2 Related Work

2.1 Emergence, CSCW and Social Software

Collaboration infrastructures dealing with the concept of *emergence* face many challenges. The latter term was introduced by the philosopher George Henry Lewes (1875), who wrote:

> *"Every resultant is either a sum or a difference of the co-operant forces […]. It is otherwise with emergent. […] The emergent is unlike its components insofar as these are incommensurable, and it cannot be reduced to their sum or their difference."*

This definition emphasizes the nature of emergent structures which, in their nature, not allow for accurate or even adequate calculation or prediction. The whole, to use a commonplace expression, is more than the sum of its parts. A newer version defines emergence as follows: "[it] refers to the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems" (J. Goldstein, 1999). According to this perspective, emergent phenomena share certain characteristics: (1) they cannot be anticipated in their full richness before they actually manifest themselves, (2) they tend to maintain some sense of identity over time, (3) the locus of emergent phenomena occurs on a global level, (4) they arise as a complex system over time and (5) they can be perceived.

Informal organization can be viewed as an example for emergence, i.e. spontaneously occurring organizational events, structures, processes, groups, and leadership (J. Goldstein, 1999). In respect of the design of self-organizing applications, a combination with emergence is common "which makes it infeasible to impose a structure a priori: the system needs to self-organize" (De Wolf & Holvoet, 2005). Working in emergent structures can be challenging due to unpredictability, incalculability and therefore uncertainty. Goldstein (1999) distinguishes between the source of an organizational structure in an organization (self-organized or imposed) and its type (hierarchical or participative). His two-by-two grid (Table 1) highlights *emergent networks* as participative and self-organized networks that "can include both intra- and intergroup dynamics and also pertain to the spontaneously arising organizational structures and practices".

Source of Structure	Hierarchical	Participative
Self-Organized	Informal Leadership	Emergent Networks
Imposed	Command and Control	Imposed Teams

Type of Structure

Table 1: Emergence and organizational dynamics (J. Goldstein, 1999)

Some environments and structures may allow precise prediction and full automation but, the academic field of CSCW has a broadly skeptical view of this prospect and aims at "supporting self-organization of cooperative ensembles as opposed to disrupting cooperative work by

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computerizing formal procedures" (Schmidt & Bannon, 1992). The field is therefore appropriate for understanding how to deal with emergences. The intent of CSCW is to:

> *"understand the nature and characteristics of cooperative work with the objective of designing adequate computer-based technologies"* (Bannon & Schmidt, 1989).

The term was first used by Irena Greif and Paul Cashman in 1984 to describe an interdisciplinary workshop they were organizing on how to support people in their work arrangements with computers (Grudin, 1994). A few years later Greif (1988) defined CSCW as "an identifiable research field focused on the role of the computer in group work". Cooperative work has been identified as a "phenomenon we can study systematically, as a category of work practice, distinct from its organizational and socio-economic form" (K. Schmidt, 2010). Besides the exclusive focus on the tasks, a distinction between (mainly distributed) cooperative work, that is concerned with the tasks itself, and articulation work, that includes all activities required to coordinate the tasks among individuals, is common (Schmidt & Bannon, 1992). *Articulation work* can be seen as "a kind of supra-type of work in any division of labor, done by the various actors" (Strauss, 1985):

> *"Who is doing what, where, when, how, by means of which, under which requirements? Articulation work arises as an integral part of cooperative work as a set of activities required to manage the distributed nature of cooperative work"* (K. Schmidt, 1994).

Awareness is further crucial factor for collaborative work and provides a "context for individual activities and thus facilitates group progress" (Dourish & Bellotti, 1992). In order to support emergent collaborative work, supporting articulation and considering awareness is essential.

When considering *emergence* in collaborative systems, with new structures, actors and/or environments in play, evolving concepts like *social software* as opposed to *groupware* have also to be taken into consideration. Groupware is defined as "intentional group processes plus software to support them" (Johnson-Lenz & Johnson-Lenz, 1991) or "computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment" (Ellis et al., 1995). Social software, in contrast, cannot be so narrowly defined. Social software will commonly be found, along with collaborative systems, in work-related contexts, but the former is also common in the private arena. Richter (2010, p. 108) points out, that one characteristic of social software is not to focus on the creation of communities to specific tasks, but to focus on the usefulness of the individual user. The term social software came into more common usage, when Clay Shirky in 2002 organized a "Social Software Summit" (Allen, 2004). He did not use the term groupware in order to gather all uses of software that support interaction in groups, even offline; he also did not use the term *collaborative software* because to him that seemed as a sub-set of groupware which just focuses on work (Allen, 2004). An early and very simple definition of *social software* is "software that supports group interaction" (Allen, 2004). It is more used in private contexts and is perceived as being a significant part of Web 2.0, which describes the innovations of the Internet after the crash of the new economy in 2000 (Alby, 2007). *Social media* is defined almost synonymously as:

> *"Group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user generated content"* (Kaplan & Haenlein, 2010)

User generated content can be seen as "the sum of all ways in which people make use of Social Media" (Kaplan & Haenlein, 2010). *Web 2.0* was first coined in 1999:

> *"The first glimmerings of Web 2.0 are beginning to appear [...] through which interactivity happens. It will [...] appear on your computer screen [...], your TV set [...] your car dashboard, [...], your cell phone [...] hand-held game machines [...] and maybe even your microwave."* (DiNucci, 1999, p. 32)

At the "Media Web 2.0 conference" held by Tim O'Reilly, the competences of the surviving companies of the new economy were summarized under the term *Web 2.0*, which was then used more frequently. O'Reilly (2005) defined them as having seven characteristics including (1) the usage of the Internet as a platform to provide different services, (2) the participation of users and a collective intelligence, (3) the consideration of the user-generated data as the capital of an application, (4) the inclusion of the user in the development, (5) using new software development models, (6) the use of services on different terminals, and (7) rich user experience. For him Web 2.0 is the "business revolution in the computer industry caused by the move to the Internet as platform, and an attempt to understand the rules for success on that new platform" (T. O'Reilly, 2006). From his perspective, the term social software describes web-based applications that support the user's interaction and communication process. In addition to this definition, there are various other considerations. Hippner (2006) defined social software as the possibility to exchange information, manage relationships and communicate in social contexts. Besides the exchange of information, Ebersbach et al. (2008) defined user generated content as an essential element. The existence of a community therefore is an important pre-condition. In summary, social software and social media encompass a range of applications from the Internet that enable different people to contact and interact with each other. A community providing the data is the basis of these applications and they support different activities: the allocation of information, the generation of information, relationship management, communication and self-expression. Different activities are often combined. Allen (2004) points out that the "core ideas of social software itself enjoy a much longer history, running back to Vannevar Bush's ideas about *Memex*[*] in 1945 through terms such as *augmentation*, *groupware*, and *CSCW* in the 1960s, 70s, 80s, and 90s". Koch (2008) also argues that "most of what currently is advertised as a revolution on the web has been there as CSCW applications years (or even decades) ago – however, not as nice and as usable as today in the Web 2.0 with social software". The use of social software and the use of groupware may therefore not necessarily be entirely different.

A common important characteristic of both, CSCW applications and social software, is that they do not focus on automation but on the support of social activities or work practices, which may be neither organized nor coordinated formally. Kieser and Walgenbach (2010, pp. 93ff) distinguish seven types of coordination: coordination by (1) programs, (2) planning, (3) intra-organizational markets, (4) organizational culture, (5) standardized roles, (6) hierarchical decision-making and (7) self-coordination by non-hierarchical communication. The mechanisms of "self-coordination and hierarchical decision-making allow ad hoc coordination"

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[*] A device in which individuals would compress and store all of their books, records, and communications.

(Wulf, 1999) make it possible to "use the potential of emergent changes". The introduction of ICT therefore should be participatory and evolutionary and applications should be technically flexible (Wulf, 1999).

The characteristics of emergence, as described, mean that it may not be possible to carry predefined processes into execution – (cooperative) work in such settings therefore needs ad hoc coordination and *improvisation* which can be defined as a "situated performance where thinking and action seem to occur simultaneously and on the spur of the moment" (Ciborra, 1996). While some authors define it from a management perspective as "to be composed while performed" (Perry, 1991), others describe it in the case of fire service management as "thinking and doing unfold simultaneously" and "retrospective sensemaking" (Weick, 1996). Improvisation becomes necessary when planned decision-making does not, for a variety of reasons, work. This is for example the case in a crisis situation, which often leads to unexpected events. The necessity to judge highly novel problems and to act quickly reduces the possibility of extensive planning: "Decision makers in emergencies must be prepared to improvise" (Mendonça & Wallace, 2007). Antecedent conditions, such as unexpected problems, changes in the structure of the problem areas or environmental and knowledge limitations, lead to the need for improvisation (Stein, 2011). Even in highly structured organizations, improvisation is a well-grounded process that can be leveraged to face those situations where rules and methods fail (Ciborra, 1999). Improvisation can be performed on different hierarchical levels and can be treated as an individual or as a team phenomenon (Moorman & Miner, 1998). Instead of trying to eradicate it through automation, the need for an appreciation of requirements for flexibility and effectiveness seems to be clear.

2.2 Field of Application: Crisis Informatics and Emergency Management

In order to develop software for social settings, especially to support group interaction, it is important to take the specifics of the field into account (Wulf et al., 2011). Depending on the work domain and the exact nature of work, the use of coordination mechanisms varies and consequently the (technical) artifacts in use may differ. The concept *coordination mechanism* describes "the use of artifacts for the purpose of coordinating cooperative activities in different work domains" (K. Schmidt & Simonee, 1996). Considering the case of crisis and emergency management, it is obvious that one unit cannot manage the situation alone; coordination mechanisms, such as ICT artifacts, are therefore needed. A definition of the application field is not trivial:

> *"Disaster, crisis, catastrophe, and emergency management are sometimes used synonymously and sometimes with slight differences, by scholars and practitioners."* (Hiltz, van de Walle, et al., 2011)

However, according to the *internationally agreed glossary of basic terms related to disaster management* (United Nations Department of Humanitarian Affairs, 2000), an *emergency* can be seen as a "sudden and usually unforeseen event that calls for immediate measures to minimize its adverse consequences". According to the same document, a *disaster* is a "serious disruption of the functioning of a society, causing widespread human, material, or environmental losses which exceed the ability of affected society to cope using only its own resources". The term, 'crisis', has not been defined in that document. Yet, *crises* are situations that the normal structural and process organization cannot overcome (BSI, 2008). The Greek root word *krisis* (judgment, decision) shows the ambivalent possibilities and leads to a very important task in such situations: decision-making.

The *emergency management process* deals with such decision-making and can be separated into four to eight phases (Turoff et al., 2009), where all classifications at least include the main four phases: (1) *Mitigation* - "pre-disaster actions taken to identify risks, reduce them, and thus reduce the negative effects of the identified type of disaster event". (2) *Preparedness* – "actions taken prior to a possible disaster that enables the emergency managers and the public to be able to respond adequately when a disaster actually occurs". (3) *Response* (also called emergency management) – "actions taken immediately prior to a foretold event, as well as during and after the disaster event, that help to reduce human and property losses". (4) *Recovery* – "enable the population affected to return to their normal social and economic activities" (Hiltz et al., 2011, p. 5-6). Quarantelli (1995) suggests separating different types of work in crisis management. He distinguishes between old and new structures as well as between old and new tasks (Table 2). He argues that crises differ from routine situations and actors have to face new and unstructured tasks. Contexts are often unforeseeable or *emergent* and cannot result from a small set of rules or events. Based on structural or functional emergence he defines *emergent behavior* as new structures with new tasks.

	Old Structures	New Structures
New Tasks	Type III: Expanding	Type IV: Emergent
Old Tasks	Type I: Established	Type II: Extending

Table 2: Types of emergent behavior (Quarantelli, 1995)

In emergencies, collaboration and, consequently, articulation between many involved actors in different phases is required in order to be able to make informed decisions. Emergency management is faced by an "unlimited variety of incidents that require interpretation, decision and coordination" (Normark & Randall, 2005). Articulation work includes reports from on-site units to the control center, information provided by the control center or even the communication between different units or organizations and public authorities with security responsibilities (German: *Behörden und Organisationen mit Sicherheitsaufgaben*, BOS) such as the police, fire departments, aid agencies, the THW and public administration. It can also include communication with actors who are not necessarily part of the official BOS, such as citizens and companies. Quarantelli (1988) derives five different categories to characterize the flow of information in a crisis: (a) intra-organizational, (b) inter-organizational, (c) from organizations to the public, (d) from the public to the organizations and (e) communication within systems of organizations. Collaboration between the "private and public sectors could improve the ability of a community to prepare for, respond to, and recover from disasters" (Board on Earth Sciences and Resources, 2011). This ability is sometimes called *collaborative resilience* (B. E. Goldstein, 2011, p. 370) and:

> *"examines a variety of ways to build resilience to violence, hazards, and resource decline. These collaborative methods range from consensus-based*

> *stakeholder agreements to collective mobilization of change in durable institutions that are dysfunctional and inequitable."*

Emergencies also fulfill other characteristics of emergent situations by Goldstein (1999): (1) they are not anticipated in their full richness before they actually arise, (2) they tend to maintain some sense of identity over time, (3) the locus of emergent phenomena takes place on a global level, (4) they arise as a complex system over time and (5) they can be perceived. In crisis and emergency management "improvisation and preparedness go hand in hand" (Mendonça, 2007): without improvisation, emergency management loses flexibility and without preparedness, emergency management loses efficiency. Based on an analysis of the responses to the 2001 World Trade Center attack, Mendonca (2007) suggests that some specifics of emergency management can be considered as characteristic. First, (a) the rarity of incidents limits opportunities for training and learning. Furthermore, (b) time pressure forces a convergence of planning and execution. (c) Uncertainty is present because the development of an extreme incident is rarely predictable. Extreme events also have (d) high and broad consequences; therefore, there is a need to manage interdependencies within a wide range of physical and social systems. The (e) complexity of the event arises, which is partly due to the high and broad consequences. Finally, (f) multiple decision-makers and responding organizations may need to negotiate with each other while responding to the event. Based on interviews with emergency responders, Chen et al. (2008) also derived characteristics of the field, which are often similar to those mentioned above and do not provide new aspects unless the "disruption of infrastructure support" occurs: (a) high uncertainty with sudden and unexpected events, (b) risk and possible mass casualty, (c) increased time pressure and urgency, (d) serve resource shortage, (e) large-scale impact and damage, (f) disruption of infrastructure support, (g) multi-authority and massive people involvement, (h) conflict of interest and (i) high demand for timely information.

Information systems are increasingly important to support the actors involved (Hiltz, van de Walle, et al., 2011). The term *crisis informatics* was coined by Hagar (2007) and later elaborated (Palen et al., 2009):

> *"Crisis informatics views emergency response as an expanded social system where information is disseminated within and between official and public channels and entities. Crisis informatics wrestles with methodological concerns as it strives to develop new theory and support sociologically informed development of both ICT and policy."*

The dynamics and specifics of crises and emergencies make it extremely difficult to find appropriate approaches to articulate information needs amongst all actors (Heath & Luff, 1992). Obviously, one single ICT-system cannot support the specific activities of all actors; cooperation and communication between different information systems is therefore necessary as a part of the collaboration infrastructure for crisis management. Based on empirical work in the field, Denef (2011) presents patterns of firefighter's activities in order to transform the existing practices into a design space. The pattern "handy multi tools" describes important characteristics of BOS working practices, relative to physical and time constraints (Denef, 2011, p. 193):

> *"Firefighters bring tools that can be used for different purposes and invent new ways of using the tools. Tools are designed open for new uses and can be combined with the environment."*

In his intention to design navigation support for firefighters Ramirez (2012, p. 160) also mentions that rigid regulations and tool definitions are adapted if the (emergent) situation requires it. Computer-based systems can allow such practices, if the system design is informed by an understanding of the cognitive processes involved in responding to unanticipated contingencies (Mendonça, 2007). Systems must support the actors in reworking their knowledge, in order to fit the requirements of the current situation. ICT which supports improvisation needs to handle ad hoc coordination, unique problem solving strategies and new or changed information needs (Waugh & Streib, 2006). Computer based comparisons of the current decision situation with past ones have been identified as appropriate in this context (Mendonça, 2007). Case-based reasoning systems, which catalogue the set of planned-for situations or decision alternatives, can be used for this purpose, too. Ad hoc re-planning and the ability to share material were identified as design challenges for large-scale events (Lindström & Pettersson, 2010). Furthermore, the following ICT-supported mechanisms for improvisation in emergency management are suggested: graphical representations of data during crisis response, intelligent systems that select and help contact experts, centralization of data to enable actors to find information and virtually supported coordination to create shared information (Adrot & Robey, 2008). Additionally, verbal communication should be made persistent, visible and accessible in order to support accountability (Landgren, 2006). Current crisis management systems cover only parts of these requirements. Based on an analysis of over 170 systems (Neuhaus et al., 2012), they can be divided into *information systems*, *alerting systems*, *command and control systems* and *communication systems*, while a shift from single solutions to hybrid systems and towards the provision of web- or mobile solutions was observed. However, “although there is a common body of knowledge, [multi-agency] disaster management is still an under-developed area” (Janssen et al., 2009).

2.3 CSCW Applications for Inter-Organizational Collaboration

Besides the consideration of the field of application, the aspect of *inter-organizational* needs to be studied. While *inter-organizational systems* (IOS) or *inter-organizational information systems* (IOIS) are automated information systems shared by two or more organizations (Cash & Konsynski, 1985), CSCW applications normally provide “capabilities beyond simple information access to facilitate communication and collaboration among partners” – and IOIS are therefore a subset of CSCW systems (Drury & Scholtz, 2005). Literature on IOIS has grown in many directions motivated by the efficiency account of cooperation or social and behavioral bases of firm relationships (Chatterjee & Ravichandran, 2004). Coordination among the organizations involved, as well as the sharing of information and expertise, is of high importance, especially in unforeseeable and emergent situations. In CSCW, *information sharing* (or *knowledge sharing*[*]) is used for artifact-centered studies, while the communication-centered *expertise sharing* focuses on the actor (Ackerman et al., 2013). Expertise sharing focuses on the “self-organized activities of the organization’s members and emphasizes the human aspects” (Ackerman et al., 2003), in addition to information storage and retrieval. IOS can provide a basis for planned and automated collaboration among organizations; however they usually do not cover emergent and ad hoc collaboration as CSCW applications do.

[*] Ackerman et al. (2013) mention to “not differentiate between knowledge and information” in their overview article about the “CSCW View of Knowledge Management”.

Many papers address coordination, information and expertise sharing practices across different organizations: A study on coordination mechanisms in software development discovered a large variety of informal communication and ad hoc coordination mechanisms (Doherty et al., 2012). The authors suggest introducing technologies that support the establishment of “less formal communication channels” instead of structured information management systems. An empirical study on municipal governments, trying to understand information sharing needs and practices, confirms this finding: due to the different information needs, *flexibility* was identified as the main requirement. They also point out that employees “rely heavily on manual methods for data sharing” (Hobson et al., 2011). A study on the challenges of sharing and coordinating information during multi-agency disaster response highlights that the “actual level of information sharing across different organizations is often limited, although it is being promoted”. A reason is that agencies “are mainly concerned with obtaining information from others, rather than providing others with information at their disposal” (Bharosa et al., 2010). A possible approach could be, as White et al. (2009) discovered in a survey study that social networks for emergency management should be considered as a viable solution to the problems plaguing information dissemination and communication.

In addition to work on flexibility, improvisation and communication, studies focusing on visualization and collaboration, especially using *geographic information systems* (GIS) – sometimes as a part of IOIS, are of interest. The study of Li and O’Hara (2009) focuses on the decision-making of geographically distributed committees and found that difficulties arose from not having shared visual access to the information being discussed. The ethnographic study of Paul and Reddy (2010) on collaborative information seeking shows that in addition to the ambiguous nature of information, the different roles and expertise of group members make sensemaking more challenging; they propose to visualize sensemaking trajectories in order to foster awareness among BOS. Kraut et al. (2002) confirm that “collaborative pairs can perform more quickly and accurately when they have a shared view of a common work area”. In terms of group work, “most spatial decisions using geographical information are done by teams, but existing geospatial information technologies […] have been designed for use by individuals”, according to Cai (2005). His approach extends distributed GIS with collaborative functionalities and proposes a system architecture that integrates web service-based distributed computing paradigms. The geocollaborative software architecture for emergency management planning of Schafer et al. (2007) combines Java-based collaborative infrastructures with GIS tools to be able to support awareness and collaboration with annotations and selections that can be shared, as well as to provide the possibility to lead or follow another user’s map or to link georeferential data to other content. These functionalities have also been used in the study of Convertino et al. (2011) that focuses on knowledge sharing and activity awareness in distributed emergency management planning with a collaborative geospatial prototype. With a series of paper and software prototypes, they show that using collaboration technology can reduce coordination efforts among spatially distributed teams. Web-based geocollaborative tools have also been examined: the approach of Chang and Li (2007) integrates collaborative tools to support participants’ awareness and their collaboration. Many of these web-based crisis mashups are described by Liu & Palen (2010), who focus particularly on “merging the professional GIS culture with the participatory neo-geographic culture to address the mapping challenges which are likely to arise in this increasingly networked world”.

2.4 Social Software for Emergent Civic Participation

This increasingly networked world and the aforementioned appearance of social software also led to its use by the public. For more than one decade, social software has been used by the public in crisis situations: after the terrorist attacks of September 11th, 2001, wikis, created by citizens, were used to collect information on missing people (Palen & Liu, 2007). In a study on the information search behavior during the forest fires in Southern California in 2007, it was found that affected people communicated via mobile phones and used the Internet to search for information and to trigger communication, to read blogs, news sites and forums (Sutton et al., 2008). During the last few years this behavior has even increased: Social software is widely used by citizens collaboratively coping with a crisis. Many published papers deal with crises in the USA and many of them focus on the use of Twitter. Its use was analyzed in the context of various crises, such as technological failures, floods, attacks, hurricanes and earthquakes (Reuter, Marx, et al., 2012), but also during political activities, such as the 2011 Egyptian uprising, during the 2011 Tunisian revolution (Wulf, Misaki, Atam, Randall, & Rohde, 2013), and while fighting against the wall in Palestine (Wulf, Aal, et al., 2013).

Other studies show that *Wikis* are used for supporting people affected by a crisis (White, Plotnick, Addams-Moring, Turoff, & Hiltz, 2008). They are useful to collaboratively collect information and knowledge and to then create collective intelligence, but there are deficits in communication. Scipionus is an example of such a crisis-related wiki, which arose during the struggle against the effects of Hurricane Katrina. It uses a visual interface that allows its users to publish and edit information on the Google Map Interface (Palen, Hiltz, et al., 2007). Other examples are Emergency Wiki or Quake Help Wiki (White et al., 2008).

Micro blogging is used to collect and distribute information, to communicate and answer help requests. However, for intensive coordination work, Twitter-users switch to other software, such as Skype (Starbird & Palen, 2011). Twitter serves as resource for situation updates (Vieweg et al., 2008) and as a platform for coordinating activities, exchanging opinions and coping emotionally with a crisis (Qu et al., 2011). As for Twitter messages, it had been found out that tweeters assume the role of the classical media if the actual news coverage by the media and organizations is not satisfactory (Sutton, 2010). The observers tried to show what distinguishes the Twitter experience in a crisis from everyday Twitter usage (Hughes & Palen, 2009). Within the first hour of an emergency, using Twitter for information retrieval is almost a default and mainstream media, it is argued, catch up to the average level of information quality on the Twitter network after about 24 hours (Mills et al., 2009). Twitter can raise awareness of a crisis because it is able to reach a large number of people at once. Therefore, the service is often used as a broadcast medium (Hughes & Palen, 2009). False information is prevented from being spread by the collective intelligence of the users, who ensure that faulty tweets are corrected: retweets serve as an evaluation mechanism for important information (Starbird et al., 2010). In order to improve the use of tweets by BOS, Starbird and Stamberger (2010) proposed the use of a particular hashtag-syntax during a crisis, which would be machine-readable and could help collect more relevant information. Starbird et al. (2012) also showed how to identify on-the-ground tweeters during mass disruptions. A study on the geographical distribution of Twitter users has shown that people who are not or who are only slightly affected by the crisis, use Twitter more often than citizens and organizations more significantly affected. However, the information generated by those who are not involved is of great help to those affected by the crisis or disaster (Sutton, 2010). As opposed to everyday Twitter activities, more *information brokers* (Hughes & Palen, 2009) were identified, who collect information from various validated sources and pass it on to help the victims of the crisis (Sutton et al., 2008; Vieweg et al., 2008). Also without specific analytic tools, Twitter is used by BOS such as fire departments, to obtain citizen-generated content and to publish their own information (Latonero & Shklovski, 2011). In the Twitter-use of the police, different strategies were observed, as an instrumental approach - where the police aimed at remaining in a controlling position and to keep a distance from the general public - or taking on an expressive approach - where they actively decreased the distance from citizens (Denef et al., 2013).

Besides micro blogging, *social networks* are an important kind of social media. Social networks enable its users - who are represented by profiles - to connect with each other and offer various interaction tools, such as sending messages, sharing photos and videos, providing information within a user or group profile, publishing notifications, reporting current status, announcing events and discussions in forums (White et al., 2009). Existing networks, like Facebook, have the advantage that users already possess a net of social relationships from everyday use before the actual crisis takes place and its functionalities do not have to be learned during a crisis. They are intensively used to create collective intelligence, serve as a source of information and contain quality control (Palen & Vieweg, 2008). Activities, tasks and domains can be identified as mechanisms of self-organization for *digital volunteers*, described as people with "new behaviors of mass interaction that ICT enables" (Starbird & Palen, 2011). During a rampage, the decentralized problem-solving behavior of students was observed: a short time after the beginning of the attack, they used Facebook to identify the victims together and used the social network's group function for that purpose (Vieweg et al., 2008). The authors show that the collective intelligence of citizens helped to correctly identify the victims, because users were concerned about reliable sources in this particular situation.

Besides classical categories of social software, crisis-related platforms specifically customized for crises are another type of relevant social software. Sahana, Ushahidi and Google Crisis Map integrate several web-based applications (van de Walle & Turoff, 2008). These and other types of social software are used by people who are physically present on-site as well as by off-site users and digital volunteers (Starbird & Palen, 2011). The ubiquitous availability of collaboration technologies leads to situated (civic) engagement (e.g. collaborative and social software use related to the current situation via smartphones), where each participant is embedded in a socio-spatio-temporal context (Korn, 2013), which needs to be allowed by the respective infrastructure.

2.5 Infrastructures and Infrastructuring

In order to research emergent collaboration infrastructures, the term, 'infrastructure' needs to be defined. *Infrastructure* comes from the Latin *infra* (below) and comprises all basic structures needed for the operation of a society. According to van Laak (1999), the term has originally been used for assets for mobility, e.g. the train stations and bridges of the French railroad since 1875, or barracks and radar stations of the North Atlantic Treaty Organization since 1950. At that time, NATO developed a program to coordinate the expansion of airports, pipelines and fuel reservoirs, and communications and air defense systems. The term was then http://www.springer.com/978-3-658-08585-8

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