

# Indoor/Outdoor Management System Compliant with Google Maps and Android® OS

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**Abstract**— Outdoor location/navigation systems are a useful support for our daily life. The majority of these systems are based on Global Navigation Satellite Systems (GNSS), which include for example, Global Positioning System (GPS) and Galileo. For indoor location systems several technologies have been presented, each of them with different characteristics. Like this, the choice of the location technology is related with several important factors such as: precision, latency, power consumption, mobile nodes and infrastructure cost. Outdoor and indoor location systems provide a huge area of application, although, the integration of both systems provide even higher levels of availability, and a huge open market for applications. One of the crucial development areas of this systems integration is the development of a robust management application, compliant with actual nowadays systems and technologies.

This paper presents a management system for indoor/outdoor location completely compliant with two important systems of nowadays, Google Maps and Android® operation system (OS). Our integrated system is based in ZigBee and GPS/GPRS modules.

**Index Terms**— location, ZigBee, GPS, Web Server, Android® OS, Google Maps

## I. INTRODUCTION

Location systems are nowadays a huge area of interest not only at academic but principally at commercial level. These location systems are based on a group of devices, technologies, techniques, algorithms and applications that together estimate the absolute or relative coordinates of a person or object in a given environment of location. When we speak about outdoor location systems, we inherently speak about cellular networks or more commonly, Global Navigation Satellite Systems (GNSS), such as Global Positioning System (GPS), Global Orbiting Navigation Satellite System (GLONASS), and Galileo. These systems are widely used for car navigation with errors of several meters, although, for dense and indoor environments, accuracy of these systems significantly degrades. For these environments, short range location systems are typically implemented. Several technologies are nowadays used for these systems. such as: based on physical contact, Radio-Frequency Identification (RFID), Wireless Local Area Network (WLAN), Bluetooth, Ultra-Wide Band (UWB), ZigBee, infrared and ultra-sounds. As location systems we could for instance, refer several interesting implementations

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such as: Smart Floor based on physical contact, Easy Living based on image processing, Active Bat, Cricket, LANDMARC, Ekahau, ZigBee location engine, based on RF and ultra-sounds signals. From previous referred technologies, ZigBee demonstrated 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 easily deployment of a mesh network. The integration of indoor/outdoor systems starts to become a nowadays demand, providing higher levels of availability, and a huge open market for applications. For this integration, a web

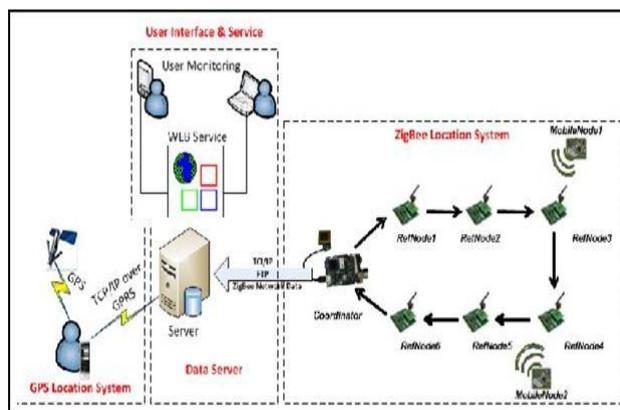


Figure 1: Indoor/Outdoor Location System

management application needs to be developed, providing an easier perception of location and a web control of the system.

A very interesting system application is implemented in the Metropolitan Museum of Art in New York, wherein Ekahau's technology is used to identify the location of works of art. Ekahau is constituted by three main components: Ekahau Finder, a web application for querying the positions of people and assets from web browsers; Ekahau Tracker, an application for objects tracking; Ekahau Logger, used for historical tracking information storing into a database. With the grown importance of Google Maps and Android® OS, location systems compliant with these two systems become significantly desired. Based on these two important systems, and taking as a reference Ekahau Finder, we developed a management system for indoor/outdoor location completely compliant with Google Maps and Android® OS.

This paper is organized as follows: we present the global architecture of the system; we describe indoor location system. is related with the Data Server and with GPS location modules. And describes the User Interface & Service and close this paper with some conclusions.

## II. GLOBAL SYSTEM ARCHITECTURE

As presented in Figure 1, our development indoor/outdoor location system is divided into 4 main blocks: ZigBee location system, GPS location system, Data Server and User Interface & Service. Briefly describing each block, the ZigBee location system is responsible for ZigBee modules positioning estimation. This system is typically used for indoor location systems. The other block of location is the GPS location system, where GPS modules or typical mobile phones integrated with GPS send its position to the Data Server over TCP/IP or Global Packet Radio Service (GPRS).

The Data Server is responsible for collecting all position information and sending it to the user interface. The User Interface & Service provides a user friendly management application with web service. Like this, management of the system can be processed with a simple remote control since we are connected into the web network.

For a better understanding of the system each of the previous referred blocks will be detailed described in next sections.

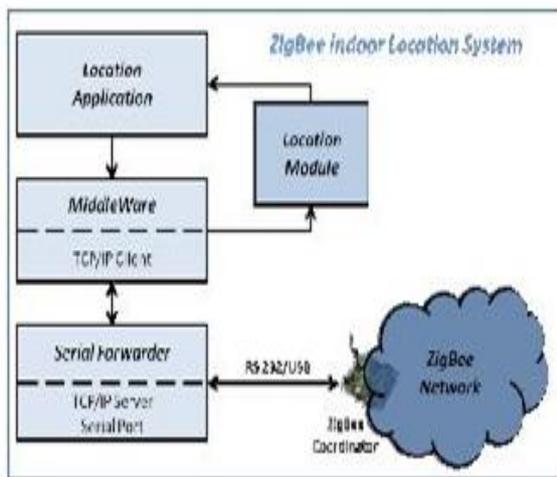


Figure 2: ZigBee indoor location system

Briefly describing each block, ZigBee network is responsible for collecting RSSI (Received Signal Strength Indication) values of mobile nodes, being this data converged on coordinator. Developed mobile nodes prototypes are presented on Figure 3.

## III. ZIGBEE LOCATION SYSTEM

As previously referred our implemented indoor location system is based in ZigBee mainly due to its low power consumption capabilities. For a better understanding of this block, an overall view of implemented ZigBee location system architecture is presented in Figure 2. As can be seen, this system is divided into five main blocks: ZigBee network, serial forwarder, middleware, location module and location application, related to the user interface.

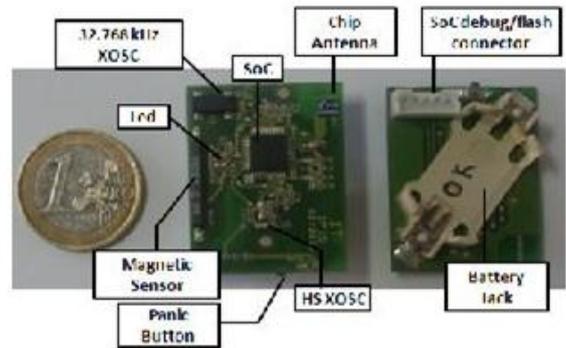


Figure 3: ZigBee mobile node prototype

```

--<LOC>
<mapType>toDefine</mapType>
--<BlindList>
--<Blind>
<ID>1540FFFFFFFFFF</ID>
<Date>2010-10-28 18:48:32.32</Date>
<lat>40.631324</lat>
<lon>-8.860119</lon>
<spd>0</spd>
<head>
</Blind>
</BlindList>
</LOC>
    
```

Figure 4: XML typical file

Then, the coordinator resends the received data to a PC by a serial port. This PC runs the serial forwarder application, an application that creates a gateway between a TCP/IP server and a chosen serial port, the port connected to coordinator.

The middleware corresponds to the TCP/IP client application, sensing the server port and resend this data to the location module. The location module is responsible of processing the data received from the middleware according with a pre-selected location algorithm which can be for instance a simple proximity location, triangulation or fingerprinting based. The estimated end devices position is then sent to the location application.

This application provides a graphical interface where relative positioning of mobile nodes can be easily seen. For a global integration, these relative positions of end devices (related to reference nodes) is after converted to GPS coordinates. This is possible due to an associated of reference nodes to fix GPS positions. GPS positioning associated to mobile nodes ID is then converted to an xml file which stores the information of each wireless end device as presented in Figure 4.

## IV. GPS LOCATION SYSTEM

On outdoor location, it is possible to use Machine to Machine (M2M) modules which send GPS receiver geo-referenced data to Data Server by the help of a GSM module. By the other

side, a mobile device equipped with a GPS, running a piece of software can work identically. Android® and Windows Mobile version of that software were also developed. This

way, any common mobile device with GPS integration can be tracked and integrated with our application



Figure 5: GPS/GPRS location module application

In Figure 5 it can be seen our developed application for GPS location tracker configuration.

## V. DATA SERVER

The Data Server is composed by a Web access and a MySQL database where position of different located devices is 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 devices, receiving and processing their data.

This server is able to receive messages from typical mobile GPS modules or even indoor location modules, just demanding packet protocol conformity. Like this, it is completely transparent for the server the reception of indoor or outdoor location information.

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 file and corresponding geo-referenced location information.

## VI. USER INTERFACE&SERVICES:

To visualize the location of different modules above Google Maps, it was developed a friendly user website as shown in Figure 6. After authentication, it is provided a multi-user platform for managements of devices according to its individual user permissions. By this interface the user can monitorize the location of his group devices. According with different applications, the overlapping of "raster" maps on specific zones is also possible.



Figure 6: Location System Interface

This option can be very useful when a higher degree of indoor details is demanded or for military applications. This option can be seen in previous figure, where an indoor map was integrated on the application making easier the identification of indoor location modules position. This interface has integrated with some more options turning this application very easy to use. These options are presented in Figure 7 and can be described as:



Figure 7: Web Server options

- 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).

Besides Web Access, it was developed a mobile application with same functionalities, compatible with Android® devices as presented in Figure 8.



Figure 8: Android® Application

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This application request information from the database through an HTTP POST, and data for the specified user is delivered. The received data is then converted in Android overlay objects that can be placed over Google Maps. This process is done periodically.

## VII. CONCLUSIONS

In this paper we present a management application for indoor and outdoor location systems. This application is compliant with Google Maps and Android® OS, being compatible with a wide group of devices.

This indoor/outdoor system integration provides higher level of availability making possible a huge level of new application. Several options were developed such as boundaries alerts and overlapping maps according with user permissions being already successful tested.

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