

# OPTIMA: Optimization of Times in the Surgical Area and Use of Equipment of a Hospital by means of a Real Time Location System

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## Abstract

The aim of the OPTIMA Project is to design and develop a general platform that enables the location of persons and objects and the exchange of information based on the Bluetooth wireless technology. This platform should be the basis for the development of management applications aimed at hospitals, although it is suitable in other environments. In order to test the proper working and possibilities of the platform, an application to reduce and optimize the time of the patients staying in the hospital surgery area is being developed. Therefore, the application will allow the automatic registration of the period of times that the patients stay in the different surgery area rooms at the same time than their location, via web. This is a lawful requirement for some hospitals, and it will substitute the current manual data register. This new method will free human resources and will optimise the system in order to increase its efficiency to reduce the waiting lists. Other possible applications thanks to the OPTIMA platform will be those ones related to a correctly management of the hospital equipment. The location of the mobile equipment in the hospital (wheelchairs and portable diagnostic devices) from any PC connected to the hospital network, or the possibility of automatic alarms to avoid the irregular removal of the hospital equipment are examples of these type of applications. The project deals with obtaining a scientific-technical solid knowledge base in the communication and information technologies field as the location systems in real time inside buildings, use of the wireless technologies, location algorithms, maps management, etc..

**Keywords:** Location, Bluetooth, Management, Hospital, Surgery.

## 1 Project Objectives

The main objective of the OPTIMA project was initially the design and development of a management platform to reduce and optimize the time of the patients staying in the hospital surgery area, and to correctly manage the equipment of the health centre.

During the development of the project, this objective has been extended to the **design and development of a “Location and Exchange Data Platform” based on the Bluetooth**

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**Technology.** The development of a great range of hospital management applications will be possible over this platform.

The platform was initially thought to support the following three applications:

- Registration of the period of times that the patients stay in the different surgery area rooms at the same time than their location via web. This task is a legal requirement for some hospitals, and is currently done in a manual way. Its automation would increase the efficiency of the surgery area, reducing the waiting lists.
- Location of mobile devices (wheelchairs, portable diagnostic devices, etc.) in order to increase the efficiency in the use of the material, by means of the location and detection of underused material.
- Safeguard of hospital devices and objects (wheelchairs, diagnostic devices, computers, etc.), by means of the use of alarms to avoid that the devices can be carry outside limited areas. This application would enable the reduction of economic damages caused by the theft of devices and objects in different low-security areas of the hospital.

But the extension of the possibilities of the platform, like the information exchange, enables a greater range of management applications. The application chosen to be developed in order to test the platform during the project is **the registration of period of times of the patients in the surgical area**, since, first, it is aimed at persons and has a direct repercussion in the patients (reduction of waiting lists), and second, it is the application that the hospital (La Ribera Hospital, Alzira, Valencia) is interested in implanting and testing. New applications can be easily developed over the general platform.

Moreover, in order to achieve a **system that can be transferred to the society and the market**, in addition to the above-mentioned technical aspects, diffusion, exploitation and business issues have been addressed in the project.

In order to achieve the above-mentioned objectives the work has been divided into seven workpackages that include the following milestones:

- WP1- System Specification:
  - Study of Art of the Positioning Location Systems.
  - Platform Modular Architecture Definition.
  - User requirements and Functional Specification of the “Time Registration” application.
- WP2- Design and Development:
  - Architecture modules design.
  - Architecture modules development.
- WP3- Integration:
  - Architecture modules integration.
- WP4- Implantation:
  - Implantation of the system for a pilot experience in the La Ribera Hospital (Alzira).
- WP5- Diffusion:
  - Diffusion and exploitation plan.

- Diffusion activities annual reports.
- Business plan.
- WP6- Validation:
  - Study of the adaptation of the platform to the hospital environment.
  - Technical validation of the platform.
  - Functional validation of the platform.
- WP7- Coordination
  - Project state annual reports.
  - Final project report.

The following figure represents the schedule of each workpackage.

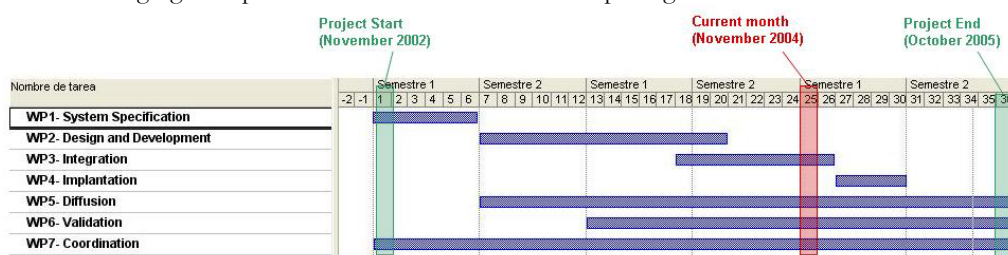


Figure 1: Project schedule

## 2 Successful Level achieved in the project

Points indicated below summarize the general state of the project, divided in the three objectives described in the previous section. State of the work performed in the workpackages related to those objectives is described:

- OPTIMA platform:
  - Specification (WP1) finished.
  - Design and development (WP2), and integration (WP3): at this moment, last tests of the platform working and final details are being performed in order to have the definitive prototype version to be implanted in the hospital.
  - Implantation (WP4): this task should start at the beginning of next year. The platform (and the time registration application) will be implanted in the La Ribera Hospital, although a first location test has been performed in the hospital environment with successful results.
  - Validation (WP6):
    - A technical validation plan has been elaborated and the first tests in laboratory are being carried out. The technical validation should be completed in a second phase, during the use of the platform in real conditions in the hospital.
    - A study of the adaptation of the platform is being elaborated in collaboration with member of the hospital staff: issues like possible interferences with medical devices, sterilization of the platform hardware devices used in the location and others are being addressed.
- “Time Registration” application:
  - Specification (WP1) finished.

TIC2002-0000-C02

- Design and development (WP2), and integration (WP3): final phase. Coordination in order to interconnect the application with the hospital data base is currently being addressed.
- Implantation (WP4): the application should be implanted in a coordinated way with the platform.
- Validation (WP6): a functional validation plan is being elaborated in collaboration with members of the hospital staff, in order to specify the indicators to measure the adaptation of the application to the requirements of the hospital.
- Diffusion and Exploitation (WP5):
  - Development of the Optima Web Site (<http://www.bet.upv.es/optima>).
  - Two publications in related congresses (see section 3).
  - Demos of the working platform prototype has been performed to the director of the “e-services for life and health” Unit of the Scientific Institute Hospital San Raffaele (Milan) and responsible staff of the NISA Hospital group, explaining the possibilities of the platform, both location and information exchange.

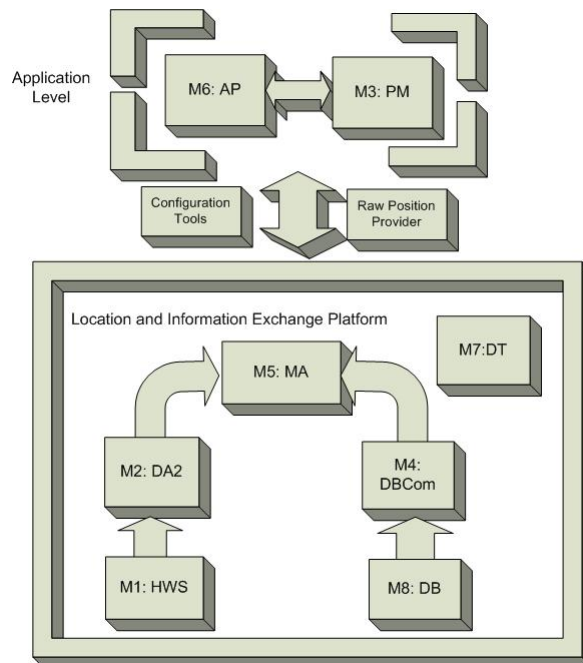
Workpackage	Milestone	State
<b>WP1- System Specification</b>	Study of Art of the Positioning Location Systems	Done
	Modular Platform Architecture Definition	Done
	User requirements and Functional Specification of the “Time Registration” application	Done
<b>WP2- Design and Development</b>	Architecture modules design	Done (under continuous modification following feedback from development tasks)
	Architecture modules development	Final phase
<b>WP3- Integration</b>	Architecture modules integration	Final phase
<b>WP4- Implantation</b>	Implantation of the system for a pilot experience in the La Ribera Hospital (Alzira)	First test of the platform in the Hospital done. Implantation expected for the beginning of 2005
<b>WP5- Diffusion</b>	Diffusion and exploitation plan	Done
	Diffusion activities annual reports	2003 and 2004 reports included in 2003 and 2004 annual project state reports
	Business plan	To be done by the month 36 of the project
<b>WP6- Validation</b>	Study of the adaptation of the platform to the hospital environment	Study currently in progress
	Technical validation of the platform	Technical validation plan done Validation in progress
	Functional validation of the platform	Functional validation plan done Validation will be done
<b>WP7- Coordination</b>	Project state annual reports	2003 and 2004 reports done
	Final project report	To be done at the end of the project

In the following subsections, the most highlight aspects of the OPTIMA system are described.

## OPTIMA System description

The OPTIMA platform has been divided into the following modules:

- M1- Hardware Structure (HWS)
- M2- Data acquisition and adaptation (DA2)
- M4- Data Base Communication (DBCom)
- M5- Management application (MA)
- M7- Design Tools (DT)
- M8- Data base (DB)



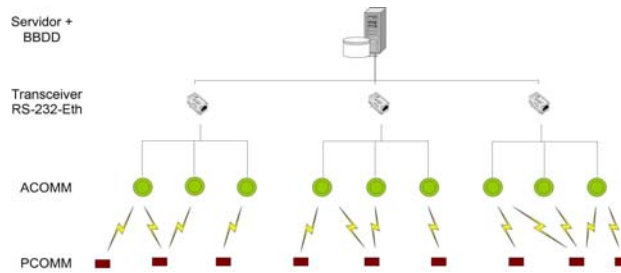
**Figure 2: Platform modules**

At the application level two more modules have been defined:

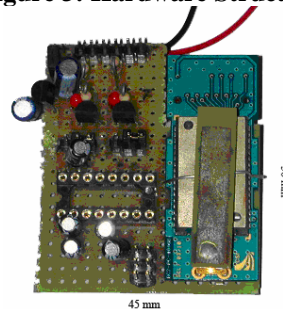
- M3- Plan manager (PM)
- M6- Application (AP)

The Hardware Structure (M1-HWS) is based in the development of two Bluetooth devices:

- PCOMM: device to be worn by people or object to be located. It will be similar to a tag.
- ACOMM: fixed located device that delimits the area of location. All the ACOMM are connected to a central server through an Ethernet Network.



**Figure 3: Hardware Structure**



**Figure 4: PCOMM first prototype**

Each ACOMM searches the different PCOMMs existing in its range and connect with them in order to calculate the power signal received of each PCOMM. This data is sent to the server where is encapsulated into XML (M2-DA2) to be forwarded to the Management Application (M5-MA). In this scheme, a modification of the hardware structure only would cause the necessity of modifications in the M2-DA2. M5-MA is in charge of calculating the location comparing the power values received from several ACOMM. It can work in two modes:

- Pull Location: data received from ACOMMs is directly stored in the Data Base (M8-DB). The location is calculated when an application demand it based on the data stored. In order to make the communication independent of Data Base used, a Data Base Communication Module has been developed (M4- DBComm)
- Push Location: location of the ACOMMs is received and the Location of each PCOMM is automatically calculated and notified to the application.

Regarding the information exchange, the PCOMM has been designed to store information (for example, related to the patient whom the PCOMM is assigned). This information will be accessible by any Bluetooth-enable device (mobile phone, PDA, PC,...). This information can be replicated in the Data Base. Therefore, when the information in the PCOMM changes and a connection with an ACOMM is established, the PCOMM sends the new information to the server through the ACOMM.

The module M6 represents any application that makes use of the OPTIMA platform. For example, in the project the application of time registration is being developed. In this case the application demand periodically of the M5-AG the location of the patients (previously assigned to a PCOMM9) and calculate the time that each patient have stayed in each surgical area. This is an example of Pull Location.

## **OPTIMA Platform Highlights and Problems**

Initially was carried out a study of art of indoor location systems in order to know if one of the products existing in the market was suitable to the OPTIMA platform. Actually there are several options in the market that allows the location (in coordinates X,Y) with high precision but high cost, only assumable by great factories but not to be used in applications that cover limited areas of a hospital. For this reason it was decided the use of a platform described above, based in the use of a very widely used wireless technology as Bluetooth, with an acceptable power-consumption, that has a low cost in the market. This way, the location of the PCOMMs is in areas (i.e., the location result is not an X,Y coordinate but a limited area, e.g. a room) and is discrete in the time (i.e., the location result is calculated each certain and configurable period of time). This lost of precision and the no continues location is not important in a lot of applications and the cost of the final system is reduced significantly. In addition, the use of Bluetooth allows the interoperability with Bluetooth-enable devices (PC, mobile phone, PDA, etc.) and the development of the functionality of information exchange.

The use of Bluetooth has caused the following problems:

- Power consumption: although the power consumption of the Bluetooth technology is lower than other similar ones like Wi-Fi, it is not enough to extend the battery-life of the PCOMM to months. In order to increase the battery-life, the number connections between the PCOMM and the ACOMMs are being reducing, and the electronic design of the PCOMM device is being improved.
- Scalability: the use of Bluetooth can reduce the scalability of the System. Currently, tests are being carried out in order to know the number of PCOMMs possible in the same area limited by an ACOMM without decreasing the system operability.

The software modules included in the server are based in the use of XML for data format and webservices based in the .Net technology.

## **Time Registration Application**

This application has been designed and developed in close collaboration with medical, management and technical staff of the La Ribera Hospital. Currently, nurse staff take in a manual way the times that each patient stays in each one of the three rooms of the surgical area (pre-anaesthesia, operating room and URPA). These data are introduced in a Data Base using a PC at the end of the day. The OPTIMA platform allows the automation of this process by means of the location of the patients and the calculation of the times based on this location.

The implantation of the application in the La Ribera Hospital will be a great opportunity to test the system operation (both platform and application) in a real environment.

## **3 Results Indicators**

The work carried out in the OPTIMA Project has made possible the following academic outputs:

- A technological research work about the use of Wireless Technologies in the Health Sector, first step in the PhD studies of Eduardo Montón (project researcher).

- The direct collaboration between ITACA and the Polytechnic University of Valencia has made possible the participation in the project of two students of this University by means of education grants.

The following papers have been presented in national congresses:

- S. Fuster, J.F. Hernández, J.L. Plaza, E. Monton, V. Traver, "*Sistema de localización e intercambio de información sobre tecnología Bluetooth*", XIX Simposium Nacional de la Unión Científica Internacional de Radio, Barcelona, September 2004.
- J.F. Hernández, S. Fuster, E. Montón, J.L. Plaza, S. Guillén, "*Registro automatizado de tiempos en el área quirúrgica mediante el uso de localización sobre tecnología Bluetooth*", XXII Congreso Anual de la Sociedad Española de Ingeniería Biomédica, Santiago de Compostela, November 2004.

The experience acquired in embedded systems and wireless technologies has allowed the ITACA participation in two EU Integrated Projects:

- SENSATION: the project aims at promoting the health, safety and quality of life of people with sleep and stress problems through the application of novel micro and nano sensors and related technologies, of low-cost and high-efficiency, for physiological state monitoring. ITACA is the leader of the work package in charge of communicating sensors with applications using embedded systems and wireless technologies.
- ASK-IT: the project aims at increasing the quality of life of disable and elderly people based on ambient intelligence.

The participation in these projects is allowing the collaboration with both national (Grupo de Biongeniería y Telemedicina of Madrid, Starlab of Barcelona, etc.) and international (University of Malta, Microvitae of France, etc.) entities.

Finally, four non-technological entities have expressed its interest on the OPTIMA system:

- La Ribera Hospital (Alzira), direct collaborator in the project.
- NISA Hospitals Group (Valencia)
- San Raffaele Hospital (Milán, Italy)
- Cruz Verde: entity that manage residential homes for the elderly.

## 4 References

All the information gathered in this document can be extended with the two Annual Status Project Reports performed so far.