out\text{-}group\text{-}tie\ centralization^2_{it} \\ &+ \beta_4 out\text{-}group\text{-}tie\ centralization_{it} \\ &+ \sum_{n=2}^{N} \gamma_n work\ group\ dummy_n + u_{it} \end{aligned}$$

In this context, "work-group-dummies" refer to dummy variables added for each work group to allow for considering unobserved heterogeneity between work groups. Table 3 shows the results for a model with fixed effects for the 120 work groups as well as for the 12 months. That means the model had the following functional form

$$
\begin{aligned}
&Group\ Performance_{it} \\
&\quad = \beta_0 + \beta_1 gender\ proportion_{it} + \beta_2 density_{it} \\
&\quad + \beta_3 out\text{-}group\text{-}tie\ centralization^2{}_{it} \\
&\quad + \beta_4 out\text{-}group\text{-}tie\ centralization_{it} \\
&\quad + \sum_{n=2}^{N} \gamma_n work\ group\ dummy_n + \sum_{m=2}^{M} \gamma_n month\ dummy_m \\
&\quad + u_{it}
\end{aligned}
$$

"Month dummies" refer to dummy variables added for each of the twelve month. Before the estimation, the variables "work group network density," "out-group-tie centralization," and "out-group-tie centralization²" were standardized to avoid multi-collinearity. Table 1 shows the Pearson correlation coefficients for the independent variables.

Table 1. Correlation matrix

	(1)	(2)	(3)	(4)
(1) Gender proportion	1.0000			
(2) Density	-0.1188	1.0000		
(3) Out-group-tie centralization	0.1023	-0.2217	1.0000	
(4) Out-group-tie centralization²	0.0635	-0.0585	0.6291	1.0000

Table 2. Model 1

	Estimate	*Std. Error*	*t value*	*Pr(>|t|)*	
Intercept	0.0173946	0.0029085	5.981	2.86e-09	***
Gender proportion	0.0606160	0.0085822	7.063	2.63e-12	***
Density (standardized)	0.0001120	0.0003102	0.361	0.718093	
Out-group-tie centralization²	-0.0002791	0.0001251	-2.230	0.025886	*
Out-group-tie centralization	0.0009485	0.0003105	3.055	0.002299	**
Work group Dummies		Yes			
Month Dummies		No			
R^2		0.2272			
Adjusted R^2		0.1556			
F(122, 1317)		3.173***			

† p < .1; * p < 0.05; ** p < 0.01; *** p < 0.001

Tables 2 and 3 illustrate our results. Dummy variables are not included in the tables due to space restrictions. As evident from Tables 2 and 3, the control variable "gender proportion" was found to have a significant effect on group performance at a .001 level of significance in both models. Contrary to our expectations, Hypothesis H1 was not supported by the data. Hence, we cannot conclude that the higher the density of a work group communication network, the higher the performance of that group.

Table 3. Model 2

	Estimate	*Std. Error*	*t value*	*Pr(>|t|)*	
Intercept	0.0177184	0.0028905	6.130	1.16e-09	***
Gender proportion	0.0606361	0.0084070	7.213	9.27e-13	***
Density (standardized)	0.0002430	0.0003090	0.786	0.431859	
Out-group-tie centralization²	-0.0002157	0.0001238	-1.741	0.081848	†
Out-group-tie centralization	0.0006555	0.0003099	2.115	0.034630	*
Work group dummies			Yes		
Month Dummies			Yes		
R^2			0.2649		
Adjusted R^2			0.1901		
F(133, 1306)			3.539***		

† p < .1; * p < 0.05; ** p < 0.01; *** p < 0.001

However, the squared term for out-group tie centralization was found to be negative and statistically significant in both models (p<.05 and p<.1). Hence, Hypothesis H2 is supported and we can conclude that there is an inverted u-shaped relationship between out-group-tie centralization and group performance.

6 Discussion

6.1 Theoretical and Managerial Implications

This study aims to help clarify which internal group network structures help work groups perform best, and how boundary spanning activities are best managed at the group level, by examining the internal distribution and structure of boundary spanning ties that influence group performance positively. For that purpose, we hypothesized and tested whether a high density of the internal work group communication network influences work group performance positively. We also hypothesized and tested whether there is an inverted u-shaped relationship between out-group-tie centralization and group performance to support our proposed work group boundary spanning management approach, which states that the best way to manage boundary spanning at the work group level is to assign boundary spanning tasks to a small number of selected group members suited to the task.

Our data did not support Hypothesis H1, perhaps explainable by the fact that there may also be negative effects on performance from high-grade dense interaction structures within a group. Higher levels of density in the interaction structure increase the likelihood that group members approach peak levels, where their workload capacity begins to reach overload from increased communication due to many communication partners and reciprocal helping activities [16], [22], [25]. Capacity overload, particularly over extended time, increases stress and reduces group member motivation, thus negatively affecting their performance and, by extension, overall group performance

[26]. Furthermore, at high levels of density, individual behavior may become determined or controlled by the system, constraining individual autonomy to cooperate or partake in reciprocal helping activities as individuals see fit and are able to handle, thereby in turn having a negative effect on group performance [22]. This is because increased visibility and accountability due to intense interaction among group members indirectly create group behavior norms and ensure that these norms are maintained [17]. While this may restrict opportunistic behavior and therefore affect group performance positively, as mentioned above, these group behavior norms may also force group members to engage in cooperation and reciprocal helping activities even if those group members are already operating at full capacity or if their capacity is strained. The increased communication and workload may create or increase capacity overload, which in turn increases stress, reduces motivation, and impairs the performance of individual group members [26], in turn having the same effect on overall group performance. Moreover, constraining individual autonomy to interact, cooperate, engage in reciprocal helping activities, and do work as the individual sees fit also reduces the satisfaction and motivation of group member's by inhibiting the gratification that accompanies culturally supported needs for autonomy, recognition, and achievement [25]; in turn, it may reduce individual performance and, by extension, overall group performance. In addition, highly dense in-group interaction structures can lead to a very strong work group-community feeling with strong positive in-group biases and negative out-group biases, therefore limiting or preventing the absorption and elaboration of alternative information generated external to the group and even perhaps leading to strong norms against associating with actors who are not members of the group [13], [15]. This is because work groups with strong positive in-group biases and negative out-group biases tend to develop an "us-versus-them" mentality [22]. Interactions with other groups are then more likely to be perceived as interfering, and information exchanges across groups that would otherwise be perceived as providing helpful feedback or constructive criticism may be seen instead as attacks [22]. These biases limit access to and absorption of new and innovative information from outside the group, creating a tendency for the information inside the group to be homogeneous and redundant [27].

In summary, one might argue for a reversed u-shaped relationship between density and performance. In other words, increased density should have a positive relationship with performance to a certain point, at which the positive aspects of a high density (see the research hypothesis development of H1) are reversed by the negative aspects highlighted in the last paragraphs.

Therefore, we reestimated Model 1, adding a squared density effect to the equation (see Table 4). However, we found neither the squared density effect nor the ordinary density effect to be statistically significant at a .1 level of significance. Hence, we also cannot conclude that there is a reversed u-shaped relationship between density and performance. This fact can be also illustrated by a scatter plot that depicts the association between density and group performance (see Fig. 1). Apparently, there is no (linear or reversed u-shaped) relationship between density and group performance.

Of more theoretical and managerial relevance are our results regarding Hypothesis H2. The hypothesis tests supported a reversed u-shaped relationship between out-

group-tie centralization and group performance (compare also Model 3 in Table 4). These findings indicate that work groups should pay attention not only to managing their interactions within the group, but that it is necessary as well to manage actively the ties to out-group members. An organization should not encourage its group members to leave out-group interactions to a central person within the team, nor should it encourage all group members to have an equal level of out-group interactions. Rather, a medium level of variance in the amount of out-group interaction among group members is beneficial for work group performance.

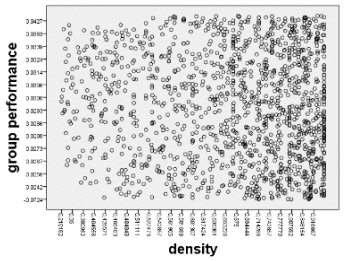

Fig. 1. Scatter plot group performance / density

Table 4. Model 3

	Estimate	*Std. Error*	*t value*	*Pr(>|t|)*	
Intercept	1.670e-02	2.947e-03	5.665	1.80e-08	***
Gender proportion	6.201e-02	8.633e-03	7.183	1.14e-12	***
Density²	2.824e-04	1.956e-04	1.443	0.149131	
Density	9.116e-05	3.104e-04	0.294	0.769082	
Out-group-tie centralization²	-2.871e-04	1.252e-04	-2.294	0.021970	*
Out-group-tie centralization	9.751e-04	3.109e-04	3.136	0.001750	**
Work Group Dummies			Yes		
Month Dummies			No		
R^2			0.2284		
Adjusted R^2			0.1563		
F(123, 1316)			3.167***		

† p < .1; * p < 0.05; ** p < 0.01; *** p < 0.001

6.2 Limitations and Future Research

Of course, as with any empirical study, ours is subject to some limitations that could be seen as affecting the rigor and relevance. First, in the panel data model we did not consider any time lags between the independent variables and the dependent variable. For example, we assumed that a higher density would cause a higher performance in the same period. However, it could be that the positive density effects pay off only later. Hence, future research should examine lagged effects from the density on the performance of a work group. Second, the examined effects were rather small despite

their statistical significance. Hence, future research should replicate our findings using different samples. Third, in this study we merely found a correlation between outgroup-tie centralization and the performance of work groups. Correlation in and of itself does not imply causation. Hence, future research should test Hypothesis H2 with different methods that allow testing for causation (e.g., controlled experiments). Fourth, to construct the informal network with its social relation ties, we used the occurrence of email communication between the employees of the organization analyzed. One could argue that using the email network as a proxy for the informal network is invalid, since some employees may have informal contact with each other without exchanging emails. Consequently, some of the informal social ties between employees and work groups may be missing in our data set – suggesting that one should construct the informal network via a questionnaire. However, using the email network as a proxy for the informal communication network also has some advantages over a questionnaire – especially that email interactions between individuals and groups can be gathered automatically. This helps avoid the social desirability bias, memory effects, and the Hawthorne effect, as well as transcription errors that occur when the adjacency matrix (which is the aggregate of the information provided by the respondents) is entered manually into evaluation software [28]. However, we suggest future research should reexamine our findings using other means for collecting the informal network. We do not consider these limitations to void our results, so long as we remain aware of them as we draw conclusions. In fact, they suggest some future research that examines the association between informal interaction networks and the performance of work groups. It is our hope that our research will assist others in conducting these types of studies and form the basis for substantial future research into the relationship between informal interaction networks and the performance of work groups.

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Appendix A.6: Paper VI

Bibliographic data	Eismann, K., Posegga, O., & Fischbach, K. (2016). *Collective Behaviour, Social Media, and Disasters: A Systematic Literature Review*. In: Proceedings of the European Conference on Information Systems (ECIS). Istanbul, Turkey.
Abstract	The widespread availability and use of social media has drastically altered disaster response in the last few years. Although a considerable amount of empirical research addresses social phenomena enabled by social media in response to disasters, the field still lacks a clear-cut knowledge base. We conduct a systematic literature review to illustrate the state of the art with respect to collective behaviour in social media in disaster situations. We find that social media have the potential to alter well-known patterns of collective behaviour, such as the distribution of activities undertaken by different types of actors over the disaster management lifecycle. Social media furthermore loosen the structural relationships between actors as they facilitate addressing wider audiences and enable communication to unspecified receivers. We conclude that future research should specifically address the causal relationship between collective behaviour in social media and the characteristics of disasters. Furthermore, research should pay particular attention to adapting existing theories and frameworks to, and developing new theoretical approaches for, the emerging digital world.
URL	http://aisel.aisnet.org/ecis2016_rp/104/

COLLECTIVE BEHAVIOUR, SOCIAL MEDIA, AND DISASTERS: A SYSTEMATIC LITERATURE REVIEW

Research

Eismann, Kathrin, University of Bamberg, Bamberg, Germany, kathrin.eismann@uni-bamberg.de

Posegga, Oliver, University of Bamberg, Bamberg, Germany, oliver.posegga@uni-bamberg.de

Fischbach, Kai, University of Bamberg, Bamberg, Germany, kai.fischbach@uni-bamberg.de

Abstract

The widespread availability and use of social media has drastically altered disaster response in the last few years. Although a considerable amount of empirical research addresses social phenomena enabled by social media in response to disasters, the field still lacks a clear-cut knowledge base. We conduct a systematic literature review to illustrate the state of the art with respect to collective behaviour in social media in disaster situations. We find that social media have the potential to alter well-known patterns of collective behaviour, such as the distribution of activities undertaken by different types of actors over the disaster management lifecycle. Social media furthermore loosen the structural relationships between actors as they facilitate addressing wider audiences and enable communication to unspecified receivers. We conclude that future research should specifically address the causal relationship between collective behaviour in social media and the characteristics of disasters. Furthermore, research should pay particular attention to adapting existing theories and frameworks to, and developing new theoretical approaches for, the emerging digital world.

Keywords: Collective Behaviour, Social Media, Disaster, Crisis.

1 Introduction

There can be little doubt that the late 20th century has seen a rapid increase in both human-made and natural disasters (Coleman, 2006; Eshghi and Larson, 2008). The emergence of new information and communication technologies and particularly social media has significantly altered disaster response in recent years (Veil *et al.*, 2011). It has also attracted the attention of the information systems (IS) discipline. Beginning with the seminal paper of Palen and Liu (2007), a new focus on IT usage in disaster response has evolved in IS and the social sciences.

Investigating social phenomena in the social media environment is exceedingly promising, as these technologies allow for exploring behavioural patterns that were once invisible (Kleinberg, 2008).The pervasiveness of such technologies and the convergence of digital and social networks enable scholars to adopt new perspectives on well-established theories and assumptions that emerged when the world was more analogue (Agarwal *et al.*, 2008; Lazer *et al.*, 2009).

Although in disasters social media are often used simply as information dissemination tools (Lindsay, 2011), there is evidence that they also promote distinct social phenomena such as digital convergence (Hughes *et al.*, 2008) and digital commemoration (Liu, 2011; Walter, 2015). The most prominent social phenomenon refers to so-called *digital volunteers*, that is, groups of people who engage in disaster relief on a nonprofessional basis, emerging and carrying out their activities mainly online.

Starbird and Palen (2011), for instance, describe the resources and constraints faced by digital volunteers. St. Denis *et al.* (2012) outline merits and drawbacks of digital volunteers, whereas Starbird (2011) relates their crowdsourcing potential. Others address interactions between digital volunteers, non-digital volunteers, and relief professionals (Hughes and Tapia, 2015; Reuter *et al.*, 2013).

While these studies contain valuable insights into disaster-related behaviours, they do not provide a complete picture of social phenomena in social media in disasters. Our particular interest is on phenomena termed *collective behaviour* that emerge when individual actions are embedded into a social context through social media (Goldstone and Gureckis, 2009). The purpose of our research is to gain a more general view on collective behaviour in social media in disasters. Our research question is:

RQ: What disaster-related collective behavioural phenomena have been observed in social media so far?

We investigate the knowledge base of collective behaviour in disasters in social media by means of a systematic literature review (Kitchenham and Charters, 2007; Webster and Watson, 2002). This enables us to address questions that cannot be answered in isolated studies, particularly those that explain the findings of previous research within the framework of theory (Rowe, 2014).

The remainder of our review is structured as follows: Section 2 provides a theoretical background on collective behaviour in disasters and introduces an analytical framework. Section 3 details our research method. Section 4 summarises the key findings on collective behaviour in social media in disasters, and section 5 discusses the implications of these findings. Section 6 is our concluding remarks.

2 Theoretical background

2.1 Collective behaviour in disasters

Our assessment of collective behaviour in social media takes place against the background of disasters, defined as "serious disruption[s] of a community or society involving widespread human, material, economic or environmental losses and impacts, which exceed […] the ability of the affected community or society to cope using its own resources" (United Nations Office for Disaster Risk Reduction, 2009, p. 9). Disasters share the attributes of common crises in that they are harmful and disruptive situations of high magnitude that occur suddenly and demand prompt response, but stand outside the affected actors' typical operating framework (Reilly, 1993). They are regarded as "crises gone bad", that is, as crises collectively framed as having bad endings (Boin, 2005).

It would be shortsighted, however, to restrict disaster phenomena to the physical realm. They do not only affect communities physically, but are in equal measure social phenomena (Quarantelli and Dynes, 1977). Having a significant impact on the functioning of the social order, disasters cannot be viewed independently of social perception (Kreps, 1984). Hence, we assume disasters are shaped by the affected community's or society's percipience, which also affects their responses to the observed disruption (Blumer, 1971).

Given that disasters are inherently disruptive, it follows that they are disposed to remove or at least shift mechanisms of social control. While individuals' behaviour is typically bounded by a variety of social institutions, these instances of supervision can easily be renegotiated by extreme events such as disasters. This gives way to emergent patterns of collective behaviour that may otherwise be unthinkable (Coleman, 1990). According to Coleman (1990), collective behaviour is characterised by three key features: it involves more than one individual taking similar action at the same time; it is by nature transient and instable, and hence lacking stable equilibria of action; and it requires that the individual actions of which it is constituted be in some way interdependent.

Although collective behavioural phenomena are not restricted to disasters, they are particularly distinct in this context. Previous research concludes that relevant collectives in disasters usually lack common features of their counterparts in other situations, especially regarding hierarchical organisation. Those that do match basic organisational requirements, however, typically lack other constituent features of

organisations, particularly with regard to their size. Finally, disaster situations frequently manifest emergent group phenomena (Quarantelli and Dynes, 1977); that is, groups of citizens otherwise not involved in disaster management emerge around perceived needs or problems associated with the disaster (Stallings and Quarantelli, 1985).

The ubiquity of social media technologies does not stop at those collective behavioural phenomena in disasters (Veil *et al.*, 2011). People – disaster victims, observers, and volunteers alike – are taking up the new technology's potential to connect with each other, participate in events, and seek and provide disaster-related information (Palen, 2008). Social media affect collective responses to disasters with respect to the coordination of disaster management activities, communication of disaster management to the public, and communication between and among citizens (Latonero and Shklovski, 2011). Additionally, social media have enriched disaster response through so-called virtual emergent groups, that is, emergent groups that originate and carry out their activities mainly online (Reuter *et al.*, 2012).

In the following, we provide a state-of-the-art overview on collective behaviour in disasters observed in the social media environment. In particular, we seek to expose the patterns of collective behaviour in social media implicit in current disaster research. Furthermore, we transfer the themes of collective behaviour identified in the literature to the analytical framework of collective behaviour in disasters presented below. In doing so, we hope to extend the theoretical foundations of collective behaviour in disasters in the social media environment.

2.2 Analytical framework

According to Kreps (1984), there are four structural dimensions of disasters along which their features can be classified: the disaster event, its impacts, the social units affected by these impacts, and the responses taken up by the affected social units. The *disaster event* describes the physical specification of a disaster. Its *impact* includes both physical and social disruptions and losses provoked by the disaster. Accordingly, the *social units* affected by the disaster can be found at various levels of aggregation, ranging from individuals to entire societies. The *response* includes all types of behaviour by the affected social units in order to adapt to the disaster.

We argue that the affected actors' responses take place interdependently in a system of interaction brought forth by the disaster-related social disruptions. These mutually dependent individual actions, in turn, add up to collective patterns of behaviour (Morgeson and Hofmann, 1999). Following again from Kreps (1984), collective behaviour is taken to comprise a sequence of activities, resources, tasks, and domains. This implies that it is triggered by *activities* by the social units in response to perceived disaster-related social disruptions (e.g., spontaneously searching for victims). Subsequently, the human and material *resources* available to the actors (e.g., previous training), as well as the particular *tasks* they perform over the course of their activities (e.g., scanning a specific area), affect the emergence of collective behaviour. In the last step, the *domain* – that is, the superordinate disaster-related function into which the task is embedded (e.g., general search and rescue actions) – determines the final shape of collective behaviour (Kreps, 1984).

Accordingly, collective behaviour in response to a disaster, as described by the sequence of activities, resources, tasks, and domains of behaviour, is shaped by 1) the physical disaster event, 2) its impacts, 3) the affected social units, and 4) these units' responses that ultimately result in collective behaviour. Figure 1 is an overview of the analytical framework. Although we focus on collective behaviour in social media, it is noteworthy that the social units' responses can take place offline as well as online.

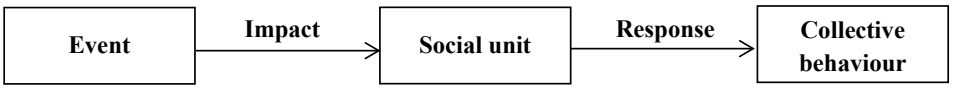

Figure 1. Framework of collective behaviour in response to disasters (following Kreps (1984)).

With respect to the physical disaster event, the *type of a disaster* has proven highly relevant in disaster research. It describes whether disasters are natural, human-made, or both (Shaluf, 2007). Natural disasters, which include both natural phenomena such as earthquakes and landslides and biological phenomena such as infestations and epidemics, are beyond human control. Human-made disasters, by contrast, are consequences of human decisions and include socio-technical and warfare disasters (Shaluf, 2007). These categories are not mutually exclusive, but allow for hybrid cases (Shaluf, 2007).

The four *phases of disaster impact* are commonly regarded as the major distinctive feature of the impact dimension. This aspect is related to the chronology of disaster events (Lettieri *et al.*, 2009). The first two phases, mitigation and preparedness, take place prior to the actual disaster event. Mitigation describes the time during which efforts are made to prevent a disaster, minimise its impacts, and reduce vulnerability. Preparedness, which follows, is the phase during which concrete actions are taken to prepare the affected population and responders for post-disaster activities. The third phase, response, begins when disaster strikes; it is when actions are taken to manage the disaster impact and control its effects, with the aim of minimising losses and damage. Finally, recovery takes place after the physical disaster event. During this phase, efforts are made to bring the affected area and population back to its normal state (Lettieri *et al.*, 2009). These phases are known as the "lifecycle of disaster management"; they can be thought of as a circle, with post-disaster activities blending into subsequent mitigation efforts (Moe and Pathranarakul, 2006).

Several secondary features of the disaster impact are not directly dependent on the disaster phase. Kreps (1995), for instance, elaborates on the duration, scope, and magnitude of disaster impact. The *duration* relates to the temporal extent of a disaster impact, that is, the time lag between the onset of social disruption and physical harm and its conclusion. The *scope* of impact refers to the social and geographic boundaries of disaster impact, whereas the *magnitude* describes its severity (Kreps, 1995). With regard to the magnitude of impact, we are particularly interested in the dimension of personal impact, that is, the severity of a disaster's impact on disaster victims (Berren *et al.*, 1982).

The literature has also elaborated upon a functional classification of *actor types* to describe the social units affected by a disaster. Any of them can be involved directly or indirectly in disaster response management. For example, the population – that is, the common people on the ground – and the media reporting on the disaster are typically involved only indirectly. Conversely, official agents – public and private organisations, as well as volunteer agencies – and researchers are usually involved directly (Lettieri *et al.*, 2009).

As we aim for an overview of collective behaviour in social media, we restrict our argument to behaviours that can be observed in the respective environment. Social media platforms are defined in terms of technology as Web 2.0 platforms open to modification, participation, and collaboration by all users, and in terms of usage as providing a forum for user-generated content created by non-professional contributors (Kaplan and Haenlein, 2010). At present, various social media platforms are used in disaster-related communication, including popular platforms such as Facebook, Twitter, and Flickr (Briones *et al.*, 2011; Liu *et al.*, 2008), but also disaster-specific applications (Ludwig *et al.*, 2015; Reuter *et al.*, 2015). Because specific social media platforms are subject to frequent conceptual and technological changes (Oinas-Kukkonen *et al.*, 2010), we focus instead on their general features.

According to Kane *et al.* (2014), social media platforms can meaningfully be described in terms of four stable features, namely whether and to what degree a platform: provides unique user profiles ("digital profile"); allows users to access digital content through and protect it from various search mechanisms provided by the platform ("search and privacy"); provides mechanisms for users to articulate a list of other users with whom they share a connection ("relational ties"); and allows users to view and traverse their connections and those of others on the platform ("network transparency").

The focus of our study is collective behaviour in such social media platforms in disasters. While offline collective behaviour in disasters includes well-known phenomena such as looting, episodes of mass hysteria, and spontaneously organised search and rescue groups (Weller and Quarantelli, 1973), its specific shape in social media is less clear. Therefore, our purpose is to investigate patterns of collective behaviour in social media and their relation to disaster characteristics in the literature.

3 Method and procedures

3.1 Systematic literature review

We investigate the knowledge base on disaster-related collective behaviour in social media in disasters by means of a systematic literature review. This method provides the means to identify, evaluate, and interpret the available research on collective behaviour in social media in disasters (Kitchenham and Charters, 2007). The goal of our review is explanatory in nature, as we seek to expose how findings on social media usage in disasters relate to the theory of collective behaviour in those situations. In pursuing this goal, we follow the recommendations and guidelines described by vom Brocke *et al.* (2009) and summarise research outcomes and particular findings of existing work around the analytical framework presented in section 2.2.

In the first step, we conducted a systematic literature search to capture a comprehensive and complete set of relevant primary studies on disaster-related collective behaviour in social media, following the guidelines by Kitchenham and Charters (2007). In doing so, we drew a representative sample of highly relevant papers to provide the reader with a meaningful overview of the current state of the art (vom Brocke *et al.*, 2009). We derived search terms from the two main aspects of our research question, that is, disasters providing the context of research and social media as mediating technology (Kitchenham and Charters, 2007). We did not restrict our search to particular forms of collective behaviour to gain a broad picture of current research. We applied "disaster" and "crisis" (both in their singular and plural forms) as relevant synonyms for the context, as these terms are often used interchangeably (Shaluf *et al.*, 2003). To capture research on social media, we used the term "social media" as a keyword. Following Berger *et al.* (2014), we also included the keyword "social network", which is often used in the same context. In summary, we used the terms "social media" and "social network" (both in their singular and plural forms) as keywords. This led to the following search terms:

Search terms: *Title, abstract, keywords: (disaster* OR cris*s) AND ("social media" OR "social network" OR "social networks")*

As systematic literature reviews should cover not only the IS discipline, but also related fields of research (Webster and Watson, 2002), we conducted a keyword-based search in seven IS and social sciences literature databases. We included the ACM Digital Library, AIS Electronic Library, EBSCOhost online research databases, IEEE Xplore Digital Library, JSTOR, ScienceDirect, and the Social Science Citation Index. We used the databases' Web interfaces to search the title, abstract, and keywords of indexed manuscripts. Our final search, conducted on 29 October 2015, yielded 3,746 hits across all databases.

After removing duplicate entries within the databases, we applied a series of exclusion criteria to remove all papers that did not contain direct and relevant evidence on our research question (Kitchenham and Charters, 2007). Table 1 shows the number of papers that remained after each step. We elaborate on our screening procedure in the paragraphs that follow.

	Overall hits	**Unique hits**	**Relevance screen**	**Format screen**	**Research design screen**	**Quality screen**
ACM	150	150	51	45	10	9
AISeL	33	33	19	17	7	6
EBSCO	2,250	1,845	407	218	49	27
IEEEXplore	293	276	39	38	9	5
JSTOR	66	55	1	1	0	0
ScienceDirect	238	236	65	53	16	13
SSCI	716	716	146	138	35	18
Total	**3,746**	**3,311**	**728**	**510**	**126**	**78**

Table 1. Number of search results in the systematic search process.

In the first screen, we excluded all content not related to the research question based on title and abstract (*relevance screen*). More specifically, we excluded papers that did not concentrate on disasters in the sense of serious disruption with widespread impacts (e.g., personal crises), social media (e.g., social support networks), and collective behaviour as relating to activities, resources, tasks, and domains addressed by social units in disaster situations (e.g., event detection algorithms).

In the second iteration, we excluded all research that did not explicitly qualify as peer-reviewed, completed research. Thus, we excluded book chapters, book reviews, dissertations, and research-in-progress papers. Furthermore, we excluded all papers written in languages other than English (*format screen*).

In a third iteration, we excluded papers not primarily empirical (*research design screen*). Most of the excluded papers at this stage had a theoretical focus or presented advice rather than describing behaviours. In this step, we identified five literature reviews on social media usage in disasters: Crowe (2011) investigates the opportunities of social media systems for emergency management professionals; Houston *et al.* (2015) present a framework of social media usage in disasters; Simon *et al.* (2015) elaborate on utilisation of social media by various actors; Veil *et al.* (2011) present best practices of social media usage for practitioners; and Wybo *et al.* (2015) explore the merits and drawbacks of social media in disasters. We did not regard these reviews as source material, but still included them as additional bases in the subsequent forward and backward search.

Finally, we assumed that the major contributions would be published in leading journals and conference proceedings (Webster and Watson, 2002). We consulted the ERA 2010 journal and conference ranking (Australian Research Council, 2011a, 2011b) and excluded all papers ranked in category C or lower; that is, we kept all papers in the categories A*, A, and B (*quality screen*). We decided against including highly cited papers in lower-ranked outlets, as screening those publications revealed they contained little if any further evidence on the topic. We did not apply additional quality criteria to keep as much evidence as possible.

Subsequently, we conducted an additional forward and backward search based on the references retrieved in the systematic literature search (Webster and Watson, 2002). In the forward search, we identified papers that cited the literature we had identified in the systematic search using the Web of Science Citation Index and Google Scholar. In the backward search, we screened the references of our selected papers for sources contributing to our own research.

Overall, the systematic literature search yielded relevant 78 hits, resulting in 52 distinct papers across all databases. An additional 16 papers that met our selection criteria were identified in two rounds of forward and backward search. This led to a total of 68 papers that served as a basis for data analysis.

3.2 Data extraction and analysis

To extract findings from the literature, we applied a qualitative content analysis based on deductive categories (Mayring, 2000). Categories are based on the concepts introduced in the analytical framework in section 2.2.

With regard to the disaster event, we recorded the specific event being investigated and specifically took note of the type of event, following Shaluf (2007). For the disaster impact, we noted the phase of event that was studied (Lettieri *et al.*, 2009), as well as the duration, scope, and magnitude of the event as specified by the respective authors (Kreps, 1995). With respect to the social units, we evaluated the type of actors and whether they were involved directly or indirectly in disaster management as specified by Lettieri *et al.* (2009). Finally, we noted the characteristics of the actors' response in social media. Therefore, we recorded the specific social media platforms utilised by the relevant actors and in what ways, as described in the texts. To assess the usage of social media by various actors, we applied as a coding scheme the functional framework proposed by Houston *et al.* (2015). Furthermore, we detailed the structure of these social media in question with regard to the structural characteristics proposed by Kane *et al.* (2014).

We then evaluated specific patterns of collective behaviour evident in the texts. Although none of the papers we examined referred explicitly to collective behaviour, we found that all patterns of behaviour we identified are adequately described by this concept as they were typically pursued simultaneously by a number of individuals and the actions were typically taken interdependently but without a recognisable equilibrium of action (Coleman, 1990). We followed Morgeson and Hofmann (1999) in assuming that collective behaviour has both a structural and a functional component. In this context, *structure* describes the individual actions and interactions of which collective behaviour is comprised, whereas *function* relates to the causal outcomes of behaviour. While the structural component yielded information on activities and resources of collective behaviour, the functional element represented the tasks and domains addressed by collective behaviour in a structured and evaluable form. In particular, we extracted individual behaviours as described in the texts, plus, if available, relevant social norms, relationships between the actors, structures of interactions, dynamic developments, and contexts of interaction. With regard to the function of collective behaviour, we took note of the specific behavioural outcomes as specified by the studies' authors, and of the relationships between the individual actors' goals and the collective outcomes (Morgeson and Hofmann, 1999).

Subsequently, we analysed how different configurations of disaster dimensions led to differences in the reporting of the structure and function of collective behaviour. Overall, we identified seven irregularities we could ascribe to systematic differences in disaster events, impacts, social units, and responses. The findings as well as the underlying literature are reported below.

4 Findings

We inferred seven key findings from the literature that illustrate the state of knowledge regarding the relationship between disaster characteristics and collective behaviour in social media in response to these very characteristics. Table 2 shows how our findings relate to the model categories presented in section 2.2. The first column contains the dimension of the framework to which the respective findings refer. We assigned a numerical indicator to each of the findings to aid the discussion that follows the table; these are enumerated in the second column and described briefly in the third column.

Framework	Finding	Description
Event	Finding 1	Sharing and obtaining factual information is the primary function of social media usage consistently across all disaster types, but the secondary functions vary.
Impact	Finding 2	Disaster management activities are not restricted to individual phases of the disaster management lifecycle in social media.
	Finding 3	The duration, scope, and magnitude of disasters influence the extent of social media usage in a disaster, but not necessarily the structure and function of usage.
Social units	Finding 4	Different actor types make use of social media in similar ways, but perceive different conditions and restrictions for social media usage in disaster situations.
	Finding 5	Social media enable members of the population to reach formerly inaccessible actors, but do not ensure two-way communication.
	Finding 6	Social media integrate unspecified and wider audiences into disaster communication, which can lead to group emergence.
Response	Finding 7	The features of social media platforms determine the structure and function of collective behaviour on these platforms in disasters.

Table 2. Affiliation of findings to framework dimensions.

Finding 1: Sharing and obtaining factual information is the primary function of social media usage consistently across all disaster types, but the secondary functions vary.

The literature indicates that the type of disaster affects the initial activities undertaken by the social units. The function of social media usage in disasters mentioned most often is to document and learn

what is happening. In disasters, be they natural or human-made, actors often perceive a lack of timely and locally relevant information in times of uncertainty and rapidly changing demands (Brengarth and Mujkic, 2016; Huang *et al.*, 2010; Sarcevic *et al.*, 2012; Shklovski *et al.*, 2008). Traditional media and other communication channels are often unavailable (Jung, 2012; Jung and Moro, 2014; Procopio and Procopio, 2007; Tagliacozzo and Arcidiacono, 2015). In some cases, media coverage is simply deemed insufficient given the urgent needs of those seeking information (Chen *et al.*, 2014; Huang *et al.*, 2015; Kaewkitipong *et al.*, 2012; Kaewkitipong *et al.*, 2016; Leong *et al.*, 2015; Monroy-Hernández *et al.*, 2013; Ostertag and Ortiz, 2015). Receiving factual information on disasters from social media enables actors not only to learn what is happening but also to make sense of events (Palen and Vieweg, 2008; Shaw *et al.*, 2013).

The relevance of other social media functions varies across different disaster types. In natural disasters such as earthquakes and floods, providing and receiving information about disaster response activities and opportunities is highly cited (Brengarth and Mujkic, 2016; Chatfield *et al.*, 2014b; Chen *et al.*, 2014; Hughes *et al.*, 2014; Kaewkitipong *et al.*, 2012; Kaewkitipong *et al.*, 2016; Leong *et al.*, 2015; Muralidharan *et al.*, 2011b; Sarcevic *et al.*, 2012; Takahashi *et al.*, 2015). Social media are also used to provide and receive disaster warnings (Ahmed and Sargent, 2014; Ahmed and Sinnappan, 2013; Carter *et al.*, 2014; Chatfield *et al.*, 2014a; Chatfield and Brajawidagda, 2013; Hughes *et al.*, 2014) and preparedness information (Ahmed and Sinnappan, 2013; Chatfield *et al.*, 2014a; Chatfield and Brajawidagda, 2013), raise awareness of the disaster and promote fundraising (Ahmed and Sinnappan, 2013; Brengarth and Mujkic, 2016; Smith, 2010; Takahashi *et al.*, 2015), and seek and provide emotional support (Ahmed and Sinnappan, 2013; Al-Saggaf and Simmons, 2015; Procopio and Procopio, 2007; Recuber, 2012; Takahashi *et al.*, 2015).

These findings, however, do not hold for other types of disasters. If the event is biological in nature, such as an epidemic, the reported focus of activity is on providing and receiving preparedness information (Kim and Liu, 2012; Tirkkonen and Luoma-aho, 2011), and furthermore on discussing causes and consequences (Gaspar *et al.*, 2014). Things are different again if disasters have a human or social cause, as in school shootings and terror attacks. In these cases, social media are used more to express emotions and memorialise victims (Huang *et al.*, 2015; Kaufmann, 2015; Mazer *et al.*, 2015; Neubaum *et al.*, 2014; Recuber, 2012), establish connections between geographically remote community members (Kaufmann, 2015; Mark *et al.*, 2009; Semaan and Mark, 2012), and engage in conversations and discussions about response and recovery efforts (Kaufmann, 2015; Mazer *et al.*, 2015). If the cause of a disaster is technical in nature, social media are used to discuss causes and implications of the event (Muralidharan *et al.*, 2011a; Yin *et al.*, 2015), and to implement traditional disaster communication activities (Diers and Donohue, 2013; Muralidharan *et al.*, 2011a).

Finding 2: Disaster management activities are not restricted to individual phases of the disaster management lifecycle in social media.

We found evidence that social media contribute to relieving resource restrictions on collective behaviour, which widens the scope of observed behavioural outcomes in social media. Disaster response is basically cyclic, which means that recovery efforts in the post-disaster phase tend to intermix with mitigation activities at the beginning of the lifecycle of the subsequent event (Moe and Pathranarakul, 2006). The literature suggests, however, that in social media the activities associated with the disaster phases not only blend into each other, but occur irrespective of the lifecycle phases.

Specifically, the literature suggests that providing and receiving preparedness and warning messages often occurs in the response and recovery stages. In natural disasters, for instance, regular preparedness messages such as weather updates and general education are distributed independently of the ongoing event (Ahmed and Sinnappan, 2013; Chatfield and Brajawidagda, 2013). Warnings in the response or recovery phase can be triggered by fear of secondary impacts such as aftershocks or severe weather (Ahmed and Sargent, 2014; Acar and Muraki, 2011; Ahmed and Sinnappan, 2013; Chen *et al.*, 2014; Jung and Moro, 2014; Kaewkitipong *et al.*, 2012; Kaewkitipong *et al.*, 2016; Leong *et al.*, 2015). In biological disasters, preparedness messages regarding preventive measures are sent out during the response phase to prevent further spreading (Kim and Liu, 2012; Tirkkonen and Luoma-

aho, 2011). In cases of ongoing violence, warnings are directed at those not already aware of the events (Ems, 2014; Huang *et al.*, 2015; Mark *et al.*, 2009; Omilion-Hodges and McClain, 2016).

Furthermore, there is evidence that response activities take place in the recovery phase in social media if the duration of the disaster event is relatively short. This is, for instance, the case for earthquakes that last only minutes but that have a long-term impact on the affected social units. The literature suggests that in those cases actors perform typical response activities – such as asking for and providing help and asking for and sharing information on one's wellbeing – after, rather than during, the disaster event (Acar and Muraki, 2011; Tagliacozzo and Arcidiacono, 2015; Qu *et al.*, 2011).

Conversely, we also identified post-disaster activities that occur particularly in the mitigation phase. The most striking example describes community building efforts typically attributed to the recovery phase (Houston *et al.*, 2015), but that actually take place during mitigation in social media. Relief agencies in particular are said to appreciate that social media allow for establishing a community of stakeholders before a disaster actually strikes, thus ensuring that there is a community on which these agencies can rely in case of disaster (Liu *et al.*, 2012; van Gorp *et al.*, 2015).

Finding 3: The duration, scope, and magnitude of disasters influence the extent of social media usage in a disaster, but not necessarily the structure and function of usage.

Research findings indicate that the secondary characteristics of disaster impact – its duration, scope, and magnitude – influence the extent to which actors utilise social media in disasters. We find that higher impacts on any of these dimensions lead to higher degrees of disaster-related activity observed in social media.

There is evidence for this relationship across all types of disasters. For natural disasters, where we found the most variation in secondary impact characteristics covered by the literature, a high level of social media activity is reported in geographically disperse earthquakes with severe consequences (Acar and Muraki, 2011; Jung and Moro, 2014), wide-scale and long-term floods (Ahmed and Sinnappan, 2013; Chen *et al.*, 2014; Kaewkitipong *et al.*, 2012; Kaewkitipong *et al.*, 2016; Shaw *et al.*, 2013), and highly destructive and distributed weather events (Chatfield *et al.*, 2014b; Hughes *et al.*, 2014). Less communication is mentioned in locally restricted earthquakes (Tagliacozzo and Arcidiacono, 2015), floods in isolated areas (Al-Saggaf and Simmons, 2015; Sutton *et al.*, 2015; Starbird *et al.*, 2010), and short-term and local weather events (Carter *et al.*, 2014; Lachlan *et al.*, 2016).

This finding, however, is accompanied by a lack of insights regarding the structure and function of interaction conditional on the disaster impact. So far, we see no systematic deviations in social media usage depending on the secondary characteristics of disaster impact. On the contrary, a wide variety of interaction structures and functions is described in both major and minor disasters. We conclude that the literature does not report consistent patterns of qualitative impact on collective behaviour.

Finding 4: Different actor types make use of social media in similar ways, but perceive different conditions and restrictions for social media usage in disaster situations.

Literature indicates that social media influence the resource restrictions perceived by different types of social units. While different types of actors make use of social media platforms in basically similar ways in disasters, they perceive different conditions and restrictions of access. For example, populations on the ground rarely experience barriers to social media usage in disasters. On the contrary, the widespread adoption and use of social media is often seen as a reinforcing factor for this actor type (Al-Saggaf and Simmons, 2015; Huang *et al.*, 2010; Monroy-Hernández *et al.*, 2013). Similarly, the easy access to social media platforms (Al-Saggaf and Simmons, 2015; Chatfield and Brajawidagda, 2013) and the possibility to participate in communication passively (Austin *et al.*, 2012; Neubaum *et al.*, 2014) and to some degree anonymously (Al-Saggaf and Simmons, 2015; Kaufmann, 2015) contribute to the popularity of social media usage in disasters by members of the population. In fact, the literature reports only confining measures taken by governments as restrictions pertaining to members of the population (Chatfield *et al.*, 2012; Ems, 2014).

However, disaster agents such as government agencies, private business organisations, and relief agencies are ascribed an initial barrier to recognise the necessity to communicate at all in social media (Bygstad and Presthus, 2013; van Gorp *et al.*, 2015). Furthermore, various actors, including official agents, media, and research agencies, are said to face resource restrictions to utilising social media in disasters. In particular, scarcity of time, staff, and training are repeatedly mentioned (Brengarth and Mujkic, 2016; Bygstad and Presthus, 2013; Majchrzak and More, 2011; van Gorp *et al.*, 2015).

This finding strongly resembles the technology acceptance model in its basic form (Davis, 1989). There is evidence that the degree of technology distribution and secondary platform features affect conditionally perceived usefulness and ease of use as they diminish or reinforce access barriers for different types of users. Therefore, they influence the technology acceptance of social units confronted with social media adoption in disaster situations.

Finding 5: Social media enable members of the population to reach formerly inaccessible actors, but do not ensure two-way communication.

While it is a major function of social media in disasters to connect or reconnect community members (Houston *et al.*, 2015), their integrative potential transcends the population level. Social media establish direct communication channels between the population and other actors from whom they were formerly separated. In regimes that underlie general restrictions on public communication, social media provide the means for members of the population to address the government (Al-Saggaf and Simmons, 2015; Qu *et al.*, 2009; Qu *et al.*, 2011). Similarly, social media constitute an alternative communication channel for governments and business organisation if the public discussion of disaster shifts from offline to social media platforms (Bygstad and Presthus, 2013; Diers and Donohue, 2013; Tirkkonen and Luoma-aho, 2011). Therefore, social media diminish personal resource constraints that otherwise apply to collective behaviour in disasters.

It is noteworthy, though, that social media do not ensure two-way communication between these actors. Apparently, social media are used as an additional channel for information distribution rather than for dialogue. For instance, members of the population may well be heard if they call for a government response, but they rarely receive attention in social media (Al-Saggaf and Simmons, 2015; Qu *et al.*, 2009; Qu *et al.*, 2011). Conversely, the government may utilise social media to disseminate information, but not engage in dialogue with the population (Carter *et al.*, 2014; Tirkkonen and Luoma-aho, 2011). And although there is evidence that business organisations do indeed engage in disaster communication in social media (Bygstad and Presthus, 2013; Chewning *et al.*, 2013; Diers and Donohue, 2013), they may fail to recognise the shifting locus of communication (Yin *et al.*, 2015).

Finding 6: Social media integrate unspecified and wider audiences into disaster communication, which can lead to group emergence.

While communication between formerly inaccessible actors would also be possible in traditional communication channels, social media enable actors to share information with an unspecific and diffuse audience (Hughes *et al.*, 2014). Thus, social media again diminish the perceived resource constraints in collective behaviour.

Not all content is actually untargeted. There is evidence that actors may try to reach related others of whose personal identity they are ignorant (Yates and Paquette, 2011). In other cases, it is possible to attribute seemingly undirected communication to the actors' intention to raise the awareness of a wider, possibly international audience (Ahmed and Sinnappan, 2013; Ems, 2014; Jung and Moro, 2014; Morris, 2014; Smith, 2010). This implies that social media have the potential to open up the audience in disaster response to social units not affected (directly or indirectly) by a disaster.

In other cases, however, actors are not at all interested in targeting their messages. Muralidharan *et al.* (2011b) and Sarcevic *et al.* (2012), for instance, indicate that relief agencies often send out information into the broad social media to be read by anyone who happens to stumble across it. Similarly, research agencies and governments utilise social media to reach unspecific audiences, as

when they issue preparedness and warning messages (Acar and Muraki, 2011; Chatfield and Brajawidagda, 2013; Jung and Moro, 2014; Toriumi *et al.*, 2013; Chatfield *et al.*, 2014b).

There is evidence that social media thus lead to group emergence in various forms and functions. For example, the literature mentions members of the population establishing institutions of civilian life in war environments (Al-Ani *et al.*, 2010; Mark *et al.*, 2009; Semaan and Mark, 2012), forming civil self-defence groups in civil wars (Monroy-Hernández *et al.*, 2013; Savage and Monroy-Hernández, 2015), coordinating protest movements (Chatfield *et al.*, 2012; Ems, 2014; Morris, 2014; Smith *et al.*, 2015), and establishing bottom-up relief activities (Dailey and Starbird, 2014; Leong *et al.*, 2015; Majchrzak and More, 2011; Starbird and Palen, 2011). Although not all of these groups are virtual in the sense that they carry out their activities online (Reuter *et al.*, 2012), they do include formerly unrelated citizens organising around perceived needs of disasters (Stallings and Quarantelli, 1985).

Finding 7: The features of social media platforms determine the structure and function of collective behaviour on these platforms in disasters.

Finally, there is evidence that features of the social media platforms affect the tasks that can be addressed by collective behaviour in disasters. According to Liu *et al.* (2012) and van Gorp *et al.* (2015), Twitter is highly useful for disaster relief professionals as it is easy to use and monitor, facilitates quick information dissemination, and can be updated from anywhere. Facebook, however, is seen as more static, but is still appreciated as it offers a broader audience base and enables longer messages. Our references reveal this pattern is robust. Twitter is the social media platform referred to most often in our sample of papers (36 times), followed by Facebook (21 times). Since there is little empirical evidence on other platforms, we restrict our argument to these two.

The literature documents that Twitter is often used to exchange disaster-related information by all types of social units in all disaster categories. In particular, this includes warnings (Acar and Muraki, 2011; Ahmed and Sargent, 2014; Chatfield and Brajawidagda, 2013; Chatfield *et al.*, 2014a; Chatfield *et al.*, 2014b; Ems, 2014), situational updates (Ahmed and Sargent, 2014; Chatfield *et al.*, 2014b; Ems, 2014; Gaspar *et al.*, 2014; Hughes *et al.*, 2014; Jung, 2012; Lachlan *et al.*, 2016; Sinnappan *et al.*, 2010; Smith *et al.*, 2015), and awareness information (Brengarth and Mujkic, 2016; Denef *et al.*, 2013; Toriumi *et al.*, 2013). There is evidence, however, that Twitter is also used for functions that require personal relations and two-way communication, such as for inquiring about another's wellbeing (Acar and Muraki, 2011; Jung, 2012; Jung and Moro, 2014) and discussing events and their consequences (Gaspar *et al.*, 2014; Jung, 2012; Kaufmann, 2015; Pang and Ng, 2016).

Facebook is clearly preferred for functions that require longer text messages and active communication. On this platform, the functions that prevail include relief coordination (Brengarth and Mujkic, 2016; Chen *et al.*, 2014; Kaewkitipong *et al.*, 2012; Kaewkitipong *et al.*, 2016; White *et al.*, 2014), keeping in touch with others (Jung, 2012; Kaufmann, 2015; Tagliacozzo and Arcidiacono, 2015), discussing events and consequences (Al-Saggaf and Simmons, 2015; Jung, 2012; Kaufmann, 2015; Schwarz, 2012), and seeking and giving advice (Ahmed and Sinnappan, 2013; Chen *et al.*, 2014; Kaewkitipong *et al.*, 2012; Kaewkitipong *et al.*, 2016; Savage and Monroy-Hernández, 2015).

Relating these patterns to the work of Kane *et al.* (2014), we recognise that social media characteristics help explain the structure and functions of interactions that take place on the particular platforms. Twitter, for instance, has enhanced possibilities to share short messages and publish direct and indirect updates. Users can "follow" other users of interest and receive automatic notifications of their messages (Huberman *et al.*, 2009). Therefore, the platform facilitates access to digital content, establishing relational ties between users, and retracing these ties in a transparent way. It provides easy mechanisms for distributing and receiving short and precise messages to and from a wide target group. Still, discussion and private communication is possible due to the platform's relational properties. On Facebook, users can also express preferences and publish status updates, but one of its outstanding features is that the platform allows users to connect with each other, which facilitates establishing and preserving relationships (Wilson *et al.*, 2012). Facebook's potential to share and access digital content is not as great as that of Twitter, yet users' ability to create a unique digital profile and establish a list

of "friends" with whom they are related is noteworthy. Thus, on Facebook it is typical to communicate in depth with a more restricted target audience.

5 Discussion

The systematic literature review presented above addresses disaster-related collective behaviour that has been observed in social media. As Palen (2008) points out, social media are frequently used by a variety of actors facing disaster-related social disruptions, including relief organisations, victims, and volunteers. Yet current research on social phenomena in social media, such as digital volunteers (e.g., St. Denis *et al.*, 2012), digital commemoration (e.g., Walter, 2015), and digital convergence (e.g., Hughes *et al.*, 2008), rarely goes beyond the context of specific behaviours, which is symptomatic of the fragmented nature of disaster research (Tierney, 2007). We show, however, that collective behaviour in social media can be quite different from its offline counterparts and therefore should be regarded as a phenomenon in its own right.

Our contribution to the field is threefold. First, we draw from established theories to develop an analytical framework to guide our research. Second, we conduct an extensive, systematic literature review to identify core papers on the topic, which we analyse on the foundation of our framework. Third, we synthesise the results of our analysis and derive seven central findings that summarise the state of the art in the investigated line of research. In doing so, we demonstrate that existing social theory is suitable to explain findings on social phenomena in social media.

We present evidence that disaster characteristics do, in fact, influence collective behaviour in social media in response to the respective disasters. Although information-sharing activities are of primary relevance in all types of disaster, we conclude that the type of a disaster affects the secondary activities pursued in social media. Additionally, the literature indicates that social media relax resource restraints on collective behaviour, which includes restrictions regarding both the disaster impact phases and the social units affected by the disaster. Finally, our findings suggest that the social media platforms available to the social units shape the tasks they perform in disaster situations. Absent further evidence, we presume that the specific domains of collective behaviour in disaster, that is, the main functions performed by the social units, are untouched by social media. Therefore, we conclude that social media technologies influence the activities taken by social units in disasters as well as the resource constraints faced by and the tasks aimed at by these actors.

Our findings show that social media have the potential to diminish established relationships between collective behaviour and disaster characteristics. On the one hand, we see that traditional functions are detached from specified actors and disaster impact phases. Disaster-related activities can be performed by anyone and at any time in social media. On the other hand, structural patterns of interaction between social units tend to resolve in social media. There is evidence that social media platforms connect audiences that are affected directly by a disaster with others that are at most concerned indirectly. At the same time, it has become possible to disseminate messages to whomever might be interested, rather than having to address any particular audience.

Although there is considerable empirical evidence that social media affect collective behaviour in disasters, to the best of our knowledge the underlying causal mechanisms remain unexplored. For example, we can infer from the literature that established social structures are expanded to formerly excluded as well as to wider audiences in social media. Furthermore, social media enable users to connect to unspecified receivers. Yet we cannot be sure whether social relationships are indeed obsolete in social media, or whether we are rather facing disinterest on the part of researchers.

Similarly, we might ask whether the established assignments of functions to actors and phases are subject to change rather than dissolution. Consider, for instance, the relation between the secondary characteristics of disaster impact and the structure and function of social media usage. We might suppose that major disasters lead to a higher degree of social media usage because they affect a greater number of social units, or because they awaken the interest of a wider audience attracted due to the increased severity of impact. Likewise, major disasters might lead to a higher degree of damage in other communication channels, which may in turn cause an increased reliance on social media. Future

research should explore how impact characteristics relate causally to collective behaviour and whether traditional variables remain valid in the social media environment.

Additionally, existing work suggests a correlation between social media characteristics and collective behaviour observed in these platforms. Again, though, we lack insights into the underlying causal mechanisms. It is highly plausible that actors use particular social media platforms because they offer certain advantages that favour the actors' purposes. At the same time, observed behaviour could be a consequence of those social media characteristics, that is, actors pursue certain paths of action because they are facilitated by the technology at hand. Further research is needed to investigate the causal mechanisms behind specific patterns of collective behaviour and social media characteristics.

As readers will have noticed, our review relies on a framework published in 1984. As disaster research is often conducted independently of theoretical developments, seminal work from this era remains highly relevant (Drabek and McEntire, 2003; Tierney, 2007). However, there is little research on the relevance of this work for digital social phenomena. Therefore, we encourage future research to investigate the transfer of existing social theory to, and develop new approaches for, the emerging digital context.

Our findings are limited further by the scope of the literature search. Relying on a representative sample of relevant texts, we systematically neglected evidence from low-ranked publication outlets, which also include expert fora. Although screening these papers did not reveal further insights, research aiming at in-depth analyses should definitely consider these sources. Additionally, our sample of text includes multiple evidence on major disasters, such as the Haiti earthquake in 2010, the Thailand floods of 2011, and the Tohōku earthquake in 2011. Less dramatic events are addressed sporadically, but are generally underrepresented. Thus, future research should consider systematic mapping studies in this field to assess the actual transferability of findings on social media usage in disasters.

6 Conclusion

Social media do not have direct impact on physical disasters, but they do shape how people respond to disasters. Considering the extensive influence on disaster response of widespread social media availability and use, our research addresses collective behavioural phenomena affected by disasters but also, to a considerable extent, framed by social media. We investigated the impact of social media on disaster-related collective behaviour by means of a systematic literature review covering 68 articles in leading IS and social science outlets. To structure our findings, we utilised an analytical framework based on Kreps' (1984) remarks on collective behaviour. Our findings shed light on how key characteristics of disasters influence collective behaviour in social media. We propose that future research should evaluate the causal relationships between disaster characteristics and collective behaviour, and furthermore contribute to the theoretical foundations of social phenomena specifically in social media. In doing so, we contribute to a growing and promising line of research that investigates the interplay between social media and social phenomena in the context of disasters.

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Appendix A.7: Paper VII

Bibliographic data	Fischer, D., Posegga, O., & Fischbach, K. (2016). *Communication Barriers in Crisis Management: A Literature Review.* In: Proceedings of the European Conference on Information Systems (ECIS). Istanbul, Turkey.
Abstract	Communication between and within crisis response organizations (i.e., fire and rescue services, medical assistance, government agencies, public organizations, police) and the public (i.e., victims, volunteers, people affected by the attacks) is essential for coping with natural or man-made crises such as Hurricane Katrina or the terror attacks of 9/11. Research, however, emphasizes that effective communication is difficult to establish because multiple communication-related barriers arise during crisis management that impede enhanced mitigation, preparedness, response, and recovery. Although research in crisis management and crisis communication gains more and more practical and scientific notice, it still lacks a comprehensive overview. Hence, we conducted a systematic literature review to examine how communication between and within crisis response organizations and the public takes place during the mitigation, preparedness, response, and recovery phases of a crisis. The results show that several techno-logical, organizational, and social barriers hinder communication between all involved. The purpose of this review is to provide a foundation based on the current literature and suggest future research directions to advance knowledge on communication and barriers in communication between and within crisis response organizations and the public during crisis management.
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COMMUNICATION BARRIERS IN CRISIS MANAGEMENT: A LITERATURE REVIEW

Research

Fischer, Diana, University of Bamberg, Bamberg, Germany, diana.fischer@uni-bamberg.de

Posegga, Oliver, University of Bamberg, Bamberg, Germany, oliver.posegga@uni-bamberg.de

Fischbach, Kai, University of Bamberg, Bamberg, Germany, kai.fischbach@uni-bamberg.de

Abstract

Communication between and within crisis response organizations (i.e., fire and rescue services, medical assistance, government agencies, public organizations, police) and the public (i.e., victims, volunteers, people affected by the attacks) is essential for coping with natural or man-made crises such as Hurricane Katrina or the terror attacks of 9/11. Research, however, emphasizes that effective communication is difficult to establish because multiple communication-related barriers arise during crisis management that impede enhanced mitigation, preparedness, response, and recovery. Although research in crisis management and crisis communication gains more and more practical and scientific notice, it still lacks a comprehensive overview. Hence, we conducted a systematic literature review to examine how communication between and within crisis response organizations and the public takes place during the mitigation, preparedness, response, and recovery phases of a crisis. The results show that several technological, organizational, and social barriers hinder communication between all involved. The purpose of this review is to provide a foundation based on the current literature and suggest future research directions to advance knowledge on communication and barriers in communication between and within crisis response organizations and the public during crisis management.

Keywords: crisis communication, crisis management, barriers in communication, information and communication technology

1 Introduction

To cope with natural or man-made crises, it is crucial to distribute relevant information and expertise in a timely manner to all crisis response organizations (i.e., fire and rescue services, medical assistance, government agencies, public organizations, police) to save lives and minimize damage. Under such stressful and highly dynamic situations, effective communication can literally be a matter of life and death. For instance, during 9/11, responding organizations could not rely on contingency plans due to the scale and uniqueness of the attack. Multiple organizations were involved in the crisis response (Kapucu, 2006a; Comfort and Kapucu, 2006); the public (i.e., victims, volunteers, people affected by the attacks) reacted in unforeseeable ways (Comfort and Kapucu, 2006); and communications technology failed (Kapucu, 2006a; Comfort and Kapucu, 2006); information flowed too slowly and at insufficient levels of detail (DeBruijn, 2006). Moreover, coordination between the various responding organizations failed because they did not establish communication with other crisis responders before the event (De Bruijn, 2006; Comfort and Kapucu, 2006; Kapucu, 2006b). It has been established that communication between all crisis responders is a key factor that positively affects preparedness, mitigation, coordination, and cooperation; empowers communities; and limits harm (Van Gorp et al., 2015). Hence, barrier-free communication is crucial for successfully managing a crisis.

Given the catastrophic failures crisis responders have faced due to the many communication-related challenges, scholars have dedicated a considerable amount of attention on the role of communication in crisis management (Allen et al., 2014; Dawes et al., 2004; Kapucu, 2006a; Manoj and Baker, 2007; Netten and Van Someren, 2011). Reliable and effective communication during a crisis response is difficult to achieve because it must be established within and between organizations and with the public. Despite multiple advances in crisis communication and related technology (Ahmed, 2011; Amailef and Lu, 2011; Chen et al., 2008b; Currion et al., 2007; Fruhling, 2006), crisis communication is often experienced as ineffective (Allen et al., 2014; Bharosa et al., 2010; Day et al., 2009). In addition, to the best of our knowledge, research lacks a comprehensive overview about communication during crisis management and the barriers hindering communication. To address this issue, we conduct a systematic literature review to synthesize existing literature on crisis communication and communication barriers between and within crisis response organizations and the public. The review also suggests several avenues for future research.

The remainder of this paper is structured as follows. In the next section, we provide a theoretical background for crises, crisis management, crisis communication, crisis responders, and communication barriers. Based on this theoretical background, we develop a framework to combine the theoretical perspectives and guide the literature review, which we explain in section 3. In section 4, we present our findings in the light of our theoretical framework. In section 5, we discuss our results and present limitations, future research directions, and a conclusion.

2 Theoretical Background

In this section, we provide a theoretical background for crises and crisis management (including the four phases of crisis management), crisis communication, crisis responders, and barriers in crisis communication. Based on this theoretical background, in the subsequent section we develop and present a framework to guide our literature review and the development of a research agenda.

2.1 Definition of Crisis and Crisis Management

According to Staw et al. (1981), there is no generally accepted definition of *crisis*. Several terms for crisis, such as emergency, disaster, or catastrophe, have been used interchangeably, although sometimes with slight differences (Hiltz et al., 2011). We adopt the definition of Kreps (1984: p. 312), who defines crises as "events, observable in time and space, in which societies or their larger subunits (e.g., communities, regions) incur physical damages and losses and/or disruption of their routine functioning." This review focuses in particular on natural and human-made crises, such as hurricanes or terror attacks (Eshghi and Larson, 2008).

A review by Lettieri et al. (2009) reveals that the literature on crisis management agrees on four time-oriented phases of crisis management: two pre-crisis phases, *mitigation* and *preparedness*; and two post-crisis phases, *response* and *recovery* (Lettieri et al., 2009; Petak, 1985). The aim of the mitigation phase is to prevent a crisis and mitigate the vulnerability of environmental and social systems. In the preparedness phase, also pre-crisis, the aim is to enable crisis managers and other potential crisis responders to respond effectively should a crisis actually happen (McLoughlin, 1985). In the post-crisis response phase, all responders react with the aim of preventing further loss and damage. The fourth crisis phase is recovery, in which the restoration and rehabilitation of the crisis environment takes place (McLoughlin, 1985). As Dorasamy et al. (2013) state, most research explores the post-crisis phases, especially the response phase.

2.2 Crisis Responders' Communication in Crisis Management

In the crisis context, communication is the process of creating a shared meaning among all involved. The specific aim of crisis communication is to address the crisis successfully. Communication serves relationship building, information collecting, coordination, information dissemination, and planning for

and managing a crisis (Sellnow and Seeger, 2013) and thus is important in all four crisis management phases. In pre-crisis phases, communication supports mitigation and preparation, and in post-crisis phases it enhances the response to and recovery from threats the crisis creates.

This literature review distinguishes between two groups of *crisis responders*: crisis *response organizations* includes all organizations involved, such as relief organizations, government agencies, medical assistance, fire and rescue services, and the police; and the *public*, comprising victims, volunteers, and other people affected by the event. We include the public and its role because increased access to and use of social media has resulted in the public taking an active part in crisis management (Ling et al., 2015).

Crisis communication takes place within and between response organizations as well as among the public, and the public also communicates with organizations during crisis management (Quarantelli, 1997; Quarantelli, 1988).

2.3 Barriers in Communication Flow and Framework

Researchers found that challenges managing a crisis are often related to *communication barriers* (Bharosa et al., 2010; Day et al., 2009; Hale et al., 2005). Manoj and Baker's (2007) research on crisis communication defines three categories of communication barriers. *Technological barriers* correspond to problems based on the technology used for crisis management. *Social barriers* in communication arise because of the differences among individuals in the various crisis response organizations or the public involved during the crisis phases. *Organizational barriers* arise between and within organizations during crisis management.

In the Figure 1 framework, for crisis responders, arrows between boxes show communication between the two groups of responders identified above and circular arrows show communication within each group. The arrows shown with the management phases emphasize that the phases play out over time and that mitigation begins again after recovery.

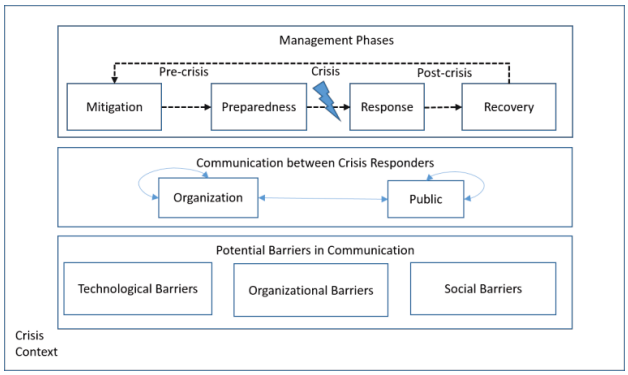

Figure 1. Framework for Communication during Crisis Management

3 Methodology

The aim of this study is to synthesize highly relevant literature on communication and communication barriers during crisis management by means of a systematic literature review (Schwarz et al., 2007). Our approach follows the recommendations of Okoli and Schabram (2010) as well as Webster and Watson (2002) as guides in structuring the review. We developed the analytical framework presented in the previous section based on an initial screening of seminal work on the topic. We use it to derive the following search terms:

*Title, abstract, keywords: (cris*s OR disaster OR catastrophe OR emergenc*) AND (mitigation OR preparedness OR response OR recovery) AND (communication OR information)*

Taking into account the interdisciplinary nature of the topic, we conducted the keyword-based search in five information systems (IS) and social sciences literature databases: AIS Electronic Library, EBSCO Business Source Complete, ACM Digital Library, Science Direct, and IEEE Xplore Digital Library. The search yielded 11,719 articles. After removing the duplicates (n=2,292), we applied the following exclusion criteria. First, we screened the title, keywords, and abstracts of all papers and excluded those that did not relate to the topic or were written in a language other than English (n=7,769). For example, we excluded articles that investigate crises that do not fall under the definition of Kreps (1984) (e.g., organizational image crises (Coombs, 2015), financial crises (Eastburn and Boland, 2015)). Second, following the recommendations of Kitchenham and Charters (2007), we defined quality guidelines and excluded literature not complying with those guidelines (n=1,582). The quality guidelines were based on the *journal quality list (JQL),* which ranks more than 900 journals based on 18 different rankings (Harzing, 2015). In this review, we included only high-quality literature published in outlets ranked as A*, A or B in the JQL. In addition, we included the proceedings of the five primary IS conferences (i.e., Americans Conference on Information Systems, European Conference on Information Systems, Hawaii International Conference on Systems Science, International Conference on Information Systems, Pacific Asia Conference on Information Systems) to account for the emerging nature of the research topic and IS focus of this article. These conferences are not ranked by the JQL. However, all five conferences are well respected in the IS community and have high standards of quality. The selection criteria have two major implications. One, we assume that major contributions are published in leading journals and conferences. This assumption is often made in literature reviews (Webster and Watson, 2002) and relaxed by conducting (1) a comprehensive forward and backward search on the included articles and (2) making justified exceptions for highly influential papers on the research topic identified in the process. Very few of those exceptions (n=7) were made if and only if all authors agreed on the inclusion of the paper in question.

The final sample included 76 studies. In an in-depth review of each of the remaining papers, we extracted all available information on communication barriers, crisis management phases, and the crisis responders. Those notes are the basis for the following review. Table 1 shows the number of articles found that corresponded to the sections of the framework. Please note that a single paper may contribute to more than one category.

Communication Barriers		**Communication between Crisis Responders**		**Management Phases**	
Technological	48	Intra-Org.	10	Mitigation	8
Organizational	55	Inter-Org.	55	Preparedness	31
Social	49	Org.-Public	35	Response	69
		Public	13	Recovery	14

Table 1. Number of articles found for each section of the framework

4 Review Results

We present the results of the subsections of the framework in this section as follows. We first present the findings regarding technological, organizational, and social communication barriers. For each type of communication barrier, we provide a table summarizing the core findings of our literature review. We then present the findings on the management phases (i.e., mitigation, preparedness, response, recovery).

4.1 Technological Barriers

Technology is vital during crisis response and recovery, because it is often the only way to overcome geographic distances and enables communication with people in the crisis area and those responding to and managing the crisis. The first technological barrier is *infrastructure failure*. For instance, communications technology became vulnerable and failed during Hurricane Katrina because the infrastructure was damaged by water and/or wind—sometimes exacerbated by previous mismanagement. Attempts to get the communications system back online were hampered by conflicts over resources among crisis responders and the system's failure itself, which made communication difficult or impossible (Garnett and Kouzmin, 2007). During 9/11, communication networks failed; networks thought to be redundant were actually running on the same damaged infrastructure (Dawes et al., 2004).

Second, crisis responder's *non-acceptance of technology* is a serious issue in crisis response and recovery that this can lead to a bottleneck of information dissemination in post-crisis phases (Lee et al., 2011; Ada et al., 2010). Aedo et al. (2010), using the well-known *technology acceptance model* designed to explain the use and acceptance of a new technology in organizations (Hu et al., 1999), pointed out that it is still difficult to get multiple organizations to accept and adopt the same technology. Crisis responders not accustomed to a new technology intended for crisis response communication may not use it, opting instead to stick to more familiar technology they already use (Lee et al., 2011; Manoj and Baker, 2007; Van de Walle and Turoff, 2007). Additionally, many systems were developed to address crisis problems without adapting usability specifically to the user group of responders (Carver and Turoff, 2007). This is consistent with the argument of Day et al. (2009), who claim that crisis responders collect data on paper and not for electronic processing because they do not see the value of the technology. Hence, *non-acceptance of technology* can hinder communication on an intra- and inter-organizational level, resulting in inefficient use of the technology (if it is used at all) and causing time delays.

The third technological barrier is the *use of different technology*. Crisis management systems are often developed to address crisis management functions within one organization and therefore have no interoperability among multiple organizations. These standalone systems, addressing only a part or parts of the crisis and usable by some but not all responders, limit the ability to exploit fully the efficiencies of crisis management as a whole (Dilmaghani and Rao, 2009). In addition, responders often to a crisis situation bring various technical resources, such as diverse data or information formats, that have never before been applied together. These differences can also lead to interoperability problems and hinder communication (Day et al., 2009).

Social media usage by crisis responders can cause the fourth technological barrier. The literature identifies many opportunities for social media in crisis management to serve as a means for collecting and integrating public information, but also notes some problems. Oh et al. (2013) argue that social media services have high potential as rumor mills because of source ambiguity. Rumors, particularly during the response phase, can be dangerous by supplying communication lines with incorrect information (Oh et al., 2013) that can interfere with the decision making of crisis responders (Oh et al., 2015). In addition, Chatfield et al. (2014) claim that the integration and verification of information generated in online forums is still a major challenge. Another key challenge with social media for crisis responders is to aggregate information and determine its reliability (Zhou et al., 2013). Further, organizations might miss the potential of social media by preferring traditional communication channels (Kaewkitipong et al., 2012).

Table 2 summarizes the findings on these four technological barriers.

Technological Barriers	Sources
Infrastructure failure disrupts the communication between physically separated crisis responders and occurs due to: • radio and cell phone blackouts; • loss and failure of communications systems—sometimes exacerbated by previous mismanagement; • the absence of backup communications networks; • disruption of infrastructure support.	Chen et al., 2008a; Chen et al., 2010; Dawes et al., 2004; Goel et al., 2004; Ipe et al., 2010; Junglas and Ives, 2007; Kouzmin and Garnett, 2007; McEntire, 2002; Pan et al., 2012; Perry, 2007; Scholl and Patin, 2012; Scholl et al., 2012.
Non-acceptance of technology is a potential communication barrier because crisis responders at different locations: • resist using a given communication system during crisis response; • resist adopting a communication system at the organizational level; • use inadequate means of communication, such as paper; • do not use the system because its design is unwieldy.	Aedo et al., 2010; Carver and Turoff, 2007; Day et al., 2009; Gomez and Turoff, 2007; Lee et al., 2011; Manoj and Baker, 2007; Reddy et al., 2009.
The *use of different technology* leads to communication problems due to: • a lack of interoperability; • inconsistent information formats or data standards that hinder information exchange between organizations.	Chen et al., 2008b; Currion et al., 2007; Day et al., 2009; Dilmaghani and Rao, 2008; Garnett and Kouzmin, 2007; Gomez and Turoff, 2007; Reddy et al., 2009.
Communication barriers between organizations and the public resulting from the use of *social media* occur due to: • rumors in social media that interfere with the decision making of crisis responders • problems of integration and verification of information and information overload • inadequate information quality; • organizations not exploiting the potential of communication with social media, preferring instead one-way communication.	Chatfield et al., 2014; Gonzalez and Bharosa, 2009; Kaewkitipong et al., 2012; Oh et al., 2015; Zhou et al., 2013.

Table 2. Technological Barriers

Technological barriers not addressed and eliminated during the pre-crisis phases can hinder communication between all crisis responders during response and recovery.

4.2 Organizational Barriers

Organizational barriers to communication occur between and within crisis response organizations during the post-crisis phases if organizations do not collaborate before the crisis occurs. The first barrier arises from *organizational differences*. In crisis response, organizations with differing organizational cultures—each with its own norms and rules and different expectations about informal and formal conversations—must work together. Organization-specific rules and norms bind organizations, and the focus on their own tasks in crisis response can hinder the communication process between responders from different organizations. A lack of understanding of these different norms and rules can lead to misunderstandings between the organizations involved in the crisis management process (Allen et al., 2014). Hence, strong norms and rules between organizations hinder communication and complicate the creation of a common perspective on the crisis. Rietjens et al. (2009) investigated crisis communication between NGOs and the military and found that their different skills, personalities, working methods, norms, terminology, and preferred means of communication created barriers to interorganizational communication. The unfamiliarity between the different organizations, as well as the absence of understanding of knowledge, capabilities, and professionalism of the other party, all impede communication. This is in line with the results of Bharosa et al. (2010), who found that a lack of awareness about or lack of

interest in the other organization limits information sharing. In addition, the multiple organizations involved have different information privacy requirements, which can limit data exchange between each organization (Dilmaghani and Rao, 2009).

Organizational structures are another communication barrier found in the crisis management literature. Professionals from different organizations are shaped by their positions and tasks in those organization. Some response organizations have a top-down, hierarchical command-and-control structure like that of the military (Manoj and Baker, 2007), with highly bureaucratic structures and detailed rules, policies, procedures, and instructions (Bigley and Roberts, 2001). Roles in such organizations are specialized and based on standardization, routines, and regular training. Other organizations have more informal structures or structures based on equality. Some response organizations are more disciplined than others (Bharosa et al., 2010). This is not a problem in the pre-crisis phase, but these differences between organizations can lead to collaboration and coordination problems when an unpredicted crisis strikes. Moreover, bureaucratic structures can hamper the response due to the size and uniqueness of the crisis, especially if that response must deviate from conventional crisis plans or protocols (Turoff et al., 2004b).

Further, *network-related communication* barriers can hamper communication; these arise when the boundaries between organizations have not been sufficiently spanned before a crisis erupts. Some crises, because of their size and dynamics, require a considerably greater degree of coordination between organizations than is typical. Underdeveloped relationships are problematic when a crisis breaks out (Kapucu, 2006a; McEntire, 2002) because the organizations may not know the proper points of contact or may not have a leading organization coordinating and overseeing the information flow (Pan et al., 2012). It may even be demanding to work with unknown and sometimes even rival organizations.

A lack of trust between organizations can hinder communication during crisis response (Garnett and Kouzmin, 2007; Kapucu, 2006a). Day et al. (2009) reported problems in information sharing with source identification and inaccessibility. Hence, crisis responders did not know where to find the required information and responsibilities and remained inactive. Day et al. (2009) also identified an unwillingness to share information with other organizations as a hindrance to communication. The reason for this could be, for example, regulatory issues, organizational policies, or a lack of trust.

Another barrier concerns *location and resource issues*. Gomez and Turoff (2007) claim that missing or insufficient training with communications systems can hamper communication in response efforts, because responders do not learn how to use a system efficiently. Also, competition for limited resources among response organizations can be an obstacle to communication. For instance, Perry (2007) emphasized that competing humanitarian agencies had poor and inadequate interorganizational coordination. Moreover, it is often not clear before a crisis which data are relevant for other responders, because there are no objective selection criteria.

Table 3 summarizes the organizational barriers found in the literature.

Organizational Barriers	**Sources**
Organizational differences impede communication because: • employees of different organizations are a product of different cultures, rules, and norms and are bound by organizational policies and bureaucracies; • organizations use different terms or languages; • organizations have different organizational structures, which can bind employees to their normal communication channels and bypass other relevant crisis responders; • response organizations have different goals and interests; • there is an imbalance in information interdependency between organizations; • there are different information privacy requirements in organizations;	Allen et al., 2014; Bajpai et al., 2010; Bharosa et al., 2010; Bigley and Roberts, 2001; Bui et al., 2000; Chen et al., 2008a; Dawes et al., 2004; Dilmaghani and Rao, 2008; Dilmaghani and Rao, 2009; Garnett and Kouzmin, 2007; Hale et al., 2005; Kapucu et al., 2010; Li et al., 2014; Manoj and Baker, 2007; McEntire, 2002; Pan et al., 2005; Pan

• employees are a product of their own roles within organizations, and have different skills, motivations, and personalities; • organizations rely on formal plans that may not apply to some specific crisis response situations.	et al., 2012; Perry, 2007; Reddy et al., 2009; Rietjens et al., 2009; Sujanto et al., 2008; Turoff et al., 2004b; Valecha et al., 2012.
Insufficiently developed networks of organizations hinder communications due to: • a lack of trust between organizations; • insufficient information sharing; • a lack of initial communication between the responders; • an unwillingness to transfer data between organizations; • responders not having proper points of contact; • the absence of a central organization overseeing and coordinating the information sharing.	De Brujin, 2006; Granatt, 2004; Day et al., 2009 Dilmaghani and Rao, 2008; Kapucu, 2006a; Kapucu, 2006b; Kapucu et al., 2009; Kapucu et al., 2010; McEntire, 2002; Pan et al., 2012; Perry, 2007.
Location and resource issues can hamper communication between organizations due to: • inadequate data sources in the crisis area; • limited resources to connect all crisis responders; • insufficient training in the use of communications systems.	Day et al., 2009; Gomez and Turoff, 2007; Gonzalez, 2008; Hale et al., 2005; Perry, 2007.

Table 3. Organizational Barriers

4.3 Social Barriers

Social barriers can hinder communication among all involved due to differences between individuals. *Diversity* can become a social barrier among crisis responders when many people are involved in crisis management and must work together to achieve successful crisis management. Individuals who must harmonize their work may have different nationalities, ethnicities, cultures, political views, religions, or ideologies (Bui et al., 2000). A lack of trust (Manoj and Baker, 2007) or language barriers can impede communication among multiple crisis responders (McEntire, 2002).

If communication does *not meet the requirements of the situation*, it may also create a barrier. For instance, the design of a message can hinder communication because the message may not be received exactly as the sender intended (Hale et al., 2005). The interpretation of the message by the receiver is often incomplete, results in conflicting interpretations, or is hindered due to missing information quality during the crisis response (Hale et al., 2005). Also, the prevalence of different resources and reports with incorrect or insufficient information complicates communication among crisis responders (Dawes et al., 2004; Day et al., 2009; Gonzalez, 2009). Moreover, Hale et al. (2005) point to filtering as another problem for communication among crisis responders. Crisis managers face a dynamic, context-rich, and intense situation of limited resources and time pressure and must make decisions quickly. Filtering is important for retrieving relevant data needed to make choices in a crisis situation; filtering the wrong information can impede decision making.

Information-related problems also are a type of social barrier. Day et al. (2009) report that organizations tend to place a low priority on ensuring reliable flows of high quality information. This may leave decision makers with missing and incomplete data (McEntire, 2002; Day et al., 2009), insufficient information quality (Horan and Schooley, 2007), a lack of information (McEntire, 2002), or too much information (De Bruijn, 2006). Further, crisis situations require decision makers to rely on different information sources. The failure to coordinate the exchange and integration of information is a typical problem in crisis situations (Dawes et al., 2004; De Bruijn, 2006) that can lead to inconsistencies across different information sources (Day et al., 2009), which can be exacerbated by incomplete and conflicting interpretations of data (Hale et al., 2005). Such information-related problems can diminish the level of confidence organizations and decision makers have in their data.

Table 4 summarizes the social barriers found in the literature review.

Social Barriers	Sources
Diversity between responders can hinder communication because of: • language barriers; • religious, ideological, political, ethnic, cultural, and/or nationality differences, any of which can complicate cooperation; • lack of trust between unfamiliar crisis responders.	Bui et al., 2000; Granatt, 2004; Manoj and Baker, 2007; McEntire, 2002; Perry, 2007.
Communication does *not meet the requirements of the situation* due to inadequate: • filtering of messages by the receiver; • message design; • message interpretation by the receiver; • decision making, which is related to cognitive overload due to the highly dynamic situation of crisis response.	Bharosa et al., 2010; De Bruijn, 2006; Hale et al., 2005.
Information-related problems can hinder decision makers due to: • information overload • insufficient information; • a lack of information quality; • incorrect data coordination and integration; • low information priority; • unreliability and low level of confidence in data; • inconsistent data from different sources; • incomplete or conflicting interpretations of data.	Bharosa and Janssen, 2010; Bui and Subba, 2009; Chen et al., 2008a; Clarver and Turoff, 2007; Dawes et al., 2004; Day et al., 2009; De Bruijn, 2006; Gonzalez and Bharosa, 2009; Horan and Schooley, 2007; Manoj and Baker, 2007; McEntire, 2002; Perry, 2007; Reddy et al., 2009; Valecha et al., 2012.

Table 4. Social Barriers

For communication among all crisis responders to be effective, they must be aware of these barriers that—if not eliminated in preparation for a crisis may hinder communication mainly during crisis response and recovery.

4.4 Mitigation Phase

In the mitigation phase, communication between and within organizations primarily concerns dissemination of information about crisis risks; establishing rules and agreed-on plans; and making decisions about land-use policies, funding sources, infrastructure, minimizing the degree of risk in crisis prevention, and the risks for social and environmental systems (Guion et al., 2007). Moreover, organizations share information with the public about possible threats affecting people (Zahran et al., 2010). Gow (2007) introduces a framework for communication policy research pertaining to crisis mitigation.

4.5 Preparedness Phase

In the preparedness phase, organizations must establish functionalities for effective post-crisis management, and must therefore be aware of communication barriers that may hinder these efforts. Hence, in the preparedness phase response organizations focus on reducing negative effects of the crisis. This includes training to improve the skills, decision-making processes, and knowledge of crisis responders (Raman et al., 2006; Yao et al., 2005); interorganizational coordination (Gonzalez, 2008); communication skills (Mendonça, 2007; Yoon et al., 2008); and guidelines to improve information management (Bharosa and Janssen, 2010). Decisions must be made about the technological infrastructure and tools used within and between organizations (Aedo et al., 2010), and regarding the actions that will be taken

in the post-crisis phases (Turoff et al., 2004a). In addition, it is important that responders communicate to keep in touch, plan together for a crisis, and develop trust between organizations (Allen et al., 2014; Bharosa et al., 2010; Kapucu, 2006a). Moreover, building relationships between all crisis responders through training and timely communication among organizations about plans and actions is critical for good collaboration during a crisis response (Kapucu, 2006a). Kaewkitipong et al. (2012) point to the importance of warnings, as in how the Thai government used social media to inform other organizations and the public with weather updates about flooding and its impact.

Researchers increasingly emphasize information exchanges between organizations and the public through social media. For example, Chatfield and Brajawidagda (2013) show that Twitter is a viable complementary warning system because of its communication speed and reach; Tyshchuk et al. (2012) also recommend Twitter as an early warning system. Websites inform the public, reduce uncertainty, provide explanations about how to react, and identify resources for assistance in advance. Van Gorp et al. (2015) show that crisis response organizations use social media to provide advice directly for crisis preparation, point to other resources with crisis advice, and offer news about the crisis to the community. Guidelines for appropriate behavior or a collaboratively developed knowledge base with active discussion spaces are also themes of preparedness (Palen et al., 2007). Ahmed (2011) points out that organizations also must conduct seminars and workshops to educate the public and disseminate plans for crisis response.

Public warnings during crisis preparation are a subject of communication research. Granatt (2004) shows that early-warning partnerships support community crisis preparedness. Examples in the United Kingdom show that these partnerships facilitate trust and security. Gomez and Turoff (2007) emphasize the recommendations of the U.S. Federal Emergency Management Agency (FEMA) for individual preparedness. To establish the preparedness of local responders, Gomez and Turoff propose training and practice for effective communication with mobile information technologies. Further, continuous device use and fostering plain-language use should facilitate technology and communication for the crisis response phase.

4.6 Response Phase

The response phase includes communication within and between many organizations in a highly dynamic environment. Communication is key to quick and efficient coordination in this phase. As described above, several studies provide evidence suggesting that poor communication during interorganizational crisis response has a negative effect on collective decision making, collaboration, and coordination (e.g., Allen et al., 2014; Bui et al., 2000; Chen et al., 2008a; Dawes et al., 2004; Ives and Junglas, 2006). Communication in crisis response includes adapting to the situation as quickly as possible, assessing the appropriateness of formal plans, and gathering and processing information for crisis professionals' decision making. Communications systems are essential to enable information exchanges between crisis responders at different locations (Leidner et al., 2009); therefore, disrupted communications systems or infrastructure must be restored quickly. Hence, crisis managers must know about available backup systems and how they can be deployed.

Social media have changed how crisis information is created and distributed (Tim et al., 2013; Yates and Paquette, 2011). As recent research shows, social media are increasingly being utilized for communication between the public and organizations, for several reasons. For example, Chatfield et al. (2014) studied how the U.S. government engaged citizens with the help of social media during Hurricane Sandy. Carter et al. (2014) analyzed government social media strategies to inform the public in response to weather-related crises. Increasingly, social media are also an information source for crisis response organizations. The pervasiveness of smartphones give people the opportunity to take photos or videos and upload them to the Web immediately. Survivors in an affected area can report what they are seeing or hearing. Social media provide information in real time (Zhou et al., 2013). Crisis responders are

increasingly monitoring comments from the public. The large amount of user-generated content, including tweets, blog posts, and forum messages, can be used to detect an impending crisis or to get details about the scope of an unfolding crisis (Ahmed, 2011; Meesters and Van de Walle, 2014; Van Gorp et al., 2015).

Another function of communication between organizations and the public is for moral and emotional support (Ahmed, 2011). People can express their thanks to crisis responders or give moral support to crisis victims.

Information technologies such as smartphones and social network sites allow the public to take an active part in crisis response (Ada et al., 2010; Ahmed, 2011; Chen and Sakomoto, 2014). Using social media and mapping software on the Web enables citizens to publish and consume their own crisis-related information. Recent research from Ling et al. (2015) shows that social media can facilitate communication between the concerned public, which may not have network access like that of professional agencies. Thus, social media provide a channel for people to inform each other, participate, and not have to rely on or wait for information from the government. In addition, information platforms such as Ushahidi, an open-source project that allows users to crowdsource crisis information they can then send out via mobile phones, enables citizens to upload information on site and play an active role in crisis management (Hyman, 2014).

4.7 Recovery Phase

Cumbie and Sankar (2012) emphasize the importance of information sharing between organizations during crisis recovery to coordinate activities and address tasks such as coordination, short- and long-term shelter, rebuilding, as well as dissemination of information about accessing aid. Communication about available assistance takes place during recovery. Organizations must coordinate and collaborate to provide shelter, rebuild infrastructure, and distribute resources (Guion, 2007) and to maintain relationships with other organizations (Doerfel et al., 2010). Kaewkitipong et al. (2012) state that governments use social media to publicize information about successful recovery activities, collect lessons learned that can help an organization better prepare for another crisis, and facilitate coordination and collaboration between organizations. Further, organizations use social media to build relationships with the public and share information and coordination of volunteer activities. The public uses forums and blogs during the response to disseminate information. For example, Torrey et al. (2007) show that the public used online networks of volunteers to facilitate the distribution of donated goods to hurricane survivors. Further, the public used social media to share moral support and organize as well as promote recovery activities (Kaewkitipong et al., 2012; Palen et al., 2007).

Managing a crisis requires planning, flexible decision making, inter-organizational coordination, training, and technology, and the phases are strongly interdependent. Moreover, as recent research shows, the role of the public has evolved and is increasingly important for crisis management. As these sections have shown, communication among all crisis responders in the different phases of a crisis serves to ensure that these various tasks can be completed.

5 Discussion, Implications for Future Research, and Limitations

This literature review reveals that many papers focus on communication and communication barriers between organizations, while research that addresses intra-organizational communication during a crisis response is uncommon. Further research could explore the barriers to the communication of a crisis response organization in a crisis context. Promising insights and a new perspective on crisis management could also lie in research into organizational crises, such as an information security breach for a large customer base, that were excluded from this review.

Moreover, we found very few papers that followed the mitigation definition introduced in this paper and that also broached the issue of communication; research on pre-crisis phases, for the most part, addresses communication in the preparedness phase. This could be because mitigation—which is about prevention work, such as erecting dams to limit flooding— depends strongly on political and economic decisions about costs and benefits (Bakir, 2004). Nevertheless, risk estimation is important for preventing future loss, and it is in the mitigation phase that long-term risk reduction measures are established. Future research on communication could provide a more integrated view on all four management phases and develop the conceptual framework with all crisis responders considered.

Traditional crisis management systems are used to assist police, fire, medical assistance, and rescue services (Amailef and Lu, 2013), but in recent years research has examined social media as a tool for including information from the public in crisis management as well. This review shows that organizations are increasingly aware of the potential for the public to provide information that can support collective problem solving. Survivors in an affected area can support responders with on-site information about what they are seeing or hearing. Ada et al. (2010) argue that social network sites are a promising form of communication media to support crisis response. But research still lacks explanations for the behavioral intention to use social media during and in the aftermath of a crisis. Future research could explore how emotions or behavioral tendencies lead to public use of social media during a crisis.

Our results also emphasize that several barriers, which occur mainly due to deficient preparation for a crisis, hamper crisis response and recovery. The negative effects of these barriers are mainly experienced in post-crisis phases. Technological barriers such as *non-acceptance of technology* are typically found in the preparedness phase, and if not overcome have a negative impact on the response and recovery phases. Moreover, social barriers often arise during crisis response, when many individuals must communicate and coordinate action in a highly dynamic and confusing situation with incomplete or poor-quality information. To address these problems, future research could examine behavior models in combination with the design of communications systems.

Beyond technological and social barriers, a major source of problems in crisis response lies in the communication between response organizations. Organizations that want to improve their crisis management must change their behavior with respect to relationships with other organizations and build a common understanding of the situation and of the contribution of other organizations in crisis response. Further, there is still no integrated approach in the research aimed at understanding how organizations can learn from past crises. Future research on crisis communication should help us understand how knowledge from past crisis management and failures can be integrated successfully into organizations, with consideration given to all phases of crisis management.

Our research also has some limitations. The quality-based selection criteria we chose typically lead to the exclusion of journals and conferences that lack clearly defined quality standards or that represent small and expert communities. Such communities are often not listed in established journal and conference rankings, which makes it difficult to assess their quality standards. Future research could include such domain-specific journals and conferences (e.g., *International Journal of Information Systems for Crisis Response and Management*) for further insights on the topic. Also, we excluded studies that did not make a clear statement about the crisis responders involved in communication (e.g., papers focused on technological developments in crisis communication). These choices were made so we could focus on papers that explicitly contribute to the research question. It is important to note that some papers may have been missed that might have been relevant for this review.

6 Conclusion

Research shows that the impact and the frequency of crises are rising (Eshghi and Larson, 2008). Crisis communication will be more effective if crisis managers consider crisis management with both foresight and hindsight and consider all four phases of crisis management—mitigation, preparedness, response and recovery—as well as integral communication tasks. Identifying barriers to avoid problems in the future is vital for crisis management. This research provides an overview of the technological, organizational, and social barriers that must be overcome in crisis management. With a comprehensive understanding of the management phases and communication barriers, crisis managers can improve the timeliness and quality of communication and decision making in crisis management and further develop their crisis management skills. The framework in figure 1 can serve as a basis for further research that examines communication and its barriers during crisis management.

A complex crisis situation, by its very nature, brings with it communication challenges for all the crisis responders involved in managing the situation. This demands that crisis responders do what they can in advance to prepare to overcome communication barriers and aid coordination efforts when a crisis strikes. Crisis response organizations can prepare for these communication challenges by building a network among all response organizations, building their understanding of different organizational cultures, being aware of the sociological diversity among crisis responders, and keeping abreast of technology developments to be ready to handle even the worst-case scenarios.

Crisis management is an ongoing process. Every day, response organizations take action to prepare and mitigate crises or watch out for the next crisis. Communication is necessary to enable collaboration and coordination between multiple crisis responders in crisis situations; communication is how people share information, goals, directions, and emotions. Our hope is that the framework provided in this review and the overview of the barriers presented here can help improve communication in crisis management for the benefit of all.

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Appendix A.8: Paper VIII

Bibliographic data	Zuchowski, O., Posegga, O., Schlagwein, D., & Fischbach, K. (2016). Internal crowdsourcing: conceptual framework, structured review, and research agenda. *Journal of Information Technology, 31*(2), 166-184.
Abstract	The use of IT-enabled crowdsourcing with employees in enterprises has increased substantially in recent years. This phenomenon, which we refer to as 'internal crowdsourcing', is distinct both from external crowdsourcing with end users and from hierarchy-based work with employees. A literature stream has emerged that corresponds with the increased relevance of internal crowdsourcing in practice. The purpose of this review paper of internal crowdsourcing is to provide conceptual development, synthesise the literature, and provide a research agenda. In the review reported in this paper, we systematically analysed and critically reviewed the literature in this domain published thus far (74 papers). We found useful findings and insights into a new and relevant IT-enabled phenomenon. At the same time, we also found conflicting definitions and conceptualisation, as well as research efforts that are not well integrated. The paper supports future research on internal crowdsourcing by providing improved conceptualisation, consolidating insights, and identifying important areas for future research.
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Appendix A.9: Paper IX

Bibliographic data	Sobiegalla, F., Posegga, O., & Fischbach, K. (2016). *Connecting Disaster Volunteers and Relief Organizations: A Design Science Approach.* In: Proceedings of the International Conference on Information Systems. Dublin, Ireland.
Abstract	The increasing number of man-made crises presents relief organizations with serious challenges. For one, paid relief workers are increasingly scarce, making disaster volunteers essential components of official endeavors. But there are several issues concerning communication with as well as coordination and organization of disaster volunteers that hamper their deployment. We propose a design theory for mobile crisis response systems to support the management of disaster volunteers, with a focus on the current refugee situation in Germany. We derive requirements from interviews with relief organization employees working at the national level and those operating in the field, as well as with disaster volunteers. We translate requirements into both functional and non-functional design principles and map them to adequate design features, which we implement in a mobile crisis response system. As a practical contribution of our research, we provide specifications that define the form and function of a corresponding system.
URL	http://aisel.aisnet.org/icis2016/ISDesign/Presentations/14/

Connecting Disaster Volunteers and Relief Organizations: A Design Science Approach

Research-in-Progress

Florian Sobiegalla
University of Bamberg
An der Weberei 5
D-96052 Bamberg
florian.sobiegalla@uni-bamberg.de

Oliver Posegga
University of Bamberg
An der Weberei 5
D-96052 Bamberg
oliver.posegga@uni-bamberg.de

Kai Fischbach
University of Bamberg
An der Weberei 5
D-96052 Bamberg
kai.fischbach@uni-bamberg.de

Abstract

The increasing number of man-made crises presents relief organizations with serious challenges. For one, paid relief workers are increasingly scarce, making disaster volunteers essential components of official endeavors. But there are several issues concerning communication with as well as coordination and organization of disaster volunteers that hamper their deployment. We propose a design theory for mobile crisis response systems to support the management of disaster volunteers, with a focus on the current refugee situation in Germany. We derive requirements from interviews with relief organization employees working at the national level and those operating in the field, as well as with disaster volunteers. We translate requirements into both functional and non-functional design principles and map them to adequate design features, which we implement in a mobile crisis response system. As a practical contribution of our research, we provide specifications that define the form and function of a corresponding system.

Keywords: Design science, design research, disaster volunteers, relief organizations, crisis response, mobile crisis response systems

Introduction

Disaster relief organizations increasingly find themselves confronted with the scarcity of paid relief workers (Sargisson et al. 2012) and the growing frequency of man-made crises (Coleman 2006). Disaster volunteers who participate voluntarily in disaster relief activities play an important role in coping with crisis situations. But along with the benefits comes the challenge of managing efficiently volunteers who are not officially associated with relief organizations. Several communication, coordination, and organizational issues hamper the deployment of disaster volunteers (Sargisson et al. 2012). For example, poor communication is likely to lead to counterproductive relief attempts. In addition, a lack of information about existing social structures and organizational processes interferes with and hinders the

efforts of relief organizations. Furthermore, a high degree of volatility in the availability of disaster volunteers sometimes results in work being left undone without notice. Thus, there is room to improve the status quo of cooperation between professionals and volunteers with respect to effectiveness and efficiency.

A crisis response system (CRS) is used to support handling all relevant aspects of crisis response. A mobile crisis response system (MCRS) expands the functionality of a CRS with state-of-the-art information technology distributed over a network of mobile devices (Yuan and Detlor 2005). Typically, though, CRSs and MCRSs do not accommodate including independent parties such as unaffiliated disaster volunteers. Thus, disaster volunteers and relief organizations often lack a bidirectional communication channel that could enable the exchange of relevant information, including information from various sensors embedded in mobile devices (e.g., GPS, accelerometers, microphones, magnetometers, cameras). Establishing such a communication channel could help improve information quality for all parties involved, resulting in more effective coordination of volunteers and, in turn, more efficient disaster management. This study strives to develop, in the context of the refugee crisis in Germany, a suitable design for MCRSs that will support managing disaster volunteers. We follow a design science approach (Hevner et al. 2004; Peffers et al. 2007) and employ software engineering methods to overcome the following problem: "The cooperation between relief organizations and disaster volunteers in the context of the refugee crisis suffers from poor coordination and communication between the parties involved."

The remainder of this paper is structured as follows. The next section summarizes the study's foundations, including the theoretical background regarding disaster management and disaster volunteers. We then introduce our methodology, including our design research approach and the software engineering methods employed. The subsequent section discusses the form and function of a MCRS based on the requirements derived from our requirements elicitation process. This includes the conceptualization of generic design principles that address specified design requirements and the mapping of those principles to appropriate design features. We then delineate technical details and the appearance of the prototype system. Next, we describe the demonstration and evaluation of the artifact. The paper ends with a conclusion and an outlook for future research.

Theoretical Background

There are several components to consider when managing an emerging disaster. Lettieri et al. (2009) define disaster management as the body of policy and administrative decisions, operational activities, involved actors, and technologies that affect the various stages of a disaster at all levels. The traditional model of disaster management acknowledges that disastrous events evolve over the course of time (Mileti 1999). The management process can be divided into three temporal and logical phases characterized by specific goals and available resources (Hensgen et al. 2003; Robert and Lajtha 2002): *pre-crisis*, the period before a disaster occurs; *crisis*, a disaster's aftermath; and *post-crisis*, the period between a crisis dissolving and the return to a normal state. The reference model for the process of disaster management also describes several phases before, during, or after an event (Hensgen et al. 2003; McEntire et al. 2002; Mileti 1999; Shaluf et al. 2003). The first phase, *mitigation*, is particularly important before a crisis develops. It aims to minimize risk, prevent disasters, and reduce vulnerabilities by deploying assessment and risk reduction (Dai et al. 2002). Preparedness is also a critical function during the mitigation period; it involves training responders and people in general for post-disaster activities (Simpson 2002). *Crisis response*, the second management phase, comprises the management and control of numerous effects in the midst of a disaster to decrease the loss of life and property; its main functions are evacuation, sheltering, medical care, search and rescue, property protection, and damage control. After a disaster, in the *recovery* phase, steps are taken to return disrupted areas to normalcy.

Shaluf (2007) identifies three general types of disastrous events. *Natural disasters* are catastrophic events caused by natural events (e.g., hurricanes, earthquakes) and are therefore beyond human control. In contrast, man-made disasters result from human decision making and can emerge suddenly or after building up over a longer period, and both may persist thereafter (Shaluf 2007). A third dimension, hybrid disasters, is the combination of the previous types. Moreover, Shaluf states that natural and/or man-made disasters sometimes trigger so-called *subsequent disasters*. In these cases, the population suffers additionally from indirect effects of an event, which further complicates the resolution of the

original problem at hand. Shaluf (2007) accentuates moving and displaced people as an example for subsequent disasters.

Due to the increasing number of non-natural disasters (Coleman 2006), the need for paid relief workers may soon exceed the number available, making volunteers an essential component of disaster response and recovery. According to relief organization employees we consulted at an early stage in our design study, disaster volunteers appear mainly during the crisis response phase. These employees also indicated that disaster volunteers are not suitable for short-term crises due to these crises' critical nature. Longer-term scenarios, however, offer considerable potential for using volunteers. The ongoing refugee situation in Germany is an example of a crisis with serious consequences for the affected population spread over a long period. In 2015, some 1.1 million displaced persons entered Germany across its southern borders, and nearly 500,000 have applied for asylum in the country (BAMF 2016). This confronts authorities with a heavy administrative burden (Eddy and Johannsen 2015); without the assistance of local volunteers, they would not be in a position to manage the flow of refugees.

In this study, we focus on disaster volunteers who are not directly affiliated with official disaster relief organizations and volunteer spontaneously. These individuals, autonomous and erratic in nature, form self-organized, *ad-hoc* groups. In addition, relief organizations involved in our study observed an increasing occurrence of this type of disaster volunteering in long-term crises.

Preceding events, however, have shown there is significant potential for conflicts between authorities and spontaneous helpers, mainly because of organizational aspects in the context of coordinating volunteer work (Sargisson et al. 2012). Spontaneous helpers are an unknown variable in this context. Therefore, it is essential to define and characterize disaster volunteers. Disaster volunteers, within the scope of the refugee crisis, are individuals who engage in volunteering tasks such as distributing food and clothing or working at refugee reception centers. St. John and Fuchs (2002, p. 400) identify several specific types of likely volunteer activities during all kinds of crises: donations of blood and money, providing professional as well as non-professional goods and services, and offering time or services to organizations helping with relief efforts. It is also important to know what motivates individuals to volunteer. Wilson (2000, p. 215) generally defines volunteering as "any activity in which time is given freely to benefit another person, group, or organization" and states that it is proactive rather than reactive. Sawtell et al. (2010) shed light on the multifaceted nature of motivation for volunteering (Dolnicar and Randle 2007; Yeung 2004). They state that motivation can be based on altruism and/or self-benefit in the form of a desire to learn new skills or fulfill obligations based on religious beliefs. Sawtell et al. (2010) also identify several complex reasons for autonomous help, including the lack of bureaucratic constraints, practical aspects of aid, friendship, and demonstrating social justice principles.

The entirety of volunteer helpers' characteristics, activities, and motivations should be regarded when building a MCRS for the management of disaster volunteers and should help shape data-gathering efforts such as interviews.

Methodology

The present study strives to develop a suitable design for MCRSs that will support the management of disaster volunteers. We followed the design science approach (Hevner et al. 2004; Peffers et al. 2007) and generated a conceptual design based on knowledge drawn from theoretical and practical sources. This research-in-progress paper covers the first four phases introduced by (Peffers et al. 2007): problem identification and motivation, objectives of a solution, design and development, and demonstration (see Figure 1). Based on our design and the feedback from early prototype demonstrations, we lay the foundation for the remaining phases: a rigorous demonstration and evaluation of our design and the communication of our findings. In the following section, we briefly describe the goals and methods of each phase of our research design.

The goal of the *problem identification and motivation* phase is to formulate a motivation to justify the value of a solution, provide a clear definition of the problem (see page 2), and limit the study's scope. In this phase, we primarily followed a problem-driven approach and conducted open interviews (King and Horrocks 2010) and expert workshops (Alexander and Beus-Dukic 2009) with official representatives from three of the largest relief organizations in Germany (German Red Cross, Johanniter-Unfall-Hilfe, Arbeiter-Samariter-Bund) to investigate the challenges arising in coordinating volunteer helpers in the

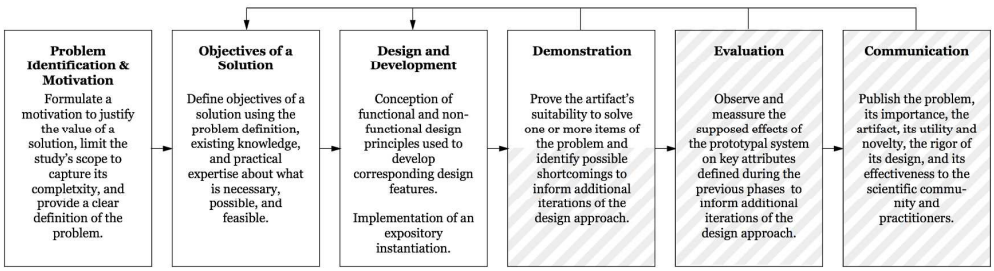

Figure 1. Research approach; based on the interpretation of Ernst et al. (2015) of Peffers et al. (2007)

context of the refugee crisis in Germany. This approach has enabled us to develop a clear understanding of the problem and secure stakeholder support throughout the design process in an early stage of the research project.

In the second phase, we aim to determine the *objectives of a solution* for the previously specified problem to define what is necessary, possible, and feasible. To achieve this goal, we followed a theory-driven approach and thoroughly reviewed related literature. In addition, we adopted a problem-driven approach and conducted a second round of interviews with stakeholders. In our literature review, we analyzed research on existing CRS solutions to identify their limitations and potential challenges for our own approach. We used the results and findings to refine the idea of an adequate software solution.

We next conducted semi-structured telephone interviews using open-ended questions to develop the conceptual MCRS design (King and Horrocks 2010). We invited participants from three stakeholder groups. The first interviewee group consisted of four relief organization employees operating on a national level who deal mainly with management and monitoring tasks. The second group was five employees with field experience functioning as experts; they constituted the professional part of the final on-site user group. The employees in both the first and second groups are members of three of the largest relief organizations in Germany. The last group included two disaster volunteers who help at various events and therefore have specific insights from their perspective as non-employees. In the first part of the interviews, we used the same general guidelines with all participants. Each participant was questioned about the situation during a disastrous event, the functions they would expect of a MCRS, characteristic problems, communication issues, and critical factors. Questions in the second part emphasized participants' individual roles and requirements in a crisis scenario. The interviews with the first group focused on administrative aspects. The topics for the second group also covered the organization of disaster volunteers. With the third group, other important aspects in the interviews included motivations for offering help and possible barriers that hinder volunteers' efforts. The interviews provided us with practical expert knowledge and supplementary insights about users' motivation to adopt a corresponding software solution, and also identified potential obstacles that might prevent its use. Further, in tandem with the interview participants, we formulated user stories to describe the functionality of individual requirements and facilitate discussion about them (Cohn 2004). These results formed the basis for the next step.

The goal of the *design and development* phase is to derive the design requirements for an artifact to solve the problem identified as well as guide implementation of the artifact. To derive the design requirements for the artifact, we analyzed the data collected in the preceding phases in three consecutive steps. In the first step, *descriptive coding*, we extracted from the interview transcripts detailed requirements, challenges, and further information regarding the problem context. In the second step, *interpretive coding*, we aggregated the descriptive codes to higher-level concepts. The last step included defining *overarching themes*, that is, recurring motives; these build the basis for defining final functional and non-functional requirements (King and Horrocks 2010).

Functional requirements describe services a system should provide, how it should react to particular inputs, and how it should behave in particular situations; non-functional requirements describe constraints on services or functions and often apply to a system as a whole, not to individual features or services (Sommerville 2007, p. 119). We developed functional and non-functional requirements based on

the approach proposed by Meth et al. (2015). In the first step, design requirements are developed by integrating the identified overarching themes. Meth et al. (2015) specify design requirements as comprising generic requirements that any artifact instantiated from this design should meet; these are closely associated with the meta-requirements concept depicted by Walls et al. (1992), as well as with general requirements, which Baskerville and Pries-Heje (2010) describe. Following Meth et al. (2015), we translated these requirements into general design principles that describe the main functions of the conceptualized system in a generic and abstract manner. Design principles are related to the concept of meta-design described by Walls et al. (1992) and general components depicted by Baskerville and Pries-Heje (2010). Further, we mapped these principles to concrete design features that would eventually constitute specific ways to implement a design principle in an actual artifact. Finally, we implemented an initial prototype of the artifact based on the results of this phase.

The final phase covered by this research-in-progress paper is *demonstration*, in which we aim to present the artifact to a diverse audience to prove its suitability to solve one or more aspects of the problem and to gather feedback on implementation. To date, as part of a project milestone in July 2016, we have conducted one expert workshop to demonstrate the artifact to stakeholders and solicit their initial feedback. The workshop brought together three relief organization employees involved in the project and five representatives of similar research projects to discuss the current state of the prototype system. Informed by this input, we aim to improve the concept and the corresponding prototype in subsequent iterations with a more diverse audience.

Evaluation and *communication* are the phases of our design research approach that remain. The former includes measuring meaningful characteristics of the instantiation to determine its adequacy for the specified problem (March and Smith 1995). This component forms the basis for upcoming iterations of our research approach. The latter comprises the final presentation of the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences (Peffers et al. 2007). Both phases are excluded from this paper and constitute tasks of ongoing research (see Planned Evaluation, Experimental Design, and Ongoing Research, below).

Designing a Mobile Crisis Response System

In this section, we present the aggregated results of the first three research phases in the form of functional and non-functional design requirements. In addition, we provide user stories to illustrate each requirement; a more comprehensive presentation of the data gathered in the first two phases would exceed the space limitations of this paper.

Functional Design Requirements, Principles, and Features

The first functional design requirement (FDR) specifies the need to *improve the registration process* (FDR 1) in terms of procedure and data comprehensiveness, necessary because existing processes used by relief organizations to manage disaster volunteers need to be revised and converted into digital form. Typically today, individuals who want to help contact a responsible relief organization employee via e-mail, telephone, or sometimes even directly at an operation. This leads to inconsistent and insufficient information about spontaneous helpers, thus burdening the organization with additional chores to collect information and consolidate it in a database. The need for FDR 1 is illustrated by the following statement from a user story: “Disaster volunteers should be able to register themselves at an early stage by providing their full name and address.” The second FDR specifies the need to *improve the provision of information* (FDR 2) to disaster volunteers and relief organization employees. Interviewees focused on the provision of preparatory information for disaster volunteers, which helps answer common questions as well as manage their expectations. Automating this with a supporting system relieves relief organization employees from having to deal with redundant inquiries, and helps ensure volunteers have a better sense of what to expect during their involvement. At a later stage, this FDR also involves simple instructions for recurring tasks, such as helping with food distribution at a refugee accommodation. For the heads of operations of relief organizations, this requirement involves the presentation of data about volunteers. The following user story motivates the first part of FDR 2: “Relief workers should be able to provide event- and task-specific information for disaster volunteers.” The third FDR addresses the need to *improve communication* (FDR 3) between disaster volunteers and relief organization employees by establishing a bidirectional communication channel. In our interviews, volunteers and employees emphasized the importance of

general information about a specific situation being as current as possible. Relief workers need to be able to communicate with volunteers in ways that account for and target their unique qualifications or characteristics (such as addressing only those with nursing skills in a particular medical situation). Thus, it is necessary to facilitate information exchange between official workers and disaster volunteers. This also enables direct feedback to messages, activities, or situations. A corresponding user story reads as follows: "Disaster volunteers should be able to communicate with other users involved in a mutual task." Another FDR focuses on the need to *improve the coordination process* (FDR 4) in terms of effectively and efficiently matching supply and demand. For the most part today, assigning activities as they arise, both to individuals or groups of volunteers, is done verbally. Interviewees reported that initial efforts to establish online allocation systems to match available resources with pending tasks have shown promising results. A system for managing spontaneous helpers should be coordinated on a unified and standardized platform. This involves creating new tasks, listing relevant entries for helpers, and defining an appropriate matching process. In this regard, a regulated procedure should control the sequence of necessary actions. This FDR is, in part, based in the following user story: "A disaster volunteer should be able to apply for a specific task created by a relief worker." The last FDR addresses the need to *enable comprehensive analyses* (FDR 5) for relief organization employees working on a national level. The system should provide an overview of current operations and enable the combination of individual statistics to extract information at a flexible level of granularity. This requirement emerges from the following user story: "Relief workers should be able to display current key performance indicators about ongoing operations."

FDRs 1, 2, 3, and 5 have in common that they positively influence the supply of information. Although they differ to some degree regarding their stakeholders, they all contribute to improving collaboration between the actors involved by enhancing the availability of information. Consequently, the first functional design principle (FDP) specifies the need to *improve information management* (FDP 1) with respect to the amount and quality of data available to disaster volunteers and relief organization employees. The similarity between FDRs 1, 3, and 4 is that they enhance cooperation between parties. They cover different points in time, beginning with the initial contact of potential volunteers and continuing through to possible long-term involvement. The second FDP therefore addresses the need to *facilitate collaboration* (FDP 2) between disaster volunteers and relief organization employees. Figure 2 shows the connections between the functional requirements and the corresponding design principles, as well as derived functional design features (FDFs), which are specific ways to implement a design principle in an actual artifact (Meth et al. 2015). We propose in figure 2 eight such FDFs as examples to address the needs identified, but emphasize that the list could be adjusted or extended during the implementation of a prototype system.

Non-functional Design Principles, Requirements, and Features

The first non-functional design requirement (NFDR) is based on the overarching theme concerned with *reducing administrative barriers* (NFDR 1). The interviews revealed that current registration processes involve extremely long waiting periods. One participant reported that it took eight weeks before individuals who volunteered during times of local crisis could be engaged in work. Furthermore, independent volunteers do not want to spend time filling out numerous forms or complete a registration process, and also have privacy concerns. These barriers lead to decreased motivation and intent to collaborate on the part of volunteers. Other issues involved in this NFDR relate to insurance concerns, data privacy, responsibilities, and general legal aspects. This requirement is connected to the following user story "A system should simplify the registration process for disaster volunteers by removing common possible obstacles during the traditional process." The second NFDR goes hand in hand with the first one. It is derived from the overarching theme demanding *increased volunteer motivation* (NFDR 2). As one interviewee mentioned, independent volunteers offer their time and work for free and are therefore flexible in two ways. They appear immediately when critical situations emerge, but they sometimes disappear just as quickly if they are dissatisfied. Hence, this NFDR has several elements, including reducing potential barriers, managing expectations, and optimizing the registration process. A system for managing disaster volunteers should enable the facilitation of incentives such as autonomous work, data privacy, and sufficient insurance coverage during an operation. Another way to motivate volunteers is to use adjusted speech when addressing users. Interviewees emphasized that disaster volunteers want to be appreciated for their work. Messages should therefore reflect this acknowledgment. The corresponding user story for this requirement is as follows: "A system should encourage disaster volunteers to continue

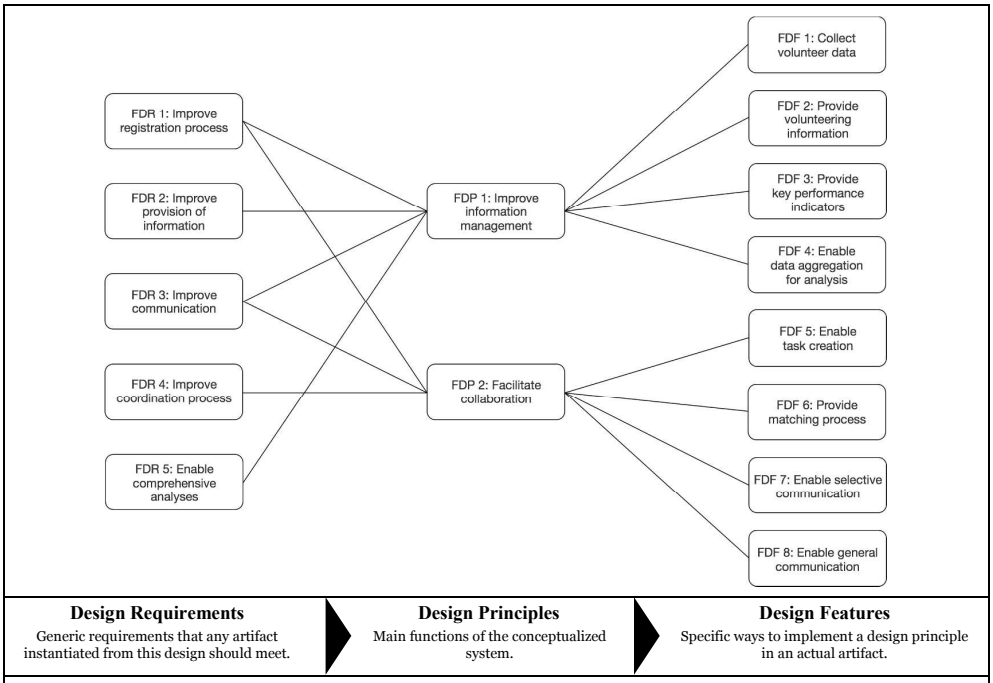

Figure 2. Functional design requirements, principles, and features.

offering their help by implementing fair processes."

NFDRs 1 and 2 are similar in that they aim to uphold volunteer commitment as they work to support disaster relief efforts. NFDR 1 contributes to this by reducing obstacles that hinder volunteer involvement in relief organization operations. NFDR 2 specifies the need for ongoing motivation, support for collaboration between the parties involved, and integration of volunteers. Both non-functional design requirements address the engagement of disaster volunteers and contribute to the collaboration of established relief organizations with individual spontaneous helpers. Hence, we derive from this the non-functional design principle (NFDP) to *maintain engagement* (NFDP 1) so the workforce of disaster volunteers can be utilized in an effective and efficient manner. Figure 3 shows the connections between these non-functional design requirements and this corresponding non-functional design principle, as well as derived non-functional design features that address the demands identified. As with the FDFs in figure 2, we propose in figure 3 five such NFDFs as examples to address the needs identified, but the list could be adjusted or extended. Further, these features describe characteristics of the system as a whole, as they are derived from non-functional requirements (Sommerville 2007, p.119). For instance, the interviewees described the importance of privacy as a general concept for the MCRS, which includes a sophisticated concept for access privileges, complete data control for individual users, and exclusion of data transfers to third-party systems.

Prototype System

A mobile crisis response system for disaster volunteers has to account for their independence and spontaneity. Therefore, we implemented a prototype system as "mobile first" solution by means of a responsive web application with a lightweight user management system. This system allows for *ad-hoc* access using mobile and other devices (e.g., desktop computers). Figure 4 shows examples of screenshots of the prototype system. The screenshot on the left displays (here, in desktop mode) information about an event observed by relief agencies. It demonstrates the provision of key performance indicators (FDF 3) in an aggregated form summarizing data from subordinate tasks (FDF 4). This screenshot also shows the implementation of general communication (FDF 8) via an event-based message board. The screenshot on the right shows the mobile version, here zoomed in on a specific task for which a disaster volunteer

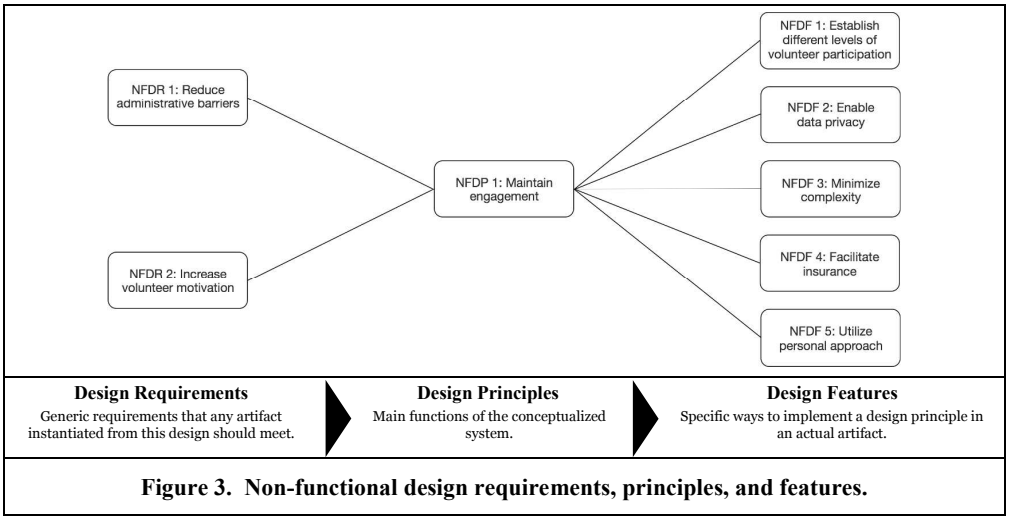

Figure 3. Non-functional design requirements, principles, and features.

applied. Users can apply for tasks created by relief workers (FDF 5) based on their qualifications entered during the registration process (FDF 1). Collaborating users are able to communicate at a task level by writing comments (FDF 7). The details and comments connected to a task are visible only to participating users as one measure to enable data privacy (NFDF 2) and reduce complexity (NFDF 3).

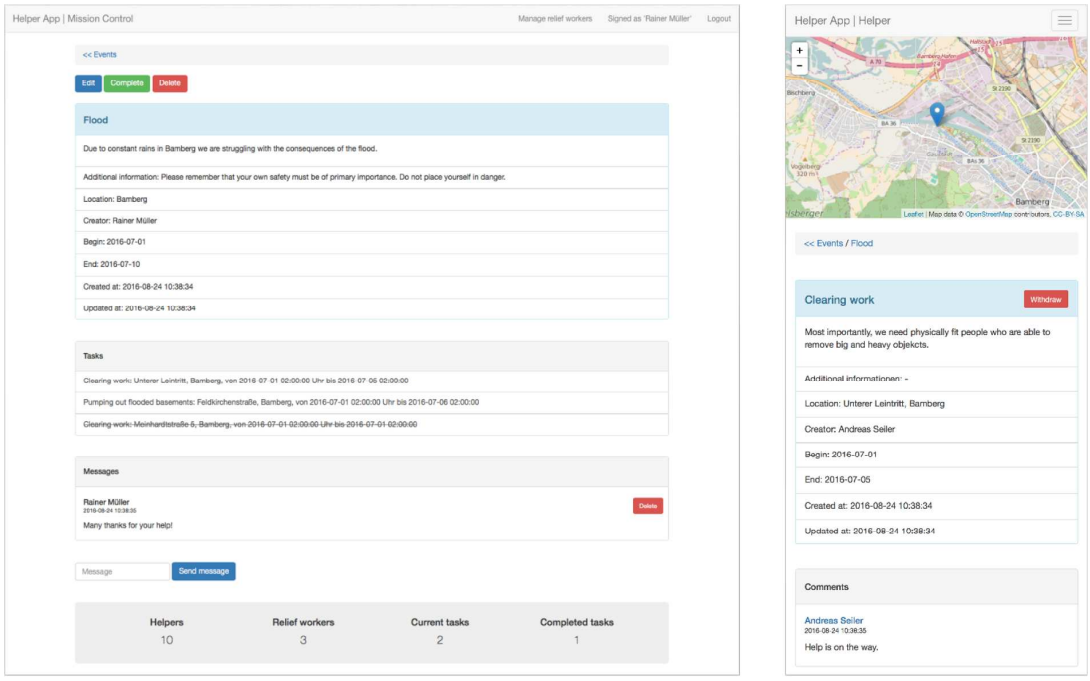

Figure 4. User interface of the prototype system (desktop and mobile version)

Planned Evaluation, Experimental Design, and Ongoing Research

We plan to conduct an additional workshop to demonstrate the artifact. Participants will include relief organization employees, experts with experience managing disaster volunteers, and members of research groups involved in similar projects. The outcomes of this workshop will be used to make additional refinements to the system we have developed. If the artifact deviates too strongly from expectations, we will go back to the design and development phase to improve the artifact based on feedback. Otherwise, the study can proceed to the evaluation phase.

The goal of the evaluation phase is to demonstrate rigorously the utility, quality, and efficacy of the designed artifact using accurate methods (Hevner et al. 2004). We will conduct a field experiment to observe and measure how well the artifact supports disaster relief efforts under simulated but realistic conditions. During a large-scale mission exercise performed by the involved disaster relief agencies, two independently operating teams will participate in a disaster scenario. The control team will use conventional methods for managing disaster volunteers, while the other team will manage volunteers employing the artifact. Participants will be drawn from available employees of the relief agencies, who will be assigned randomly to one of the groups. Two randomly formed groups of civilian participants will be assigned to each of the two teams and take on the role of the disaster volunteers. The details of the evaluation will be designed in cooperation with the relief agencies and, in part, based on their existing evaluation systems for such exercises. Both groups of participants, volunteers and employees, will include participants in our earlier expert workshops and interviews. If the results of the evaluation deviate too strongly from our expectations and the external instantiation does not appropriately address the identified problem, we will repeat the build-and-evaluate loop (Markus et al. 2002) based on the evaluation feedback.

Conclusion

As discussed in the introduction, the focus of this research-in-progress paper is on deriving a theoretically grounded MCRS design formulated for the specified problem. To complete the study, our ongoing research needs to evaluate an artifact based on this design. In particular, ongoing research needs to assess whether management of disaster volunteers supported by the artifact developed actually increases the effectiveness and efficiency of collaboration compared to existing manual methods. We propose a collection of functional and non-functional design principles that inform future development and instantiation of MCRSs. This research also introduces specific design features that constitute the form and function of an appropriate system. Building on the design requirements, principles, and features, we develop an artifact and provide an experimental design for the planned evaluation.

To interpret the implications of these research results, readers should consider the following limitations of our study. Its focus is on the first half of the design science methodology introduced by Peffers et al. (2007), namely problem identification and motivation, objectives of a solution, design and development, and parts of the demonstration. The evaluation of a corresponding external instantiation is excluded. However, this paper proposes recommendations for this phase and thus provides some guidance for future research. Thorough evaluation will show whether the identified requirements are met by prototypes that will be developed based on the suggested principles and features. Furthermore, it will help in analyzing the suitability of the specified solution.

The proposed design is dedicated to volunteering in the context of the current refugee situation in Germany. Choosing a more general context could result in different or additional design requirements and principles. With few changes, however, the design could also be generalized and applied to other crisis- and disaster-related contexts. This is assured by the high degree of aggregation regarding the derived functional and non-functional design principles and features.

In addition to improvements to the recommended conceptual design, there are many possibilities for extending this research. Future studies could broaden the current design by conducting additional design cycles, each utilizing a different theoretical focus and research concept. This diversification facilitates supplementary contributions to both practitioners and scientists by approaching the topic from diverse perspectives.

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Appendix A.10: Paper X

Bibliographic data	Sobiegalla, F., Posegga, O., & Fischbach, K. (2017). *Evaluating a Mobile Crisis Response System for the Management of Disaster Volunteers.* In: Proceedings of the International Conference on Design Science Research in Information Systems and Technology (DESRIST). Karlsruhe, Germany.
Abstract	As part of an ongoing research project, we have designed and implemented a mobile crisis response system (MCRS), which creates a nexus between relief organizations and unaffiliated disaster volunteers. We developed the MCRS using a design science approach and address information management, coordination, and motivation challenges in the context of managing unaffiliated disaster volunteers in crisis response and disaster relief activities. In this research- in-progress paper, we propose a design for the evaluation of the MCRS prototype based on a field experiment, which will be conducted during a joint mission exercise performed by three major German relief organizations. We adapt the enterprise systems success model and suggest evaluating the system quality, information quality, individual impact, and organizational impact of the prototype.
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Evaluating a Mobile Crisis Response System for the Management of Disaster Volunteers

Florian Sobiegalla[1], Oliver Posegga[1], Kai Fischbach[1]

[1] University of Bamberg, An der Weberei 5, 96052 Bamberg, Germany
{florian.sobiegalla, oliver.posegga, kai.fischbach}@uni-bamberg.de

Abstract. As part of an ongoing research project, we have designed and implemented a mobile crisis response system (MCRS), which creates a nexus between relief organizations and unaffiliated disaster volunteers. We developed the MCRS using a design science approach and address information management, coordination, and motivation challenges in the context of managing unaffiliated disaster volunteers in crisis response and disaster relief activities. In this research-in-progress paper, we propose a design for the evaluation of the MCRS prototype based on a field experiment, which will be conducted during a joint mission exercise performed by three major German relief organizations. We adapt the enterprise systems success model and suggest evaluating the system quality, information quality, individual impact, and organizational impact of the prototype.

Keywords: Design Science · Design Research · Evaluation · Unaffiliated Disaster Volunteers · Relief Organizations · Field Experiment · Crisis Response · Mobile Crisis Response Systems

1 Introduction

Relief organizations increasingly find themselves confronted with a scarcity of paid relief workers [1] and even growing frequency of man-made crises [2]. Unaffiliated disaster volunteers who participate voluntarily in disaster relief activities, and who often self-organize via social media [3], play an important role in coping with crisis and disaster situations (e.g., by providing goods, services, and time [4]). For example, when more than 80 percent of Thailand's provinces were surprised by a severe flooding crisis in 2011, citizens used social media to disseminate crisis-related information, provide emotional support, and coordinate their collaborative relief efforts, when authorities and official relief organizations were overwhelmed by the impact of the crisis [5]. The benefits of the volunteers' support, however, comes with the challenge of managing them in crisis situations. Unaffiliated disaster volunteers—that is, individuals not affiliated with official relief organizations who engage spontaneously in crisis response activities—are particularly difficult to integrate into the organizational processes and structures of professional relief organizations. One reason for this is the absence of a technical and organizational nexus between relief organizations and unaffiliated disas-

ter volunteers, which leads to various information management, coordination, and motivation issues that hamper the management of unaffiliated disaster volunteers [1, 6]. Motivational issues, for example, can occur with regards to the sustained encouragement of unaffiliated disaster volunteers. A concern frequently voiced by the relief organization officials we interviewed in the context of this study is the high of degree of volatility in the availability of unaffiliated disaster volunteers. While their help is a welcome resource to relief organizations, unaffiliated disaster volunteers are not bound by formal hierarchies and tend to operate on their own schedule, which can result in work being left undone when they leave without notice. By providing a nexus in the form of a technical artifact that connects unaffiliated disaster volunteers and relief organizations, we enable the integration of unaffiliated volunteers into the organizational structures and processes of relief organizations. In doing so, we aim to overcome some of these issues and improve the effectiveness and efficiency of unaffiliated disaster volunteers in crisis response activities.

As part of an ongoing research project, we have designed and developed such an artifact: a mobile crisis response system (MCRS) to support the management of unaffiliated disaster volunteers. It provides unaffiliated disaster volunteers with a central platform they can use to register as volunteers and offer their help with specific tasks. It offers relief organizations a simple interface for managing tasks with which they need help and allows them to receive information provided by unaffiliated disaster volunteers. In contrast to crisis response systems (CRS) typically used by relief organizations [7], we focus on providing a technical platform to connect unaffiliated disaster volunteers with relief organizations and integrate these volunteers into the organizational processes and structures of the relief organizations. We developed the MCRS using a design science approach [8, 9] and seek to answer the following research question: "Does MCRS usage improve the management of unaffiliated disaster volunteers?" Results from earlier stages of our design science approach have been published in [10]. In this research-in-progress paper, we present the design of our evaluation phase, which is based on a field experiment.

The remainder of this paper is structured as follows: Section 2.1 introduces the research problem we address. Section 2.2 briefly describes the proposed artifact. Section 2.3 focuses on the planned evaluation. Section 3 presents our conclusion.

2 Designing a MCRS

We use the design science approach [8] to develop a design for a MCRS that will support the management of unaffiliated disaster volunteers. This paper covers the first five steps of the methodology proposed by [9]: problem identification and motivation, objectives of a solution, design and development, demonstration, and evaluation (see Fig. 1). Thus far, we have generated a conceptual design based on knowledge drawn from theoretical and practical sources. We implemented this design as a responsive web application, which we demonstrated to relief organization employees, experts in the field, and professionals working on similar projects. We refined the artifact based on their

feedback and repeated this procedure several times before reaching a stable state in the artifact development.

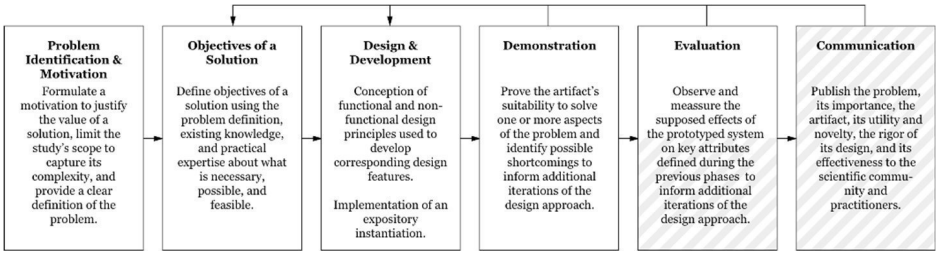

Fig. 1. Research approach; based on the interpretation of [11] of [9]

The following sections briefly illustrate the results of the steps already performed and describe in detail our plans for evaluating the artifact.

2.1 The Problem

We followed a problem-driven approach and conducted open interviews [12] as well as expert workshops [13] with official representatives of the three largest relief organizations in Germany, i.e. German Red Cross, Johanniter-Unfall-Hilfe, and Arbeiter-Samariter-Bund. Similar to organizations like the German Federal Agency for Technical Relief (THW) or UNICEF, the involved relief organizations employ professional full-time helpers, but depend on the support of volunteer helpers, which formally join and affiliate themselves with the organizations. The activity of the organizations involved in our work, however, focuses primarily on emergency services and social services. In this context, unaffiliated disaster volunteers play an increasingly important role in providing additional resources in crisis situations. The goal of this phase was to identify problems arising in the context of managing unaffiliated disaster volunteers in various types of crises and disaster situations. As a result, we defined the problem addressed in this research as follows: There is neither an organizational nor a technological nexus between unaffiliated disaster volunteers and relief organizations, which leads to several information management, coordination, and motivation challenges.

2.2 The Solution

To define the objectives of our solution, we first analyzed research on existing CRS solutions. This allowed us to identify limitations of similar projects and potential challenges for our own solution. In addition, we adopted an empirical approach and conducted semi-structured telephone interviews with the system's stakeholders, i.e. relief organization employees and unaffiliated disaster volunteers, using open-ended questions [12] to develop the conceptual MCRS design. By focusing on both, the relief organizations and the unaffiliated disaster volunteers, we developed a middle ground solution that avoids an overemphasis on the top-down model of disaster management,

which undermines the role of the community [5]. Further, we used user stories to describe the functionality of individual requirements and facilitate discussion about them [14]. These results formed the basis for the next step.

As part of the design and development phase, we derived design requirements for an artifact, which we propose as a solution to the problem identified, by analyzing the data collected in the preceding phases in three consecutive steps: descriptive coding, interpretive coding, and definition of overarching themes, that is, recurring motives [12]. We developed functional and non-functional requirements [15] based on the approach proposed by [16].

In the first step, we derived seven design requirements by integrating the overarching themes identified. Following [16], we then translated these requirements into three general design principles that describe the main functions of the conceptualized system in a generic and abstract manner: improve information management, improve coordination, and maintain engagement. Further, we mapped these principles to 13 concrete design features that would eventually constitute specific ways to implement a design principle in an actual artifact. Those comprise eight functional design features (FDFs) and five non-functional design features (NFDFs). The FDFs are: collect unaffiliated disaster volunteers' data (FDF 1), provide crisis related information to unaffiliated disaster volunteers (FDF 2), provide key performance indicators on volunteer activities to relief organizations (FDF 3), enable data aggregation for analysis (FDF 4), enable the creation of tasks for relief workers to call for support (FDF 5), provide a matching process to recommend tasks to unaffiliated disaster volunteers depending on their skills and qualifications (FDF 6), enable directed communication in the form of task related message boards (FDF 7), and enable broadcast communication in the form of mission-wide notifications and news provided by heads of operations (FDF 8). The NFDFs are: establish different levels of unaffiliated disaster volunteer participation (NFDF 1), enable data privacy (NFDF 2), minimize complexity (NFDF 3), facilitate the provision of insurance to unaffiliated volunteers (NFDF 4), and utilize personal approach (NFDF 5). The core functions of the artifact to address the most important specified design features comprise: a simple registration process; a management interface to create, update, and delete crisis response activities offered to unaffiliated disaster volunteers; message boards to provide a central communication nexus for response activities; and news feeds to distribute official information provided by relief organizations. To improve the coordination of tasks and helpers, we further specify design features for an appropriate matching process that presents available crisis response activities to unaffiliated volunteers who meet potential requirements (e.g., possess a driver's license; have first aid skills). The matching system provides unaffiliated disaster volunteers access to crisis response activities based on their preferences and qualifications. Further, it enables relief workers to prioritize specific activities by recommending them manually to individual volunteers. In addition, we propose features to motivate unaffiliated disaster volunteers during their involvement, such as a low entry threshold for new users, data privacy, and low complexity (for further information on the development of the design features and a more detailed description of the artifact, see [10]).

Finally, we developed an initial prototype of the artifact based on the results of this phase. To account for the unaffiliated disaster volunteers' independence and spontaneity, we implemented a prototype system as a "mobile first" solution by means of a responsive web application with a lightweight user management system. This allows for ad-hoc access using mobile and other devices (e.g., desktop computers). We arranged an expert workshop [13] and asked relief workers to conduct functional tests to demonstrate the artifact to a diverse audience and evaluate its capability for solving the problem. Based on the feedback, we refined the prototype, which will be used in the planned evaluation.

2.3 The Planned Evaluation

This section describes in detail the evaluation phase of our design science approach. Its goal is to measure meaningful characteristics of the artifact and to determine its adequacy for the specified problem [17].

To design the evaluation, we applied the four-step DSR (Design Science Research) evaluation research design method proposed by [18]. We plan to conduct a field experiment [19] to assess the system's quality. The experiment is based on a joint mission exercise which will be performed by the involved relief organizations (German Red Cross, Johanniter-Unfall-Hilfe, Arbeiter-Samariter-Bund). During the exercise, the relief organizations will simulate a crisis scenario under realistic conditions, which are derived from a real natural disaster that took place in a medium-size German city in 2013. During a festival located on the banks of a river, heavy rain resulted in a substantial rise in the river's water level, which in turn caused a rapidly rising flood that confronted the festival's organizers and responsible relief organizations with tremendous challenges. Visitors had to be evacuated from the affected area, and then employees of the relief organizations involved had to manage unaffiliated disaster volunteers who wanted to help with urgent tasks. For example, tents had to be taken down and injured persons provided with care. The situation is ideal for studying the phenomenon of unaffiliated disaster volunteering and to evaluate our artifact.

Within the limits of this mission exercise, we suggest an adjusted post-test only/control group design [20]. Accordingly, we will divide the experiment between two independent groups, the control group and the treatment group. Both groups will perform the same tasks with the same resources. The control group will manage unaffiliated disaster volunteers based on the traditional approach—oral communication—while the treatment group will use the MCRS prototype. Each group will be comprised of three types of participants: relief organization employees responsible for the coordination of the overall mission (i.e., heads of operations); relief workers directly involved in field activities and who are in contact with unaffiliated disaster volunteers; and unaffiliated disaster volunteers who appear spontaneously, are not affiliated with official relief organizations, and engage in self-organized disaster relief activities.

In total, there will be 73 experiment participants: one head of operations, located at a distant command center, who will be directing the operation and coordinating both the treatment and control groups (necessary due to a limitation imposed by the design of the mission exercise that provides the foundation for our field experiment); two

groups of 26 relief workers each (six coordinators and two task forces of ten in each group); and two groups of ten unaffiliated disaster volunteers each. As stated before, both groups of relief workers and disaster volunteers will be given identical assignments comprising various tasks of different natures and complexity and requiring varying degrees of cooperation. Once the experiment is completed, relief workers in the field and unaffiliated disaster volunteers will be asked to complete a survey, and some will participate in follow-up interviews. The head of operations will be interviewed based on differentiated, open-structured questions to analyze the effect of MCRS usage during the evaluation. Figure 2 shows the overall constellation of the experiment.

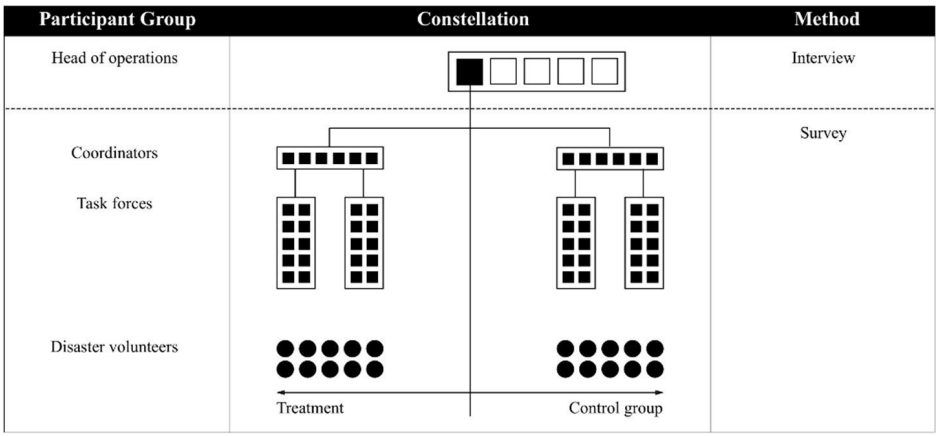

Fig. 2. Experimental Design

The central premise of our artifact's evaluation is to demonstrate that MCRS usage improves the management of unaffiliated disaster volunteers in a crisis context. In other words, we want to prove the success of our proposed design. That is why we use the IS Success Model [21, 22] as a basis for the survey design. In addition to describing a causal/process model of the dependent variable success, the IS Success Model also depicts a measurement model [23]. The model's constructs fit the core elements of the problem identified. Information quality addresses poor information management, individual impact addresses the unpredictable motivation of unaffiliated disaster volunteers, and organizational impact addresses coordination problems. In addition to the adequacy of our solution for the problem identified, we want to understand the artifact's system quality based on the respective constructs. Therefore, we use the proposed constructs as dimensions to design an adequate survey instrument. We adapt the Enterprise

System Success Model proposed by [21] to the context introduced and use it accordingly. For this purpose, we remove measurements that are not relevant for the context of an MCRS and add three additional constructs. The result is a model consisting of four dimensions: system quality (seven measurements), information quality (six measurements), individual impact (seven measurements), and organizational impact (five measurements) (see Table 1). The added constructs are necessary to measure properties that are distinctive for a MCRS and that are not part of a typical enterprise system. Both

matching effectiveness and matching efficiency address the quality of the implemented matching process, which helps to coordinate the accrual of tasks and available helpers. Similarly, we added a construct to determine the prototype's effect on unaffiliated disaster volunteers' motivation to maintain their engagement. We use the term "system" for the MCRS prototype in using the dimension system quality for both experimental groups; the term also describes the traditional system of managing unaffiliated disaster volunteers.

Table 1. Adaption of the *Enterprise System Success Model* [21]

System Quality		Information Quality		Individual Impact		Organizational Impact	
SQ1	Ease of use	IQ1	Availability	II1	Learning	OI1	Organizational costs
SQ2	Ease of learning	IQ2	Usability	II2	Awareness/ Recall	OI2	Staff requirements
SQ3	User requirements	IQ3	Understandability	II3	Decision effectiveness	OI3	Increased capacity
SQ4	System features	IQ4	Relevance	II4	Individual productivity	OI4	Overall productivity
SQ5	System accuracy	IQ5	Format	II5	Matching efficiency*	OI5	Improved outcomes
SQ6	Flexibility	IQ6	Conciseness	II6	Matching effectiveness*		Cost reduction†
SQ7	Integration			II7	Motivation*		e-Government†
	Sophistication†						BP Change†
	Customizability†						

†removed, * added

The treatment and control groups will receive the same surveys. The first survey will be administered to relief workers in the field (i.e., the second type of participants described earlier) and will include all four described dimensions. The second survey will be administered to unaffiliated disaster volunteers (i.e., the third type of participants) and will comprise all but the last dimension, since this group is not part of the organization itself. The additional interviews with both participant types, as well as the open-structured interview with the head of operations, will also be based on these dimensions, but will leave room for additional comments and detailed feedback.

Since the size of the experiment and the number of participants is subject to limitations beyond our control, we plan to conduct qualitative and descriptive analyses of the results to assess the design's success. If the feedback is unsatisfactory, we will revisit the design phase and revise our solution. Otherwise, the design study will enter the concluding communication phase.

3 Conclusion

The focus of this research-in-progress paper is on developing an appropriate evaluation design to determine the artifact's adequacy for the problem of managing unaffiliated disaster volunteers during crisis response activities. To complete the study, we need to conduct the actual evaluation of the prototype. In particular, we need to assess whether the artifact developed, when used as part of managing unaffiliated disaster volunteers, increases the effectiveness and efficiency of collaboration compared to existing methods. To achieve this, we propose a detailed plan for a comprehensive field experiment involving 73 participants from all stakeholder groups. Subsequently, we need to analyze the elicited data to assess the success of our design, which may then inform another

build-and-evaluate iteration. If we can successfully test the appropriateness of the artifact for the problem identified, we can move to the last step of the design study—that is, the communication of our results. We plan to present the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant parties [9]. It is especially important to communicate the results of our research to relief organizations so they can employ an appropriate MCRS and improve the management of unaffiliated disaster volunteers.

To interpret the implications of the evaluation design presented, readers should consider the following limitations of our study. The field experiment will be restricted by organizational constraints of the relief organizations involved, which are ultimately responsible for the execution of the experiment. Hence, we have had to adjust the traditional post-test only/control group design. We are aware that the artifact will not be tested under optimal conditions, but we are certain that the field experiment will contribute considerably to the artifact's improvement. If, however, the evaluation we have described should not suffice, we plan to conduct an additional lab experiment that could, for example, place a stronger focus on the head of operations subgroup (the participant of the first type described earlier).

The proposed design provides a nexus in the form of a technical artifact that connects unaffiliated disaster volunteers and relief organizations. Choosing a more general context could result in different or additional design requirements and principles. We expect, however, that the design could be generalized and applied to contexts, in which groups of volunteers are willing to provide their time and resources to solve simple location-based tasks, which are specified and monitored by a coordinating organization (e.g., UNICEF and Doctors Without Borders). The generalizability of our solution is facilitated by the high degree of aggregation with regards to the functional and non-functional design principles and features.

Finally, [22] have shown that there are few design science studies that evaluate instantiated artifacts using illustrative scenarios, which allow for evaluation of the artifact under realistic conditions. Rather, researchers tend to apply limited technical experiments to test instantiations under laboratory conditions. We hope to contribute to the knowledge base about scenario-based evaluations in IS design studies by proposing an exemplary approach based on a combination of a comprehensive field experiment and a customized measurement framework derived from the IS Success Model.

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Appendix A.11: Paper XI

Bibliographic data	Posegga, O., & Fischbach, K. (2017). Soziotechnische Netzwerke und Digitale Spurendaten. *Soziologie, 46*(1), 54-57.
ISBN	3593507293

Appendix A.12: Paper XII

Bibliographic data	Posegga, O. (2017). *Social Network Analysis in Information Systems Research*. Working Paper.
Abstract	This work revisits the foundations of network research on digitally enabled social networks. We discuss the role technology plays in traditional social network analysis and network theory and establish challenges and opportunities of contemporary network research in the context of sociotechnical systems. Based on our assessment of the field, we identify several areas for future research that are important to advance network research on digitally enabled social networks.

Social Network Analysis in Information Systems Research[1]

Oliver Posegga
oliver.posegga@uni-bamberg.de
University of Bamberg

Abstract

This work revisits the foundations of network research on digitally enabled social networks. We discuss the role technology plays in traditional social network analysis and network theory and establish challenges and opportunities of contemporary network research in the context of sociotechnical systems. Based on our assessment of the field, we identify several areas for future research that are important to advance network research on digitally enabled social networks.

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Introduction

Social network analysis and in a broader context, network research, have gained a considerable amount of interdisciplinary attention over the past two decades (Kleinberg, 2008; Watts, 2007). Accordingly, a broad variety of complex systems has been studied from a network perspective in the natural and social sciences (Newman, 2003). With the advent and pervasiveness of digitally enabled social networks, information systems scholars have begun to develop a growing interest in the topic (Agarwal et al., 2008; Oinas-Kukkonen et al., 2010). This trend is reflected by the growing number of publications and several special issues in the community's most relevant journals (Berger et al., 2014; Cao et al., 2015). The fundamental difference between traditional network research and network research in the information systems community, however, is the community's focus on sociotechnical systems. While a plethora of theories, methods, and techniques of traditional network theory and social network analysis are readily available and seemingly easy to apply to sociotechnical systems, they are often based on specific assumptions, which should be carefully assessed in the context of such systems to avoid validity issues and flawed conclusions (Howison et al., 2011; Kane et al., 2014).

In this work, we analyse network research in the information systems community. To provide a foundation for our analysis, we first distinguish between research on social networks, social networks analysis, and network theory. Based on this, we provide a conceptualisation of digitally enabled social networks, which emphasises the sociotechnical nature of the systems that are subject to information systems research. The goal of this paper is to establish an overview on how the specific characteristics of such systems affect theoretical and methodological aspects of network research. To achieve this goal, we investigate the anatomical components of network research and point out the differences between traditional network research and network research on digitally enabled social networks. In our discussion of the differences between the two lines of research, we elaborate on the challenges and opportunities of contemporary approaches to analysing digitally enabled social networks from a network perspective. In doing so, we establish the state of the art in this emerging field and contribute to a line of research that critically revisits the foundations of network research in the context of digitally enabled social networks.

The remainder of this article is structured as follows. In the next section, we provide a brief overview on network research in the information systems community and lay the conceptual foundation for the remainder of this work. Based on this foundation, we analyse the differences between traditional network research and network research on digitally enabled social networks along the anatomical components of network research studies. Next, we discuss our analysis and suggest avenues for future research, before we present our conclusion in the last section of this paper.

Social Networks in Information Systems Research

Research on social networks has gained a considerable amount of interdisciplinary attention over the past decades and has even been described as a twenty-first century science (Kleinberg, 2008; Watts, 2007). One of the reasons for this is the growing success and pervasiveness of interactive information and communication technologies, which play an important role in organisations, everyday life, and society in general (Agarwal et al., 2008; Oinas-Kukkonen et al., 2010; Winter et al., 2014). Among those technologies, social media (Kaplan & Haenlein, 2010), social media networks (Kane et al., 2014), and enterprise social media (Kane, 2015; Leonardi et al., 2013), have proven to be significant drivers of change in organisational environments and beyond. While the overall design and purpose of such technologies often depends on the specific context of use, most of them provide two fundamental affordances to their users (Leonardi et al., 2013, Kane et al., 2014; Leonardi & Vaast, 2017): First, they enable the creation and consumption of user-generated content. Second, they provide communication and interaction features to their users. In doing so, they enable novel and affect known patterns of social interaction and enable new forms of organising. Understanding the phenomena arising in the interplay between such technologies and their users is a promising and challenging opportunity for interdisciplinary research, as it frequently requires scholars to revisit their theoretical and methodological foundation, which have often been developed in the absence of comparable technologies (Lazer et al., 2009; Watts, 2007).

While research on social networks has been subject to information systems research long before the rise of social media (e.g. Aydin & Rice, 1991; Rice, 1994; Stein, 1992), the impact of social media has lead information systems scholars to develop a growing interest in the topic (Berger et al., 2014; Cao et al., 2015; Kane et al., 2014). Berger et al. (2014) review information systems research on online social networks between 2003 and 2014, identifying a total of 510 journal and conference publications on the topic. They reveal five major areas of research on online social networks, i.e. research on network characteristics, user behaviour, privacy, the design of online social networks, and the role of online social networks in organisations and society. Similarly, but with a narrower scope, Cao et al. (2015) review social networks research in ten of the leading community journals and identify 136 papers, which have been published between 2004 and 2014. They find that most social network research is dedicated to two topics: Factors influencing social networks, in particular their use, and the effect of social networks, e.g. on the behaviour and performance of individuals or organisational processes. Further, Cao et al. report that 80% of the reviewed articles follow a quantitative approach, while only 16% adopt qualitative methods. While both studies conclude that information systems research on social networks is maturing, they identify several areas for future research. In particular, they point towards the potential differences between digitally enabled and offline social networks. Berger et al. (2014) find that research on the

characteristics of online social networks is often grounded in theories that have been developed with regards to offline social networks. In line with Kane et al. (2014), they call for a critical reflection of this theoretical foundation and further research on the structural characteristics of online social networks. Further, Cao et al. (2015) find that information systems research on social networks often lacks a solid theoretical foundation. They specifically call for the development of theories and methods that account for the unique characteristics of social networks studied in information systems research.

In information systems research, the term *social network* is often used interchangeably in reference to two different things. First, it is used to describe specific types of information systems and technologies. For example, in research on online social networks (Garton et al., 1997), social network sites (Boyd & Ellison, 2007), digitally enabled social networks (Agarwal et al., 2008), social media networks (Kane et al., 2014), and broader sets of such technologies (e.g. Cao et al., 2015), the term is used in reference to the systems comprised of the mentioned technologies, their users, interactions and the contexts they are embedded in. Second, the term is used in the context of social network analysis, where it refers to graphs modelled from networked systems. Thus, the former use of the term usually refers to the systems scholars seek to understand, while the latter refers to models of such systems. To emphasise the conceptual distinction between the studied systems and their models, we refer to the former as digitally enabled social networks to the latter simply as networks, structures or graphs. Similar to Agarwal et al. (2008), we define *digitally enabled social networks* as sociotechnical systems comprised of social actors and their relationships, which are at least partially enabled or extended based on interactive information and communication technologies and the affordances they provide. In contrast to the terms mentioned above, this definition is more inclusive as it captures a broad variety of systems that are of interest to information systems research. Further, it emphasises the sociotechnical nature of such systems, which is not adequately reflected by the term social network. This aspect of the definition is important in the context of social network analysis, as it has been developed with an emphasis on social systems rather than technical or sociotechnical systems (Contractor et al., 2011).

Social network analysis is a collection of methods and techniques (Howison et al., 2011; Wasserman & Faust, 1994) accompanied by vast and growing body of interdisciplinary network theory, which emerged from network-based research in various domains (Borgatti & Halgin, 2011; Watts, 2004). The fundamental idea behind social network analysis is to model social relationships and interactions between individuals as graphs, comprised of nodes representing individual actors and edges representing their relationships (Butts, 2009; Mitchell, 1969; Wasserman & Faust, 1994; Watts, 2004). The goal of social network analysis is to analyse the structure of such graphs to gain insights into the complex social systems they represent. The origins of the methods and techniques

comprising social network analysis lie within sociology, social psychology, mathematics, graph theory and anthropology, with many of the fundamental ideas and assumptions of network analysis dating back to the 1970's (Freeman, 2004; Galaskiewicz & Wasserman, 1993; Wasserman & Faust, 1994). With the increasing popularity of social network analysis, it has grown beyond the domain of social systems and has been applied to a wide variety of networked systems, including organisational, biological, technological, and socio-technical systems (Borgatti et al., 2009; Contractor et al., 2011; Newman, 2003).

In the ongoing effort to further the understanding of the role technology plays in and outside of organisational contexts, information systems scholars, too, have recognised the potential of social network analysis. In contrast to the disciplines social network analysis emerged from, however, information systems research is concerned with digitally enabled social networks rather than social networks. Such systems are not exclusively comprised of social actors and their interactions, but also of the technological artefacts that afford and mediate their access to other actors and information (Kane et al., 2014). Social network analysis and most network theories have not been developed for such systems, as is indicated by the fact that fundamental introduction to social network analysis provided by Wasserman and Faust (1994) does not even mention the role of technology in network research beyond its capability of enabling the computational analysis of networks. The ubiquity of modern information and communication technologies, however, makes it increasingly difficult to distinguish social interactions from interactions between individuals and technology (Contractor et al., 2011; Lyytinen & Yoo, 2002). With the increasing maturity of theoretical foundations and methodological approaches that account for the entanglement of social interactions and technological artefacts, scholars have begun to revisit the foundations of network research on sociotechnical systems (Contractor et al., 2011; Howison et al., 2011; Kane et al., 2014).

In the light of the above, we aim to investigate how information systems research has used social network analysis and how it has adapted its methods and techniques to account for the specific characteristics of digitally enabled social networks with an emphasis on their sociotechnical nature. Thus, we pose the following research question: *"What role does technology play in social network analysis in information systems research?"*

The Anatomical Components of Social Network Analysis Studies

In the following, we present the analytical framework (see Figure 1), which we use as a foundation to review how information systems research on digitally enabled social networks accounts for the role of technology in using social network analysis. The framework is based on Sarker et al. (2013) notion of a study's *anatomical components*, which they describe in terms of its research focus, up-front theory, methodology, and contributions. In the following, we further specify each of those anatomical components and discuss them in the context of network research in the context of digitally enabled social networks.

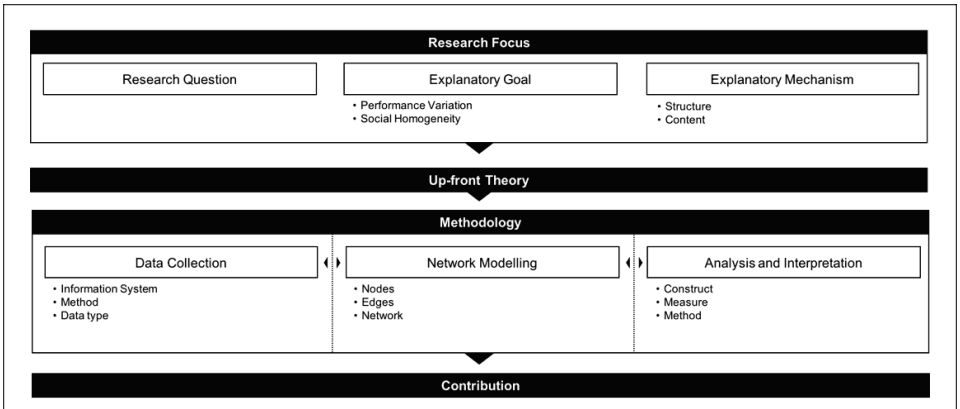

Figure 1. Anatomical Components of Social Network Analysis Studies

Research focus

The component *research focus* refers to the fundamental research questions raised by a study as well as to its general goal and the causal mechanisms investigated in its pursuit. We build on the framework provided by Borgatti and Foster (2003) to guide our investigation of the goals and mechanisms social network analysis studies in information research focus on. Borgatti and Foster (2003) distinguish between two fundamental *explanatory goals* in network research, i.e. the explanation of phenomena related to performance variation of actors and the explanation of phenomena related to social homogeneity. Studies of former category assume the network structure to be given and aim to explain how an individual node's position in the network affects its performance and behaviour. Studies of the latter category assume that the characteristics of individual nodes shape their behaviour, which in turn affects their network position and the network structure in general. Borgatti and Foster (2003) further discuss two *explanatory mechanisms* those explanations can be grounded in: mechanisms explained by either the network structure or the content diffusing through it. Based on this two-dimensional classification scheme, Borgatti and Foster (2003) identify four "canonical" study types:

Environmental shaping, contagion, structural capital, and resource access studies. Environmental shaping and contagion studies aim to explain social homogeneity. While studies of the former type focus on the effect of the network structure, i.e. the social relationships, values, and contexts they represent, on the behaviour of individual nodes, studies of the latter type focus on the effect of content spreading through the network. Structural capital and resource access studies aim to explain performance variations between individual nodes in a network. Structural capital studies emphasise the role of the nodes' access to relationships, while resource access studies focus on the role of the content available in the network.

Kane et al. (2014) revisit the classification of Borgatti and Foster (2003) in the context of network research on social media networks. They argue that social media networks are novel phenomena, which require scholars to ask different research questions which account for the role technology plays in the context of explanatory goals and mechanisms. With regards to the explanatory goals, Kane et al. (2014) point out that the design and affordances offered by the technologies underlying social media networks are likely to affect social homogeneity as well as performance variations. Those technologies mediate how their users can perceive, access, and navigate through structures and contents. Kane et al. (2014) discuss that the focus of traditional network research does not necessarily account for the effects of technology in this regard and that very little is known about the effect technology plays in this context. Thus, they call for a shift the in the focus of network research on social media networks towards the role technology plays in the four canonical study types.

Up-front Theory

The component *up-front theory* refers to network theories that are used in conjunction with methods, techniques, and measures borrowed from social network analysis. Network theory comprises a vast amount of different theories that have emerged from different domains. There is a profound difference in the use and perception of network theory in different disciplines and network research has often been criticised for a lack of theory due to its fragmented nature (Borgatti & Halgin, 2011, Borgatti, 2014). In essence, as described by Borgatti and Halgin (2011), the issue is not that research on networks lacks theory, but that the theories that have been developed or influenced from a network perspective are often not recognised as such. Notable examples are theories on social capital (Coleman, 1988), the strength of weak ties (Granovetter, 1973), and homophily (McPherson et al., 2001), which are cornerstones of network theory and have diffused into the mainstream of organisational and sociological theory. When those theories become detached from the contexts they originate from, their underlying assumptions must be carefully considered. The otherwise simplistic application of social network analysis and network theory without its adaption to the specific

characteristics of the analysed systems has lead scholars to question the value of network research (Kilduff et al., 2006). Instead of simply revisiting and adopting core network theories, scholars have called for the extension of known and the development of novel theories, which account for the unique characteristics of the systems studied in their respective disciplines (Kilduff et al., 2006; O'Donnell, 2014; Parkhe et al., 2006).

The defining characteristic of digitally enabled social networks is their sociotechnical nature. Acknowledging this has two major implications for network theory: First, capturing their sociotechnical nature might require an ontology that allows for a clearer conceptualisation of technology to further the understanding of its role in network theory (Contractor et al., 2011). Second, the affordances provided by technological artefacts might lead to novel dynamics that are not explained by network theory and thus require revision or the development of new theories (Kane et al., 2014).

With regards to the first implication, social network analysis has been developed based on an ontology that is grounded in research on social systems. With the growing interest and an increasing amount of research dedicated to the interplay between technology and social interaction, the natural extension of this ontology has led to the predominant assumption that technology exists separately from what we consider as social (Contractor et al., 2011). This dualistic world view is reflected in network research that investigates the effect of technology on social structures, the effect of social structures on technology, or the interplay between both. While this perspective is not necessarily wrong, it is problematic with regards to the assumption that technical and social elements can be easily separated. In practice, however, the opposite seems to be the case: Social and technical elements are increasingly difficult to distinguish (Lyytinen & Yoo, 2002; Orlikowski, 1992, 2007). Alternative conceptualisations aim to lift the dualistic distinction between the social and the technical. Notable examples of such views are: Actor-network theory (Callon, 1984; Latour, 1992, 2005), sociotechnical ensemble (Bijker, 1997), relational materiality (Law & Mol, 1995), sociotechnical congruence (Cataldo et al., 2008), and sociomateriality (Orlikowski, 1992, 2007). They view sociotechnical systems through a lens that assumes that social and technical elements are intertwined and that our perception of such systems as well as the phenomena they produce are based on their continuous interplay and the context they are embedded in. Thus, they provide an ontological foundation that avoids an overemphasis on social actors and processes and allow for the inclusion of non-social factors in the description or explanation of phenomena emerging from sociotechnical systems.

Contractor et al. (2011), for example, demonstrate an approach to social network analysis grounded in sociomateriality. Acknowledging that the ubiquity of technology renders the separation of social interaction and the interaction of social actors with technologies increasingly difficult, they suggest treating technology as endogenous to

social networks. Consequently, Contractor et al. (2011) propose modelling networks that include not only social actors but also non-social actors (i.e. technologies or their features) as nodes as well as their interactions with social and non-social actors as edges. In doing so, they build on the ontological foundation of sociomateriality, which assumes a constitutive entanglement of social actors (i.e. the social) and the features of technologies (i.e. the material). The concept of constitutive entanglement has been coined by Orlikowski (2007) and implies that the social and the material are recursively intertwined in the context they are embedded in. This concept is grounded in the assumption that everything material (e.g. technologies and their features) is also social, because it has been designed based on social interaction, while everything social is also material, as it is enabled or constrained by properties of something material (Leonardi, 2009). To give an example, a technological platform like Twitter provides a web interface to its users that offers a variety of technical features (e.g. content and contact recommendation systems). While the website and its features are material, they are also social because they are the outcome of a development process that is based on social interaction. Similarly, the interaction taking place between the users of the platform is social, but at the same time material as it is enabled and constrained by the material features of the platform. While Contractor et al. (2011) demonstrate that their approach can provide novel insights into phenomena emerging from digitally enabled social networks, they also acknowledge that it raises further questions with regards to the complexity of modelling and interpreting network structures from this perspective.

This leads to the second implication of embracing the sociotechnical nature of digitally enabled social networks. The vast body of interdisciplinary theories comprising network theory have not been designed for digitally enabled social networks. Kane et al. (2014) point out two primary reasons why traditional network theory is not well equipped to explain novel phenomena arising in the context of digitally enabled networks. First, the technologies enabling such networks are the outcomes of decisions made by platform designers, which define how users can present themselves, create and consume content, and engage in various types of social interaction. Second, the features of such technologies offer affordances that are often novel in the sense that they have not been available when traditional network theory has been developed. Social media platforms, for example, enable their users to bypass relational constraints in the search for new contacts by enabling them to explore, search for, and quickly build relationships with other users. Similarly, features of such technologies enable access to available content without requiring individuals to rely on their relationship to others, potentially diminishing the value of those relationships with regards to their ability to grant access to desirable content. Kane et al. (2014) argue that affordances like these are likely to cause dynamics that are not explained by traditional network theory. In the light of if this, Kane et al. (2014) raise a series of research questions with regards to the canonical

study types, calling for a critical evaluation of the assumptions traditional social network analysis makes with regards to the nature and value of social relationships and content, as well as their interplay with design features of social media platforms. They conclude that simply applying social network analysis to social media networks without taking their unique characteristics into account might lead to false conclusions. Consequently, they argue to shift the traditional research focus of social network analysis studies towards the role technology plays in social media networks. This shift allows for a critical investigation of network theory and social network analysis, including practices of data collection, modelling, and analysis, and thereby enables scholars to advance network research in the context of digitally enabled social networks.

Methodology

The third anatomical component is a study's methodology, which refers to its general research strategy. In network research, this involves a chain of interdependent assumptions ranging from the collection of network data over the modelling of network structures to their analysis and interpretation.

Data collection

One of the fundamental differences between network research on digitally enabled social networks and traditional network research is the availability and type of network data. The technologies underlying digitally enabled social networks generate constant streams *digital trace data*, which provide a detailed history of their users' activities and interactions. Howison et al. (2011) define digital trace data as "records of activity (trace data) undertaken through an online information systems (thus, digital)." and proceed to describe their characteristics in contrast to traditional network data as found rather than reported, event-based rather than summarised, and longitudinal rather than cross-sectional. Digital trace data are the by-product of information systems, which continuously log the activity of their users as part of their operational routines. Those logged activities and events form time series of sociotechnical interactions between users and technological artefacts, which allow scholars to infer social relationships between users. This type of data can be obtained very efficiently by querying database or application programming interfaces as well as through the collection and aggregation of log files. Digital trace data provide the unique opportunity to study the complex dynamics of social interaction and human behaviour without introducing biasing measurement effects to the systems they emerge from.

Collecting network data using traditional methods is considerably more time consuming, as it requires scholars to elicit network data from individuals by asking (e.g. interview, name generator, roster) or observing them directly. While it might not be as

efficient as using digital trace data, it is far from being obsolete. Digital trace data, while providing almost revolutionary opportunities for scholars, have several shortcomings, which require scholars to make crucial assumptions when using them in the context of social network analysis (Howison et al., 2011). One of the major deficits of digital trace data is their lack of contextual and contentual information. Network data that is collected by traditional means is acquired based on methods that are tailored towards a specific system in a specific social, cultural, and organisational context. For example, asking the employees of an organisation to list their most trusted colleagues or to name who they seek advice from in a specific subject matter requires scholars to understand the organisational context the actors are embedded in. Further, it requires the employees to think about a specific type of relationship they share with others, which in turn allows scholars to make grounded assumptions with regards those relationships, their value and the content that can be assumed to flow through them.

In this regard, digital trace data is much less reliable and prone to false interpretation, which might lead to validity issues and false conclusions (Howison et al., 2011). As described by (Howison et al., 2011), using digital trace data requires scholars to develop an in-depth understanding of the technology and how it is used in the studied setting to avoid such false interpretations. Further, the combination of digital trace data and traditionally collected data in a mixed methods approach has been suggested to overcome some of the limitations of digital trace data (Behrendt et al., 2014).

Network Modelling

The act of modelling social network structures involves the definition of nodes, edges, the aggregation of those to network structures. The network paradigm itself is very flexible with regards to the decisions that have to be made when modelling complex systems as graphs. Usually, there are many ways of modelling the components of networked systems as nodes and edges. The way a system is modelled as a network, however, has profound implications for the interpretation of the measures and methods used in social network analysis (Butts, 2009). To ensure the validity of network research, the modelling decisions made in this context have to carefully aligned with research focus, the up-front theory, and especially the ontological assumption a study is based on.

While there are many assumptions to be made in the modelling of nodes (Butts, 2009), two are focal: the level of aggregation and the number of classes to be modelled. The level of aggregation refers to the decision whether to model individuals or groups of individuals as nodes. In the social sciences, for example, nodes often represent human individuals, which are assumed to show certain behaviours and which are attributed with properties like social agency, i.e. the ability to influence their relations according

to their goals. In organisational research or research on team dynamics and group performance, in contrast, nodes are sometimes assumed to be aggregated entities comprised of multiple individual actors. The decision for either one of the options obviously affects key characteristics of the modelled network structures, such as the number of nodes and edges, the density, or centrality measures and their interpretations (Butts, 2009). With regards to the second assumption, i.e. the number of classes to be modelled, one can distinguish unimodal and multimodal networks (Contractor et al., 2011). Unimodal networks contain just a single class of nodes (e.g. the employees of an organisation). Multimodal networks, in contrast, contain multiple types of nodes (e.g. customers and products or employees and information systems).

In the context of digitally enabled social networks, Contractor et al. (2011) suggest modelling social actors and technical artefacts as nodes of multimodal networks. In doing so, they align their modelling process with the ontological assumptions of sociomateriality (Orlikowski, 2007) and allow for the analysis of network processes taking place between social and technical actors. While they can demonstrate that this approach can lead to novel insights in the study of digitally enabled social networks, it entails a series of difficult assumptions that have to be made. Kane et al. (2014), for example, discuss the nature of user profiles in social media networks and whether they should be modelled as nodes or as content. The authors point out that user profiles are, on most platforms, a virtual representation of the corresponding user. At the same time, however, user profiles provide feeds of information, which are associated with the corresponding user. Whether to model a user profile as a node depends on the research focus and the platform design Kane et al. (2014).

Depending on the entities that have been modelled as nodes, the edges modelled between them can represent a broad variety of relations. Borgatti et al. (2009) provide a taxonomy of edge types, in which they distinguish between edges representing similarities (e.g. based on proximities, group memberships, or actor attributes), social relations (e.g. in terms of kinship, social roles, or affections), interactions (e.g. based on advice giving, helping, or sexual interaction) and flows (e.g. in terms of information, beliefs, or goods). An important difference between some of the edge types listed above is whether they represent states or events. Social relations, for example, represent states that persist over a reasonable timespan. Interactions, on the other hand, are events that take place at a single point in time. Modelling networks based on event-type edges usually involves additional assumptions with regards to the stability of the relations inferred from events. Depending on their type, edges can further be modelled with additional attributes, like a direction, weight, or sign. Similar to the distinction between unimodal and multimodal networks, networks can also be uniplex or multiplex, depending on whether only one class of multiple classes of edges are modelled.

Contractor et al. (2011) suggest modelling multiple classes of edges to account for the different types of relationships between different classes of nodes in their socio-material approach to network analysis. While this approach allows for a detailed analysis of the sociotechnical processes taking place between social and technical actors in digitally enabled social networks, it complicates the quantitative analysis of such networks, as many traditional measures and methods provided by social network analysis have not been designed for multiplex networks. In addition, technologies like social media platforms enable multiple types of the interactions and relations between their users, which can exist simultaneously (Kane et al., 2014). As described by Kane et al. (2014), such technologies decouple the different types of relations discussed by Borgatti et al. (2009) from each other. In doing so, they contradict the traditional assumption that some types of ties serve as the foundation for other types (e.g. similarities benefit social relations, which in turn enable social interaction, which are the foundation of flows) (Kane et al., 2014). In addition, it is often unclear how those edges can be interpreted. Howison et al. (2011) discuss this issue in detail and point out the difficulties arising in using digital trace data as inference for relations between social actors. The two inherent properties of digital trace data, i.e. that they are observed instead of reported and that they are often describing events and interactions, which are mediated by technological artefacts, require scholars to make strong assumptions with regards to their interpretation (Howison et al., 2011). Further, the design of the technological platforms underlying digitally enabled social networks determines the type of relations that are available to their users. Thus, the design of those platforms is not only an enabling, but also a limiting factor that might constrain individuals in expressing their relations (Kane et al., 2014). The role of technology, in this context, is not well understood and not covered by traditional network theory (Contractor et al., 2011; Howison et al., 2011; Kane et al., 2014).

Once nodes and edges have been defined, they have to be aligned and aggregated to represent the studied system at a single or at various points in time. In addition to the decisions made with regards to the modelling of nodes and edges, the characteristics of those snapshots are strongly affected by the way they are aggregated over time (Howison et al., 2011). Traditional network research is primarily based on the analysis of small networks, which have been aggregated to a single point in time (Lazer et al., 2009). Over the past decades, however, scholars have criticised this static perspective on networks and advocated a dynamic understanding of network structures, which resembles the dynamic nature of the complex systems at study (Ahuja et al., 2012; Doreian & Stokman, 1997; Snijders & Doreian, 2010, 2012). While a static design simply neglects time, dynamic approaches to network analysis can be broken down further, depending on whether the emphasis lies on analysing change, dynamics or evolution. While the three terms are often used interchangeably without further distinction, Doreian and Stokman (1997) discuss point out their differences. Given at least two

snapshots of a network at two distinct points in time, change can be observed if the snapshots differ with a sufficient statistical significance. Since a network is only a metaphor representing a complex system of individuals and their relationships, change is a social phenomenon, which can be highly complex and hard to explain; especially in networked systems of social individuals, where such phenomena are the result of interdependent decisions of multiple individuals over time (Watts, 2007). According to Doreian and Stokman (1997), subsequently observed changes through time are referred to as the dynamics of a network. While change and dynamics are directly observable and measurable phenomena, their underlying mechanisms, i.e. social processes, are usually invisible, not directly measurable and highly complex. Stokman and Doreian describe the dynamics of networks as symptoms of such processes and continue that the evolution of a network cannot be understood by a mere structural, descriptive understanding of the observed dynamics. The evolution of a network is more than just change through time – it is defined by the underlying social processes, which govern the observable patterns of change in a network's structure. Accordingly, understanding the evolution of networks implies understanding the processes behind observable dynamics, i.e. the coherent sequences of events causing them.

In the context of digitally enabled social networks, digital trace data comes with the advantage of being longitudinal. Thus, in contrast to studies based on network data collected by traditional means, studies based on digital trace data provide the opportunity to study the dynamics of networked systems. At the same time, they require scholars to make difficult assumptions. Howison et al. (2011) discuss the temporal aggregation of digital trace data in network analysis and potential validity issues arising from the temporal aggregation of network data. When aggregating digital trace data over longer periods of time, unevenly distributed user activity may seem stable and more evenly distributed than it is when data is aggregated over smaller or different periods. This, in turn, can cause network measures to appear stable over time. To avoid false conclusions in this context, Howison et al. (2011) suggest conducting sensitivity analyses with regards to the stability of network measures. An additional issue that occurs when modelling digitally enabled social networks over time arises from the technical artefacts that might themselves be subject to changes. The features of such technologies determine the behaviour of their users. Changes to them might, in turn, affect this behaviour. Facebook, for example, allowed their users to like the content provided by others. This rating was strictly positive and did not allow for the expression of negative emotions. At some point, Facebook changed this feature to allow users to rate content on a broader scale, which includes negative emotions. This change is likely to affect the behaviour that can be observed on the platform and thus the properties of networks that are modelled from Facebook data. Finally, with regards to the analysis of network evolution in digitally enabled social networks, the social processes that are

assumed to drive network dynamics are partially enabled and constrained by technological artefacts. When those systems are studied based on an ontology that acknowledges their sociotechnical nature, the focus on social processes shifts towards sociotechnical processes, which explain network dynamics based on the interplay between social and technical actors. This is a novel frontier of network research, which pushes the limits of traditional network theory and invites novel theorising (Contractor et al., 2011).

Analysis and Interpretation

The last part of the methodology component refers to the analysis and interpretation of network structures. In analysing and interpreting network structures, constructs derived from a study's theoretical foundation have to be operationalised by means of corresponding network measures, which can then be computed based on the modelled network structures and subsequently be used in quantitative and qualitative methods to analyse those structures. Social network analysis provides a plethora of measures and methods to analyse network structures (for a comprehensive overview, see Carrington et al., 2005; Wasserman & Faust, 1994). A common approach in network analysis is the analysis of network structures on multiple levels, ranging from the level of individual nodes to the dyadic and triadic relationships they are involved in, their direct neighbourhoods (i.e. their ego-networks), the groups they are embedded in and the network level, where the complete network is analysed (Contractor et al., 2006). Contractor et al. (2006) refer to this approach as multi-level multi-theory approach and suggest grounding the analysis taking place at the different levels in theories that align with the research focus. Howison et al. (2011) discuss that the theoretical alignment between a study's theoretical foundation, the hypothesised network processes, and the modelled nodes and edges is important to avoid validity issues. They specifically point out two common issues in this context, i.e. issues related to data completeness and inference and issues with regards to the uncritical importation of measure interpretation. Issues of the first type refer to the completeness of the network data. Traditional social network analysis is often based on data sampled from a larger population and statistical methods as well as the interpretation of their results are grounded in the assumption that the analysed data is in fact a sample. As described by Howison et al. (2011), this is not always the case for digitally enabled networks. For example, in the study of virtual communities, which exist exclusively online, the digital trace data generated by the underlying platform might not be a sample but a census. Thus, the simple application of traditional methods, which follow an inferential logic, might lead to flawed statistical conclusions. The second issue discussed by Howison et al. (2011) refers to the use and interpretation of network measures in general. If network measures are used without carefully considering their underlying assumptions and the characteristics of the analysed system, their interpretation can lead to flawed conclusions. Borgatti (2005) discusses this issue with regards to network centralities, which are frequently used in

network research. Some of those centralities, like the closeness and the betweenness centrality, are measures that describe the position of actors based on geodesic distances. In doing so, they follow the assumption that the content that is assumed to flow through the network travels along the shortest paths between actors. Borgatti (2005) points out that this assumption is not always justified. In the context of digitally enabled social networks, such assumptions have to be carefully considered when those and similar measures are used and interpreted. Many of the network processes studied in traditional network analysis and traditional assumptions with regards to the flow of contents are less well understood in digitally enabled networks (Howison et al., 2011; Kane et al., 2014) -- especially when those are modelled as multimodal or multiplex networks that contain non-social actors.

Contribution

The last anatomical component refers to a study's contribution. In the discussion of the previous components, we summarised some of the challenges and opportunities arising in the application of social network analysis in research on digitally enabled social networks. Many of those issues call for a critical assessments of network theory and social network analysis, as well as for the development of novel approaches to network analysis in the described context. The questions raised by Kane et al. (2014), Howison et al. (2011), Contractor et al. (2011), and others provide ample starting points for future research in this direction, which might lead to novel theoretical, conceptual, methodological, and empirical contributions to further the understanding of digitally enabled social networks. In the following, we discuss four types of contributions that can be found in network research.

The most common form of contribution to network research from an information systems perspective is the application (i.e. *transfer*) of theories and methods borrowed from network research. Given the increasing availability of network data and the growing maturity of network analysis tools, it is often tempting to simply use well-known network measurements in the context of digitally enabled social networks. As outlined above, this approach is prone to validity issues and can be limited with regards to a study's potential contribution. Notable examples that fall into this category are the early work of Aydin and Rice (1991), Stein (1992), Rice (1994), and Segars and Grover (1994), who were among the early adopters of network research in the information systems community. Among few others, they pioneered social network analysis in the information systems community before it gained additional traction due to the growing relevance of social media.

With the arrival of network research at the core of information systems research, the value of the contributions of the former category is diminishing. The growing ma-

turity of network research and the increasing number of studies published in this context have revealed some of the shortcomings of traditional network research in the context of digitally enabled social networks. As described in the discussion of the previous components, this has led scholars to call for an *adoption and extension* the theories and methods provided by traditional network research. Gray et al. (2011) demonstrate this approach in their study on the use of social bookmarking systems in an organisational setting. They draw on Ronald Burt's theory of structural holes and explore their impact on the innovativeness of employees in the context of social bookmarking systems. Based on a careful analysis of the mechanisms and overall design of the analysed social bookmarking system, they find that the default interpretation of a structural hole, as devised by Burt, does not make sense in their case. Consequently, they perform a theoretical pivot and develop a revised understanding of structural holes and their impact in the context of social bookmarking systems. In doing so, they extend the concept and its theoretical foundation to the scope of their work. Thus, in addition to their empirical contribution, they revise one of the most well-known and influential network theories in the context of a specific information system. In doing so, they provide an ideal example of the extension of traditional network theories to the domain of digitally enabled social networks.

More recently, the *critical revision* of network research in the information systems community has led to some notable contributions. Examples can be found in the work of Howison et al. (2011) and Kane et al. (2014), which we discussed in the previous sections. With its growing maturity, the revision of the foundations of network research has become an important subject of the field. Contributions of this type take a critical stance on the contemporary approaches to network analysis and put them into the context of traditional network research. Butts (2009), for example, provides a brief but thorough review of the fundamental assumptions of network research in response to its growing popularity. Similarly, Borgatti et al. (2009) discuss the fundamental differences of network research in the natural and social sciences. While both studies review and structure recent contributions to the field, they also emphasise challenges and opportunities of emerging and established research streams. Howison et al. (2011) contribute in this way by pointing out a series of validity issues in network research based on digital trace data, while Kane et al. (2014) review the foundations of network research on social media networks. With the goal to critically examine network research on digitally enabled social networks, our work falls into the same category.

The development of *novel theories and methods* represents the last category discussed in this article. Naturally, this is the rarest, most demanding, and most promising type of contribution. Despite the growing popularity of network research, we still know very little about the mechanisms that govern digitally enabled social networks - especially with regards to the role of the underlying technologies and their design (Kane et

al., 2014). Recent contributions by Contractor et al. (2011) and Kane et al. (2014) provide promising starting points for the development of overarching theories and methods to further the understanding of digitally enabled social networks.

Discussion and Research Agenda

In the previous section, we analysed four anatomical components of network research in the light of digitally enabled social networks and their sociotechnical nature. In this section, we summarise the focal points of our analysis and point out avenues for future research.

Social network analysis and network theory have proven to be valuable assets in understanding phenomena related to digitally enabled social networks and information systems in general. With the growing popularity and maturity of network research on digitally enabled social networks, information systems scholars have begun to revisit the foundations of network research in this context (Howison et al., 2011; Kane et al., 2014). One of the key findings in this context is that much of traditional network theory has been devised with an emphasis on social rather than sociotechnical systems. Therefore, the mere application of traditional theories without a careful adaption and extension might lead to flawed conclusions and to limited contributions. To further the understanding of digitally enabled social networks and the phenomena emerging from them, theories that account for their sociotechnical nature and the affordances provided by enabling technologies are needed. The research questions raised by Kane et al. (2014) emphasise the need for a network perspective that actively accounts for the role technology plays in the sociotechnical processes that govern digitally enabled social networks. While there are some approaches to ground network analysis in overarching theories and frameworks enabling such a perspective - most notably in the form of the work of Contractor et al. (2011) and their sociomaterial approach to network analysis - they are still in early stages and need further research.

One of the reasons for the difficulties in developing novel theories lies within the ontology that provides the foundation for social network analysis. When it comes to analysing social networks in the traditional sense, i.e. in terms of networks that are comprised of social actors and their well-defined relationships, social network analysis provides a simple and intuitive modelling language. When this language is used in the context of sociotechnical systems, much of this simplicity and intuitiveness can be lost. If technological components are modelled as nodes of multimodal networks comprised of social and technical actors, they tend to become multiplex due to the potential presence of edges representing sociotechnical relationships (e.g. Contractor et al., 2011; Kane & Alavi, 2008). This increases the complexity of their interpretation and makes

it difficult to interpret traditional network measures; especially path-based measures, as their interpretation is non-trivial when paths span multiple edges types with different meanings. While this, in some ways, is a limitation, it also provides fruitful ground for innovative contributions that contribute to the understanding of such structres. The work of Kane and Alavi (2008), Kane and Borgatti (2011), and Kane & Ransbotham, (2016), are excellent examples of research that successfully explores the possibilities of modelling sociotechnical systems as multimodal networks. However, there are few studies that succeed in this challenging endeavour. Further, while the plethora of work dedicated to the understanding of the nature of social relationships is part of the foundations of network theory, the body of work that aims to understand sociotechnical relationships remains detached from network research. Bridging this gap would greatly improve the potential of network research on digitally enabled social networks.

An additional shortcoming of network research (in general and in the context of digitally enabled social networks) is the lack of research on the dynamics of social networks. As outlined in the sections above, understanding the dynamics of social networks requires understanding of the social processes governing the underlying social systems. In digitally enabled social networks, those processes are sociotechnical rather than social. Understanding such processes adds an additional layer of complexity to network research and requires additional methods to trace sociotechnical processes (e.g. Bygstad et al., 2016). While this is an underexplored area in research on digitally enabled social networks, it is promising in two ways. First, it provides a valuable contribution to further the understanding of the emergence of digitally enabled social networks and helps to identify the causal mechanisms behind structural changes in such networks. Second, in doing so, it also increases the validity of network research based on digital trace data, as it provides a foundation to explain the data generating mechanisms that lead to the generation of digital trace data.

With regards to the use of digital trace data, there are still some unanswered questions that provide fruitful ground for future research. There is no doubt that the availability of digital trace data provides novel and grand opportunities for research on digitally enabled social networks. With the increasing digitalisation of social interaction, this type of data has quickly become a key in understanding patterns of social interaction in the digital era. In network research, digital trace data helps to overcome many of the limitations of traditional network data (for a comprehensive overview, see Marsden, 1990). It comes, however, with its own limitations. Howison et al. (2011) describe some of the potential pitfalls in using digital trace data in network research. Since the publication of their work, however, there has been little progress in overcoming many of the issues they described. One of the key problems in working with digital trace data is their interpretation in the context of traditional network theory and anal-

ysis. Without a theoretical and ontological foundation as well as a systematic understanding of the data generating mechanisms underlying digitally enabled social networks, it is difficult to infer meaning from digital traces of social and sociotechnical interaction. Promising approaches to overcome this limitation lie within mixed methods approaches, which systematically combine digital trace data with traditional network data (Domínguez & Hollstein, 2014). Behrendt et al. (2014) provide an example of mixed methods research in the context of enterprise social networks and Kane and Labianca (2011) demonstrate a multimethod approach to understand IS resistance in the health-care industry from a network perspective. In both cases, the authors successfully triangulate the results obtained using digital trace data with additional qualitative and quantitative data. While this approach is promising, it remains underutilised in research on digitally enabled social networks. Further research on mixed methods approaches and empirical contributions would be a welcome addition to the growing body of work in this line of research.

Conclusion

In this paper, we critically revisited the foundations of social network analysis and network theory in research on digitally enabled social networks in the information systems community. In doing so, we provided a conceptual clarification of digitally enabled social networks, which we used to analyse the anatomical components of network research in the light of the sociotechnical nature of such networks. We established several shortcomings of contemporary network research in this context and discussed the challenges and opportunities in overcoming them. Our contribution lies within the critical examination of the state of the art in this line of research and the identification of key areas for future research. We find that information systems research, with its strong focus on interdisciplinary research on sociotechnical systems and a growing interest in research on digitally enabled social networks, is in an ideal position to contribute to this field.

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Appendix A.13: Paper XIII

Bibliographic data	Spiegel, O., Abbassi, P., Zylka, M. P., Posegga, O., Fischbach, K., Schlagwein, D., & Schoder, D. (2014). *Getting Boundary Conditions Right: Towards a Classification of the Information Economy Sectors.* In: Proceedings of the Academy of Management Annual Meeting. Philadelphia, PA.
Abstract	Just as most people are not WEIRD, the assumption of industry uniformity may not be true in all cases. Several reviews showed that IS research does not take industry seriously enough. Neglecting industry context can have a severe effect on research results by underspecifying theory or by leading to general explanations that do not hold in other contexts. This paper examines the so called "Information Economy", an industrial context comprising of the ICT, Content and Media, and Internet sectors. We analyze a unique, very large data set that contains employee mobility data of 27,387 organizations. We derive some interesting descriptive statistics that help to differentiate the Information Economy sectors. In addition, with the application of a clustering algorithm, we derive industrial clusters on our data. Our analysis reveals that the OECD's conceptualization of the Information Economy reaches its limits when it comes to more granular sub-sectors within the industry, at which point it no longer seems appropriate from a social/cultural industry perspective. Our study contributes to ongoing discussions around generalizability and boundaries of research results, as well as to the still small body of industry research in the IS field. These findings have important implications for future research and practice.
DOI	10.5465/AMBPP.2014.15984abstract

Appendix A.14: Paper XIV

Bibliographic data	Jungherr, A., Posegga, O., Schoen, H., & Jürgens, P. (2017). *Characterizing Political Talk on Twitter: A Comparison Between Public Agenda, Media Agendas, and the Twitter Agenda with Regard to Topics and Dynamics.* Working paper.
Abstract	Twitter has become a ubiquitous element in political campaigns. Although politicians, journalists, and publics increasingly take to the service, we know little about the determinants and dynamics of political talk on Twitter. We examine Twitter's issue agenda based on popular hashtags used in messages referring to politics. We compare this Twitter agenda with the public agenda measured by a representative survey and the agendas of newspapers and television news programs captured by content analyses. We show that the Twitter agenda had little, if any, relationship with the public agenda. Instead, political talk on Twitter was somewhat stronger connected with related mass media coverage, albeit following channel-specific patterns most likely determined by the attention, interests, and motivations of Twitter users.

Appendix A.15: Paper XV

Bibliographic data	Jungherr, A., Schoen, H., Posegga, O., & Jürgens, P. (2017). Digital Trace Data in the Study of Public Opinion. *Social Science Computer Review, 35*(3), 336-356.
Abstract	In this article, we examine the relationship between metrics documenting politics-related Twitter activity with election results and trends in opinion polls. Various studies have proposed the possibility of inferring public opinion based on digital trace data collected on Twitter and even the possibility to predict election results based on aggregates of mentions of political actors. Yet, a systematic attempt at a validation of Twitter as an indicator for political support is lacking. In this article, building on social science methodology, we test the validity of the relationship between various Twitter-based metrics of public attention toward politics with election results and opinion polls. All indicators tested in this article suggest caution in the attempt to infer public opinion or predict election results based on Twitter messages. In all tested metrics, indicators based on Twitter mentions of political parties differed strongly from parties' results in elections or opinion polls. This leads us to question the power of Twitter to infer levels of political support of political actors. Instead, Twitter appears to promise insights into temporal dynamics of public attention toward politics.
DOI	10.1177/0894439316631043

Zusammenfassung (German Summary)

Die vorgelegte Arbeit befasst sich mit den kollektiven Dynamiken (engl. *collective dynamics*) digitaler sozialer Netzwerke. In einem übergeordneten Rahmenpapier werden zunächst die theoretischen Grundlagen und historischen Wurzeln des Konzepts sowie verwandter Forschungsbereiche beleuchtet. Auf Basis einer ausführlichen Darstellung einschlägiger interdisziplinärer Literatur werden dann die Unterschiede zwischen traditionellen Ansätzen der Erforschung kollektiver Dynamiken in sozialen Systemen mit denen in soziotechnischen Systemen verglichen. Digitale soziale Netzwerke, die zum letztgenannten Systemtyp zählen, unterscheiden sich vor allem durch die ihnen zugrundeliegenden technologischen Plattformen von jenen sozialen Netzwerken, welche die historische Grundlage für die Vielzahl an Methoden und Theorien im Bereich kollektiver Dynamik und verwandter Forschungsbereiche darstellen. Aus dem Vergleich der daraus resultierenden Konsequenzen für die Anwendung der Methoden und Theorien der Netzwerkforschung wird die folgende Forschungsfrage abgeleitet, die im Mittelpunkt der vorgelegten Arbeit steht:

> Welche Rolle spielt Technologie in den in digitalen sozialen Netzwerken auftretenden kollektiven Dynamiken?

Im weiteren Verlauf des Rahmenpapiers werden die besonderen Eigenschaften digitaler sozialer Netzwerke herausgearbeitet und vor allem in Zusammenhang mit den Methoden und Theorien der Netzwerkanalyse gestellt, welche eine zentrale Rolle in der interdisziplinären Forschung zu kollektiven Dynamiken einnehmen. Auf Basis dieser Unterschiede werden drei untergeordnete Forschungsfragen formuliert:

> (1) Welche Rolle spielen technologische Faktoren in der Emergenz neuartiger Phänomene, die sich auf kollektive Dynamiken in digitalen sozialen Netzwerken zurückführen lassen?
>
> (2) Welche Rolle spielen technologische Faktoren in der Steuerung und Kontrolle kollektiver Dynamiken in digitalen sozialen Netzwerken?
>
> (3) Wie können digitale Spurendaten genutzt werden, um kollektive Dynamiken in digitalen sozialen Netzwerken zu verstehen und zu erklären?

Die Beiträge zu diesen Forschungsfragen verteilen sich auf fünfzehn Papiere, die im Rahmen der Dissertation vorgelegt werden. Zur Einordnung der Papiere wird im Rahmenpapier ein übergeordnetes Framework präsentiert, das die individuellen Beiträge den einzelnen Forschungsfragen und vier verschiedenartigen Anwendungsbereichen zuordnet. Fünf der Papiere tragen zur Erforschung der Grundlagen kollektiver Dynamiken in digitalen sozialen Netzwerken bei. Von den verbleibenden elf Papieren, entfallen je vier Beiträge auf den organisationalen Kontext sowie den Bereich des Krisenmanagements. Zwei weitere Beiträge erfolgen im Feld der Erforschung der öffentlichen Meinung

(engl. *Public Opinion Research*). Die drei Anwendungsbereiche repräsentieren klassische interdisziplinäre Forschungszweige in der Untersuchung kollektiver Dynamiken und kollektiven Verhaltens (engl. *collective behaviour*).

Die individuellen Beiträge der Arbeiten lassen sich hinsichtlich der untergeordneten Forschungsfragen wie folgt zusammenfassen.

Die Artikel I bis VII entfallen auf die erste Forschungsfrage. In Artikel I wird ein großes, vornehmliches deutschsprachiges *Social Media Netzwerk* aus der Perspektive des *Link-Prediction-Problems* untersucht. In einer umfassenden empirischen Analyse dyadischer Beziehungen gewährt der Beitrag Einsicht in die Entstehung von Beziehungen in digitalen sozialen Netzwerken; dabei werden insbesondere temporale Aspekte der Netzwerkstruktur und nachbarschaftsbasierte dyadische Kennzahlen untersucht. Eine zentrale Erkenntnis der Studie ist, dass statische soziale Beziehungen im Vergleich zu dynamischen Interaktionsbeziehungen einen höheren Erklärungsgehalt für die Entstehung zukünftiger Beziehungen aufweisen. Die Artikel II und III befassen sich mit dem Konzept der Daten- und Informationsqualität in digitalen sozialen Netzwerken. Auf Grundlage einer konzeptuellen Arbeit und einer systematischen Literaturanalyse werden traditionelle Konzepte der Daten- und Informationsqualität mit den Eigenschaften digitaler sozialer Netzwerke (insbes. soziale Informationssysteme) verglichen. Aus der durchgeführten Analyse ergeben sich neuartige Erklärungsansetze für die Entstehung von Daten- und Informationsqualität in selbstorganisierenden soziotechnischen Systemen; Kern dieser Ansätze ist eine theoretische Linse, die auf dem Konzept soziotechnischer Prozesse und kollektiver Dynamiken aufbaut. Artikel IV untersucht die kollektiven Dynamiken des sozialen Netzwerkes einer *Crowdfunding* Plattform unter Verwendung stochastischer agentenbasierter Modellierung. Im Rahmen der Studie werden unter anderem strukturelle Muster nachgewiesen, die auf hierarchiebildende kollektive Dynamiken und direkte Reziprozität in den Funding-Beziehungen der Plattformmitglieder hindeuten. Artikel V widmet sich der Untersuchung des Zusammenhangs zwischen den kollektiven Dynamiken in den digitalen sozialen Netzwerken organisationaler Gruppen und deren Leistung. Im Kern zeigt die Analyse einen umgekehrten kurvenlinearen Zusammenhang zwischen der Konzentration ausgehender Kommunikationsbeziehungen und der Gruppenleistung. Artikel VI und VII befassen sich mit kollektiven Dynamiken im Krisenkontext. Auf Basis einer systematischen Literaturanalyse zeigt Artikel VI sieben zentrale Aspekte kollektiven Verhaltens in sozialen Medien im Krisenkontext auf. Artikel VII, ebenfalls basierend auf einer systematischen Literaturanalyse, befasst sich mit sozialen, organisationalen und technischen Kommunikationsbarrieren im Krisenkontext. Beide Beiträge betonen die Rolle von Technologie und deren Designaspekten in der Entstehung kollektiven Verhaltens und angrenzender Phänomene im Krisenfall.

Artikel VIII bis X entfallen auf die zweite Forschungsfrage, die sich mit der Rolle von Technologie im Kontext der Kontrolle und Steuerung kollektiver Dynamiken in digitalen sozialen Netzwerken befasst. In Artikel VIII wird auf Basis einer strukturierten Literaturanalyse das Konzept des internen *Crowdsourcings* geprägt und systematisch von konventionellem Crowdsourcing und traditionellen Organisationsformen abgegrenzt. Die Arbeit leistet einen Beitrag zum Verständnis des Konzepts und zu dessen Implementierung und Steuerung auf Basis digitaler sozialer Netzwerke. Das Artikel IX und X zugrundeliegende Forschungsprojekt widmet sich der gestaltungsorientierten Erforschung kollektiver Dynamiken von ungebundenen Spontanhelfern im Krisenfall auf Basis der Entwicklung eines technologischen Artefakts. Artikel IX beschreibt die bis zur Implementierung und Demonstration reichenden Phasen des *Design Science* Projekts, während Artikel X dessen Evaluation im Rahmen eines umfänglichen Feldexperiments vorbereitet. Ziel des Artefakts ist die Anbindung spontan auftretender Helfer an die Strukturen und Prozesse professioneller Hilfsorganisationen im Krisenfall. Grundlage für die Anbindung stellt ein durch das Artefakt getragenes digitales soziales Netzwerk dar, auf dessen Basis die kollektiven Dynamiken der Spontanhelfer sichtbar und durch die Hilfsorganisationen kontrollierbar gemacht werden sollen.

Die Artikel XI bis XV sind der dritten Forschungsfrage zuzuordnen, die sich mit dem Potential sowie den Grenzen digitaler Spurendaten in der Erforschung kollektiver Dynamiken in digitalen sozialen Netzwerken befasst. Artikel XI und XII leisten einen gemeinsamen Beitrag zum besseren Verständnis kollektiver Dynamiken in digitalen sozialen Netzwerken, indem sie systematisch die Unterschiede traditioneller Theorien und Methoden der Netzwerkanalyse mit den Eigenschaften digitaler sozialer Netzwerke vergleichen. Das Ergebnis der Papiere ist eine Forschungsagenda, die im Kern auf die Notwendigkeit einer kritischen Hinterfragung bestehender Ansätze der Netzwerkanalyse hinweist und mögliche Ansätze zur Erweiterung des Repertoires der Netzwerkanalyse und Netzwerktheorie im Kontext soziotechnischer Systeme skizziert. Artikel XIII demonstriert ein innovatives Verfahren zur Generierung von Industrieklassifikationen auf Basis digitaler Spurendaten. Auf Grundlage eines Datensatzes, der inter-organisationale Mitarbeiterflüsse dokumentiert und von einer karriereorientierten internationalen Social Media Plattform erhoben wurde, werden in der vorgestellten Studie *Community-Detection-Verfahren* der Netzwerkanalyse angewendet, um Unternehmen gemäß des durch Spurendaten abgebildeten Verhaltens ihrer Mitarbeiter zu klassifizieren. Neben der Demonstration und Einordnung des Verfahrens bietet der Beitrag empirische Einblicke in die Struktur der *Information Economy*. Artikel XIV und XV untersuchen die Eignung spurendaten-basierter Analysen in der Erforschung der öffentlichen Meinung auf Grundlage eines umfänglichen Datensatzes zur Bundestagswahl 2013 in Deutschland. Artikel XIV widmet sich dem Vergleich der mit klassischen Methoden der empirischen Sozialforschung erhobenen öffentlichen und Massenmedien-Agenda mit den auf Social Media Plattformen dominierenden Themen. In einer kritischen Analyse liefert

die Studie empirische Belege für die Existenz datengenerierender Prozesse, die digitalen sozialen Netzwerken zugrundeliegenden und welche die direkte Vergleichbarkeit traditioneller Agenden mit der auf Social Media Plattformen messbaren öffentlichen Meinung in Frage stellen. Artikel XV untersucht in einer analogen Logik die Eignung digitaler Spurendaten zur Vorhersage politischer Wahlintention. Auf Grundlage einer umfänglichen qualitativen und quantitativen Analyse identifiziert der Beitrag potentielle Validitätsprobleme, die bei der Prognose politischer Wahlabsicht auf Basis digitaler Spurendaten unter Verwendung aktuell diskutierter Methoden auftreten können.

Von den in der Dissertation zusammengefassten Artikeln wurden dreizehn Artikel in den Tagungsbänden einschlägiger interdisziplinärer Konferenzen und Journale veröffentlicht. Artikel XII liegt als unveröffentlichtes Arbeitspapier vor. Artikel XIV liegt nach zwei Revisionsrunden im *International Journal of Public Opinion* Research ebenfalls als unveröffentlichtes Arbeitspapier vor und wird zum Zeitpunkt der Abgabe der Dissertation für eine erneute Einreichung vorbereitet.

Publications

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