EmergenSIG: An Integrated Location-based System for Medical Emergencies

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Abstract

Several IT solutions have been proposed for medical emergencies scenarios. These solutions propose solving several challenges, such as, real-time communications, localization, coordination, and decision-making challenges. This paper proposes a location-aware system fully oriented to emergency scenarios called EmergenSIG. This system provides and gathers important field information resulted from an occurrence (emergency situation) and shares it to all the different agents and their health/emergency entities (police, firefighters, medical emergency teams, etc.) mobilized to the same theater of operations. Therefore, EmergenSIG enables a faster and integrated response to all the involved partners, enhancing the emergency management of the occurrence. This solution uses a low-cost solution including a Web application for the health/emergency entities and a mobile application for the field agents in medical emergencies scenarios.

1. Introduction

The constant evolution of mobile technology and communications brought new possibilities to several emergent areas, such as, emergency management. Mobile devices and applications are now capable of promoting a tactical effectiveness on several emergency operations scenarios. Civil protection organizations often require a centralized service for enabling the interconnection and communication of different entities and forces to stimulate cooperation, coordination, efficiency, and smarter management. For a better and effective response, field agents have a constant and urgent need of real-time information resulted from a determined occurrence (emergency situation) that they are addressing. In a theatre of operations, this lack of information can lead to disorientation and delays. Time and location-aware are key issues in emergency responses scenarios. Furthermore, real-time information awareness is crucial for an accurate knowledge of the evolution of the occurrence. If the occurrence information is not delivered in time, it can endanger the effectiveness of the operation or even lead to response failure of the agents.

In the last years, the scientific community has reported, numerous IT solutions to deal with real-time communication, localization, coordination, and decision making challenges in emergency scenarios [1]. However, few solutions have reached field agents. These results comes, mainly, from the lack of knowing how field agents should use IT systems and the high cost of such solutions [2]. Location-aware, situation reporting, and agents tracking are of great importance to manage any theater of operations where multiple and diverse entities may be involved and whose cooperation is a key issue [2]. In the last decade, several approaches were presented and proposed to address the above-mentioned challenges [3-6]. However, they do not promote integration and cooperation among different agents commonly mobilized to the same occurrences, such as, police, medical emergency teams, etc.

This paper presents EmergenSIG, an integrated and collaborative tool that provides and collects real-time data of field agents and shares it among them promoting cooperation in different types of occurrences, such as wildfires, urban fires, medical emergency, and accidents. Moreover, it allows locating, tracking, and gathering information about the occurrence evolution and statistic data collection, that is extremely useful for agents mobilized to a specific emergency scenario. This application promotes the integration of different forces that guarantee the people protection and rescue, such as medical emergency teams, police agents, and firefighters. It also includes entities that are commonly involved on tactical support to field agents, such as, fire departments, District Command of Relief Operations (DCRO), Guidance Center of Urgent Patients (GCU), and National Command Relief Operations (NCRO).

The EmergenSIG system is a low-cost solution that focuses on data exchange effectiveness, real-time agents tracking, decision making support, multiple-agent information sharing, and patient health data collection. This paper presents and describes EmergenSIG in a medical emergency response scenario.

The remainder of this paper is organized as follows. Section II describes the system architecture, the application conceptual design, and the used technologies, while the main application functionalities and user interfaces are addressed in Section III. Finally, Section IV concludes the paper and discusses future work.
2. EmergenSIG Solution

This section describes the system architecture and the used technologies. It also highlights the strong aspects of the application focusing on a medical emergency scenario.

EmergenSIG system architecture is presented in Figure 1 and includes four main modules: i) agents, ii) involved entities, iii) public services, and iv) administration center. EmergenSIG mobile application (developed for Android OS) users (agents) can send and receive information, through encrypted REST Web services via GSM/Wi-fi Network. Entities interact with the system through the EmergenSIG Web application, developed in JavaServer Pages (JSP). It consumes several Web services requested by JavaScript in background, updating the information displayed in defined intervals, almost, in real-time. Public services use REST Web services that use XML format documents, replying information concerning the current state of occurrences on client location. This Web service receives the client place, by defining on the request input the region name and the country name. The response includes information about the current and local occurrences that are active at that place, such as, the type of active occurrences, number of injured people, number of involved agents, and the occurrence time.

The administration center (and corresponding view), also developed in JSP, provides administration privileges to users, such as the possibility to add entities, view the general information updates, add geographic information, and other features for database management. This view was designed and created for the NCRO server due to the exchange of sensitive data and for security reasons.

The generic encryption used a 128-bit AES cipher, exchanging a symmetric key between the server and the mobile application. Web applications used the HTTPS protocol for interaction with the server. The GIS database contains markers and shapes that characterize interesting geographical information to the agents and their entities, such as interest points, agent coordinates, hospital coordinates, etc. The operational database contains all the information about vehicles, occurrences, agent devices and all related data among them.

The proposed architecture allows entities that control only their agents and no others that are associated to different entities. For example, agents from the medical emergency and resuscitation vehicle (MERV) can only see information from the local commander of relief operations LCRO. The local emergency relief commander also can see information of MERV or other agents. The selection of the LCRO is due when the first more graduated agent arrives or when another agent requests such post, and the request is accepted by the current LCRO. Medical emergency is a type of occurrences supported by this system. It allows agents to share their location coordinates, the location of the occurrence, share the health state of the patient, calculate the estimated arrival time to the hospital since the beginning of the patient transportation, and send green line alarm to hospitals. Green line is an operational term, which features a preorder by agents for the triage section of urgencies to create conditions for the patient having immediate health care as soon as he/she arrives at an hospital. This request of immediate assistance is only allowed in situations where the health state of the patient is unstable during his/her transportation.

![EmergenSIG System Architecture](image)

**Figure 1: EmergenSIG System Architecture.**

The strongest aspect of this proposal is the real-time location-aware agent of the transported patient. Moreover, this application provides his/her state awareness, allowing the hospital personnel following user health behaviors during transportation. This solution notifies hospitals about the remaining time a specific ambulance needs to arrive at the emergency department. Therefore, hospital professionals can prepare all the procedures according to the patient health condition under transportation.

This system provides a specialized Web service for public use oriented to all the multiple agents and multiple entities involved in an given occurrence. The main goal of this Web service includes information about the affected community, accidents, fires or other type of emergency during their occurrence, keeping the attention on ethical issues and never exposing sensitive information.

3. System Demonstration and Validation

This section presents an overview of the EmergenSIG system usage. The application demonstration and validation is performed in a real scenario. This section describes the mobile and the corresponding Web application.
3.1 Mobile Application

The EmergenSIG user’s interface is simple, uses large buttons, includes appropriated size for fingers use, and is customized according to the sizes of different screen devices. Figure 2 shows the use of the mobile application. An arm accessory sustains the mobile device providing an excellent position for information access and interaction. Figure 2 presents a firefighter sending his GPS coordinates through the application.

Figure 2: Example of an agent using the application

The application always requires the user authentication. Credentials are created by the EmergenSIG Web application entities and shared to the agent to conclude the corresponding authentication. This procedure allows entities to control undue actions from their agents, allowing or blocking the agent device. The mobile application communicates with the Web Service in order to return a Globally Unique Identifier (GUID), which is used in every request in order to authenticate all the agent requests.

Afterwards the agent must select a vehicle, as shown on Figure 3. This activity presents only vehicles that are available at that moment. The agent must select, if he/she wants to create a new occurrence or select a registered occurrence that was created by another agent through EmergenSIG mobile application or by their entity in EmergenSIG web application. The activity that enables the agent to select the current occurrence is synced with the server every 2 seconds, requesting only if there are new updates saving, this way, data transmission. Furthermore, in the process of selecting registered occurrences the agent must select one of the active and available occurrences.

Created or selected occurrences are shown on Google Maps Fragment (also presented in Figure 3). This allows the agent to determine the path to the patient location. Other agent, in case of registered occurrence, could already done the displayed path. In case an agent creates a new occurrence, he/she can see other unit paths that have been mobilized to support him/her. This functionality was developed under the hierarchy notion that agents organization, in cases such health emergency occurrences, allows the recognition of the LCRO on particular patient location. On the LCRO view, it is possible to observe the location of others agents and provide their own location track path to other agents on the move. Agents can see the position of the LCRO and their tracking path, in order to know, in case of rural roads, what is the most exact path to reach the patient location.

The LCRO tracking path functionality send the coordinates at every 10 meters traveled to reduce data transmission that at the same time reduces the real-time location gap. When the agent arrives to the patient location, he/she must send the arrival status.

Figure 3: Select Vehicle Functionality on the left and screen shot of the LCRO tracking path functionality on the right.

Figure 4 presents the application activity that allows the agent to describe the patient health condition. The agent can submit different types of the patient health data, such as, name, age, gender, saturation, glycemia, temperature, pulse, blood pressure, state of consciousness, if the patient breath or not, the state of pupils, if the patient is in shock and the anatomical location of different lesions, such as open wound, closed wounds, burns, fractures and bleedings. This procedure includes two main objectives. One of them consists on describing, in detail, the health state condition of the patient. That information is immediately shared to the hospital and local firefighters department. The second one allows sending a green line alarm to the selected hospital. This action turns the hospital able to anticipate the patient arrival on more serious cases.

3.2 Web Application

The main goal of the Web application focuses on providing a set of tools that enables the control of agents in a mobility environment. Figure 5 presents the user’s interface of the EmergenSIG Web application. This view informs the medical staff through visual and beep sound alarms who requested the green line and how long the
ambulance takes to arrive at the hospital. Furthermore, it points the current geographic ambulance position and provides information, such as the patient state condition. At the bottom of the screen is shown the Situation Points section and the patient health records submitted by the agent. The green line alarm dialog is triggered by any agent request. This dialog describes the information about the request and the vehicle that transports the patient. Furthermore, it provides the direct link to more information about the patient health status, the agent, and the estimated time for the hospital arrival.

4. Conclusions and Future Work

This paper presented EmergenSIG, an emergency management and location-aware system that promotes the integration of different agents mobilized to a medical emergency scenario. The main goal of this solution includes the agents’ location in real time, collecting detailed data collection about the occurrence, and the patient health status description. EmergenSIG is available to all the involved entities providing interfaces for easy use and was designed to share detailed information among different involved people. The proposed application is based on two different modules, a Web application oriented to entities and mobile application oriented to field agents. EmergenSIG Web services provide data communication among agents and their entities, in real time.

Future improvements include the cloud technologies deployment for data storage, better load balance resources management and distribution, and use the device accelerometer to motion detection in order to save energy expended on the continuous use of the GPS.

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