THE UTILIZATION OF PDAs AND RFID TECHNOLOGY IN ADVANCING HEALTHCARE INFORMATION SYSTEMS' ADOPTION IN TODAY'S HOSPITAL

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The acceptance of Information Systems' (IS) applications in the clinical sector is limited while the contrary is observed for the administrative sector. The computer equipment design and the nature of the office environment find an exact and perfect application match. The clinical working conditions demand the medical personnel to provide their services in various places within the department. The conventional data entry procedures with the desktop's keyboard are incompatible to the availability of the nurses and doctors who spend most of the time away from the office requiring the computers to follow them at their practice. PDAs and RFID technology applications allow the personnel to carry the computers while the medical profession is performed. Clinical medical personnel appreciate the use and process of reliable patients' data but it is impossible to spend a large fraction of time by typing behind a desk. In this paper, the need of introducing handheld devices along with RFID system in health care establishments in Greece is presented, as a way of improving IS acceptance by the clinical personnel.

The nature of most of the medical profession's specializations requires the presence of the physicians and nurses next to the patients' side, away from the office's desk and the installed personal computer or terminal. The elapsed between the moment the vital information is spawned at the contact point of the medical professional with the patient and the time a doctor or a nurse sits behind a computing set to follow the data entry procedures is quite large. The length of the intermediate time causes a proportional decaying of the information's value since all the data of the patient relies on the professional's live memory. The number of examined patients' cases by the medical professional acts, as another aggravating parameter, against the integrity and the thoroughness of the collected information validity.

Healthcare Information Systems (HIS) contribute major benefits in the direct support of patients care, providing great advantages over the traditional paper-based record in reporting, organising and locating clinical data. At the same time, HIS can assist physicians' decisions by providing information such as protocols, reminders and alerts. In spite of the obvious benefits, HIS applications have not been successfully implemented in numerous cases. In such cases, the physicians react in an indifferent manner avoiding to provide on-time adequate data and causing the starvation of HIS from receiving input data. There have been observed instances where the lack of physicians' acceptance led to the discontinuation of the implementation of the complete projects [5, 6, 7].

In the case of "G. Gennimatas" Hospital, an analogous behaviour was experienced [5, 6]. The clinical departments are usually understaffed and the clinical personnel is most of the times occupied with its regular duties and it is proved that it is rather difficult to obliged them to use computer terminals too. The Hospital's Administration offered as outsourcing a number of data-entry operators to assist the physicians and the rest of the personnel to enter medical data into the system. To a certain degree, the flow of work in the clinical departments is changed due to the introduction of the HIS, altering traditional medical procedures followed for years, making it, especially for the older physicians, more difficult to accept the use of the system.

The contemporary data-entry practice demands for the use of the keyboard and the mouse device, which requires an operator to spend some time seating in front of a terminal. The nature of the physicians' work does not allow the extensive use of a terminal since the medical doctors are required to be present at various locations within the clinic offering their services. The traditional terminals do not provide such a user friendly computing environment for the physicians due to the time consuming process of typing, most of the medical professionals do not have enough time for typing practice, and the typing process is getting tedious for the older ones. Apparently, it is necessary to investigate and find more efficient and friendlier interfaces for the interaction between the medical personnel and the HIS. Thus, two of the most mature, reliable and promising technologies today, are PDAs and RFID.

Personal Digital Assistants (PDAs) are lightweight, compact handheld computers that literally fit into one's palm or pocket. The terms "PDA", "handheld computer", handheld", "Palm Pilot" and "pocket PC" all refer to similar devices with comparable computing

capabilities [4]. The physical dimensions refer to limited computing resources with unlimited operational impact in the medical professionals' everyday duties. Moreover, the rapid development of wireless networks provides an additional boost allowing the mobile devices to productively carried anywhere within the network.

Mobile computer technology satisfies the requirements for electronic media presence in all actions of the medical professionals. The capability of the handheld devices to receive valuable data related to the professionals' duties at the point where the information is spawned, it accomplishes, on the one hand, the user's willingness to accept the system recording medical data and events, and on the other hand, the upgrade in the quality of the stored information. Reliable information is stored with a minimal cost by the medical staff using mobile computing devices. The embedded software's development has to be oriented in such a way that certain aspects of the medical professionals needs in their everyday practice to be included in conjunction of the devices' operational peculiar characteristics. Among the most significant features are the limited program and memory spaces of the handheld devices, the restricted screen's area to interact with the user, and the networks' bandwidth and the applied protocols, just to mention a few of them. Mobile computing devices in a clinical environment require an IT infrastructure in order to provide the promising benefits from their use.

Mobile computing devices such as PDAs are becoming gradually an important tool in health care as shown by various studies [1, 4]. The four leading types of handheld devices currently used are: a) Palm OS-based PDAs, b) Pocket PCs, c) Smart Phones, and d) BlackBerries. A first approach to classify applications into categories may result into: 1) Decision support applications (accessing patients' data and retrieving vital medical information), 2) Administrative support (scheduling and billing applications), 3) Documentation (taking notes and recording information), 4) Professional activities (personal information management.), and 5) Education and research (collecting data for medical protocols).

The major benefits obtained by the utilization of PDAs in health care organizations may be enlisted in discrete categories as follows: A) Cost saving. In a trial period of six months applying PDAs, it was observed a reduction in the cost associated with electronic documentation accomplished by pharmacists offering document services to physicians with a turn around value of about 660,000$ [1]. B) Time saving. There are various estimates for enormous time savings but it is always related to the exact operational functioning of the employed PDA. The drastic improvement of medical units' synchronization with on-line rescheduling medical services, it is a suffice argument. C) Education. Reports show improvement in the participating medical staff's educational experience [4]. D) Clinical impact. The literature suggests [4] that the utilization of PDAs saves clinician's time, omitting much of the office's bureaucratic paper work and hence, it frees clinicians from spending time in documentation providing the chance to do more direct patient care. Obviously, the utilization of PDAs in health care environments provides remarkable advantages. In addition, it seems that PDAs may act as a vehicle for advancing HIS adoption. Studies show that most health care professionals perceive PDAs as useful tools that it can be enhanced their practice by offering mobility and functionality in a small device that fits in one's pocket [1]. Such studies have demonstrated a widespread adoption on the handheld computers in health care, and many information technology leaders and executives have agreed that handheld computers will have a significant role in the future of health care.

Within this context, the utilisation of mobile computing devices at the "G. Gennimatas" hospital is under exploration. The considered objective is to convince physicians in the use of the handheld devices as the means to input clinical data into the system during the morning's visit to the wards. At that time, and due to the nature of the procedures carried out, it is impossible to utilise some kind of a traditional PCs. On the contrary, palmtop computers seem to be an adequate, if not perfect, alternative solution. Physicians are able to operate portable computing devices under any circumstances, at any place, within the hospital, and thus, making it obtainable, to satisfy the requirements of their assigned responsibilities.

The contemporary handheld devices' electronic scale of integration provides the appropriate technical specifications adequate for operation in a hospital's environment. Also, the networks' standardization offers many opportunities for the development of polymorphic topologies operating under various protocols and developing various schemata of virtual networks. The installed software applications have the option to interact either directly or traditionally through the employed database system by evolved pigeonhole or mailbox methods. The mobile computing devices are embedded within the information system providing a new perspective to the concepts of reusability, extendibility, scalability, and security. At the same time, new issues arise focusing on matters related to the integration and synchronization of distributed information of distributed applications, the re-engineering of simplified workflows, and the design of more efficient data-entry and identification software procedures. The data-entry procedures have to be designed in such a way that there is the demand for a minimal effort from the medical professionals. Data structures such as lists and combo boxes prepared in advance for the medical user provide selection options to the medical staff instead of requiring the medical staff of writing extensive reports. Moreover, using mobile computing devices, each event related to patients' treatment is recorded providing a continuation in the applied workflows applying event-driven software applications. The capability to record events and data at the point of patients' care is the most important issue in the use of mobile computing devices. The patients' data that must be recorded is examined during the early stages of the analysis phase in the development of the information system and usually end

up with numerous variables and functions waiting to receive values from the data-entry processes carried by the medical professionals. Set-ups providing the means to record a large number of data on user's behalf, automatically, through the prisms of reliability and discretion are a necessity.

The other promising technology that may help towards HIS acceptance is RFID.

Radio-Frequency Identification (RFID) is the recently employed technology to precisely identify objects [2]. Radio waves comprise the communication media between a radio transmitter and the corresponding receiver. The transmitter comes in the form of a regular tag which it is consisted of a silicon chip. In its simplest form, the transmitter is built from a coil of known flux. The obtained, each time, flux allows us to assign specific flux-values to each object and thus, to uniquely identify it among other objects carrying similar coils or tags. There are two types of RFID tags: the active and the passive ones. In the case of active RFID tags behave similarly to the wireless nodes of a network of sensors which are continuously scanning and emitting the sensed information. Active RFID tags uninterruptedly transmit their identification to the surrounding exposing their discrete frequency provided there is some source of energy. Passive RFID tags function in the way the active ones behave under the condition of the presence of the proper electromagnetic field. Between the two RFID tag types there is no difference in their capabilities, but in the usage model. Both RFID tag types provide to radio wave receivers, or RFID readers, their identification along with some minimal information related to the self exposing object that carries the tag.

An RFID system is consisted of a reader and a special purpose tag, such as those described in the previous paragraph. The reader is equipped with an antenna radiating electromagnetic waves serving two purposes. First, it provides the developed electromagnetic field's power to the tag allowing both the reader and the tag to synchronously oscillate on the same frequency while other co-existing tags that they are synchronized at different frequencies do not expose themselves. Second, the developed field is the asymmetric communication link between the reader and each of the tags. The capability of the passive RFID tags to take advantage of the radio waves' energy sets them so attractive since there is no need for external electric power, their small physical dimensions allow them to be hidden anywhere, even to be embedded into objects, and their manufacturing cost is negligible. Such characteristics and capabilities open new design possibilities in an environment where each object has a unique identification that it is directly entered in the local information system. The noted progress in the area of semiconductor technology provides opportunities in the development of cost effective RFID technology application which is known for quite some time presenting remarkable reliability [2].

The employment of RFID infrastructures in health care organizations allows the spontaneous identification of both persons and objects. Such a perspective provides the opportunity to personalize and individualize the patients' care during hospitalization. RFID tags on cards or on wristbands provides a permanent and efficient solution to the problems related to patients' identification bringing forth the patients' set of data whenever the patients' tag is detected by the authorized RFID readers. In a similar fashion, objects related to the patients are discretely identified using either active or passive tags on them. For a presentational example, consider the case of a blood sample that waits to be transported to the analytical medical laboratory or the case of a medicine that has been placed next to the patient's bed and its tag gets activated at predefined intervals of time as a reminder to let the patient receive the medication. It is concluded that patients' treatment is closely monitored by the interconnected information system comprised of the usual IT equipment and the mobile computing devices in a way that a near to optimum medical management services are offered according to each patient's needs since the medical staff is set free from the desk.

The patients' and objects' automatic identification and their consequent monitoring of their position provide to the installed Information System the capability to trigger event driven procedures with no interventions from the medical personnel. The fact that tagged patients and objects reveal their identity raises two issues. First, the software implemented procedures have to be reconsidered and some of them have to be re-engineered to cooperate adequately with the employed RFID tags and the mobile computing devices. Second, additional floes of works have to be embedded into the IS in order to comply with the existing legislative requirements obliging to redesign the printing services of the IS along with the validating procedures. In the center of all these re-engineering actions, the patient and the medical staff must have the centered position in order to save time in advantage of the patient's care and treatment.

The necessary network infrastructure is going to be consisted of two parts: a wired and a wireless part. The installation of the scattered sensors (readers) on and inside the building's structural elements is another issue that has to be considered since the interior spaces had not designed with the application of wireless networks in mind. The wireless network's active elements, the RFID readers, must be placed in such a way that localization is achieved and the patients are spotted in the supposed area of care. The information has to be provided by the sensors continuously enabling the IS to be aware about the patient's position and corresponding patients' needs.

Collecting information from the RFID sensors via the tags or the mobile computing devices and gathering data in the IS, offers the opportunity to assist in the scheduling of the services provided by the medical departments. The IS oversees the operation of all procedures taking place in the health care providing organization and it is capable to apply the predetermined scheduling policies. The objective aim of all applied policies is the avoidance of jamming or overcrowded situations. Also, exceptions in the

scheduling policies have to be considered making it possible to serve the patients under all circumstances, for example, the patients from the Emergency Department have higher priority at the radiology department than the hospitalized patients that are more tolerable in performing regularly scheduled examinations. Handheld computing devices allow to set up an appointment and refer patients to other departments while the RFID tags allow patients and objects to self expose their presence informing the IS about their presence. The IS must be redesigned in such a way that the work load of the various departments is balanced according to each service's processing capabilities and resources allowing a dynamic distribution of the available resources. Extending further the applicability of the RFID tags and the mobile computing devices, the administrative departments of health care institutions are benefited applying the necessary managerial control. As an example, all the stationary equipment and furniture are controlled without experiencing tedious recordings each one of them since each one of them reveals its presence without any effort by the administrative personnel.

The unification of alternatively handled streams of information such as voice, picture, and signaling demand for the reconsideration of the entire IS specifications, not just the users' interface. RFID technology along with mobile computing devices improves the overall attitude against the healthcare IS since the technological achievements take a place in the everyday medical practice without changing the stream of the performed work. The majority of the required information is self exposed and self introduced to the IS and the medical staff performs limited typing selecting among the available information, provided there is a well defined software infrastructure with determined databases referring to diseases, examinations, medicines, and so on. The availability of such encoding in databases, as preconditions, advances the system's acceptance and the overall system's intelligence demanding the average medical user to retrieve, choosing among the available information, the one fitted better in each of the required occasion. Consider the case of issuing a prescription, the medical doctor in the patient's bedside has available the demographic data due to the RFID tag and it remains to choose from a list the appropriate medicine either by its commercial name or its active substances.

Handheld computing devices along with the adoption of RFID applications are capable to affect the acceptance of integrated information systems within the clinical wards. The property of PDA's portability achieves such pervasive results since the mobile computing devices are carried by the medical staff providing critical and vital information when it is needed with a minimal typing effort. At the same time, patients and selected objects, automatically, self introduce their identities to the PDAs and consequently to the local IS whenever it is required eliminating the cases of reproducing the same information many times as the patients moves from one department to the other. Also, a number of beneficial side effects take place observing advancement in the reliability of the medical archives, cost and time saving from typing, leveling up of the quality of the clinical medical services allowing the medical staff to spend more time with the patients, and eliminating the repetition of already available information. On the other hand, a number of issues is raised concerning the re-engineering of the available IS procedures, the current legislation to comply with the new practice, and the installation of wireless sensors' network. These considerations are endless and find the technology's evolvement and its achievements as constraints during their adoption to the existing Information Systems.

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