LOCATION AND EXCHANGE INFORMATION PLATFORM FOR THE DEVELOPMENT OF MANAGEMENT APPLICATIONS IN HEALTH CENTRES

J. F. Hernández, E. Montón, D. Aparisi, G. Ibánez, J.L. Plaza, V.Traver, S.Guillén
ITACA Institute, Polytechnic University of Valencia, TSB Area, Spain

johercu1@itaca.upv.es

Abstract: Location systems offer a wide number of applications nowadays. This paper presents a platform based on Bluetooth that offers location and information exchange capabilities. The functional hardware prototype that supports the platform is described. Although this system is focused on health centres, technology and know how is valid to be applicable for any service dealing with Ambient Intelligence.

Introduction

Location of assets and persons in a hospital can be the basis for several management applications in a health centre allowing the management of the resources of these centres in a more efficient way. In addition, the possibility of access to information related to a patient or an object with standard devices as Laptops or PDAs increases the number of possible applications.

An open and modular platform that allows the development of management applications in health centres, based on the two functionalities previously described: indoor location of persons and objects, and information exchange, is presented. It makes use of Bluetooth wireless low-power communication technology, which allows the reduction of costs comparing with the actual indoor location systems usually based on proprietary radiofrequency technologies [1]. There are other location systems based on GPS [2] or WiFi [3], but the first one doesn't work in indoor environments and the second one has higher power consumption.

Materials and Methods

Location Systems State of the Art

The first task performed in the project presented a state of the art of location systems, both already finished products and R&D projects. In general, they were radiofrequency (RF) proprietary systems with a similar structure, based on the use of mobile RF tags, located by a mesh structure of fixed antennas, and a central element in charge of calculating the position of the tags, usually by means of triangulation algorithms.[1]

The precision of this systems is high (<3 m.), but their cost is unreasonable to be used in reduced environments.

Therefore, it was decided the development of a location system aimed at applications in this type of environments, loosing precision in the location, unnecessary in a lot of cases, but reducing the cost. To achieve this objective the use of the standard wireless technology Bluetooth was decided. The decision of using Bluetooth was also made because offers the possibility of adding other functionality to the system, not only the location, but the capability of information exchange.

System requirements

The initial objective was to provide a platform that would offer two main functionalities:

- Indoor location based on power comparison, discrete in both space (location in areas, usually rooms separated by walls) and time (customisable location period sampling).
- Information exchange between the different devices of the platform and external devices like PDAs, laptops, etc.

The platform would be the basis for the development of application based on the two functionalities above described.

System architecture - Hardware

The platform is composed of the following hardware modules:

- PCOMM: Personal Communicator. Small module (5 x 3.5 x 2 cm.) that allows for the location of the object or patient that wears it. In addition, it can store information related with that object or person.
- ACOMM: Area Communicator. Device (13 x 6.5x 4 cm.) that works as a beacon, usually installed in the ceiling in a fixed way, which allows for the location of PCOMMs in an area.
- Server: Receptor of all the information from the ACOMMs to be processed in order to locate the PCOMMs

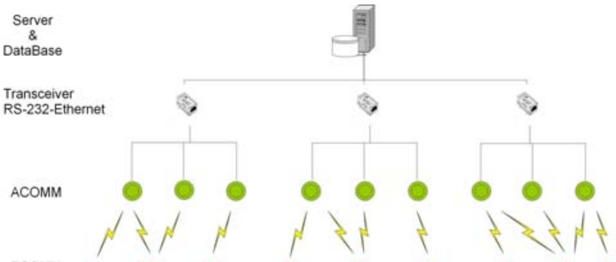

Figure 1: Platform Hardware Architecture

PCOMM and ACOMM devices are based on Bluetooth 1.1[4] with Blue Core 2 and have been

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developed with CSR Casira SDK [5] [6]. Bluecore provides a powerful single-chip solution (onchip radio, base band, microcontroller, a mono codec, and 4Mbits flash memory). The Casira SDK provides, in addition to hardware platform developing devices, a debugger software, a C language code compiler for the embedded microcontroller, and a powerful set of C code libraries ready to use on projects.

The election of this technology instead of other options can be justified by several reasons. Firstly, it is a standard technology that provides the needed functionalities for the information exchange between devices. Second, it fulfilled the requirements regarding power comparison, which were necessary for the implement the location. Finally, Bluetooth covers the necessities for the design of a low cost, transparent and low consumption system.

Software

The platform has been designed in different layers to make independent all software and hardware components.

ACOMM and PCOMM are programmed using the C programming language. The server is programmed using the .Net technology. A gateway to connect ACOMM with the server through a TCP/IP connection has been developed, and the information exchanged follows a XML format. The gateway communicates with a set of Web Services for management and location. In addition, the server includes a web site for system configuration and basic location and a viewer based in .Net Remoting.

Location and Exchange information

The ACOMM devices (fixed beacons), designed to cover all the area where the PCOMMs should be located, are in charge of searching all those PCOMMs that are in its coverage area, connecting them and calculating the link power. Then, each ACOMM connects with the server and send the information related to the PCOMM (identification, power level and sequence number).

In the server the power levels that arrive from different ACOMMs related to the same PCOMM and number of sequence are compared, choosing the location of the PCOMM in the ACOMM, and in consequence in the area assigned to this ACOMM, with the lower power level.

On the other hand, the PCOMM has the capacity of storing up to 256 KB. This information can be accessible using a Bluetooth capable PDA or laptop. If this information is updated, it is sent to the server during one connection in the location process above described. Therefore, the information stored in the PCOMMs is always synchronized with the information stored in the server.

Application development

The final objective is to allow the deployment of applications that make use of the two functionalities described in this paper. For this reason the platform offers an interface to the development of this type of applications.

This interface is provided through a web service that offers two basic services:

- Location on demand: it’s possible to know the real time position of a user using the web service.
- Tracking user: collected data may be used for doing a track of any user inside the location environment.

In order to validate the fundaments and development of the platform, a management hospital application has been performed. This application deals with the necessity of the La Ribera Hospital of registering automatically the times that patients stay in different rooms of the surgical area, task performed up to now by nurses manually.

The specification of the application was performed based on a study of this manual register.

Surgical area in La Ribera Hospital is formed by three types of rooms:

- Pre-anaesthesia room: one room divided in three parts with a capacity of 9 patients.
- Operating rooms: there are 10 operating rooms (one of them for emergencies)
- URPA: recovery room, where patients wait for a free room in the hospital.

In the figure 2 a scheme of the La Ribera Hospital surgical area is presented. In addition, it is represented the usual route of a patient.

A patient usually comes in to the surgical area using a stretcher and he/she is carried to the pre-anaesthesia room, with a capacity of 9 patients.

When the patient is going to be operated, he is translated to one of the nine no-emergency operating rooms.

After the operation, the patient passes to the recovery room, before the final translation to a bed in the hospital.

The main problem is that this route is not always fixed and accesses and leavings can be produced through unusual ways, which makes impossible the use of detection elements in the fixed places.

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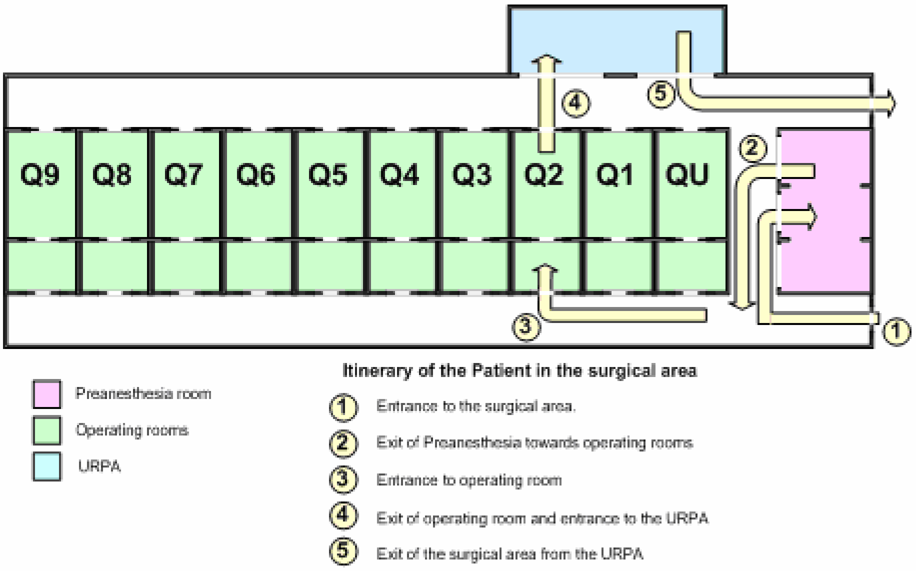

Figure 2: Usual route of the patients in the surgical area

Results

A general platform for development of applications based on discrete location and information exchange has been developed. It provides an interface that allows an easy interaction between system and applications.

Figure 3: PCOMM device

Figure 4: ACOMM device

Exchange of data between Bluetooth-enabled mobile devices and the PCOMMs and Server of the platform is possible.

The platform provides a generic web interface for the access to administration, configuration and locations visualization tools.

Administration tools include the management of devices (ACOMMs y PCOMMs), areas and users, allowing, for example, to include a new ACOMM in the system, to remove it, to activate/deactivate or to test its functioning. ACOMM devices are associated to different areas, usually close rooms, being possible to create or remove areas, to associate areas to different ACOMMs, etc.

Regarding location visualization, it is displayed the ID of the PCOMM, the ACOMM where is detected with less power, the area associated to the ACOMM, the time stamp of the location, power value and the reliability of the location. In addition, is possible the determination of the route followed by a ACOMM.

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Figure 5: Screen capture of the platform general web interface

As example of the location by means of comparison of power levels, the location of a PCOMM in the situation represented in Figure 6 is presented below.

The PCOMM number 42 is in the position indicated in figure 6 (Area 1). There are 3 ACOMMs: ACOMM 129 (Area 1) and ACOMMs 128 and 126 (both in Area 2). Graphic of Figure 7 represents the power levels (normalized in a scale between -20 and 6, the level 10 represents no connection) arrived to the server. It can be observed that the power level arrived from ACOMM 129, which is in the same area than the PCOMM 42 is in general less than the power level of the other two ACOMMs in the Area 2. Therefore the location is correct in most of cases (97 %).

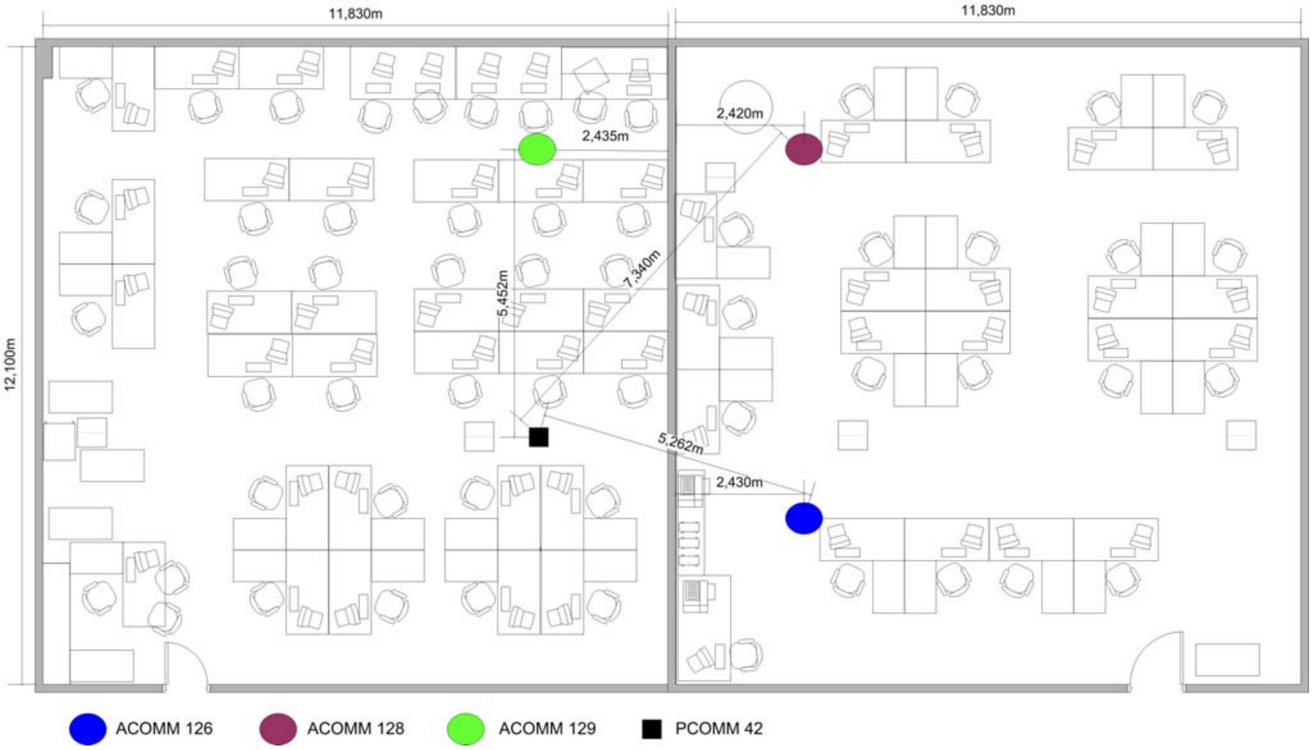

Figure 6: Situation of the ACOMMs and PCOMM

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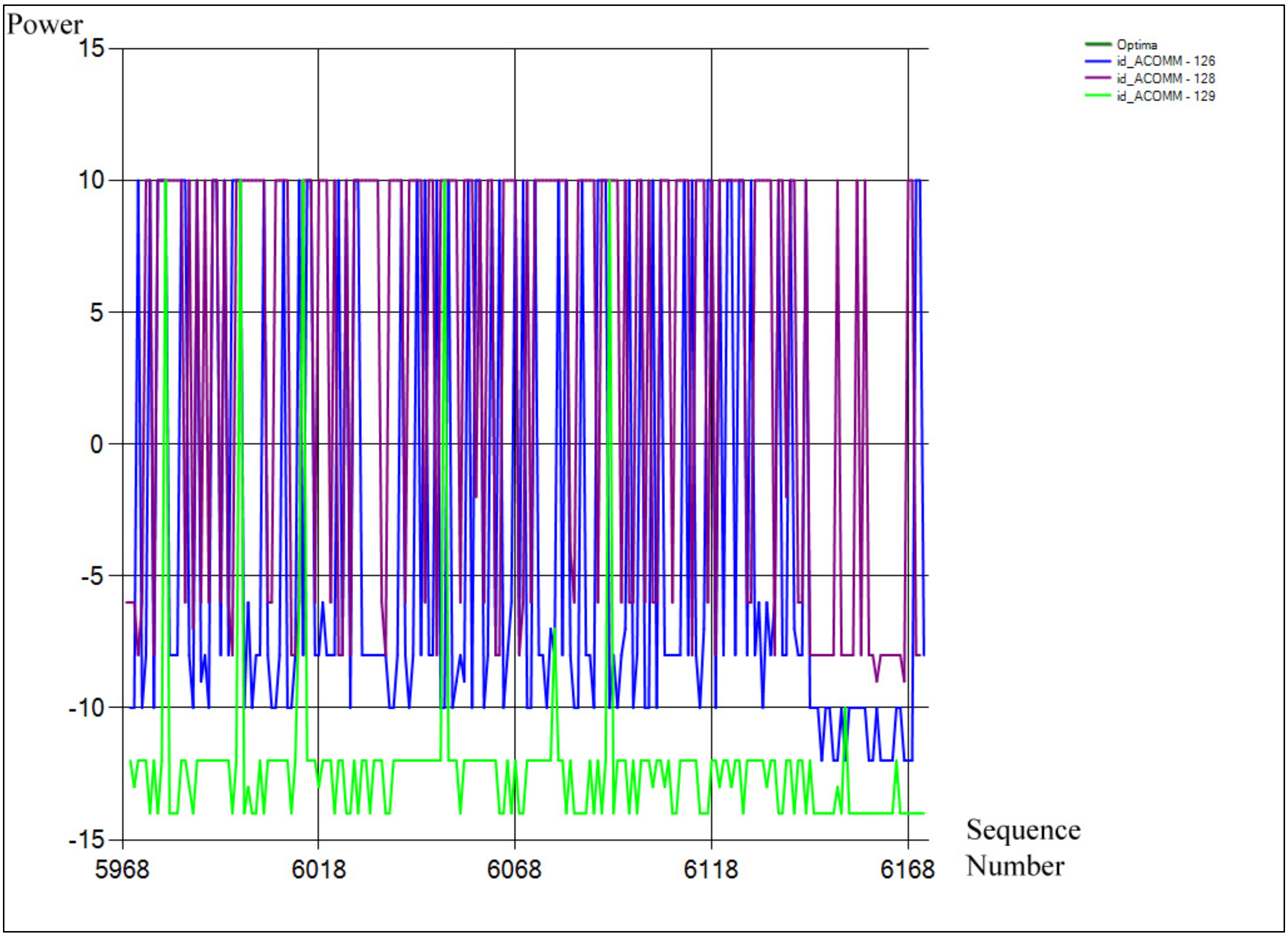

Figure 7: Power level comparison

In Table 1 are represented the data corresponding to this case.

Period test: Start: 15/09/2004 21:30:37 End: 16/09/2004 05:56:23 Duration: 30079 s.
Number of locations: Total: 202 Correct locations: 196 (97 %) Wrong locations: 4 (2 %) No locations: 2 (1 %)
Elapsed times between locations: Average: 147,45 s.

Table 1: Location results of PCOMM 42

Time Register in a Surgical Area application

As an example, an application has been developed for registering the time that patients stay in the different rooms of a hospital surgical area.

The application uses the platform to localize a patient and to calculate the periods of time that he/she stays in the different rooms when he leaves.

A patient is provided with a PCOMM when he/she enters in the pre-anaesthesia room, first room of the surgical area. The system localizes the patient during all his/her path (pre-anaesthesia room, operation room and recovery room). Once the patient leaves the recovery room, the PCOMM is disassociated of the patient and the following parameters are extracted from the information of location in the server:

- Time of access to the pre-anaesthesia room.
- Time of leaving the pre-anaesthesia room.
- Time of access to the operation room.
- Time of leaving the operation room.
- Time of access to the recovery room.
- Time of leaving the recovery room.

The information is stored in the hospital data base. Thus, the hospital can be aware in automatic manner of this information to manage its resources optimally.

The application is going to be implanted and tested in the last trimester of this year in La Ribera Hospital in Alzira (Valencia – Spain).

Discussion and Conclusions

The presented platform allows the deployment of cost-effective location based systems, even though there is not a high quantity of elements to locate and the area has not great dimensions. In addition, it allows the exchange of information with existing Bluetooth-enabled devices in the market. This is possible because the system doesn't make a continuous location of the

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patient or object in time and space, but only a location in a delimited area in discrete time periods.

Other advantage of the system is the possibility of adapting to different topologies in environments with a lot of obstacles or practically free of them.

One of the main problems of the system is the scalability, since Bluetooth connexions duration limits the number of PCOMM devices to locate in the same area. This fact can be enhanced using several ACOMMs in the same area, although the system is thought to be used with not a great number of objects to locate.

Batteries are other issue to take into consideration. Although Bluetooth has less power consumption than other technologies like Wi-Fi, using batteries, is not enough to keep PCOMMs alive for months neither weeks. The tests performed with the first PCOMM prototype show one day duration of the batteries. Although the prototype and functioning of the system can be improved to extend the battery-live in the PCOMMs, it is not possible to achieve PCOMMs being used during months without recharging the batteries (that is the solution offered in this platform).

Other wireless low power technologies have appeared recently, as Zigbee. This can be a very good option for the development of location systems with better power consumption than those based on Bluetooth. There are already some experiences based on this technology [7]. Main problem of using Zigbee is that currently don't exist mobile phones, PDAs or laptops with this technology embedded, that makes more difficult the information exchange with external devices and you have to combine this technology with others like IrDA [8].

The last test to validate the functioning of the system will be done during the implantation and the validation of the application of time register that patients stay in the different rooms of the surgical area in La Ribera Hospital. This application has been developed at the location and information exchange platform, and its good functioning will allow to know and to increase the efficiency in the surgical area, being possible the decrease of waiting lists. The automated acquisition of the times liberate the manual tasks of the nurses, which means more time for the direct attention to the patient and avoiding a task where errors can be produced.

In addition to the time register application, other possibilities are those related to a correct management of the equipment of a hospital, for example, the location of the mobile equipment in the hospital, or the possibility of automatic alarms to avoid the irregular removal of the hospital equipment.

References

[1] WhereNet Web Site, Wireless solutions for tracking and management assets (last visit: September, 2005): http://www.wherenet.com/

[2] GPSWorld Web Site (last visit: September, 2005): http://www.gpsworld.com/

[3] AeroScout Enterprise Visibility Solutions Web Site (last visit: September, 2005): http://www.aeroscout.com/

[4] BRAY, J., STURMAN, C.F. (2002): 'Bluetooth 1.1 Connect Without Cables', Prentice Hall

[5] KAMMER, D., MCNUTT, G., SENESE, B., BRAY J. (2002): 'Bluetooth Application Developer's Guide', Syngress

[6] CSR Bluetooth Products Web Site (last visit: September, 2005): http://www.csr.com

[7] SHNAYDER, V., CHEN, B., LORINCZ, K., FULFORD- JONES, T.R.F., WELSH, M. (2005): 'Sensor Networks for Medical Care', Technical Report TR-08-05, Division of Engineering and Applied Sciences, Harvard University

[8] CHRISTIAN, A., HICKS, J., AVERY, B., KURIS, B., DENNING, D., AYER, S., ANKCORN, J. (2005): 'Fingertips of the Network: Featherweight Communicators and Sensors', HP Laboratories Cambridge, HPL-2005-114

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