Towards a Governmental Platform for Citizen Safety and Crisis Management Using Advanced Mobile Technologies

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Abstract *The exponential development, which the mobile communications market has experienced in the past years, gives us the technological means to imagine new ways of addressing main concerns of our society, such as citizen's safety, crisis situation management and communication between authorities and citizen in situations varying from natural disasters to terrorists attacks. In this context, this project intends to use modern mobile technologies as means to obtain additional control in crises situations, thus contributing to a more secure society.*
The project will implement a technological platform, placed under government control, which offers key services for emergencies management, such as services for quick information and alert dissemination to people, collaboration and coordination services between intervention teams and members of the same team, information aggregation services and personal assistance services in distress situations. Mobile devices are used as both the source and the destination of critical information.
Keywords: mobile devices, citizen safety, crisis management

1. Introduction

Mobile technologies are changing people's day to day life: people make use of them in order to interact, communicate and collaborate, to reach their personal or business goals. While scientists are working to improve the exiting technologies' features, or to develop new ones, research studies have also been conducted in order to discover the best ways of using the always enhanced power that resides in the existing mobile technologies. Thus, new paradigms of computer science have been proposed: we may hear today about ubiquitous, pervasive computing.
Emerging mobile technologies have changed not only people's personal communication style, but have also made possible an environment where public services are provided by using such technologies as a carrier. For example, as an evolutionary step from e-government, m-government benefits from mobile technologies and offers efficient services to both administrative staff and citizens, in an attempt to improve interaction with government, to provide more real time information, to create a new degree of freedom for citizens and governmental employees.
The present paper reflects some of the latest research studies being conducted at "Politehnica" University in Bucharest, in the laboratories of the Automatics and Computer Science Faculty. Under collaboration with a leading Romanian IT private company - UTI Systems -, as a response to a national research initiative launched by the Romanian Government, the team proposed a platform that uses mobile technologies in order to improve the way authorities succeed in managing and responding to crisis events.
By crisis events, both old and new challenges to our societies' evolution should be understood: beside old challenges, related with the appearance of natural disasters such as floods, earthquakes or earth slides, new dangers take shape due to the increasing risk of terrorist actions, to climatic unbalances and to the eruption of some hard to control epidemics. In this context, this project intends to use modern mobile technologies in

order to cope with the increased challenges and to offer a useful instrument by which the government may obtain additional control during crises, thus contributing to the shaping of a more secure society.

The main objective of the project presented in this paper is the implementation of a technological platform, placed under governmental control, which offers key services for emergency situations' management. These services enrich the communication channels and the quality of information exchanged between rescuers and between rescuers and those that are being rescued.

For attaining such an end, some innerent scientific, technical, difficulties have to be overpassed: results obtained in a variety of fields (such as distributed systems and databases, mobile computing, workflow systems, groupware, event-based systems, expert systems, ad-hoc networks) have to be used in an eclectic and efficient manner.

In Section 2, we present several projects that have the same area of research and point their main contributions. Section 3 states the main goals of the proposed project and how it relates with context of local and European development of mobile technologies. In Section 4, we present the proposed architecture, underlying the main functionalities and how they translate into services offered by the platform. We conclude, in Section 5, by stating the importance of such a project for our region, in the context of the massive adoption of mobile technology and in the light of recent natural threats.

2. Background Material

Acting quickly and efficiently in case of emergencies can save human lives and reduce economic losses. While various alert systems are in place, most of them rely on fixed infrastructure. Recognizing the vital role that mobile technologies play, recently there has been growing interest in exploring their potential for avoiding or managing crisis situations.

In (Addams-Moring, Kekkonen & Zhao, 2005) a simple taxonomy was proposed for classifying mobile emergency announcement systems (MEA). The following kinds of MEA systems are differentiated:

- Pre-planned MEA systems. Pre-planned MEA systems are built to be robust and to function reliable for a sufficient period of time during a crisis situation. Unfortunately, because of the costs involved by the necessary infrastructure, such systems often don't offer coverage of all areas. There is also the risk that they are inappropriate for unforeseen scenarios.
- Semi ad-hoc MEA systems. Semi ad-hoc systems try to address part of these problems, by not relying entirely on fixed infrastructure. Authorities can recreate in a short time the necessary communication means to act during crisis situations by using a combination of mobile and fixed equipment.
- Ad-hoc MEA systems. Ad-hoc MEA systems are not priori planned. Being designed for other purposes, such systems can still be used when other MEA systems are not available, or as additional communication means.

Ad-hoc MEA systems have been used in recent years with success. For example, during the 2002 floods in the Czech Republic, rescue teams used mainly mobile technology for communication, the fixed infrastructure being wiped out by the flood (JSCE, 2003). In Malaysia, local authorities are able to send SMS to farmers when water levels rise, so that farmers can take the appropriate measures and reduce damage to their lands (Automo, 2006). Another example is the earthquake and tsunami in South-East Asia, December 2004, where many lives have been saved by the collaboration between local authorities and Swedish, Norwegian and Finish phone operators that enabled sending of group SMS with instructions to the affected people (Addams-Moring, Kekkonen & Zhao, 2005).

Because mobile technologies have proved valuable in managing crisis situations, we believe the next step is to plan and design a system capable of exploiting their potential in a more efficient and predictable manner. This could mean shortening the time of putting an ad-hoc system into function, finding solutions for avoiding network congestion, more precise identification of target groups, increased reliability etc.

Although information dissemination towards the affected population is a critical part of emergency and crisis management, good communication and coordination between governmental units such as police,

firefighters and ambulances is also important. In (Tatomir & Rothkrantz, 2005), the authors describe a possible solution for a disaster management system using ad-hoc communication between mobile devices such as PDAs. Each team member is equipped with a PDA and is able to interact with other members or to collect information from the field by using an iconic language. The problem of introducing meaningful data into the system in a given situation is especially challenging because of adverse conditions like smoke, noise, heat and/or time constraints. A good designed iconic language can help as long as team members are familiar with it. Such a solution can be enhanced with automatic extraction of context by means of sensors and GPS.
Because the amount of dynamic data can be overwhelming for decision-making, a possible solution would be the use of autonomous agents for information logistics and coordination, as described in (Miller & McBurney, 2005). Using information extracted in the field by means of sensors or by manual input, the system could aid crisis management experts in taking the right decisions.

3. Goals

The proposed solution exploits mobile communication technologies - widely used in our region - for the purpose of alerting and assisting people in crisis situations, for information aggregation and for the collaboration and coordination between the intervention teams.
We believe that an integrated system based on mobile technology, which offers not only dissemination and personal assistance capabilities, but also communication and collaboration means between team members, as well as decision-making support, is the next step in emergency response and crisis management. The novelty of our undertaking is the high integration we are aiming for, which provides the opportunity of building an effective system that can be used by authorities to save people lives and reduce economic damage.

4. A sample scenario

In order to have a wider view of the proposed platform, and to highlight the scientific and technological challenges brought by the proposed solution, we present an overview of the system by illustrating the different steps involved in responding to a crisis from our system's point of view.

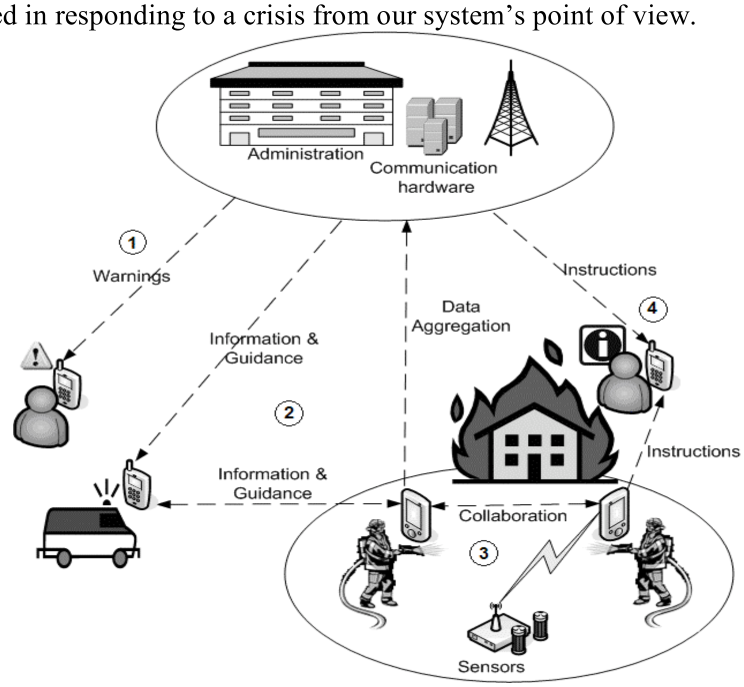

Figure 1. General view of the system

The first step in handling a potential crisis situation would be to disseminate alerts to the affected population. For example, in case of a flood, if a dam is about to break, warning the people in the affected area can significantly reduce the loss of human lives (and potentially reduce economic damage if people are able to take appropriate measures to secure part of their goods).
In the second stage, the system should provide means to gather and organize information available from different sources such as rescue teams, police and local authorities. This information can be used to aid decision makers into taking appropriate actions according to the situation on the field (eventually using prior knowledge, from similar events), and to provide a complete overview of the situation to the parties involved (for example, firefighters could learn information related to the incident before arriving at the destination).
In third step, rescue teams located at the incident's place should be able to collaborate and share information. For example, GPS-enabled mobile devices can provide real-time information about the whereabouts of each team member. Different sensors can be used at this stage in order to extract information from the environment and share it in the system (temperature sensors, humidity sensors, cameras etc.).
Finally, people caught in the incident, could benefit from the system by using mobile devices in order to receive assistance in the form of building plans, directions, available exists etc.

5. Proposed architecture

The design of a platform that strives for the goals stated in section 3 faces one major challenge: the integration of a large set of distinct and very specific services, but which are highly depended on each other. Each service handles one or more specific issues (like citizen assistance, model reasoning or transmission security), targets a different set of clients (like citizen in danger, intervention teams' members or crisis analysts) and is operated by different entities (such as the police, the firefighter's stations or the crisis central commandment). Each one of these services receives, processes and delivers information to other services, thus creating a network of interconnected entities that act and react upon the context changes which themselves or other entities have inflicted.
For these reasons, we have tried to delimit and group, as far as possible, the functionalities of the platform and how they are made available for their clients, in order to obtain a component-based platform, in which each module has its own limited but well-defined functional horizon.

5.1. The functionalities of the system

We consider the functionalities of the system as services offered by the platform, grouped in four major areas by purpose and target entities. The first considered area is *the area of services for fast dissemination of information and warnings from authorities*. One of the first services must be identification of target citizen's group for warnings disseminations. For instance, the system must be capable of sending messages to the population located in some arbitrary geographic zone. As we send sensitive information, the system has to ensure the security of transmission. In order to prevent some malicious exploits of the system it is very important to guarantee the integrity and the authenticity of the messages. Another important part is quality of service. The platform must be able to reduce to minimum the message transmission times and ensure the reliability of the system in case of networks overloading. Finally, as we identified the target audience and we laid a secure and reliable path to deliver the messages, the system must offer a message composition service, as the content of the actual message is a challenge on its own. This problem has two aspects: first, there is a sociological and psychological aspect related to fact that message content must not provoke panic and emotional distress, but at the same time must describe the situation and give directions to be followed. The second aspect deals with the enriching the message with graphical and multimedia elements, as supported by the mobile device.

The second area includes s*ervices for collaboration and coordination between the intervention teams and between the members of the same team*. The first service must be concerned with extracting and using the contextual information. It is obvious that the manual data input is not viable in cases that require fast intervention, so the system must be capable to acquire and manage automatically information, using every input source available, from sensors integrated within the system to weather reports. The second service is information sharing. In order to obtain higher efficiency, it is necessary that the information acquired in some point of the system must be made available to all teams and members in real time, based on predefined or even ad-hoc rules and policies. The exchange of the information must include some form of organization of the involved entities. Thus, a service for the collaboration between devices is needed, in charge with auto-organizing them in ad-hoc networks, in which other services can be registered and consumed.

As we get to the higher level of the platform, we identify a new area of *services for information's aggregation*. This can be achieved by using an intelligent system for knowledge's management. The goal of this component is to analyze the situation and to deliver some conceptual representation, usable by man or by other applications for further processing. With the acquired knowledge at disposal, at the highest level, an expert system can process the information to create a conceptual model and provide usable hints in the decisional process. For example, based on information about the position of involved persons, the climatic conditions and the nature of the incident, the system can provide suggestions for the arrangement of team's members on terrain.

As the system has the best affordable view of the situation, it must act in order to help the people in distress. Thus, we have the last area of *services for personal assistance on crisis situations.* Two steps must be followed in these situations, each managed by a possibly separate component. The first step is the identification of people who need assistance. The second step is providing a rich and interactive content for the people needing help. As examples of very useful information we may consider: the building plan, real time images of incident's evolution and the ways of evacuation, indications from the rescuing teams.

5.2. Architectural details

Corresponding to the functional areas identified above, the platform consists of a set of four interconnected core modules, which use each other to produce the maximum outcome, as depicted in Figure 2.

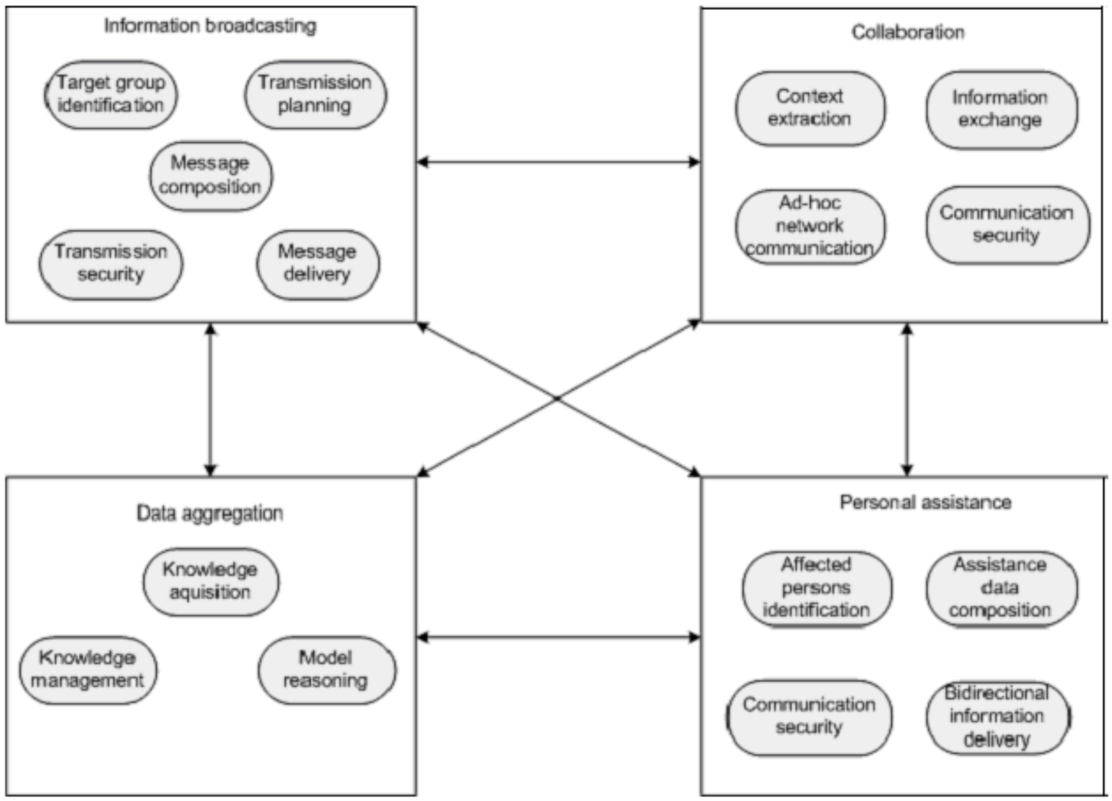

Figure 2. Architecture of the system: modules and their services

Information broadcasting module

This module will implement the infrastructure needed for duplex wireless communication between citizens and authorities or between the authorities and the intervention's teams. As communication protocols, various established and emergent technologies, like SMS, WAP, GPRS, WiFi or 3G, will be used. This module will provide a set of technical services as corresponding to the functional requirements. Thus, the s*ervice for identification of the target group* must provide the capacity for sending information in an arbitrary geographical zone. The technical solution considers the communication management in a cell phone network and the way of precisely localization of telecom cells corresponding to the zone. The s*ervice for planning the transmission* implies the analysis of some scheduling algorithms for sending data under the constraint of limited physical resources of the network, which must remain operational in the event of overloading. Next, the s*ervice for delivery of the message* must ensure the delivery of the warning messages. It implies the usage of technologies for transmission like SMS, GPRS. Depending on the chosen technology, the service provides the initiation and realization of data transmission between the authority's server and the mobile devices. As mentioned before, security is primary issue of the platform, so a special s*ervice for securing the transmission* must exist. Its role would be to ensure the integrity and authenticity of the warnings messages, and to block fake or malicious messages from propagating through the network as well as any other attacks (like denial of service).

Collaboration module

This module will implement the infrastructure needed for cooperation between teams. A more suitable decentralized way of interaction (ad-hoc) will be used, when fixed infrastructure may be unavailable. The platform will support wireless technologies for short and medium distance interaction, like IrDA, Bluetooth, and WiFi. Also, a set of other technologies like GPS and other context sensors will be supported, in order to attain a greater efficiency of mobile devices usage. The collaboration services are grouped into several categories. The *service for extracting the information from context* will run on the mobile devices of the members of rescuing teams. The devices will be equipped with context data acquisition components. Examples of such components are GPS modules, sensors for temperature or humidity, photo cameras. Data provided by the GPS can be used for a number of advanced services like estimation of fire evolution according to firemen positions, estimation of ad-hoc network configuration according to a mobility model of intervention team's members, delivery in real-time of a image of incident place with the positions of the involved persons. Another must have component is the s*ervice for sharing the information*. Data gathered by a mobile device has to be shared for many reasons. For once, it has to be corroborated with data coming from other sources in order to obtain a wider view of the situation. There are some other practical issues for which data cannot be processed on the device that acquired it, such as limited storage or/and processing power. For these reasons, this service must facilitate the discovery and communication with various data, storage and processing power sources. As we mentioned communication, a s*ervice for communication in an ad-hoc network* is essential. This service will provide the appropriate protocols for fast and reliable communication between devices. An additional *security service* is also necessary as not all the devices have access to the information exchanged in the network. For instance, the reporters aren't always allowed to access raw data until it is analyzed and an official statement is issued. Also, it is vital that the information is intact and comes from a known, traceable source. For these reasons, this service must ensure the confidentiality, authenticity, integrity and non-repudiation of the exchanged data.

Module for information aggregation

This module represents a knowledge management sub-system, which aggregates all the information available from various sources and assists the decisional and interventional entities, by providing them the best possible consolidated view of the event. The first needed service is *knowledge acquisition*, which provides the system with a conceptual representation of the environment, based on the analysis of data coming from rescuing teams as well as other context sensing sources. After data gathering, there is a need for a *knowledge organization service*, in charge with the modeling of the acquired data into a knowledge repository, in order to facilitate the processing of this knowledge either by the analysts or by the automated analysis components. The final service will be *model reasoning*. By reasoning upon the data gather in the knowledge repository, the expert system should assist the crisis management personnel in the decisional process with suggestions, precedents and possible scenarios, thus helping them to choose the best possible course of action.

Module for personal assistance

As its name states, this module is designed to assist the citizens in distress, with critical information and directions to follow, like the direction in which the fire goes, the building plan, the position of rescuing teams, possible exits. In order to make this information available to people, various technologies will be used: short distance technologies will be used for interaction with the rescuing teams and long distance technologies will be used to maximize the number of sources of information. For this module, the first service should be the s*ervice for identification of the involved persons*. In order to help the people involved in crises, it is necessary to integrate these persons into the system. Several solutions can be implemented, from the simple and limited SMS based solutions, to the most complex and desirable solution of a special crisis assistance application, preinstalled as a precaution measure. The communication can be established by using any wireless technology available: Bluetooth, GPRS, 3G, WiFi. After establishing a communication line with the person in distress, there is the need for a *service for the composition of information required for assistance*. That is because the information received by the involved person must be both relevant and useful. Preferably, the information will comprise the person's position, the position of rescuing teams, the existing exits and the routes to follow. However, the amount of delivered information depends on the used communication technology; for instance, GPRS technology has a reduced bandwidth in comparison with WiFi or 3G. Another equally important service should be a s*ervice for duplex information delivery*. In order to deliver the best possible assistance, besides the information send to the person in distress by the system, based on prior knowledge, it is sometimes essential that the person itself delivers accurate information about the situation, as he or she is perceiving. This information can consist of pictures of place, the location coordinates or its medical condition. As always, this module must provide a *security service*, which must prevent any malicious intrusion, especially in cases of terrorist attacks, when confusion and panic can be easily inoculated.

6. Expected results

The expected result of this project is a prototype of the described platform, capable to warn and assist people in distress, and to aggregate information and share it in a collaborative environment to all the teams engaged in the management of the incident.

We hope that the result of our work will lay the foundation for a national information system that will bring real benefits to those engaged crisis events. Thus we intend to measure our effort through a set of reference pointers, as mentioned below:

- The percentage of warned population in case an alert is transmitted. The indicator is dependent on time, on the area of dissemination and on population density. We aim to reach an alert level of 90% of the endangered population, capable of being alerted, in under a minute, under spatial conditions of one square km area, with a medium level of population density.
- The system's response time in case of a personal assistance request. The indicator is dependent on the system's load level. We propose a response time of less than 3 seconds for 99% of the requests, in case of 100 simultaneous connections.
- Transport capacity of the ad-hoc network's formed by an intervention team's members. The indicator is dependent on the used communication technology. We hope to achieve a bandwidth of at least 1.5 Mbs between two directly connected devices.
- Storage capacity of the ad-hoc network's formed by an intervention team's members. The indicator is dependent on the number of devices which are connected within the network and on the individual storing capacities. We propose that each mobile device can access the whole network's storing capacity.
- The maximum period after which the contextual information extracted by a device becomes available in the system. The indicator depends on devices' interconnection level. We propose to obtain a period proportional with the maximum number of intermediaries between any two devices within the system.

7. Conclusions

M-government has an undisputed chance of becoming a reality in countries with high levels of mobile devices penetration. In Romania such a high level of mobile penetration is already a fact came true. Yet, the potential of mobile devices and wireless communication technologies is not used at the moment: there are just a few incipient m-government projects, at the local level, focused on pure official information provision for the citizens: news about the activity of the local councils' work, news about the laws and regulations being made.

The presented solution uses the existing well-developed mobile infrastructure in order to address a more complex scenario: a crisis situation, be it a natural, like the recent floods in Eastern Europe, or human-provoked one. As compared to other initiatives, the proposed project aims for a higher degree of integration of all the components involved in citizen safety and crisis management, from sensors to a model reasoning expert system. Thus, from a technical point of view, the project requires the collaboration of various computer science research areas, adapted to the constraints of the wireless environment: ad-hoc networks, context-aware computing, knowledge management systems, and intelligent human interfaces design.

M-government can be seen not only as the pure information provisioning via mobile phones from government to citizens: it can be seen as a complex strategy for efficient utilization of all wireless devices and technologies with maximal benefits for the society. From a social point of view, the proposed system ensures better management of the crisis events, in an attempt to avoid as much as possible human life loss. It also aims to better handle incidents that could provoke material damage, acting as a help in the prevention of economic losses.

Thus, the presented platform stands as an innovative initiative in the Romanian space of research.

Following and trying to enrich the current research tendencies regarding m-government, such a project has the goal to bring Romanian genuine contributions for the promotion of the domain.

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