Requirements and Open Issues for ISs Supporting Dynamic Community Bonding in Emergency Situations

Di Mascio, T.; Gobbo, F.; Tarantino, L.

DOI
10.1007/978-3-319-23784-8_20
Publication date
2015
Document Version
Final published version
Published in
Empowering Organizations
License
Article 25fa Dutch Copyright Act

Citation for published version (APA):
Di Mascio, T., Gobbo, F., & Tarantino, L. (2015). Requirements and Open Issues for ISs Supporting Dynamic Community Bonding in Emergency Situations. In T. Torre, A. M. Braccini, & R. Spinelli (Eds.), *Empowering Organizations* (pp. 257-271). (Lecture Notes in Information Systems and Organisation; No. 11). Springer. https://doi.org/10.1007/978-3-319-23784-8_20

Requirements and Open Issues for ISs Supporting Dynamic Community Bonding in Emergency Situations

Tania Di Mascio, Federico Gobbo and Laura Tarantino

Abstract Studies show that in emergency situations, like in the aftermath of natural disasters, people tend to self-organize into so-called ephemeral organizations and transitional communities based on common problems, common places, etc. Strict interactions among victims, fundamental to strengthen such small communities, may be efficiently supported by a new generation of mobile-empowered disaster management systems based on the social networking approach, with crowd-generated and geo-referenced data. In this paper we discuss how a shift of perspective in the interaction, conceptual, logical and physical models adopted for the social network can efficiently support the dynamic bonding/de-bonding/re-bonding of communities that emerge based on alliances around shared problems and/or objectives.

Keywords Social network · Interaction · Emergency management

1 Introduction

As the European Environmental Agency (EEA) recently reported [13], the impact of disasters due to natural hazards and technological accidents increased in Europe in the period 1998–2009, with nearly 100,000 fatalities, more than 11 million

T. Di Mascio (✉) · L. Tarantino
Università Degli Studi Dell'Aquila, L'Aquila, Italy
e-mail: tania.dimascio@univaq.it

L. Tarantino
e-mail: laura.tarantino@univaq.it

F. Gobbo
University of Amsterdam, Amsterdam, Netherlands
e-mail: f.gobbo@uva.nl

F. Gobbo
University of Milano Bicocca, Milan, Italy

F. Gobbo
University of Torino, Turin, Italy

T. Torre et al. (eds.), *Empowering Organizations*, Lecture Notes in Information Systems and Organisation 11, DOI 10.1007/978-3-319-23784-8_20

people affected, and economic losses of about EUR 150 billion. In the observed period extreme temperature events caused the highest number of human fatalities, flooding and storms were the most costly hazards, while earthquakes ranked second in terms of fatalities and third in terms of overall losses. EEA observes that the increase in losses can be explained, to a large extent, by higher levels of human activity and accumulation of economic assets in hazard-prone areas and underlines the necessity of measures for risk reduction and management. Although some EU policies have already been adopted or initiated, more effort is needed to implement an Integrated Risk Management approach that includes prevention, preparedness, response and recovery, the four main phases of a cyclic emergency management process [1].

The study discussed in this paper refers in particular to the support that ICT, and Information Systems (ISs) in particular, may provide to response and recovery after natural disasters that cause a massive failure in essential infrastructures and the disruption of the integrity of the affected community.

The subject of social and psychological impact of disasters is widely debated in the literature (e.g., [3, 4, 6, 14, 16, 17, 23, 24, 29]) and it is generally agreed that one of the most relevant effect of a disaster is the relaxation or, in the worst case, the disruption of the social linkages upon which a community is based. Immaterial damages are less evident (though often more relevant) than material ones and may remain unnoticed for a long period of time. It has to be noticed that, in the immediate aftermath of a disaster, the attention of rescuers is usually captured by the material needs of the victims, leaving sociological and psychological needs usually not addressed or addressed by means of standard protocols unable to reach the entire population.

This standard approach for facing emergency is mirrored by the emergency-related ICT proposals, which, in most cases, aim at providing support to rescuers and institutions, mainly offering top down and push communication (from institutions to citizens). Conversely, based on the literature on social recovery and on field evidences (still being) collected after the major moment magnitude 6.3 earthquake that hit L'Aquila and its neighboring territories on April 6, 2009, we are interested in offering a peer-to-peer (among citizens) communication, in order to directly supporting victims and the social dynamics that spontaneously arise in the aftermath of a disaster.

Overall, the L'Aquila earthquake caused 308 deaths and more than 1,500 injured persons. L'Aquila was devastated, both in its residential areas and in the historical center, with massive damages to cultural heritage (churches, monuments, museums, etc.) and fundamental public services (such as the City Government building and even the main hospital). The whole city of L'Aquila was evacuated and the historical center (now the so called "red area") has been isolated. The earthquake made L'Aquila (in particular its city center) a ghost town: all the social areas, the main squares, the churches, the shopping areas were heavily damaged and made inaccessible to the citizens (and so are now). The municipal offices were moved to different locations; factories, commercial areas, public utilities, infrastructures were (and partly are still) unusable. In a handful of seconds more than 70,000 persons (counting just L'Aquila, but the situation in the surrounding villages was not better) lost not only the private sphere of their homes but also all ordinary work and public environments.

The experience of the 2009 L'Aquila earthquake clearly highlights the necessity of online services and multimodal forums able to support social interaction not only in the immediate aftermath of the disaster but also in the medium and long run, to allow citizens to be active agents in the redefinition of their social connections. To have an idea of the length and the pace of the process, one can compare the 2013 and 2014 official figures on the evacuated population [22]: on April 2013, while waiting for the reconstruction of their homes, about 6500 persons were living in self-arranged accommodations, about 250 were still housed in temporary shelters (barracks and hotels), and about 15,000 were housed in more than 20 small new villages built after the quake under the coordination of the Civil Defense and located around the city territory, along an approximately 100 km closed path; in April 2014 the same figures were about 4500, about 150, and about 14,000, respectively.

Based on the experience in the post-earthquake in L'Aquila, our research group launched a number of projects to study and evaluate complementary aspects of ICT support to social dynamics arising in the aftermath of a disaster. While we refer to [5, 6] for discussions on a web 3.0 platform combining mobile computing, social web and semantic technologies, with stress on the role of ontologies, semantic annotation and natural language computing, in this paper we discuss *Emepolis*$^{+}$, primarily focused on a major re-thinking of social network models, at interaction, conceptual, logical and physical viewpoint aimed at supporting community recovery.

The remainder of this paper is organized as follows: after discussing in Sect. 2 the social dynamics activated by a disaster, in Sect. 3 we reason on how and to which extent existing ICT and ISs proposals provide support to these social processes, singling out stakeholders and requirements; in Sect. 4 we discuss the features of *Emepolis*$^{+}$; in Sect. 5 we discuss the technical choices that allowed us to attain our objectives; finally, in Sect. 6, open issues are discussed and conclusions are drawn.

2 Social Dynamics in the Aftermath of a Disaster

Communities hit by large disaster have to face massive and evident material evidence while also experiencing psychological and social wounds [14, 16, 17]. The disaster causes a sort of "cultural mourning" in the community, i.e., the loss of the world of meanings and social places that constituted the customs, the rituals, and the geography of such a community; victims and witnesses of a disaster tell of a community that is forever changed, no matter how effective the material reconstruction is [14].

Similarly, after a disaster, many "transitional communities" emerge [14], involving groups of displaced people, rescuers, people who shared a particular event, or share a particular problem or common places (e.g., temporary shelters, like tent camps or barracks), etc. These new social communities become very useful in supporting the process of development of new meanings and, ultimately, of a new social order. Figure 1 schematically illustrates the community re-bonding process as described by Gordon [16]: starting from a pre-disaster situation in which social linkages shape the community as a network of inter-connected social subsystems (Fig. 1a), the community then undergoes the sudden tearing of its structure in the area immediately affected by the disaster with disturbance in surrounding areas (Fig. 1b), followed by a first re-bonding—based on newly established linkages and alliances—along the "impact line" in the immediate aftermath of the disaster

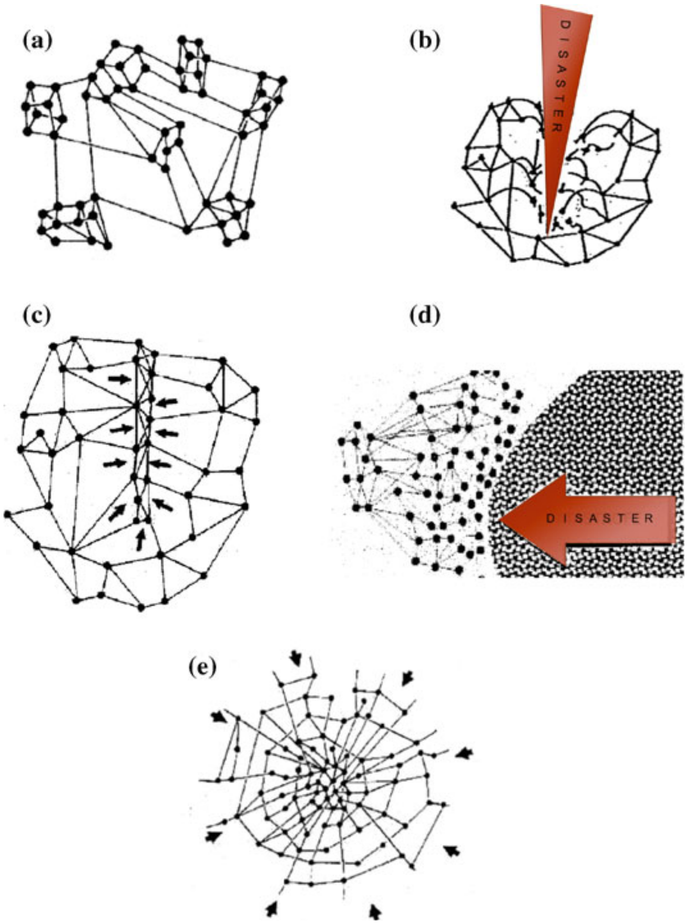


Fig. 1 The community re-bonding process according to Gordon [16], **a** A community in a normal situation. **b** A community when a disaster comes. **c** A community in re-bonding. **d** A community in de-bonding. **e** A commuinity in re-bonding

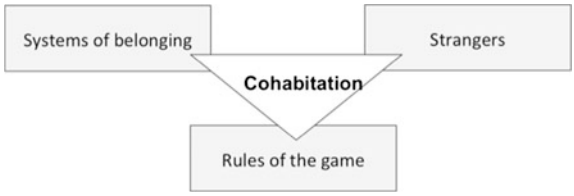


Fig. 2 Cohabitation definition

(Fig. 1c); in this new structure, social ties tend be intense along the impact line and quite loose with the enlarged context, leading to a de-bonding stage (Fig. 1d), after which, gradually, new relationships are built in a second re-bonding stage (Fig. 1e).

As reported in [14], an additional vision useful for analyzing emergency situations is proposed by Carli, focused on the process that allows human beings to achieve cohabitation. According to this vision, cohabitation is made possible by the articulation of three factors (see Fig. 2): (1) development and attainment of systems of belonging to the local community, (2) existence of external entities ("strangers"), fostering self decentralization and opening to the diverse, and (3) writing of the "rules of the game", to define belonging and strangeness. In other words, cohabitation is possible within the framework of a "glocal" model, able to assign value to the local while envisioning the community in a global context. The emergency situation, forcing a massive intrusion of strangers (e.g., rescuers), may become an opportunity to redefine cohabitation through new, possible more advanced, rules of the games.

3 Do Existing ICT Proposals Support Social Recovery?

Summarizing the discussion conducted so far, we can say that the reconstruction of meanings is to be considered a social process that takes advantage of rich and extensive interactions among actors that co-create a shared new universe of legitimate meanings. The adoption of *strategies, techniques and tools to support i nteraction between individuals* is therefore vital to the process of sense-making.

From this consideration clearly emerges the golden role that ICT and ISs can play in supporting the social dynamics that take place in the aftermath of a disaster. The description of the scenario also highlights basic requirements for an ICT platform able to provide effective support to victims:

- Peer-to-peer communication;
- Sharing of (geo-localized) information and resources;
- Efficient support to intra- and inter- small networks interactions;
- Dynamic bonding/de-bonding/re-bonding of social connections;
- Mechanisms for re-writing the "rules of the game".

It is worth recalling that, as observed by [14], psychological studies recognize four "levels" of victims, who should hence be considered possible stakeholders of ISs supporting the re-bonding process:

- *Primary victims* (people directly hit by the disaster);
- *Secondary victims* (people having tight ties and links with primary victims);
- *Tertiary victims* (rescuers and people that have to deal with primary victims for professional reasons);
- *External victims* (people that live in neighboring areas).

The inclusion among victims of rescuers, professionals, and people apparently non involved in the disaster enlarge the view and identifies a context of use rich of mutual influences among (people belonging to) different groups and interactions that one expects that disaster-oriented ISs take into account and support. It is therefore reasonable to analyze existing proposals under this perspective.

Over the years, many ICT-enhanced support tools, categorized as Disaster Management Systems (DMSs), have been developed (e.g., [8, 20, 21, 25–28, 30]), aimed at supporting institutions, formal organizations, and rescuers in one or more phases of the emergency management process: besides systems mainly useful for prevention and mitigation (like, e.g., NHSS[1]), other DMSs are designed to support also management and coordination of resources and rescuers during response and recovery (e.g., [21, 30]). A notable example is given by the suite of products offered by the Sahana Foundation[2] [8]: in particular, Eden is a configurable platform, allowing easy integration with maps, with the goal of coordinating and improving the efficiency of rescuers activities through organization registry, project tracking, messaging, scenario, and repositories for human resources, inventory and assets, while Vesuvius, focused on disaster preparedness and response needs of the medical community, contributes to family reunification and assistance with hospital triage.

It has to be noticed that most DMSs are oriented to support organized aids (i.e., tertiary victims) and just a few offer citizens (i.e., primary and secondary victims) the possibility to participate in the response/recovery phases by information sharing, whereas the recourse to Internet resources and to virtual spaces is instead expected and natural in a situation in which human relationships cannot take place in their natural physical space. In this sense, an exception is provided by Ushahidi [20, 26], a platform to easily crowd-source information using multiple channels (i.e., SMS, email, Twitter and the Web). Ushahidi enables citizens, besides organizations, to collect and visualize real-time geo-referenced information. However, the ultimate goal is to provide tools oriented to information collection and digestion, rather than supporting people in the reconstruction of a social community.

General purpose social networks, like Facebook and Twitter, certainly prove useful to this aim [18], but the unstructuredness of news feeds and the lack of

---

[1] http://nhss.cr.usgs.gov/.

[2] http://sahanafoundation.org/.

effective tagging/search mechanisms of posts, along with a "friend-centered" rather than "topic-centered" approach, concur to make both interaction and data management inefficient, particularly when posting rate is very high (as in emergency situations). These are exactly the issues we are addressing in the *Emepolis*$^+$ project.

4 From a Friend-Based to an Issue-Based Network

The aim of *Emepolis*$^+$ is to help local citizens in the reconstruction of their city and in the recovery of their community through a mobile application available for the major mobile platforms (i.e., Google Android, Apple iOS, and Windows Phone). The first test-bed is the territory of L'Aquila. *Emepolis*$^+$ was the concrete context where to re-think mobile-empowered social networks from scratch, since it was soon evident that we could not simply rely on existing social networks—as, for instance, Facebook or Twitter—for the interaction and the data management if we wanted to support efficiently the process of community re-bonding.

The current status of the project is the result of two stages of design and development, respectively aimed and supporting: (1) a peer-to-peer exchange of information among citizens through an efficient interaction with news feeds in emergency situations, (2) the flourishing of "alliances" among citizens (the first goal was attained within the Emepolis project financed by Fondazione Italiana Accenture, whose proof-of-concept was preliminarily discussed in [9], under an "interaction in third places" perspective).

With these goals in mind, and according to the indications elicited from the literature and extensive field studies, differently from traditional social networks the focus of *Emepolis*$^+$ was not put on user profiles, but rather on the issues posted by the users themselves, which becomes the primary "locus of interaction". In other words, *the information core is in the actual crowd-generated content*, not in the original author who proposed the content itself. Let us explain this view with an example scenario.

4.1 An Example Scenario

In a profile-centered social network (like Facebook), Alice shoots a photo of a dangerous hole in the road caused by the earthquake, with a sharp comment, raising an issue potentially interesting for the community. This issue (actually, a post in the data flow) can be seen only by Alice's friends—in the sense of social network friendship. Bob puts a "like", Charles adds a comment while Dave shares Alice's issues in his wall. The point is that what happens to Dave's copy of the original issues (comments, likes, etc.) forms a *new* data flow which is completely independent from Alice's one, thus preventing the creation of a unitary network of people based on the posted issue (e.g., in an emergency situation, the creation of a

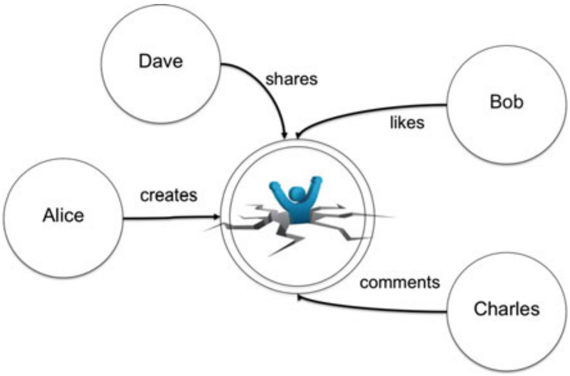


Fig. 3 The example scenario

transitional community). This is clearly a severe limit in the model of current social networks with respect to the above-mentioned goals.

What happens if we change the perspective, shifting from user's profiles to user's posted issues? If we consider the example scenario, Alice's issue and the associated photo becomes an *issue node,* with attributes, of the social network. The node is created by Alice, whose *user node* represents the issue author or, better said, *initiator* of the issue node. As depicted in Fig. 3 (which illustrates the scenario without being yet a formal model) Bob's like, Charles' comment and Dave's sharing concur to form a sort of "micro-world" around the issue shaped by the crowd-generated data flow testifying the vigor of the issue itself (similar to the concept of *narrative process* in [7]).

With this new vision in mind, we find it more appropriate a different terminology: sharing and likes actions become adoptions with votes. Therefore, issues can be even evaluated and classified so to eventually form "alliances" of users based on the similarities of goals and objectives, favoring the creation of linkages in the re-bonding stages of the process illustrated in Fig. 1.

4.2 Main Interaction Features of Emepolis^{+}

According to this scenario, the concept of *issue* is central in our system; the basic idea is that an issue is defined along with a vector of attributes, among which, title, description, and photo. While Table 1 summarizes at a conceptual level the main actions that users (citizens and administrator) can do on issues, Figs. 4, 5, 6 and 7 illustrate them at interface level:

- *Issue feeds* User interacts with issues visualized either as customary news feeds or on a map; Fig. 4 depicts the two cases along with the visualization of the notifications following a user click on the corresponding status bar icon.
- *Issue creation* Creation/modification of issues can be performed through familiar interactive forms; an example of creation is given in Fig. 5.

Table 1 Main action on issues in *Emepolis*+

Role	Name	Description
Citizen	Issue opening	User inserts title, description, photo, category, date, status, geo-tagging data
Citizen	Issue adoption	User adopts, possibly voting (5-star model), another citizen's open issue
Citizen	Issue updating	The initiator user modifies issue attributes, system notifies adopters
Citizen	Issue sharing	User creates a message for Facebook, Twitter, g+ , etc. with a referral link to one's issue
Citizen	Issue filtering	User filters issue feed(s) according to preferences, attributes, users, geo-localization options
Citizen	Issue flagging	User sends a message to an administrator when another user's issue/comment is inappropriate
Citizen	Issue comment	User comments an issue
Administrator	–	Besides all above citizens' actions s/he handles flags

Fig. 4 Visualization of issues and system notifications

- *Feed filtering* The issue feed can be filtered according to user preferences (Fig. 6). We notice in particular the possibility of restricting the geographic area of interest around the user; this is, for example, particularly useful in the immediate aftermath of a disaster when users are delocalized into tent camps, barracks, temporary shelters, each with different needs and problems.

Fig. 5 Issue creation/modification

Fig. 6 Filtering options

Fig. 7 Feed selection

- *Issue visualization* When the user selects a particular issue, it is visualized as depicted in Fig. 7, which highlights how the system visualizes possible changes in the status of the problem the issue refers to.

In the next section we discuss how to efficiently support such interaction environment from an implementation point of view.

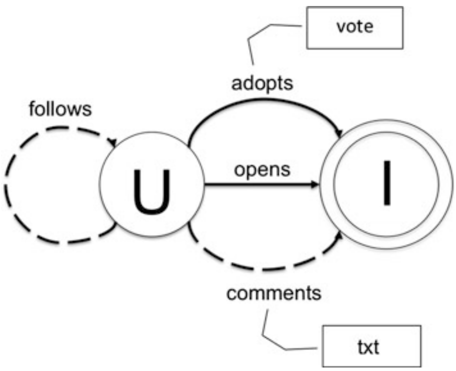
5 Supporting the Issue-Based Interaction

On the system side, in order to implement the issue-based social network perspective, we decided to reverse the perspective directly into *Emepolis*$^+$ database design, which influences also the kind of interaction that can be carried on. In particular, we have chosen to use a graph database to model the social network underpinning *Emepolis*$^+$ on the server side, instead of a relational database.

Actually, there has been much interest, recently, in data store that does not use SQL exclusively, the so-called NoSQL movement (sometimes referred to as NOSQL—Not Only SQL), based on the assumption that a relational data model may not be the best solution in all situations. Besides new proposals, like Google's BigTable [10] and Facebook's Cassandra,[3] based on features from row-oriented and column-oriented

[3] http://cassandra.apache.org/.

Fig. 8 The *Emepolis*+ data model



databases, also graph database models are regaining the relevance they had in the 80s and the 90s (we refer to [2] for an extensive survey on graph databases).

This renewed interest in graph database models is motivated by real-life applications where information about connectivity of its pieces is a salient feature, like in *complex networks* that can be found in social networks, information networks, technological networks and biological networks [19]. Classical relational query languages offer little help when dealing with the type of queries needed in these areas, e.g., in social networks, determining distance, neighborhoods, shortest paths, specific subgraphs, betweenness, size distribution of finite connected components [12]. Graph database models, on the contrary, provide special storage graph structures and efficient graph algorithms for realizing specific operations.

In particular, Neo4j[4] is the concrete graph database chosen for the implementation of prototypes of Emepolis and *Emepolis*+. In production for some years, it is used for research and industrial purposes, also thanks to its convenient license policy. Its query language Cypher is human-readable and far simpler than SQL if graph traversals are needed. Furthermore, it is easily integrable in a RESTful development environment, as the one used for *Emepolis*+client-side mobile application, based on PhoneGap,[5] a framework supporting multiplatform mobile application development.

Thanks to the features of graph databases, *Emepolis*+ is simply modeled by two types of nodes, issue nodes and user nodes, and four relationships as depicted in Fig. 8 (plain arrows denotes the relationships defined by the original Emepolis project, while dashed arrows denotes the relationships added in *Emepolis*+). The user node attributes are user name, password, e-mail, and flag, while the issue node attributes are title, description, category, status, date, coordinates, and photo.

[4]http://neo4j.org/.

[5]http://phonegap.com/.

6 Conclusions and Open Questions

In this paper we discussed the main results of the Emepolis and *Emepolis*⁺ projects, aimed at developing a mobile social application able to support the social dynamics taking place in the aftermath of a disaster. At this stage of the work, we have released the Emepolis prototype (depicted in Figs. 3, 4, 5 and 6), which is being evaluated on the L'Aquila territory in cooperation with no profit and no-gov local organization involved in the community recovery, and we are implementing the *Emepolis*⁺ prototype. The main challenge we brought in the design and development of Emepolis and *Emepolis*⁺ is to support the response and recovery phases of the emergency management process, which lead to a spontaneous yet not erratic re-organization of the wounded community. In particular we discussed how a shift of perspective in the interaction, conceptual, logical and physical models adopted for the designed social network can more naturally and more efficiently support the dynamic bonding/de-bonding/re-bonding of transitional communities and organizations that emerge based on alliances around shared problems and/or objectives. In term of *Emepolis*⁺ concepts, this process translates into micro-worlds that arise around issues. It may be noticed that *Emepolis*⁺ can also act as an accelerator of the cohabitation re-definition process, discussed in Sect. 2, by adhering to a "glocal" paradigm.

As to our technical choices, the flexibility offered by graph db-models, their inherent capability of representing connectivity, their ability of keeping all the information about an entity in a single node along with its connections, their natural support to dynamic re-organization, along with their capability of defining data manipulation by means of graph transformations, make them a first choice when looking for a system able to reify the social dynamics typical of the post-disaster.

Actually, the balance between a stable framework of sense-making support and a flexible and adaptive system is not trivial and some open questions have to be solved in future studies. For example, one important problem is related to issue tagging (necessary for allowing users to filter/searching issues). Comfort [11] highlighted that *the vital but elusive characteristic of self-organization is its spontaneity. While influenced by the actions of other organizations or groups, it cannot be imposed by external regulation*. If a free folksonomy (i.e., a tagging system decided by the crowd [15]) might therefore appear as the right solution to the issue tagging problem, an uncontrolled folksonomy may lead to unfocused practices of *Emepolis*⁺ and/or prevent efficient searching mechanisms. On the other hand the adoption of a (dynamically evolving) taxonomy raises the problem of who—and with which criteria—should be responsible for it (presently, for the purposes of the on-going system evaluation, we borrowed possible issue types from the results of the EU-funded project Smart Cities[6]).

Actually, it remains open the role(s) that institutions can have in a system like *Emepolis*⁺, besides being normal users of the application. On the other hand the

[6] http://eu-smartcites.eu/.

importance of some kind of monitoring is underlined by Gordon [16], who proposes a view in which rescuers and organized aids not only “bring help” but also favor the active role of primary victims while maintaining a global vision on how the community is reacting and evolving. We believe that an issue-centered social network like *Emepolis*+ can provide valuable support also under this perspective, by offering a sort of reification and “registry” of the dynamics of bonding/de-bonding/re-bonding of social connections.

As a final remark, it is worth observing that the fact that a social network can be a valuable support after a disaster is, on the other hand, already demonstrated by an interesting population-based cross-sectional study conducted in L’Aquila after the earthquake [18], in which authors proved that continual use of social network for at least two years produced a positive effect on mental health and improved the quality of life.

References

1. Alexander, D.: Principles of Emergency Planning and Management. Oxford University Press, New York (2002)
2. Angles, R., Gutierrez, C.: Survey of graph database models. J. ACM Comput. Surv. **40**, 1–39 (2008)
3. Barbini, F.M.: Organization in disaster: The failure of disaster-recovery plans in the aftermath of the AZF explosion. In: 24th EGOS Colloquium. Amsterdam (2008)
4. Barbini, F.M.: Organization in disaster: International cooperation and relief activities coordination during the indian ocean tsunami emergency. In: 25th EGOS Colloquium. Barcelona (2009)
5. Barbini, F.M., D’Atri, A., Tarantino, L., Za, S.: A new generation DMS for supporting social sensemaking. In: De Marco, M., Te-eni, D., Albano, V., Za, S. (eds) Information Systems: Crossroads for Organization, Management, Accounting and Engineering, pp. 105–11. Springer, Heiderlberg (2012)
6. Barbini, F.M., D’Atri, A., Tarantino, L., Za, S.: EagleVox: An innovative information systems to support social sensemaking in the aftermnath of large scale disaster. In: 27th EGOS Colloquium. Reassembling Organizations, Gothernburg (2011)
7. Benini, M., Gobbo, F.: Virtual communities as narrative processes. In: Maggiorini, D., Provetti, A., Ripamonti, L. (eds.) BOF’07—Between Ontologies and Folksonomies: Tools and Architectures for Managing and Retrieving Emerging Knowledge in Communities, CEUR-WS, vol. 312. http://ceur-ws.org/Vol-312/ (2007)
8. Careem, M.: Sahana: Overview of a disaster management system. In: International Conference on Information and Automation (ICIA), pp. 361–366. Colombo (2006)
9. Caianiello, P., Costantini, F., Gobbo, F., Leombruni, D., Tarantino, L.: The adoption of urban public space as a driving force for third places in the remediation of democracy. In: Proceedings of CHI’13 HCI3P workshop (2013)
10. Chang, F., Dean, J., Ghemawat, S., Hsieh, W.C., Wallach, D.A., Burrows, M., Chandra, T., Fikes, A., Gruber, R.E.: Bigtable: A distributed storage system for structured data. J. ACM Trans. Comput. Syst. **26**, 1–26 (2008)
11. Comfort, L.K.: Self-organization in complex systems. J. Public Adm. Res. Theory **4**, 393–410 (1994)
12. Dorogovtsev, S.N., Mendes, J.F.F.: Evolution of Networks From Biological Nets to the Internet and www. Oxford University Press, Oxford (2003)

13. European Environment Agency: Mapping the impacts of natural hazards and technological accidents in Europe—an overview of the last decade. EEA Technical report n. 13/2010, ISSN 1725-2237 (2010)
14. Fenoglio, M.T.: La Comunità nei Disastri: una Prospettiva Psicosociale. Rivista di Psicologia dell'Emergenza e dell'Assistenza Umanitaria **1**, 6–23 (2006)
15. Gobbo, F.: Improving flickr discovery through wikipedias. In: Maggiorini, D., Provetti, A., Ripamonti, L. (eds.) BOF'07—Between Ontologies and Folksonomies: Tools and Architectures for Managing and Retrieving Emerging Knowledge in Communities, CEUR-WS, vol. 312. http://ceur-ws.org/Vol-312/ (2007)
16. Gordon, R.: Engineering Aspects of Disaster Recovery. Local Government Guide to Disaster Management. State Government Printing Office, Melbourne (1991)
17. Lanzara, G.F.: Ephemeral organizations in extreme environments: Emergency, strategy, Extinction. J. Manage. Stud. **20**, 71–95 (1983)
18. Masedu, F., Mazza, M., Di Giovanni, C., Calvarese, A., Tiberti, S., Sconci, V., Valenti, M.: Facebook, Quality of Life, and Mental Health Outcomes in Post-Disaster Urban Environments: The L'Aquila Earthquake Experience. Frontiers in Publich Health, 2, art. 286 (2014)
19. Newman, M.E.J.: The structure and function of complex networks. J. SIAM Rev. **45**, 167–256 (2003)
20. Okolloh, O.: Ushahidi, or testimony: Web 2.0 tools for crowdsourcing crisis information. Participatory Learn. Action Workshop **59**, 65–70 (2009)
21. Risk EOS. http://www.riskeos.com/actus/pge/index.php?arbo=0
22. SED Spa per SGE/STM Abruzzo. www.6aprile.it
23. Sellnow, T.L., Seeger, M.W., Ulmer, R.R.: Chaos theory, informational needs, and natural disasters. J. Appl. Commun. Res. **30**, 269–292 (2002)
24. Solé, A.: Createurs de Mondes. Nos Impossibles. Editions du Rocher, Monaco, Nos Possibles (2000)
25. Turoff, M.: The design of emergency response management information systems. J. Inf. Technol. Theory Appl. **5**, 1–35 (2004)
26. Ushahidi. http://www.ushahidi.com
27. Van deWalle, B., Turoff, M., Hiltz, S.R. (eds.): Information Systems for Emergency Management. Advances in Management Information Systems, vol. 16. M.E Sharpe, Armonk (2010)
28. Wallance, A., De Balogh, F.: Decision support systems for disaster management. Public Adm. Rev. **45**, 134–146 (1985)
29. Weick, K.E.: The collapse of sensemaking in organizations. Tha Mann Gulch Disaster. Adm. Sci. Q. **38**, 628–652 (1993)
30. White, C.: A real time online delphi decision system, V 2.0: Crisis management support during extreme events. In: International Conference on Information Systems for Crisis Response and Management. Lisbon, Portugal (2010)