Digital Interactive Public Pinboards for Disaster and Crisis Management - Concept and Prototype Design

[1]Peter-Scott Olech, [1]Daniel Cernea, [1]Helge Meyer, [1]Sebastian Schoeffel, and [1]Achim Ebert
[1]Computer Graphics and HCI Group, University of Kaiserslautern, Kaiserslautern, Germany

Abstract— *Recent natural disasters, like the earthquakes in Port-au-Prince, Haiti (2010), Christchurch, New Zealand (2011) and the Tohoku earthquake in Japan (2011), which also triggered a tsunami resulting in the catastrophic failure of numerous nuclear power plants, pose the question how to support first responders in providing fast and adequate help. When first responders arrive on-site it is crucial that the flow of information is ensured: important fields are logistics, communication, personal management and the deployment of up-to-date information. Unfortunately the events in the past showed that there are certain shortcomings, especially in terms of communicating information from local responders to arriving responders. Our approach proposes the utilization of large public displays, seizing the idea of traditional pinboards, referred in our work as Digital Interactive Public Pinboards (DIPP). DIPPs are set up in hot spot locations and provide fast and reliable information to first responders as well as citizens in the area of the natural disaster.*

Keywords: Large displays, Public Displays, Mobile Interaction, Information Hotspot, and Decision Support.

1. Introduction

The years 2010 and 2011 drastically showed how vulnerable we are when it comes to natural disasters. Therefore it is essential to provide effective help as fast as possible. After recent natural disasters, like the earthquakes of Port-au-Prince, Haiti (2010) and earthquake of Tohoku, triggering a tsunami and causing a nuclear disaster, we learned that international aid can be improved. For example, responders in Haiti had to struggle with outdated road maps; all while roads where impossible to pass due to debris. Precious time has been lost in order to find an alternate route to arrive the destination location on-site, where help was needed so urgently. Another example of disaster management gone bad was the way it was dealt with foreign first responders after the earthquake/tsunami disaster in Japan in 2011: arriving first responders had to come off empty handed, shortly after arrival, due to a serious lack of information and coordination.

Providing up-to-date information, ensuring constant information flow and reaching the people, in need of this information, to organize and coordinate, are the designated factors to ensure efficient help, aside from technical factors. In this paper we address existing issues by introducing *Digital Interactive Public Pinboard*, as an efficient and reliable way to share information in case of natural disasters. Traditional bulletin boards have been used to post messages like advertisements, public announcements and lost & found messages in public. The chosen locations of such traditional bulletin boards were places which were frequently visited, by a large number of people, namely *hotspots*.

However, the problems of these traditional bulletin boards were the correctness as well as actuality of the posted information. In order to optimize this, we propose DIPPs, set up in hotspot locations. The advantage of hotspot locations is the availability to a large number of people, like first responders arriving on airport and immediately having access to an up-to-date situation report with important information like current news, where to find shelter, and where is help needed. Furthermore another issue is addressed by using DIPP in hotspot locations: having a fixed location for the public displays, it is obvious for users where they can access information. DIPPs also serve as contact points, enabling social interaction between first responders.

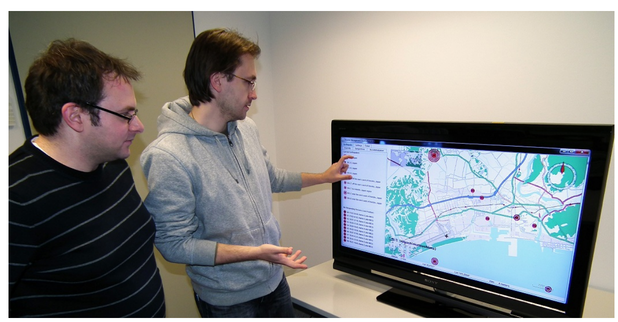

Fig. 1: Testing the prototype on a large display.

An important requirement for DIPPs is comprehensibility of the provided information. A variety of users, with diverse backgrounds, have to be able to access information and to understand the displayed content. Therefore the visual representation of the displayed information has to be easy accessible and comprehensible without a long training period and studying a user guide. Since smart phones and handheld devices are very popular today, new ways of interaction are enabled, due to the functionality these devices offer, nowadays. Modern mobile phones allow for many communication modalities: WIFI network, Bluetooth, GPS, camera etc. which can be exploited in natural disaster scenarios.

The experiences of the Tohoku earthquake and the aftermath showed that Internet still was available, when landline, as well as mobile phone networks, has been compromised.

The main goal of our approach is to overcome the shortcomings of past experiences in ensuring an adequate flow of information tailored to our DIPP approach, featuring a system able to provide the needed information to the users by mobile device interaction, to achieve maximum flexibility.

In the following we will provide a brief overview of related work, especially in the fields of public displays and also disaster management. Then we provide a more detailed view of DIPP, describing the concept. After that a system prototype is described, giving an overview of the client/server architecture. Finally we highlight the conclusion and outlook for this research.

2. Related work

Using public displays to present news and advertisements has been popular for years. Digital billboards mainly have been used for signage and for commercial advertisements; users could watch but interaction was limited or impossible. Users today have a different mindset: they expect being able to interact with displays. In the following we provide a brief overview about recent developments in the area of public displays and digital billboards.

The *Notification Collage* (NC) is introduced by Greenberg and Rounding [Greenberg]. With this groupware system users are enabled to share files and information on a designated real-time collaborative display. Within an office environment sharing of files is made possible by the NC, which basically is similar to a public bulletin board. Lui et al. [15] present an *Interactive Wireless Electronic Billboard*. With their approach users are able to see advertisements on public displays and interact with the display. With mobile phone interaction the user is able to retrieve further product information and even purchase the advertised product. *Plasma Posters*, an approach of Churchill et al. [5], are used to share information within teams and different groups of users. These *Plasma Posters* are used in an office environment to share information in public spaces. The approach itself is described and an evaluation is conducted. The *KIMONO* (Kiosk mobile-phone knowledge sharing center) allows user to interact with a public display via mobile phones. Both acquisition and exchange of data are enabled [11]. Gronbak at al. introduce *InfoGallery* [9], an approach to provide visitor guides, visitor information and other digital content via public screens in libraries and art galleries. With *BlogWall* [3] Cheok et al. present an approach to use mobile messages displayed on public screens for artistic and social communication. With the *BlogWall* approach a new form of cultural computing is created, because it also features multi-language support. Hosio et al. [10] present the utilization of public displays and mobile phone interaction in an urban environment. The approach is also evaluated and limitations are discussed. Thelen et al. present a *Digital Interactive Pinboard* [23], enabling users to interact with public displays. The public screen is used as a digital pinboard, enabling users to share multimedia information by mobile phone interaction. Two scenarios are presented and discussed: an office and an enterprise scenario.

The discussion of how to harness information technology to respond and to manage natural disasters, as well as man-made disasters, is going on for years. Quarantelli [20] examines ten non-technical questions, dealing with the issues of information overload, communication between different actors involved in disaster response, as well as the crucial problem of information validity, if the information provided is current or already outdated. Stephenson and Anderson [22] give a historical overview in how information technology (IT) and computer science have been used from the 1970s and also provide an outlook of future utilization possibilities in the field of disaster management. Fischer [7] also provides an overview of new information technologies and how they have been used to help in emergency mitigation and also how these technologies can be used in enhancing training scenarios for emergency personnel. The work of Kapucu [13] examines the role of interagency communication networks during emergencies. He presents a theoretical framework and illuminates the positive as well as the negative aspects of information technologies and interagency communication. Marincioni [16] proposes that information technology has to reach one level, so that the diverse actors involved in disaster management can equally use the available knowledge and information. Mes [17] examines in how population in an earthquake zone can be warned in a most efficient way. He points out that mobile phone networks tend to survive earthquakes, which is true for the Haiti earthquake (2010) but not valid for the Japan earthquake (2011) where both landline and mobile phone networks broke down, making communication over phone impossible. The article of Underwood [24] points out that the sheer availability of technologies (both hardware and software) do not resolve crisis. They have to be adopted by governments as well as aid agencies. Landgren and Nulden [14] present how to use patterns of mobile phone interaction for organizing time-critical data in the field of emergency response. Disaster education with the *Sandankai System Method* [18] is performed in a workshop environment, in order to develop an action plan in case of a disaster. Na et al. carry out a case study in a high school, in order to develop a three-step action plan to respond to a possible disaster. In the work of Palen et al. [19] an outlook of future emergency management is given. Rauschert et al. [21] propose the utilization of large screen displays and novel interaction methods (voice and gesture recognition) to overcome the shortcomings of traditional Geographic Information Systems (GIS), allowing multi-user interaction during emergency management situations. Currion at al. introduce open source software for disaster management

[6]. Their *Sahana* disaster information system is evaluated. Another open source approach is presented in the work of Abed et al. [1]. The aim of the work is the study on how open source web based GIS can be used to aid in emergency response and to which level it is a suitable tool for decision making. Chen et al. [4] propose the implementation of GIS and computational models into the emergency management and spatial decision making process.

3. Conceptional Design

In the following subsections we will provide an overview on what we considered in the development of the concept and also implementation of a first prototype of our disaster and crisis management system.

3.1 General considerations

According the definition of disaster, it is a damaging event, that can't be resolved neither at a local nor at a supra-regional level within a reasonable timeframe. Therefore exterior levels have to be included in order to resolve this damaging event, which in general means international aid [2]. Having that in mind we did focus on external first responders, arriving on-site and needing information and guidance. The Haiti earthquake (2010) has shown that not only large organizations like the Red Cross are providing aid (humanitarian aid, search and rescue etc.), but also smaller organizations (Non-government organizations, NGOs) or even individuals are reaching disaster areas in order to provide help. Our goal was to provide a centralized information platform that captures current information for all help parties, in order to organize arriving responders and provide them with all necessary information.

3.2 Why Public Displays?

Inspired by traditional pinboards, which are still well known from universities and supermarkets, we want to provide arriving aid personnel with a contact point at a so called hotspot location. The modern day variant of a pinboard features a large public display, where basically all important information is displayed, visualized in a way that allows groups with a diverse background to perceive and comprehend the data fast fast, without a long training period. Effectiveness and efficiency is key, to minimize losses and provide suitable help as fast as possible.

3.3 What is the purpose?

The purpose of our system is to provide a basic, locally centralized information system to organize, collect, share, and distribute information to first responders after natural disasters. Therefore we propose the use of digital interactive public pinboards enabling user interaction with mobile devices over WIFI network. Our system is a client/server system, providing an information infrastructure over a WIFI network at hotspot locations. The clients (mobile phones) can communicate with the server (for example registration, uploading pictures, and search functionality).

3.4 What are the essential features needed?

Considering the previous subsection the following features are essential for arriving first responders:

First responder management: by creating a user profile (name, profession, contact information like email address, GPS camp coordinates etc.) users are able to search for other first responder e.g. by profession in order to collaborate and in this way facilitate the cooperation and being able to ask for support.

Deployment of up-to-date information: up-to-date information can be accessed at the information hotspots (e.g. map material, actual satellite images, contact information, GPS coordinates of accommodation possibilities, camps, where help is needed). The client/server approach also minimizes the risk of unverified and invalid information.

Logistics: Organization and coordination of accommodation, water supply, and food supply, medical supplies, coordination of search & rescue teams etc.

Communication: Centralized communication, to ensure that the information provided to first responders is accurate, up-to-date, and verified.

Hazards: Visualization of known hazards, e.g. aftershocks, leaking oil pipelines etc.

3.5 What features should be included?

Besides the essential features, there are many other features that are useful and can extend the user group also to the population in the disaster area.

Missing people: The functionality of adding missing people and providing basic information (name, picture, last known position).

Specific tasks: organize open tasks: search for missing persons, explore area which has been damaged badly, restore basic infrastructure. If an engineer is taking care of a specific task, the engineer marks the task as *taken*, in order to ensure that there is no overlap on tasks (Open task, Pending/taken task, and Solved task). Furthermore information about the group or individual, the previous record in solving tasks is displayed (competence level, reputation).

Visual representation of information: the representations will not only include statistics, but also predictions (e.g. water supply sufficient for 2 more days). The users can interact, collaboration in the UI and in the visualization data has to be supported, most likely asynchronously.

4. The Prototype

The prototype of the DIPP system is based on the NASA World Wind Java SDK [1]. Based on the conception of an emergency management system, described in the previous section, a prototype is implemented, realizing these requirements. The NASA WWJ SDK framework was released in July 2011 as version 1.2, for the first time as a *stable release*. The framework is flexible, so that it can be extended and tailored to the needs of the user. Similar to Google Earth [2] data is loaded from local buffer memory and a 3D view is offered, based on a peculiar elevation model. Unlike Google Earth it offers the advantage of being platform independent; if the OS supports OpenGL, one is good to go. Another plus is that the framework is published under NOSA license (internal NASA licensing, Nasa Open Source Agreement), making it available for free to the research community.

4.1 Implementing the server

One of the key features of our prototype is accessibility and therefore the visual representation of events. For representing the events on the DIPP we did choose symbols which are easily recognized, without users having to read a manual or go through a list of keys. To ensure a high recognition value we designed the symbols according to the standards of U.S. Department of Defense (DoD).

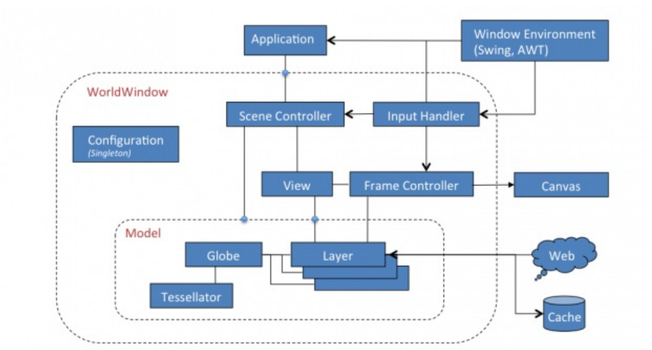

Fig. 2: WWJ framework overview (goworldwind.org).

The basis of our application is map material from the Open-Street Map (OSM) project [3]. It is editable and can be provided from designated servers. In addition it is the only map material which is available for free and offers high precision. GeoRSS offers additional geo data tailored to specific application areas, for example earthquake data is provided by the United States Geological Survey (USGS).

[1]http://worldwind.arc.nasa.gov/java/
[2]http://www.google.com/intl/en/earth/index.html
[3]http://www.osmfoundation.org

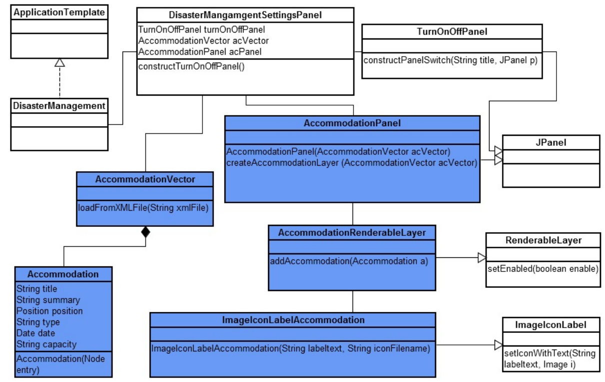

Fig. 3: Prototype implementation. Accommodation class.

Figure 2 provides an overview of the framework. The globe model represents a planet and an elevation model. A *tesselator* generates the elevation model and layers are projected onto the globe, displaying grid and vector data. The displayed objects keep their position during user interaction (navigation). The model consists of all data responsible for displaying the layers. The view sets the user's view on the model, triggered by the user and the *InputHandler*. The *SceneController* draws the model and determines when it is drawn, combining view and model. The object *WorldWindow* is produced during run time in the AWT/Swing environment and can be integrated in the Canvas.

In order to implement the requirements for our system prototype, new classes and packages had to be created. Figure 3 shows the 5 standard classes (highlighted in blue) and provides insight of the prototype feature *accommodation*. After creating the *DisasterManagement* main application, a DisasterManagement *SettingsPanel* is created. In this panel the user can make adjustments and enter data, e.g. switch on and off layers. The *DisasterManegementSettingsPanel* creates an accommodation vector by calling the method *loadFromXMLFile* (String xmlFile). After loading the accommodation vector a *AccommodationPanel* is created, which loads the information bar, based on the elements of the accommodation vector. At the same time the objects from the accommodation vector and the method *addAccomodation* (Accomodation a) are parsed to the *Accomodation RenderableLayer*. By doing so an *ImageIconLabelAccomodation* is created and added to the *AccomodationRenderableLayer*. All elements added to the *AccomodationRenderableLayer* are then displayed in the map. The images are loaded from the subfolder *img/*.png*, whereas the file name corresponds the attribute *title* of the XML-file. At the end the *DisasterManagementSettingsPanel* loads a *TurnOnOffPanel* enabling users to turn on or off the different layers. By setting a checkbox the *RenderableLayer* is activated or deactivated with the method setEnabled(boolean enable).

4.2 Features implemented in the server

Based on the requirements posed in section 3, the following features have been implemented in the system prototype.

Fig. 4: Icons. Earthquake. Number of rings represent magnitude according to *Richter* scale (left). Shelter possibilities. Color coding indicating availability (middle). Water supply. Color coding indicating availability (right).

The prototype features an earthquake scenario, as one possible example of natural disasters. Earthquakes are visualized on the map and therefore are visible for both emergency personnel as well as refugees and citizen. The earthquakes are represented as concentric circles, while the number of circle rings provides information on the magnitude. The last aftershock is visualized by a flashing symbol, catching the attention of the user. In addition, the positions of the emergency personnel in the field are displayed, as well as dangerous structures. More details are accessible in the left-hand information bar, providing more in-depth information, if needed.

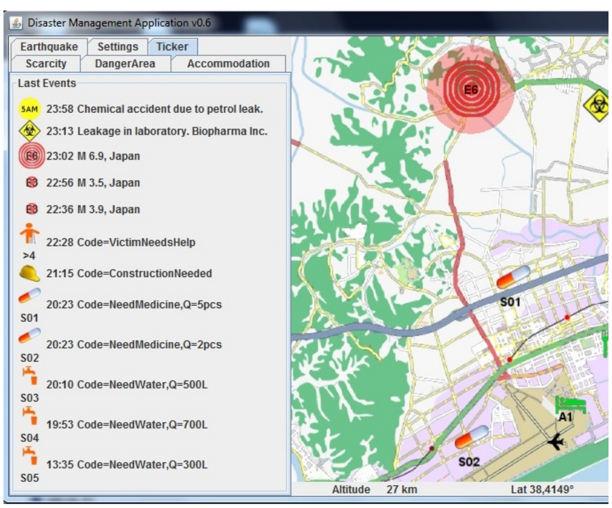

Fig. 5: The News Ticker function allows users to see all events, ordered by time of occurrence, most recent events on top.

Where to go? This crucial question many arriving responders have. Since local personnel is working full capacity to provide help and support for the population in the disaster area, our system can provide guidance to incoming personnel in order to find accommodation. Our system provides information where accommodation is available (green symbol: available; small number, number of available beds; red symbol: occupied) based on the field of expertise. If medical help is needed nearby a certain camp, then a doctor will be advised to go to this camp, by the system (based upon the registration).

The vigilance system informs users about bottlenecks of essential goods, like drinking water, food and medicine. Icons visualize the status of the goods in certain areas. Flashing symbols, showing that e.g. medicine is needed very urgent and where it is needed catch the user's eye. To provide information about hazardous areas the prototype features the functionality to mark potentially hazardous areas, similarly to weather maps. This feature provides refugees information if it is safe to return home or if there are other dangers, like contamination. Emergency personnel in this way can prepare themselves by wearing adequate protective clothing before entering such areas. Our prototype also features news ticker functionality. This function combines the information of all layers and displays everything, unfiltered, based on the time of events. The most recent events are shown on top of the information bar, providing real-time updates of events.

4.3 Features of the client

The client system is implemented in Java and is currently functional under Windows Mobile. Other major mobile platforms, like iOS and Android, are also considered; here the clients are in development. The devices that can connect to the server require a WIFI interface. The WIFI allows for a direct connection to the server and the corresponding screen. The user can interact with the content on the large display through the touch screen of the mobile device. The specific interactions that the smart devices support can be grouped into:

User registration: rescuers, refugees or citizen that reach a hotspot with one of the DIPP systems installed need to initially register and be included in the databank. The registration can take place as an individual or as a group. Furthermore, the system needs to capture in a central databank information like identity, type of users (medical rescuers, refugees, wounded, army), status values (e.g. level of health, equipment at disposition), possibilities of contact (e.g. radio frequency for rescuers with handheld transceivers). Once this information is gathered, the server stores it locally and, if a Internet connection is still available, it synchronizes with the other DIPP hotspots.

Displaying and downloading information: Once registered, users can manipulate the large display in order to highlight particular pieces of information, e.g. where is the nearest rescue shelter. At the same time, useful information can be downloaded to the mobile devices, like: maps with safe area, dangerous area, shelters, sources of food and water, temporary medical facilities, rescue

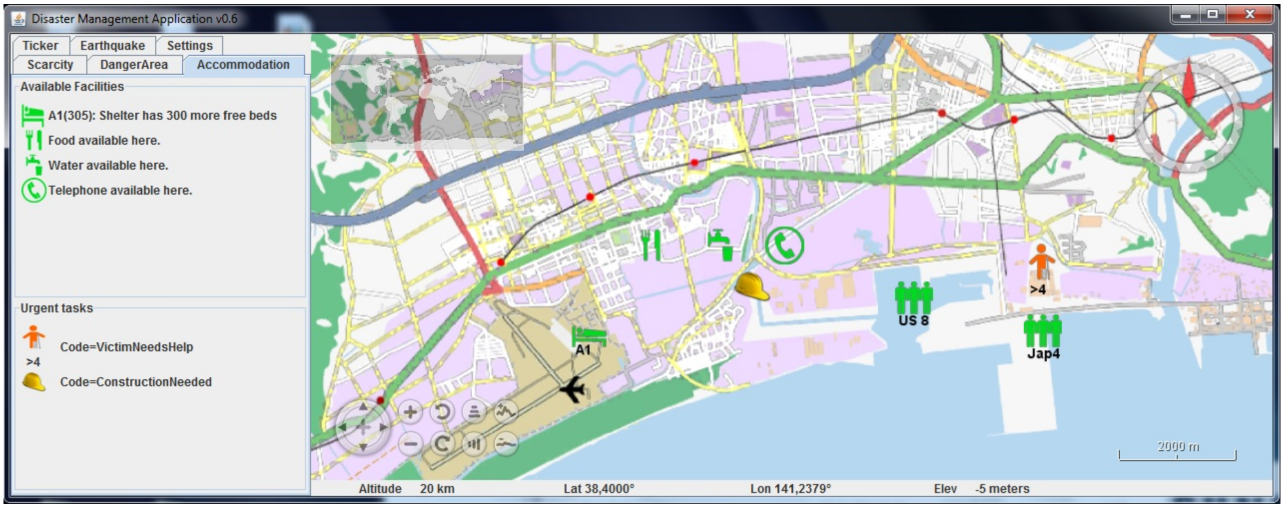

Fig. 6: DIPP application with accommodation layer enabled.

headquarters, current estimated position of rescue teams, areas already inspected or evacuated by rescue personnel, etc.; lists of teams, list of missing people, lists of people in a particular shelter, etc.; various media files, like videos and pictures that could give assistance to the rescue efforts. Depending on the type of the user or group, some of the mentioned operations are emphasized, both on the large display and the mobile system, in order to give a better overview of the existing possibilities. While this is primarily meant to speed up visual analysis on the map, it also has the advantage of only suggesting dangerous operations for the individuals with proper training (e.g. a citizen should not be given information on dangerous areas with missing people, as he might decide to investigate and help himself, which can be very dangerous without proper assistance).

Uploading information: All users have the possibility of uploading textual or media information. For example, a user can upload a video of a damaged building in the category damaged structures, and at the same time, give the coordinates on the map where this video was recorded. Therefore, it is important that the users first have to select the type of the information and its relevance before committing it to the system. If a user with limited authority posts certain data / information (e.g. a citizen that just registered), the information is labeled as *unverified* until it is validated by an authorized party (e.g. rescuers). Such information can be further enforced or denied by other users.

4.4 Agricultural scenario: iGreen

To demonstrate the flexibility and portability of the DIPP approach, its applicability has been tested in a second scenario in the agricultural domain. The iGreen project designs and realizes a network for knowledge and location based services in order to combine and utilize distributed and heterogeneous information sources of both public and private origin. The iGreen platform supports and optimizes energy-efficient, economic, environmentally friendly and frequently collaboratively organized production processes in the agricultural sector. iGreen offers the end-user standardized connectivity with intelligent technologies that provide collaboratively organized services based on actual and site-specific data. In this context, the large public display, where basically all important information is displayed, is mainly intended to be used by agricultural service supply agencies. This user group needs a fast, reliable and interactive overview on the overall situation (weather condition, positions of agricultural engines, seedtime, etc.). Their main goal usually is the optimization of cost and time efficiency. On the other hand, the farmers need to work with this data too. However, they are not interested in the global data, but in the localized information. Their mobile clients connect to the DIPP server in order to update and display the related information (maps, schedule, machine settings, warnings, etc.).

5. Conclusion and Outlook

Our DIPP approach makes a contribution to the problem of information distribution and information availability in case of natural disasters. When a country is hit by such a damaging event, local emergency personnel are dealing with coordination of local first responders, so there are no capacities for supporting of arriving supranational emergency personnel. This leads to a lack of information flow, thus hindering efficient and effective aid. The DIPP emergency management system is based on a client/server architecture and mobile device interaction over a WIFI network. It is easy to setup and use, which was the major goal of this system: not limiting the group of users due to cumbersome usability. In this way we take account of the diversity of emergency personnel of various branches (e.g. medical personnel, engineers, fire fighters, police, military, and search & rescue parties). The approach of using public displays is suitable for a disaster and crisis management system. Unlike other systems specially tailored for expert users, familiar with the use of GIS and more complex software, our system is tailored for a wider, more diverse group of users. It is necessary to provide the variety of first responders with the needed and important information, without the need of a long training period or reading a user's guide on how to use the disaster and crisis management system. In order to verify the suitability of our proposed system, we conducted an informal evaluation with non-expert users, representing the variety and diversity of future users. The remarks we received after the cognitive walkthrough have been mainly positive, especially regarding the perception of the displayed information and the easy way of accessing it. The icons used for visualization were self-explanatory and comprehensible, aiding users to minimize the training period. However, one has to keep in mind that our system is still work-in-progress, some functionality still has to be added, but these issues will be addressed in future. The overall reception of the prototype system has been positive. For future, we want to extend the functionality of both server and client and also conduct a formal evaluation of the system, by performing a user study.

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