

## Towards An Intelligent Environment for Urban Flood Rescue Scenarios

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### ABSTRACT

In a city devastated by flood is common that communication infrastructure is disrupted. An alternate communication infrastructure to provide basic services to victims is proposed in this paper. We introduce an intelligent environment design to handle urban flood alert and rescue scenarios. It is based on three different types of wireless communication networks: a Wireless Sensor Network to measure the level of rivers and alert people living in flood prone lands; an Ad hoc Mobile Network to route messages from victims to care facilities, and a Wireless Mesh Network to handle people information hosted in temporal shelters. The Wireless Mesh Network includes the usage of RFID technology. People hosted in temporal shelters use smart labels to access instantly a website link, send an e-mail, send a SMS or dial a phone number.

**Keywords** - Ambient Intelligence, Mobile Ad Hoc networks, Wireless Mesh Networks, Wireless Sensor Networks, Disaster relief operation.

### I. INTRODUCTION

When a catastrophe occurs, rescuers cannot communicate with survivors due to destruction of pre-existing communications infrastructure. The main reason is that reachable base stations and antennas, might not be available immediately after a disaster. In order to overcome these failures, a wireless architecture is proposed to integrate both mobile Ad-Hoc and wireless sensor network into a robust distributed disaster information network system that would allow for interaction between rescuers and survivors.

There exist encouragement for researching preliminary solutions in this kind of disaster to mitigate and help in rescue operations. Tragic floods happened in Tabasco, Mexico in 1999 and 2007. In 2007 the homes of as many as half million people were destroyed and damaged by massive floods. Torrential rain pounded the region giving rise to widespread flooding by several rivers burst their banks. All communication systems were disrupted caused by overload and transportation system and roads were paralyzed attributable to traffic jam and large queues of vehicles fleeing the city. For this reason, there is opportunity to use information and communication technologies to develop systems to support in rescue and relief processes. This system would be useful for both rescuers and victims. One of the main goals of this system is to provide information about collection centers, emergency shelters, road conditions, flooded areas, etc.

In this study is described a general design framework of a wireless network architecture for emergency situation (flooding by overflow of rivers)

and it also presents preliminary design results to consider when developing applications using smart tags to register and track people that live temporarily in shelters..

### II. BACKGROUND

Once floods happen, damages of electrical systems and power outages can be found in that area. It could also result in existing networking infrastructure being damaged or becoming unreliable and communication means for people cannot be used in disaster area. Computer networks cannot be used if primary network channel is unavailable due to unexpected damages on the communication infrastructures. It is commonly known that cellular networks are frequently broken down due to many phone calls.

Wireless networks could be capable to support some tasks and services during emergency situations, so it is closely related to the concept of Ambient Intelligence (AmI) [6] [4] [5], that attempts to create technology with communication and calculation capabilities to be integrated with users. Moreover, it is embodied in an individual broadly surrounded by intelligent and intuitive interfaces that are built in parts and everyday objects, all in an environment that is able to recognize and respond to the presence and needs of different individuals, a completely discreet and imperceptible.

A large number of works have been proposed to disaster situations [7] [3] [12] [14] [10] [17] [18], some of them were designed for solving problems related to disasters such as hurricanes, tsunamis and earthquakes. Other works have

proposed solutions related to AmI centered in healthcare, social wellness, ambient assisted living (AAL), home assistant. In [11] is presented a vision of how AmI environments may be used in future to support emergency services during first response, it also presents a futuristic scenario for each of the emergency services. AmI technologies are used to support communication amongst members of a virtual team. However, to our knowledge there is no sufficient amount of specific works related to AmI applied for solving these disaster situations in published scientific literature.

Our proposed framework based on three sorts of networks such as: MANET (Mobile Ad Hoc Network) [8], WSN (Wireless Sensor Network)[1] [13] and WMN (Wireless Mesh Network) [2] [9]. It is a propose specially designed for transporting and sharing of information among users (like voluntary workers and first-responders).

The proposed design must have information about locations where flood victims are sheltered (e.g. names of emergency shelters, hospitals, schools, even morgues) in order to be located by their members. Therefore, it is very high priority to elaborate a list of services, tasks and the most common information during this type of emergency. Hence, software applications of the proposed architecture must be designed considering these services. Applications or services icons will be displayed on mobile devices screen. Users can see icons on screens such as drinking water, first-aid, emergency shelter, finding family, injured person, ambulance, hospital, police, rescue team, and so forth.

### III. NETWORK ARCHITECTURE

Figure 1 shows a whole view of the wireless network model. First, (right) sensor node gauges the river level variations, this information is sent to MANET users, then citizens living in low-lying areas prone to flood or at risk to be flooded receive an alert message (flash flood warning) on their mobile phones (they will take reasonable measures when flood disaster comes). Depending on the kind of protocol available after a disaster, the wireless network proposed might communicate through a technology such as Wi-Fi, ZigBee, GPRS, Bluetooth and GPS. Each network is responsible for:

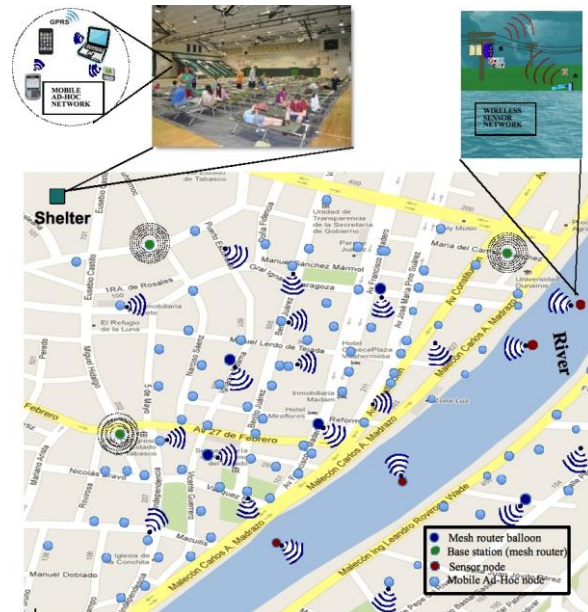


Fig 1. Schematic view of different kinds of networks. A WSN (sensor nodes in the river), a MANET (mobile device users in the city), and WMN (specific places of public interest: shelter, police station, fire station).

- WSN measures and computes the changing conditions during an inundation. It is a general monitoring system for tracking river level. Sensor nodes predict or estimate the water has risen to so many meters. As instance, as soon as a WSN node triggers a signal that the water level has risen to a high river level, WMN and MANET get warned by WSN which in turn must advice people living near flood prone lands, that they might be inundated.
- MANET supports emergency information network and basic needs of mobile communication. This MANET is for rescue purposes after disasters. It is formed by devices of rescue team and volunteers.
- WMN supports efficiently rescue and relief operations in flood disasters. This wireless mesh network is responsible for receiving messages from WSN and MANET and coordinating one another.

### IV. NETWORK OPERATION

Ideally, the best way to deploy a WMN is to place carefully mesh routers in preferred locations, equipping them with an appropriate numbers of antennas, and connecting them to Internet. But, given the conditions of a natural disaster situation, it is highly impractical spend time planning a mesh network (it is unknown the current state of the communication infrastructure, immediately after a disaster).



Fig 2. Networks in action. Sending, relaying and receiving alert messages during a flood disaster.

In Figure 2 is depicted the procedure to send, relay and receive alert messages.

1. A sensor node detects the rise in the river level. Sensor node sends the alert messages toward the base stations (mesh routers).
2. A base stations forwards the alert messages toward mesh network nodes (Mesh router balloons).
3. A mesh router balloon broadcasts the alert messages toward other mesh router balloons or mobile ad hoc nodes.
4. A mesh router balloon, which receives these messages, it broadcasts toward the MANET nodes.
5. MANET users, who live near riverside or flood prone lands, receive the alert messages.

## V. CREATING SERVICES FOR INTELLIGENT ENVIRONMENTS

Thus far a theoretical scheme has been explained in this paper, two applications are deployed as part of the solution proposed above. The first one is related to intelligent environments in disaster scenarios, which is a Mashup Web application and is published in [16]. Locations, services and points of interest are discovered by users on a Mashup Web application, users can explore in a Google map for looking up some services near them for immediate needs. The second one, it involves RFID technology, users wear chips, these smart tags are placed to victims of disaster hosted in temporal shelters, another application uses emergency and safety signs stuck on RFID tags.

### Building Intelligent Environments for managing victims

An intelligent environment system should be deployed into the emergency shelters, where flood victims' belongings are identified using RFID smart tags, so that the NFC [15] capable phones can offer services to those who read tags.

#### A. Emergency medical and safety signs stuck on RFID labels

An application of Ambient Intelligence (AmI) oriented to our problem is described as

follows: users utilize emergency signs or fridge magnet containing embedded images such as red cross, brigade, police, 066, army, food, and so forth. Images will be printed on RFID smart tags which will be attached as sticker on these charts.

Every image printed on RFID sticker smart tag has information stored about user identification and localization data. This information will be written on RFID smart labels, which are represented by emergency medical and safety signs. In Figure 3 is shown when a read/write unit RFID reader can communicate with the RFID sticker tag (Mifare DesfireTag).



Fig. 3. Multi-ISO (OK 5553) RFID reader writing data on RFID stickers (Mifare DesfireTag)

As above mentioned, our solution uses an icon with emergency sign attached that is tapped by a smartphone and an application linked to a sign sends an alert message to a rescuer team. It is necessary that users must wear mobile phone equipped with a radio-frequency reader (NFC technology). This application will automatically send to users data previously stored on their mobile phone. To be able to tap the tags, users must bring closer their mobile phone to the RFID tag. When tapping the RFID tag with a smart phone, it will automatically take them to the information that has been written in the RFID tag. Thus, users avoid typing messages on their mobile phones. Victims in shock or panic, children, visually impaired and elderly could easily call for help and be rescued.

Figure 4 shows this service based on RFID tags, which allows to users to transfer information by touching mobile devices with a NFC reader. A user must just tap a NFC device to RFID sticker (emergency sign) to instantly access a website link, send an e-mail, send a SMS, or dial a phone number.



Fig. 4. RFID Stickers (Left). Emergency signs (Center). A user taps the red cross icon attached onto NFC RFID sticker tag, the sticker tag can be read if passed near a reader (Right).

### B. Temporal shelter management using RFID Bracelets

Flood victims hosted in emergency shelters have to wear a bracelet tag (electronic tracking bracelet) on their wrists. The aim of the bracelet is to control input/output into the emergency shelters and to know the identity of the people housed in shelters. The bracelet tag also will reveal when leaving the emergency shelter. The information about people registered in emergency shelters will enable to offer a location service, that is, if a user is looking for a person, the information system can be used in order to know if the person is registered in this emergency shelter. In Figure 5 a read/write unit writes personal data on a wristband tag.



Fig. 5. Multi-ISO (OK 5553) RFID reader writing data on a bracelet tag (ISO 15693).

The bracelet tag identification will be linked to a database which contain relevant data, such as name, age, birthplace, if needed some special medical care, relative names, important remarks, and so on. The above information will provide services taking into consideration identity, address, arrival date/time, and activity or employment. Other information services can be take in advantage across using electronic tracking bracelet, it might be food distribution or inventory of belongings or other services related to emergency shelters (mattresses, blankets, pillows, and so on).

## VI. CONCLUSION

At this moment, the system is focused in a theoretical framework. We have just developed three single applications for real situations using mobile devices, communication equipments based on RFID tags, NFC readers and one more software application based Mashup Web using Google maps for looking up some services near them.

Throughout this paper, it is outlined the design considers the coexistence of three different types of networks, a WSN for measuring the river levels as a preventive action to alert users; a MANET for supplying software application necessary to provide information and rescue services for people effected, first responders, rescue workers and authorities, and finally, a WMN for connecting mobile devices to the fixed Internet infrastructure.

Right now, it has been studying research topics to enhance and provide more functionalities of this architecture. It also is planned to implement software applications on mobile devices running a lightweight platform that supports connectivity over

Bluetooth, TCP/IP over GSM or IEEE 802.11 wireless LAN. This system will be presented on an initial implementation using Smartphones based on Android OS. So far, the applications considered are: help request, information about emergency shelters, finding relatives and neighbors, food and grocery stores, firefighters, and so on.

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