Location System applied in Management of Emergency Scenarios

Luis Brás*, Marco Oliveira*, Ludimar Guenda*, Nuno Borges* and Pedro Pinho **
* Departamento de ETI, Telecomunicações e Informática, Instituto de Telecomunicações, Universidade de Aveiro Aveiro, Portugal
** Instituto Superior de Engenharia de Lisboa, Lisboa, Portugal

***Abstract*— This paper proposes a management and location system integrated with several technologies which can support soldiers of peace activity under emergency scenarios.**

The proposed scheme combines GPS, ZigBee and UHF communications with a robust database scheme to improve emergency scenarios operations. This paper will describe the implemented solution and its main drawbacks and advantages.

***Keywords* — Emergency Scenario; Event Keypad; GPS; Location System, Soldier of Peace; UHF; ZigBee.**

I. INTRODUCTION

When we speak about firefighters, police forces, medical support or even military groups restrict protocols are followed in order to minimize the human risk. On individual operations but even more important in cooperative actions, a correct management of the group forces is a crucial issue to account for, moreover when fast response is a demand.

Under emergency scenarios, soldiers of peace go through risky situations where communications unavailability in several circumstances is a reality. This situation can lead to non optimal use of human resources and in worse cases, impact on human lives. On these scenarios, a correct management of the task forces having in consideration their positioning and knowledge of actual events is of crucial importance. This previous referred points is typically performed by radio communication and visual contact which can be affected by environmental and human reasons.

In these application scenarios location is a hot topic of nowadays, being one of the most interesting services that can be provided by wireless systems. Its importance gains so much attention that in September 1999, it was referred as one of the 21 most important technologies for the 21st century [1].

When we speak about outdoor location, we inherently speak about cellular networks or more commonly, Global Navigation Satellite Systems (GNSS), such as the American Global Positioning System (GPS) [2], the Russian Global Orbiting Navigation Satellite System (GLONASS) [3], and the European system Galileo [4].

When we move to indoor location, several other technologies are nowadays used such as: based on physical contact, image analysis, Radio Frequency Identification (RFID), Ultra-Wideband (UWB), Wi-Fi, Bluetooth, ZigBee, Infra-red (IR) and ultra-sounds [5].

Each technology brings their own advantages making the decision for a location system technology dependent of several parameters, such as: precision, complexity, scalability, tags/infrastructure cost, time of calibration, range, power consumption and availability.

From previous referred technologies, ZigBee shows to have an important role for location in the area of monitoring and control due to its low consumption characteristics, simplicity of the stack protocol and easy deployment of a mesh network.

Due to higher availability demands, the integration of indoor/outdoor systems started to receive special attention, providing an open market for new applications. For this integration, the web management is of crucial importance providing an “everywhere” control of the entire system. A very interesting management application was implemented in the Metropolitan Museum of Art in New York, wherein Ekahau’s technology was used to identify the location of works of art [6].

When we apply location into management systems, we open a new and larger panoply of applications. One of these scenes is emergency scenarios or military actions, where both indoor and outdoor environments can be applied, with the special condition that no infra-structure is available. In these cases, the knowledge of each element position either as its events objective description is of primary importance to an efficient coordination of operational groups.

The correct knowledge of people and events location can turn possible a faster and more efficient management of human resources, critical on these scenarios.

This paper presents a full management location system which can support the action forces leaders to perform optimized decisions due to entire system positioning information. Based on previous described information this paper is organized as follows: Section II describes the problem of emergency scenarios and the proposed support system. Each associated block will then be presented. Section III describes the mobile node, Section IV the ZigBee location system, Section V the Data Server and VI the User Interface and Service. Section VII will present the conclusions drawn.

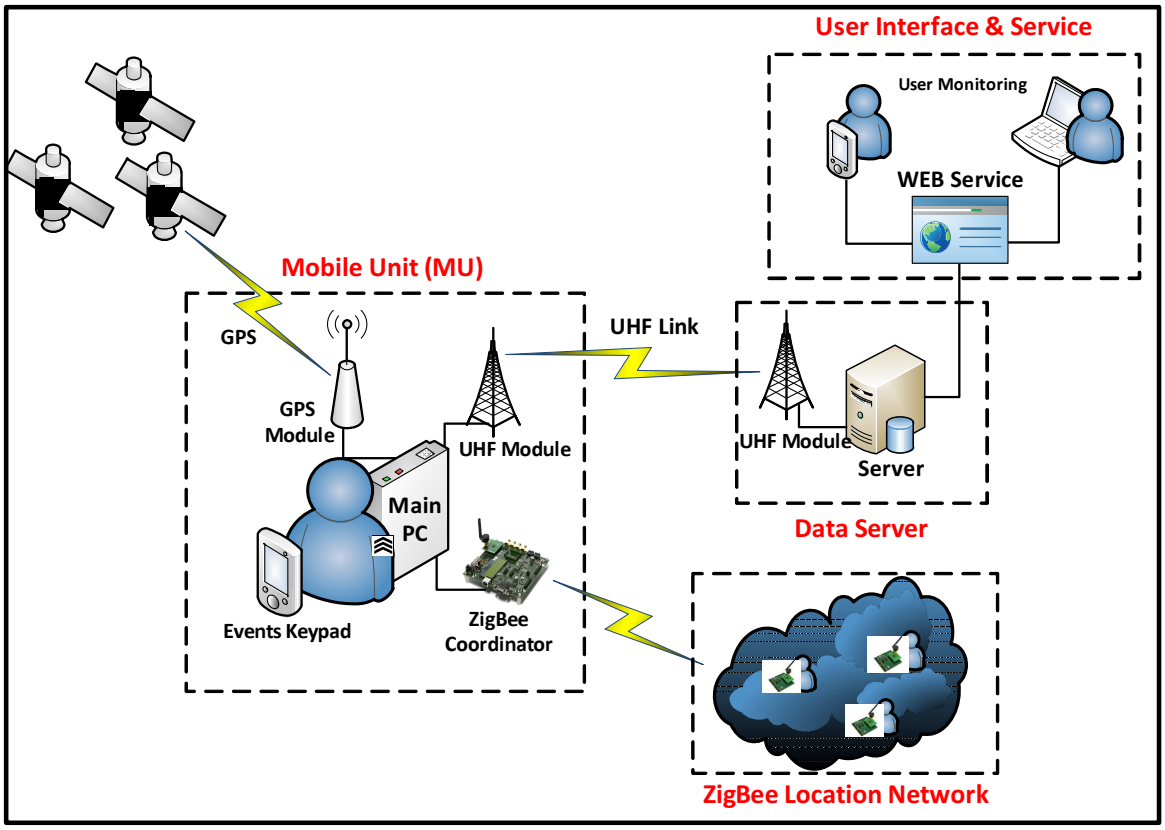

Figure 1. Emergency support system architecture

II. Problem Description

On emergency scenes or military actions, the location and description of events is typically performed by radio and visual contact. According with different scenarios, visual contact and radio communication can become a difficult problem to deal with, or in some cases totally unavailable. We could for instance refer smoke or foggy scenarios, which can obstruct the visual contact; or civil panic and environmental disturbs which can lead to noisy scenarios, interfering on radio communications and proper description of the running events.

In order to compensate the previous described problems an emergency support system was developed. This system provides location and events description capabilities, integrated with a management system locally accessed or by intermediate of a web service.

The support system architecture is presented in Fig. 1 and can be briefly described into four main blocks, ZigBee location network integrated with panic alerts; Mobile Unite (MU) integrated with a GPS module, ZigBee coordinator, event detection keypad and UHF module; Data Server; and a user interface which provides a web service to location and events management. These four blocks will be detailed described in the next sections.

III. Mobile Node

The Mobile Unit represents the main element of the support system, being carried by each intervention group leader. This mobile unit is constituted by a small Personal Computer (PC) integrated with a GPS module providing its absolute position; a ZigBee coordinator to detect panic alerts and relative positioning of ZigBee mobile nodes; a keypad to discriminate events without radio communication needs; and a UHF module for range distance data transfer with the server.

The mobile unit, presented in Fig. 2, runs a java application on startup which automatically activates all the system. Like this, the user just needs to turn on the PC to initiate all the correspondent location process.

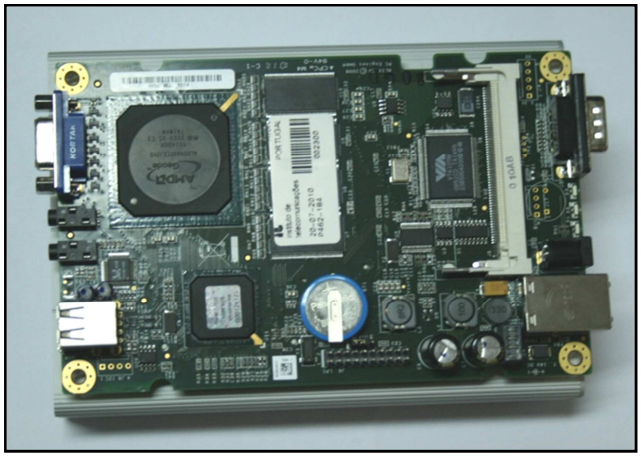

Figure 2. Mobile Unit (MU)

Starting the location process and in case of satellites coverage, the GPS module cyclically sends the absolute location to the main PC by a serial port.

The information of the ZigBee network is converged on the network coordinator and resent to the main PC by a pre-defined serial port. The running java application collects all the data and sent it to the location module which estimates the relative position of the nodes according with a specific algorithm. In this case, the location is based on a Received Signal Strength

Indication (RSSI) propagation model. The system will then calculate each GPS position, for each person based on the GPS value of the main PC and the distance to each ZigBee sensor, this way even if the person that contains the ZigBee node has not a clear view to receive GPS values, can be located using this method.

For a global integration, these relative positions of end devices are converted into absolute coordinates with the association of GPS module received data.

As previous referred a correct management of intervenient action groups and a correct description of the events is of crucial importance. To reduce the chance of information misleads events discrimination is not performed by voice description but instead, by the use of an event keypad. The group leader can select different events simply pressing the correspondent button with a need of confirmation to avoid mistaken selections. The referred event keypad is presented on Fig. 3.

Figure 3. System Events Keypad

All GPS, ZigBee network and event keypad data is converged into the mobile unit running application which cyclically merge all the received data into a XML file as presented in Fig. 4.

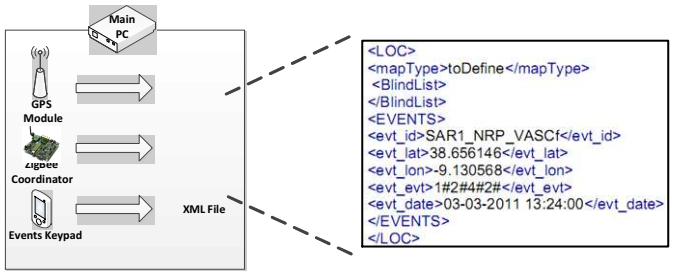

Figure 4. System XML file example

Finally, the created file is sent to the data server by a UHF link. UHF links provide high coverage suitable for emergency scenarios, although, they provide low bandwidth and consequently low data rates .For our system this is not dramatic because only a small size XML file is sent periodically.

IV. ZIGBEE LOCATION SYSTEM

The WSN location system is based in ZigBee providing like this, low power consumption and a cost effective hardware solution. On this system, the network infrastructure is constituted by a single coordinator for each action group being the WSN managed by a star network topology.

The mobile node, presented in Fig. 5, periodically send blasts to the coordinator, providing the support for location based in RSSI. The nodes provide alert functionalities with the integration of a panic button and a magnetic sensor.

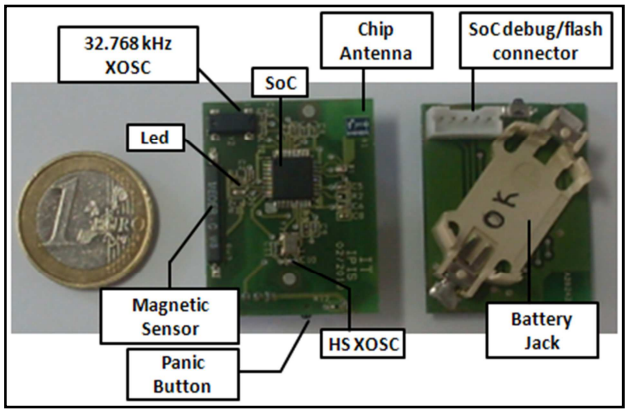

Figure 5. ZigBee module prototype [7]

Another functionality implemented on the end devices is the network scan, changing PAN_ID whenever out of range with the main coordinator. The mobile node flowchart is similar to the one presented in [7] with the addition of PAN_ID changing functionalities.

The mobile node flowchart is presented in Fig. 6**Erro! A origem da referência não foi encontrada.**. It is important to notice that panic alerts performed by external interruptions were omitted on the flowchart.

Figure 6. Mobile Node flowchart

V. DATA SERVER

The Data Server receives the XML sent by the UHF link. The server is composed by a Web access and a MySQL database where geo referenced position of different located devices and events are stored.

This server runs an application which listen a pre-defined TCP/IP port. It is also responsible for establishing a TCP connection with the UHF module, working as a TCP/UHF gateway, providing the link between the mobile unit and the Data Server.

On the special case of ZigBee modules location, each PC associated to each ZigBee coordinator creates and sends an XML file to a FTP server. With this process accomplished, a message is sent by TCP/IP to data base server referring the uploaded file name. The reception of this message implies the

data base server to read referred XML files and corresponding geo-referenced location information.

VI. User Interface & Service

The location of different modules can be performed on pre-defined maps or above Google Maps. Its access can be performed locally or by a web page, for this purpose a friendly user website as shown in Fig. 7 was developed. After authentication, a multi-user platform for devices management is also provided.

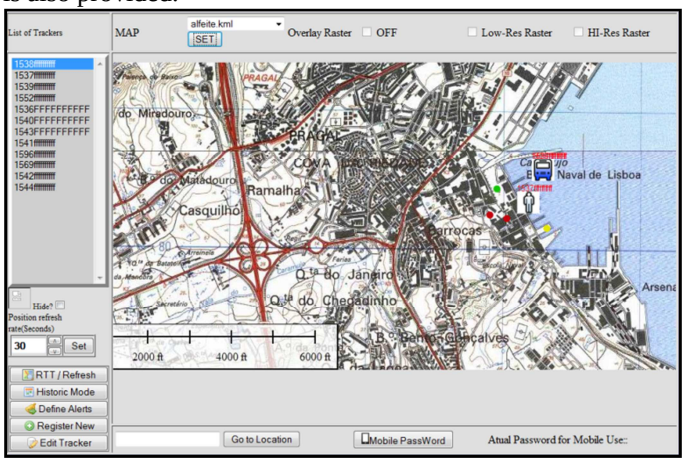

Figure 7. Location System Interface

By this interface the user can monitor the location of his action group devices as well as events location.

Maps for the different location must be prepared in advance. Maps are geo-referenced images in KML format; this file is loaded and used as the map. This way, the user has the capability to create maps that offers the level of detail he needs for a certain indoor or outdoor location. This feature can be seen in the previous figure, where a map image was integrated on the application, so it is easier to identify modules and events geo-referred.

This interface was integrated with some more options, turning this application very easy to use. These options are presented in Fig. 8 and can be described as:

- Set refresh rate (rate of database access);
- Real Time Data (Location data in "real time");
- See Data Historic (Show location between two dates);
- Define Alerts (Alert the user when a device enter or leaves a defined area);
- Add new Device (Add new device to defined group);
- Edit Existing Device (Edit icon and device permissions).

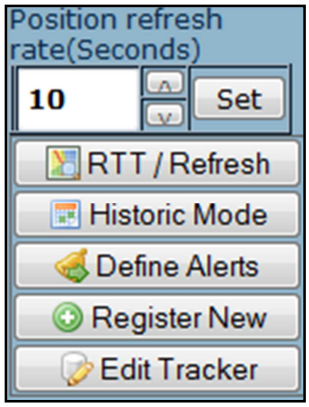

Figure 8. Web Server Options

VII. Conclusions

This paper proposes a management and location system integrated with several technologies which can support the actions groups' activity under emergency scenarios.

This system presents a plug and play solution, crucial for emergency situations. A system integrated with a ZigBee, GPS, keyboard for events description, UHF (Ultra High Frequency) communication link which can be locally managed locally or with an a web access has been presented.

Acknowledgment

This work was supported by Fundação da Ciência e Tecnologia (FCT), reference SFRH/BD/61834/2009, Lisbon, Portugal. We also would like to acknowledge the Portuguese Navy for its supply of needed material and technical support.

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