

# Patients' Location-Awareness in the Emergency Department

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## Abstract

*The nature of the medical services offered at the hospital's Emergency Department (E.D.) presents important peculiarities in comparison with the rest of the clinical departments within a Hospital, mainly due to the required necessity of immediate provision of medical care. As a consequence there exists limited time for administrative procedures. In parallel, the optimal utilization of all-available material and human resources is a common demand. The observed discrete features, indicates the need for adoption and utilization of advanced Information and Communication Technology (ICT) systems.*

*The efficient patients' management and the limited availability of resources in ED find promising the suggestions from the application of advanced, in concept, information technologies. The employment of reliable technological achievements allows the patients' tracking within the ED spaces, assisting in the effective and improved management of the offered medical services. The objective aim is to obtain such supporting software that is capable of developing the required context to cooperate with the medical professionals and assisting in the decision making.*

## Keywords:

Emergency Department; Location awareness; Medical Informatics

## 1. Introduction

The National Healthcare System's hospitals' Emergency Departments operates according to a defined schedule. In particular for the 5 millions population of the area of Athens, Greece, the large General Hospitals operate every four days. The personnel employed at the Emergency Departments is borrowed from the Hospital's clinical departments in a rotational fashion. The visits to a large hospital at the Emergency Department are of the magnitude of a 1,000 each time. At the "G. Gennimatas", the General Hospital of Athens, an 800 bed general hospital spread in an area of 64.000 square meters. It serves a population of over two million people when the Emergency Department is on duty. It has over 800 physicians, 1200 nurses, and almost 200 administrative personnel and an annual

budget of about 100 million Euros.

The time window for the provision of medical care is critical at the Emergency Department (ED) and the quality of medical services must be relative to the circumstances. The utilization of the available resources, material and personnel, must be efficiently spread within the Emergency Department in order to meet the financial affordability. It seems that technology is a key parameter in the efforts to improve the overall performance in the operation of the hospitals' ED. In this paper, it is proposed the employment of Information and Communication Technologies (ICT) for the improvement and measurement of the quality of services offered to visiting patients. The assistance and cooperation of the installed Information System (IS) in the ED must be augmented acquiring location tracking data and processing information facilitating efficiently the visiting patients. Hence, it is necessary the development of an appropriate IS module with suitable characteristics with respect to interoperability to comply with the rest of the operating Hospital's subsystems.

The ED's operation determines the philosophy of the desired IS module which it is described in the next section. Then, the technical specifications are drawn from the description of the detailed ED's operation in the following section. Next comes, the design of the desired location awareness system and its integration with the currently available IS. It follows the description of the proposed technologies and last, the paper ends with the drawn conclusions.

## **2. The Hospitals' Emergency Department**

The quality of the medical services provided at an Emergency Department (ED) is affected by the underlying infrastructure in building properly formed spaces' and equipment availability. Time is critical at the ED which is called to offer the total hospital's services in a very narrow time window depending on the nature of each incident. The information related to patients is valuable to the acting medical professionals to promptly provide adequate services both to historical data and each currently facing incident's related information. The responsiveness on the emergency incidents reflects on the reliability of the healthcare system.

The Emergency Department's operation in Greece notes deficiencies creating such a picture that it is lagging behind due to administrative and technological matters and not related to poor medical services. The ED employs visiting personnel from other clinical departments limiting chances for specialisation in such a demanding working environment. Recent legislative actions describe the requirements for an efficient operation of the Emergency Departments in Greece missing out referrals to the required data management that allow subjective opinions in the interpretation about the operation of the accompanying Information System. Objectively, the quality of service at an Emergency Department is directly related to the promptly responsiveness and the reliability of the available information to the medical professionals to act on each patient's case. Hence, there exist data that is considered as critical for the outcome of patients' cases and require a well designed Information System to accommodate both the personnel's operations and the data administration. Scheduling and exploiting human resources, supporting medical decisions, connecting the hospital's facilities with ambulatory services, administering and supporting the regular operation are some of the functions afforded by an installed Information System.

The time response is considered as the primary objective in an Emergency Department's operation and it prescribes the application requirements for state of the art information and communication technologies. Therefore, technological achievements including wireless networks, palmtop computers, bar-coding systems, radio frequencies identification (RFID)

systems, utilisation of voice recognition systems constitute some of the necessary ingredients for the successful application of Information Systems at the Emergency Departments.

There exist a number of important design parameters that affect the efficient introduction of an Information System in healthcare organisations. The Emergency Department, as part of the hospital's organisation must have similar, if not identical, design characteristics including data privacy and security, systems' inter-operability founded its functions on standards, continuous supporting and training services. The principles applied in the design of an Emergency Department's Information System must exhibit both its availability and capability to operate with the rest of the Hospital's services and with other individual but external organizations.

### **3. Current operations at the ED**

The flows of works taking place at the Emergency Department focus and watch the patient's presence at the various internal locations. There exist three sets of processes administering the patients' tour within the department. The first set of activities concerns the patient's health screening and identification. The second one refers to the provision of medical services for the patient's treatment while the last set of processes has decisive nature about the further patient's luck.

Practice and experience set the specifications of the structure and operation of the desired Information System at the Emergency Department since there is a lack of well known and recognized standards to follow and the application is limited referring to protocols. The arriving patients must be declared and identified by the Information System the soonest possible in order to be discretely followed even when there is no way of obtaining their actual demographic data. At the patient's arrival it is required to obtain the largest set of data concerning the patient's identity and healthcare status applying automated, if possible, Information Technology arrangements with minimal users' intervention in the data-entry process. The retrieval of patient's demographic identification is certainly important since it may allow the appearance of any related medical records but the most important issue is related to the enrollment, into the Information System, of currently obtained medical data with minimal users' effort. The users' primary concern is related to the diagnosis of patient's health status and since time usually critical, the installed Information System is following the medical professionals' actions obtaining data instead of the opposite. Therefore, the two issues at the first stage at the Emergency Department are patients' identification and diagnosis for further proper medical treatment.

There are a number of possible pathways to be followed by the patients leaving the Emergency Department's reception stage. In each case, the Information System follows the patient pace providing vital medical information to the medical personnel concerning the patient health status and providing the necessary arrangements for the efficient flow of patients. Scheduling actions, events and assigning dynamically priorities focused on the patients' needs consist the primary IS specifications. There are three links of the ED's Information System with the rest of the Hospital's Informatics infrastructure. First, the Laboratory Information System must be capable of receiving and sending back results of analytical laboratory medical examinations. The second link concerns the availability of the Radiological Information System to provide the diagnoses of the related referred patients. The last link refers to the Clinical Information System that must be capable of providing information related to the availability for further medical attendance. Hence, the Emergency Department's Information System has a double role to play, first by gathering information

related to patient's current health status, administering the patients' presence and needs, and last to get in cooperation with other hospital's information systems. In order to cover extreme but possible to occur patients' cases, there is also the need to occasionally build bridges with the intra-organizational information system, for example ambulatory services for transporting patients to other medical facilities such as intensive care units. Therefore, the design principles of the Information System employed by an Emergency Department must be based on the capability of tracing the patients' needs at each location taking all the necessary measures to facilitate the desired efficiency augmenting the patient's electronic record with additional and useful content.

The patients exiting from the Emergency Department have in the Information System a documented record, an evidence based diagnosis, and either a discharge or a transfer note. Hence, the patient either receives medical instructions issued by the IS and departs or is transferred to other facilities away from the Emergency Department for further or other services. The set of information gathered is filed to the patient electronic record and it may be available electronically depending on the over all Informatics infrastructure. The relevant information to the patient's treatment is obtained, stored, and made available for future referral in addition to the increase of the level of quality provided by the Information System as services to the patients' presence within the Department.

#### **4. Integrating location awareness technologies with current ICT**

The employment of proper biometric sensors provides the capability to identify the arriving patient with a minimal probability error, while at the same time, a personal identification tag is issued (e.g. smart tag in some form of a card or wristband) with which the patients are supplied for the entire duration of their hospitalization. Then, the patients' position monitoring, allows the individualization of their situation in such a way that it is attempted the optimum management according to each patient's needs.

Technical methods allowing the patients' automatic identification and the monitoring of their position provide to the installed Information System (IS) the capability to realize and perform the necessary procedural actions with the minimal personnel's intervention. Hence, most of the available time turns in advantage of the patient's care and treatment.

Installing properly scattered adequate sensors (readers) on and inside the building's structural elements the localization is achieved and the patients are spotted in the area of the Emergency Department. The information provided by the sensors enable the IS to be continuously aware about the patient's position and his/her needs.

Gathering information in the IS, gives it the capability to schedule the provided services with the optimal, in each case, way, turning away jamming or overcrowded situations and facing in a more proper manner cases of shortages in the availability of biomedical equipment and supplies. In an analogous way, it is provided the facilitation by the IS to the personnel for immediate and optimal control of the appearing workload (e.g. dynamic distribution of resources).

Additionally, aggregating information in the IS, provides reliable information about the level of spaces' usage. Therefore, reliable assessments are evident for maintenance and eventual but necessary space-panning intervention with endmost and objective aim the regular flow of the performed procedures.

## 5. Available technologies for location sensing

The explosion of wireless systems, mobile computing devices as well as the Internet itself has leverage the research towards location-aware systems and services. Many application in our days need to know the exact location of an object.

Various wireless technologies have been used for indoor location sensing. The most widely accepted are Infrared, IEEE 802.11, Ultrasonic and RFID [3].

**Infrared.** Active Badge use diffuse infrared technology to realize indoor location positioning. The need for visual link and the short range signal transmission are the two major limitation of this approach.

**IEEE 802.11.** An implementation of a system based on IEEE 802.11 wireless network technology has been made by a research group from Microsoft. This implementation offers two advantages: it requires only a few base stations, and it uses the wireless infrastructure of the building's wireless network. On the other hand it has two disadvantages: the object to track must support wireless networking (impractical for small badges) and generalizing this technique to multi floored building is not a trivial problem.

**Ultrasonic.** Ultrasonic based systems use an ultrasound time-of-flight measurement technique to provide location information. The main advantage of such systems is the high accuracy they provide. On the contrary they require a great deal of infrastructure in order to be effective which means that the implementation cost is very high.

**RFID.** Radio Frequency Identification based systems use three dimensional location sensing based on radio signal strength analysis. These systems need several basic components including a number of RFID readers, RFID tags, and the communication between them. The RFID reader can read data emitted from RFID tags. RFID readers and tags use a defined radio frequency and protocol to transmit and receive data. RFID tags are characterised as either passive or active. Passive tags operate without a battery and reflect the RF signal transmitted to them by a reader adding information by modulating the reflected signal. Thus their range is very limited. Active tags contain both a radio transceiver and a small battery to power it. They have more range and are ideally suited for identification of moving objects.

By comparing the above techniques our team proposed the RFID solution for the ER department's needs.

In the above framework the RFID technological solution has identified as the most suitable in "G. Gennimatas" ED needs. It seems that RFID is a revolutionary technology which will have widespread impact in every market in the next 10 years [1].

## 6. Discussion - Conclusions

The description of the implementation of a patients' location-awareness system employed in ED is given above. The co-existence of such a system with the Hospital's IS will improve the quality of services offered by ED and the efficiency of the available resources too. The application of patient badges with embedded RFID chips together with RFID readers as well as the appropriate software satisfies the defined design specification with the required operability. Location aware systems support patient safety by ensuring that the right patients are in the right place for the right procedure. Also, the time spent by patients involved in the various flows of works can be measured in order to identify areas for improvement. Location-awareness systems may be viewed as a first step approaching the digital hospital era in the healthcare sector.

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