User Requirements for a Collective Intelligence Emergency Response System

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ABSTRACT
This document reports on the HCI experience gained in WeKnowIt, a European project aiming to design, implement and deliver technologies and methodologies enabling both Emergency Response organisation personnel and community citizens to participate in the monitoring of an emergency incident. In order to better capture the richness and complexity of the scenario, user studies were conducted to elicit user requirements from both user groups to understand how their requirements can be met by an application that combines organisational and community intelligence.

Categories and Subject Descriptors
D.5.2 [**Information Interfaces and Presentation**]: User Interfaces - *User-centered design, Graphical user interfaces (GUI), Input devices and strategies (e.g., mouse, touchscreen).*

General Terms
Design, Human Factors.

Keywords
User Requirements, Emergency Response, Collective Intelligence.

1. INTRODUCTION
The advent of the user-generated content sites, as new media channels, offer individuals the possibilities of instantly sharing and broadcasting content (text, images, videos). People tend to communicate information and share content related to their individual experience and current situation, mostly with family, friends or known colleagues. However from the summation of this communication an overall understanding of events and trends may emerge. This can be very useful in domains such as Emergency Response (ER) [11], where Situation Awareness (i.e. having accurate, complete and real-time information about an incident) is key to effective decision-making. With the increased use of mobile devices and digital cameras, people have become accustomed to immediately capturing events and sharing information, and ER organisations are realising the potential offered by citizen involvement and content generation to provide useful information from the "ground-up", especially where the emergency is large-scale and widespread.

The use of such user-generated content to assist emergency planners would provide access to information that is currently inaccessible. This information could pertain to a wide range of issues concerning an emergency situation, such as: affected locations, transport issues, potential threats, etc. The information can be utilised to dramatically improve the understanding of the emerging situation and thus facilitate emergency planners in determining effective actions to prevent, contain or respond to critical situations as they arise. It will enable emergency managers to quickly assess the best use of, and location for, scarce resources and therefore dramatically improve service delivery. In addition, it is increasingly the case that individuals, given the instant publishing capabilities of Internet media, expect to be well informed during an emergency and ER organisations are expected to respond to this demand.

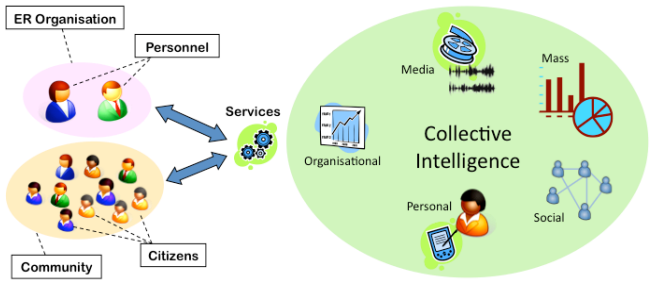

Figure 1 - Overview of the WeKnowIt system

Information technology solutions to the provision of accurate, timely information generally fall into two categories: those aimed at ER organisations and personnel, and those aimed at the citizens involved in the emergency. WeKnowIt[1] is a European Research Project aiming to develop methodologies and tools which will enable the synergistic combination of information from the organisations and communities involved in emergencies, and provide appropriate means for both these parties to access this information.

[1] http://www.weknowit.eu/

Figure 1 provides an overview of the WeKnowIt system. On the left of the diagram are the two user groups involved in the emergency situation: organisations and communities, or more specifically organisation personnel and citizens. These users provide (upload) various forms of information into the system and have information (access) requirements that the system attempts to satisfy. On the right of the diagram is the common repository for the information. The particular WeKnowIt services used to upload, process and access the information from/to the repository depends upon the nature of the information, which is defined by the following five types:

- Organisational – This information is generally derived from clearly defined systems and procedures, providing well researched and verified information. For example, event logs from emergency services.
- Personal – This information concerns individual's experience, ideas and perspectives.
- Social – In networks of individuals the interactions can produce useful information, that is, the social network can indicate good source of information and provide verification.
- Mass – The behaviours exhibited be a large number of individuals can lead to useful statistical patterns and trends.
- Media – In its various forms (text, images, video, audio) media can provide useful information, either explicit information, which can be readily utilised, or implicit information, which requires some degree of media processing to extract the useful content.

In effect, Organisational information is derived from ER organisations, whilst Personal, Social and Mass information is derived from the communities. Media based information is provided by both user types. More details are available on the WeKnowIt project website (mentioned above) which contains links to publications, including project overviews (e.g. [10]).

WeKnowIt aims to design, implement and deliver technologies that will enable citizens distributed across the region to participate in the monitoring of an incident or event. This will benefit ER planners by enhancing the available real time information upon which they can base their decisions and strategies, enabling them to better react to an emergency. Moreover, the system will consider the issue of combining information from multifarious (organisation and community) sources to generate an accurate, comprehensive picture of the situation, and how this can be portrayed to the citizens (e.g. information about open roads, information about relatives involved, etc.). Therefore the system also aims to encourage and enable dialogue between the Emergency Responders and individuals, groups and communities.

A critical factor in the successful development of the system is to ensure that the requirements of both users (organisational and community) are met. While much work exists on the subject of ER technologies and applications ([7], [9]), less research has been carried out on the User Requirements for applications involving citizens. In particular, whilst there are a number of studies ([2], [4], [5], [8]) that analyse user requirements with an emphasis on the ER organisational users, there is a gap when considering the general public's needs, and how they match or differ from the ER organisational users' ones.

The aim of this paper is to understand the agreement and divergence between the user requirements of the two user groups, and how these user requirements can be met by an application that combines organisational and community intelligence. To this end the work follows a user-centred design methodology to derive requirements for both users. The next section presents the methodology applied in the user studies, followed by a section analysing the derived user requirements.

2. HCI Methodology

Designing with a user-centred approach requires the involvement of the user from the very beginning, as it is fundamental to understand the reality of peoples actions, i.e. what, how, when, and why actions are performed. A user-centred design approach often works by trying to answer typical questions like who are the users, which are the user tasks and goals, what information do the users need and so on. Therefore, when starting a project aiming to adopt a user-centred design, the first phase is to gather the necessary understanding of the users and their needs in order to formulate an initial list of requirements.

As outlined by Benyon [1] requirement analysis is particular important when dealing with intelligent systems, such as WeKnowIt, as they involve a higher number of features than traditional systems. Benyon highlighted five different analyses that are fundamental when designing intelligent systems: functional, task, user, data and environmental. In our case, the requirement gathering activity was focused on understanding the needs and restrictions of two very different but at the same time similar groups of users: ER personnel and citizens.

Detailed interviews with ER team members (Sheffield City Council Emergency Planning Team (SCC), Police, Fire Services for a total of 8 participants) were conducted to understand the emergency process, their tasks and goals, and understand the environment in which they work: the participants were invited to talk about their experience during the floods and asked open ended questions by the researcher, with special interest for the usage of mobile or internet technologies; further semi-structured questions were then asked with reference to the main requirements. Questionnaires and interviews with Sheffield citizens affected by the floods in 2007 were conducted to understand how citizens react when involved in an emergency, if and how they contact emergency services and how do they use information technologies in such situations. The results of the questionnaire (47 respondents) have been analysed and a small sub-sample of (4) users has been chosen for more in-depth, one-to-one interviews about their experience. For data analysis, samples were collected and analysed with the support of expert users.

The initial interviews with the ER personnel and citizen questionnaire were then elaborated to produce faceted-scenarios ([3]) with representative personas: John, Lucy, Andrea and Mark, where John, Lucy, Andrea are members of the Emergency Planning team, Andrea being a Forward Liaison Officer for the Sheffield City Council, and Mark is a Sheffield citizen caught up while going back home from his workplace, when the water starts to rise in the River Don. The scenario describes in detail the steps that each of the personas (a representative user identified by name, personal profile, interests, job description and skills) will take in the specific situation and the functionalities they will use when interacting with the WeKnowIt system. The scenario has then been evaluated during iterative walk-through sessions with

members of the Emergency Response Team in Sheffield (4 participants for 4 sessions) and with citizens (4 participants in just 1 session). In addition to providing a means to elicit and record user requirements, the scenarios were also used to highlight the main technologies and research challenges for the project, with a particular focus on the cooperation between various areas of work (e.g. data processing, user interface, architecture).

A complementary activity to the scenario creation was the definition of user interaction models to capture the essence and functionalities behind the user interaction with the system. From the evaluated scenarios a list of functional and non-functional requirements were then derived for each user community (presented in the following section). The user interaction models and requirements have then been realised into visual mock-ups that exemplify steps of the models with reference to the scenario of use.

3. User Requirements

In the following sections we will detail the elicited user requirements, divided into functional and non-functional. In summary an overlapping set of requirements was identified between the two user groups, with both ER personnel and citizens citing the need for real-time ubiquitous access to relevant information during an emergency

3.1 Functional Requirements

Table 1 provides a summary of the agreement and divergence between the priorities (High, Medium, Low, or blank if not deemed relevant) given to the functional requirements by the two user groups. As can be seen the Organisational user generally has more strict requirements upon the system, as they have a greater vested interest in the performance of the system.

Table 1 - Summary of User group Functional Requirement Priorities

Functional Requirement		ER Personnel	Community Citizen
MultiModal Interface	GUI, Touchscreen, Pen Input, Keypad (Mobile Phone/ PDA)	H	H
	GUI, mouse-based interaction (PC)	H	H
	Speech Recognition	L	
Content Upload	Text	H	H
	Image	H	H
	Video	H	L
	Audio	L	
Information Enrichment	Geographic	H	H
	Temporal	H	L
	Importance/ Priority	H	
	Semantic	M	
	Social	L	H
Search		H	H
Browse		H	H
Personalised Access	Multiple Users and Visualisations	H	M
	Information Control	M	
	Prioritisation/ Filtering	H	L
	Alert	H	L
Recommend-ations		M	M
Checklist/ Task Management		H	
Feedback/ Rating		M	L

The key requirements are now analysed in more details, explaining how they were derived and some example scenarios.

3.1.1 Multimodal Interface

From the questionnaire it clearly emerged how in emergency situations people are increasingly using their mobile phone to communicate (54% of users used text messages, mobile calls or MMS, while the remaining 46% used their mobile to access online services like social networks, public forums, emails, instant messaging), due to their immediacy and ease-of-use, although, currently, this is used as a communication medium between family/friends and not with ER services. PCs are the preferred choice for information access as their interface provides the ability to present a greater amount of information.

Interviews with ER team members showed how the possibility of using multiple devices and modalities would be key to allowing real-time information upload and access. For example, members of the ER team could adopt touchscreen mobile devices, or speech recognisers to communicate during an emergency. WeKnowIt should therefore have interfaces accessible by different devices using multiple modalities both in input and output.

3.1.2 Content Upload

Uploading content is an important requirement for both ER personnel and citizens as it enables information to be immediately posted from the emergency scene; real-time content upload would also enable direct communication and request of more information (for example, the ER coordinator could ask the Forward Liaison Officer to take another image from a different position). The questionnaire also highlighted how citizens are keen to capture content (in particular photos) and share it, primarily with their friends but also publicly on forums: 62% of the users took pictures, 41% with a mobile phone, 21% with a camera. The most shared content type were photos: 57% of the users shared their pictures about the floods, in particular 51% used online photo sharing websites (e.g. Flickr), 18% news websites (e.g. BBCNews), 14% forums (e.g. Facebook), while 6% used instant

messaging or other methods. 17% of the users took videos of the event, mostly shared (94%) using video sharing websites (e.g. YouTube).

There was a general expression by ER personnel that pictures and videos are particularly useful as they can provide a more easily digestible indication of a situation and avoids the editorial bias of textual communication.

3.1.3 Information Enrichment

Both user groups expressed the desire to enrich the content they upload with comments, associations and relevant words (tags or annotations). Citizens' being more concerned with social interactions, e.g. tagging individuals in an image or adding comments, whilst ER personnel were more interested in providing (and accessing) semantic information regarding the content, e.g. type of incident mentioned/represented, incident severity. In addition the geographic location of content was important to both user groups.

3.1.4 Search and Browse functionality

Both user groups expressed the need to access the information space in a very fast and user-friendly manner. In particular the users want to browse for related information. For example, both ER and citizens want to retrieve geographically co-located information (looking for all the available content near to a chosen area), temporally similar (looking for all the available content in the last 30 minutes) or, for citizens, socially similar (looking for all the available content generated by friends on the Sheffield network).

3.1.5 Personalised Access

Providing a personalised and customised access to information is of much more importance to the organisational user than to the citizen, as ER organisations need to make sure only the right information is available to the right people. It is therefore fundamental to provide

- S*upport for multiple users and visualisations* – Support different visualisations of the content, for example filtering according to user role, the user history, user preferences and user profiles. Moreover different visualisations should be available to each user, with the possibility to easily switch between several dimensions (i.e. geographic, temporal) to visualise information.
- *Information Control* – In order to guarantee the usability for organisational functionalities must be provided to support a layer of control over the available content. For example, content may need to be confirmed by ER personnel before being made available to the general public or content may sensitive therefore needing removing.
- *Communication Prioritisation/Filtering* – In order to support the organisational user, there is a need for prioritisation of communications based on social, environmental and other factors. At times of high network usage, this prioritisation information can be fed into the communications network to ensure key data is received. Also it must be possible to filter and forward information to other control centres or users.

3.2 Non-Functional User Requirements

Table 2 provides a summary of the agreement and divergence between the priorities (High, Medium, Low, or blank if not deemed relevant) given to the non-functional requirements by the two user groups. Whilst there was a good deal of agreement on functional requirements priorities between the two groups, ER personnel expressed more desire for specific non-functional requirements. Worth noticing how citizens did not mention accessibility as requirement, though this maybe have been biased by the set of participants (no disabilities and high familiarity with internet and mobile technologies).

Table 2 - Summary of User group Non-Functional Requirement Priorities

Non-Functional Requirement	ER Personnel	Community Citizen
Trust	H	M
Privacy	H	L
Resilience	H	M
Robustness	H	L
Reliability	H	L
Ease of use	M	H
Speed	H	H
Documentation/Help	M	L
Accessibility	M	
Scalability	H	L
Security	H	L
Familiarity	M	M
Latency	M	
Extensibility	L	

The key non-functional requirements are now analysed into details.

3.2.1 Trust

The users need to trust the system and the information it provides. This is a significant issue for the ER organisation, as they will use the information as basis for their decisions and actions, therefore they need to be able to verify as much as possible its trustworthiness and have a clear indication of this level when analysing it. One of the key ways of assessing information is independent validation; this might come from other users or external sources. The system must also always provide means for user confirmation and the responses provided by the system should be consistent and reasoning processes (if applied) should be transparent.

3.2.2 Privacy

Different user roles must be accounted for when displaying information. Moreover all personal information and data should not visible to other users if the owner does not explicitly agree on that.

The privacy issue becomes even more relevant for ER organisations, as it may be the case of dealing with sensitive information that should not be reported or distributed by

unauthorised sources (for example in the case of a person death there must be no unverified rumours or images distributed).

3.2.3 Resilience/Robustness/Reliability

In order for ER organisations to adopt a new system, this must be resilient, maintaining an acceptable level of operation in case of external influences, such as network faults. For example ER personnel expressed the need for a caching feature, allowing browsing for information offline. In fact as the proposed system is intended to add value to the information flow received by the ER organisation, in the event of system failure (for example due to internet or mobile network disruption) Situational Awareness should degrade, but not catastrophically.

3.2.4 Ease of use

In general for community users the system must be easy to use, as they will access the system only in times of need. However the ER organisation personal are willing to accept that training may be necessary, if the benefits of using the system outweigh the cost of learning to exploit its functionality.

4. Related Work

The majority of research into ER User Requirements tends to focus on the analysis of the Professional ER community. For example, an analysis of User Requirements for Emergency Management aimed to designing and developing a system for supporting the *response* and *short-term recovery* phase ([5]), a very in depth Analysis of Functional Requirements for the USAF Emergency and Incident Management Systems: the requirements identified (ranked in order of priority) are focusing on the organisational user needs ([8]) and user studies in the professional ER community to define large-scale scenarios relevant to Europe, with a particular focus on the organisational functions ([2]). All these works highlight the need for geo-located information retrieval and sharing, use of mobile hand-held devices, reliable communication. One study which analyses the requirements for ER in the Netherlands ([4]) takes into account 6 user classes, amongst which the general public, however the work does not go in the details of the general public's requirements or on how they compare to the organisational user ones. The aim of our project is to target both the ER professionals and the general public user communities, therefore analysing and comparing their user requirements in order to produce an effective and usable system.

Most of the applications available for ER generally tend to focus on providing help and support for ER organisations or for citizens, not for both. Most commercial systems are aimed at organisational use, such as ATLAS Incident Management System (AIMS)[2] and Vector Command Support System[3] for managing and coordinating resources during an emergency. An interesting research system is presented by [7]; on developing a mobile Visual Analytics tool to support command centre controllers and in-field operators. The tool uses 2D and 3D visualisations to show scene and personnel related information, supports playback of videos for reviewing events and so on. The tool supports also the after emergency scenario, by providing real time analysis of actions taken during the emergency.

Social Networks and Web Applications to help managing emergencies and communicating with citizens include the US Federal Emergency Management Agency (FEMA)/MySpace tool for hurricane management. This tool has information on how to get help, helps users to locate victims, facilitating donations, volunteer registers and tracks the approach of the hurricane. The open source system Sahana[4] is a Web 2.0 platform for connecting organizational emergency response with volunteers. Initially, it was developed by a Sri Lanka government organization to support coordination and knowledge management during the emergency after the 2004 Tsunami. Sahana has a number of built-in domain specific functionality like lists of missing persons, camps, and volunteers. Furthermore, it has the ability to manage profiles of users and to establish collaborations among them for certain tasks. The project 911.gov ([9]) aims at developing a Web 2.0 platform supporting the collaboration of organizational entities for emergency response and citizens. One goal is to shift communication from phone centres to the web platform. Since this work is in an early stage, no further results are given.

Currently ER applications focus on satisfying either ER organisations' or citizen's needs. Even in the recent ER Social Network applications the organisation's involvement tends to be as a provider rather than consumer of information. The WeKnowIt project aims to develop an ER process that enables a two-way communication paradigm in which the citizens have an active role in information gathering and communication.

5. Future Work

The mock-ups generation activity is in its initial phase, focusing on the high priority requirements for both user groups. In particular mock-ups for the displaying and browsing of information according to geographical and temporal dimension, using a mobile phone interface, have been designed (see Figure 2). These mock-ups are focusing on the display of an event (e.g. a fire or region of flooding) and all the contribution that has been uploaded by users or automatically retrieved by the system about the event.

As event is seen as an information flow over time, a movie timeline representation has been chosen, this allows the user to pause, restart and rewind the timeline, zoom in and zoom out (thus changing the temporal granularity used to visualise the event). The content that is available for that event at a given time is visualised on a map, that can be zoomed using touchscreen controls, keypad interaction or speech recognition (by using the corresponding screen portion number). The content visualised is

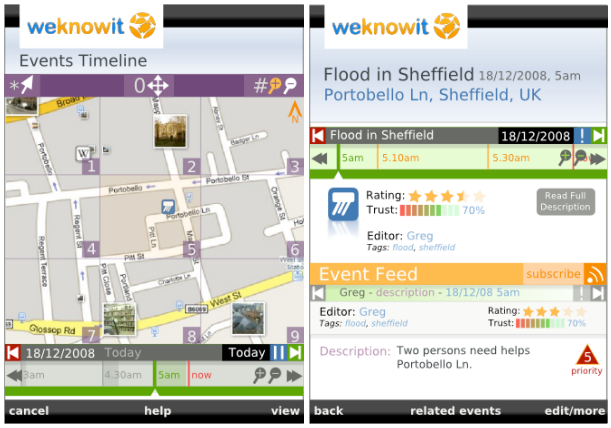

Figure 2 - WeKnowIt User Interface Mock-ups

[2] http://www.atlasops.com/

[3] http://www.emergencycommandsystem.com/

[4] http://www.sahana.lk/

then represented with reference to its provenance, rating and trustworthiness (clearly representing if the content has been verified by ER professionals or not).

These mock-ups aim to satisfy various requirements, including: multimodal Interface, browsing of related information (geographically and temporally), personalised access (information control and alerting), feedback/rating, trust, ease of use, accessibility and familiarity.

Future work will concern the evolution of the mock-ups to represent all the tasks identified in the User Interaction Models and the prototyping of the WeKnowIt system, with particular attention on how to cope with the divergent requirements of both user groups. In particular, much attention will be devoted to supporting multiple users and visualisation on multimodal interfaces, so to make sure that the most important needs of ER personnel can be met (i.e. information control, user roles etc.).

Aside from the user interface development, the work in the WeKnowIt will focus on how to better support the two user groups with intelligent technologies and tools. For example, as the questionnaire showed that citizens, during an emergency, are primarily interested in finding out about the status of family members (59%) or friends (29%), thus providing a simple notification service would benefit the citizens in easily and quickly getting news about family/friends for which they have concerns, and potentially free the time of ER organisations that would need to take calls concerning those individuals.

Another example of how intelligent technologies will be adopted to help the communication in an emergency is the use of Media Analysis techniques to automatically discover annotations and tags for the uploaded content and deliver them to the user in a personalised way. This is needed as, during an emergency, users may not want to spend time tagging the content uploaded; nonetheless this information enrichment is fundamental for delivering recommended and personalised content. The project will explore data enrichment of the various media types from social data sources (for initial results see [6]).

6. Conclusion

With the advent of mobile interfaces and online social websites users can upload information directly from the site of the incident, thus providing real-time critical information about the event. This information, if promptly available to the ER team, could increase their Situation Awareness, thus improving the decision making process and the consequent actions.

While there are still many difference in how the information is gathered and used by individual citizens and by the ER organisations, both groups could benefit from sharing this information: ER organisations will have more information readily available from different perspectives and citizens will have confirmed reliable information conveyed in real-time by the ER organisations.

Of course this poses many issues about trust and privacy: moving to a scenario where the information is managed in a cooperative way, the professional ER organisations no longer have full control over the information. Content generated by users may be speculative rather than definitive, or simply incorrect or misleading. This may lead to inappropriate resource allocation or of damages to the reputation of an organisation.

WeKnowIt is trying to address these issues by providing an integrated system targeted both at citizens and ER organisations, that make use of information gathered from multiple sources (citizens, ER forward liaison officers, CCTV recording, online data) delivering it to the user in a personalised way, so to match their information needs and requirements.

7. ACKNOWLEDGMENTS

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