

Case Study: Wireless Handheld Application for an Emergency Department

Raj GURURAJAN

Department of Information Systems

University of Southern Queensland

Toowoomba, QLD 4350

ABSTRACT

Healthcare industry in Australian has started using Personal Digital Assistants (PDA) due to the flexibility and ease of use. While certain applications are suitable to PDAs, due to the sensitivity of operations in an emergency department in a hospital, the use of PDAs is not attempted in Western Australian hospitals. In 2002, a team of third year students from Murdoch University, Perth, Western Australia developed a wireless system for the emergency department at St. John of God Health Care (SJOGHC) in Perth. The Centre for Electronic Commerce and Internet Studies (CECIS) at Murdoch University in conjunction with SJOGHC facilitated this project using wireless technology. This paper discusses various engineering issues encountered and how they were resolved.

KEYWORDS

wireless technology, healthcare, technology management

1. INTRODUCTION

Wireless Information Technology is used in healthcare settings due to the flexibility and mobility offered by the technology (Wisnicki, 2002). Wireless technology includes the concept of mobile computing, which consists of portable devices that can connect to traditional networks without the utilisation of cables (Simpson, 1996). In healthcare settings, this technology can be used to access data about a patient, to enter certain predefined terms in order to process billing details or to capture patient data at the point of entry. Common to all these activities is the transmission of data from a mobile device at the point of entry to an existing legacy system commonly found in healthcare settings (Stevenson, 2001).

Current healthcare systems, due to the ever increasing costs and due to the complexities in managing the patient data and associated information such as billing and pharmaceutical information, are not functioning at their expected level (Davis, 2002). This has resulted in compromising the level of service provided to the customers. While it can be argued that these problems can be sorted out with proper integration and access to systems (Craig & Julta, 2001), it is also possible to argue that the wireless technology will be able to provide better access to data from anywhere at any time (Stuart & Bawany, 2001). This notion has prompted healthcare organisations to consider wireless devices in their overall information technology development (Zhu et al., 2005).

The need for wireless technology in healthcare may be justified as a solution to the financial crisis encountered in many healthcare systems (Davis, 2002); to address the increasingly complex information challenges (Yacano, 2002); to reduce the medication errors (Turisco, 2000); to generate affordable healthcare applications that allow for greater mobility and in retrieving data (Athey & Stern, 2002). However, not all problems encountered in healthcare can be solved using wireless technology (Wisnicki, 2002) as these devices are still in their infancy stages and slower in speed compared with the desktop computers (Shah, 2001), high costs to initially set up these may be warranted (Shroeder, 1999), lack of real time connectivity

due to the mobility of the device (Stevenson, 2001), the size of the screen (Rogoski, 2005) and hence the problems that may be encountered to display data (Toms, 2000), little or no provision for high quality graphic display (Atwal, 2001) and hard-to-see display (Bevan, 2001). Therefore, any design should consider these issues prior to the development of a solution. The following sections describe how a wireless system using a hand held device was developed for SJOGHC by a team of students and how a number of engineering issues were resolved.

2. GENERAL NATURE OF EMERGENCY DEPARTMENT IN A HOSPITAL

Emergency department in a hospital is an area filled with time critical activities such as administering procedures for a heart attack. This department needs to capture patient data as soon as the patient is brought into the department, mostly by ambulances. The data capture should be accurate, precise and concise in order to comprehend the problems and prescribe the right initial and immediate treatment to patients (Wisnicki, 2002). In essence, the data capture procedures should be accurate, fast, timely and useful. While a number of common entities such as experienced staff is found in healthcare settings, due to the increasing cost in providing healthcare services to public, these common entities are stretched to their maximum and almost in the verge of a major collapse (Davis, 2002). In order to minimise the burden felt on these entities, wireless technology may be considered in healthcare settings.

Wireless technology comprises a combination of applications, handheld end-user devices, and new wireless network infrastructures that support the transport of information to and from the handheld devices (Simpson, 1996). There are two basic approaches to wireless networks, each using a different base technology. One is used to create a wireless LAN (Stowe, 2000), and the other to establish wireless connectivity to the Internet (Stuart & Bawany, 2001). The latter infrastructure also is referred to as a wireless Web, wireless telecommunications, or a wireless wide-area network (Turisco, 2000; Yacano, 2002). Both infrastructures are accessed by means of a portable, mobile-computing device such as a PDA. Current mobile-computing applications of relevance to healthcare organizations include alert messaging (Wisnicki, 2002), capturing time sensitive data (Shah, 2001), decision-support to applications (Simpson, 1996), laboratory reporting (Athey & Stern, 2002), prescription order entry (Stevenson, 2001) and management (Skiba & Cohen, 2000). Although wireless and mobile computing are available now at a basic level, there remain some obstacles to realizing their full potential. Device limitations such as screen size, memory, and storage capabilities dictate the amount and types of data that can be displayed at one time (Shah, 2001). Beyond these device constraints, the two most significant limitations of wireless networks are the slow data transfer rate/speed and the lack of a single connectivity standard that enables devices to communicate with one another and data to be exchanged (Kasper, 1996). The rapid evolution of this wireless technology, and the desire on the part of vendors and standards organizations to address these limitations, however, suggest that it may not be long before these issues are finally resolved. In addition, vendors are likely to introduce many more products, with richer functionality, as the market matures (Smith & Andrews, 2001) and this might warrant advanced thinking as to how to integrate wireless products into an organization's existing IS.

3. OPERATIONAL DIFFICULTIES ENCOUNTERED IN AN EMERGENCY DEPARTMENT AT SJOGHC

SJOGHC is a private healthcare provider in Australia with four major hospitals in Western Australia and the remaining in Victoria. The Emergency Department (ED) is an 'active' department in the hospital system as this is an entry point to some of the critical patients. When patients are brought to the emergency department, staffs in the department assess the conditions of the patients to suggest appropriate treatment. Currently, the patient data are captured using a 'paper' system and then transcribed into a computer. This data then serve the purpose of 'patient record' for various services provided by SJOGHC. While the current manual and semi automated systems are functional in the ED, suggestions have been made for improvement in the recent months due to the difficulties encountered such as real time validation of customer details. One specific area

that needed immediate attention was the billing procedures in the ED. The current manual system is limited in data capturing procedures, as treatment details need to be entered only after the completion of the treatment. Doctors attending to emergency cases may not have time to 'enter' this in the paper system as the 'hands' are occupied in attending to the patients and specific set of codes need to be entered by the doctors. General staff in the ED may not be aware of these codes. Further, standard data such as time and date when the doctor has attended to the treatment need to be entered manually before transcribing to the computer.

While the operational difficulties are beyond the control of an Information Systems area, real time data capture and data validation can be addressed by wireless technology. Wireless information technology has the potential to have a significant effect on the healthcare industry' Physicians, working longer hours and seeing more patients, are demanding a more efficient means to enter and retrieve data (Shah, 2001). Mobile computing applications can offer physicians such a means since they can provide access to critical patient information at the point of care (Skiba & Cohen, 2000). Mobile computing also will simplify data entry and retrieval for nurses (Stevenson, 2001), an important benefit given the current shortage of nurses in Australia. The need for such technology, in SJOGHC, stems from the fact that the hospital system is endeavoured to provide the best service to its patients and doctors. While both physicians and nurses face increasingly complex information challenges in an ED, including more exacting clinical documentation regulations and a need to reduce medication errors, currently SJOGHC doesn't have sufficient IT resources to trial a project of this nature. As a result, while there is pressing need for affordable applications that allow for greater mobility and ease of use in entering, sending, and retrieving data, there appears to be no obvious solution to the problem.

4. WIRELESS TECHNOLOGY SOLUTION TO THE OPERATIONAL DIFFICULTIES ENCOUNTERED IN SJOGHC

A team of third year students in the School of Information Technology undertook the challenge of developing a solution to address some of the problems of the emergency department at SJOGHC. These students worked with the IT team to develop the solution and this ensured the acceptance of the solution by SJOGHC. During our initial discussions, it was decided that the solution would encompass a wireless technology, as this is the strategic direction of SJOGHC. The initial discussions resulted in identifying critical areas of solution direction including easy entry of medical fields based on predefined codes (to avoid any writing). Other aspects pertinent to the development include the generation of patient waiting list, selection of diagnostic items from an existing list of items in order to minimise errors, linking these to payment options for both patients and doctors, real time validation with the main database, provision for information update on the main database by building a middle tier for verification and confirmation, as patients are provided with treatment, details will be updated on the database.

While wireless information technology holds the promise of important benefits for healthcare providers, care must be exercised in identifying the right solution as the devices in this domain are improving and varied (Davis, 2002). It should also be remembered that mobile computing might not solve every problem. As mentioned previously, wireless devices still are limited by slower information-transfer speeds, high initial infrastructure costs and lack of real-time connectivity (Johnson, 2004). In addition, handheld devices have small, hard-to-see display screens and often little or no graphic capabilities. Moreover, many of today's handheld applications are "slimmed down" versions of desktop applications that do not allow data entry into, or full integration with, desktop/server applications.

Therefore, for all of these reasons, it was decided that it may be too soon to begin large-scale implementation of wireless technology at SJOGHC. Further, it appears that only a few mobile computing applications appear to have reached a stage where they can be useful in health care (Athey & Stern, 2002). While it is hoped that the benefits of wireless information technology for health care will begin to outweigh its current limitations (Davis, 2002), any current solution should be initiated as a prototype to establish its adoption at SJOGHC.

A solution to some of the problems encountered by SJOGHC ED should do so based on a clear understanding of business needs and realistic views of what the technology would offer (Craig & Julta, 2001). It should be remembered that not all applications will meet every organization's requirements and therefore prior to the allocation of any major funds, to purchase a wireless technology, healthcare managers

need to consider the application and vendor be carefully evaluated (Atwal, 2001). This is important in two counts: the application, for its long-term appropriateness with respect to the organization's overall care processes; the vendor, for the degree to which its business emphasis corresponds with the needs of the healthcare organization.

It is important to note that the earliest healthcare-related applications primarily targeted non-physician clinical staff in inpatient areas, to facilitate performance of activities such as measurement of vital signs, medication administration, documentation, and data collection (Wisnicki, 2002). Recent trends have focused on designing applications that can also be used by physicians in outpatient settings to improve workflow and increase revenue (Wisnicki, 2002). These applications include wireless charge capturing, prescription ordering, and connections to clinical data and information regarding regulatory and health plan requirements. Nonetheless, many current solution providers are extremely averse to risks associated with adoption of new information technologies, given the huge amount of money they have had to spend on compliance initiatives, as well as on preparations for implementation of prospective payment systems (Davis, 2002). Demonstrated value and the assurance of a return on investment therefore appear to be the major factors that will determine providers' acceptance and use of wireless technology (Dornan, 2001). Many vendors also have adopted marketing tactics to minimize providers' costs (Foong & Desai, 2001). For example, some vendors provide the PDAs and software for free and charge on a per-use basis.

In essence, any proposed wireless solution is expected to provide enormous efficiency gains to the overall IT systems in the hospital setting. Significant improvements include minimisation of errors and time delay encountered between the data capturing and data transmission, easier data entry for nurses during critical operational sequences, and the ability to monitor the patient's health in order to plan for the patient's return to the main ward. Further, because mobile computing frees healthcare professionals from being tied to a desktop, it has the potential to improve workflow and efficiency, allowing clinicians to spend more time providing patient care.

5. SOLUTION USING WIRELESS TECHNOLOGY

The current system is three tiered and uses a web based interface developed using Oracle Forms. Clerical staffs enter data into the system from paper forms used by medical personal treating patients. The middle tier is based on an Oracle 9i AS application server and the database server is running Oracle 8i. Our solution had to integrate with this system. A Java programming language was used as that made it possible to produce a cross platform solution using freely available development software. The solution required the development of two separate applications that communicate with each other, as described below.

The first application was for the handheld device. This application provides a user friendly interface that allows medical staff to select patients from a list of patients currently in the Emergency Department, and then to enter dates and times patients are seen (for treatment) along with details of any treatments or test they had. Once a patient is ready to be discharged from the Emergency Department, whether they are being admitted as an inpatient, transferred to another hospital or going home medical staff may enter discharge details. Data entry associated with all these activities involved selection from a predefined list of items. This solution approached is developed to avoid the problems of typography errors. Once the selection is completed, only a 'one bit' data for the field need to be transmitted to ensure faster transmission rates. The design was such that medical staff do not need to remember every code or item name and replicates the paper form they use presently. At any stage the user may upload the data to the server and select a new patient from the refreshed patient list.

The second application is the middleware on the application server. This consisted of Java Servlets that connect to the handheld and supporting Java classes that processed and validated the data and connect to the existing Oracle 8i database. This approach was implemented as the data residing in the server is ensured of their integrity. Further, due to the critical nature of the ED, it may not be possible to validate all the data. This middleware will hold the data till the data are validated and then transfer them to the server. Both these applications were tested by local healthcare staff for acceptance. The technology acceptance valuation criteria were subsequently produced to the management.

6. SOFTWARE ENGINEERING ASPECTS

User acceptance was extremely important for this project, as without it the medical staffs are unlikely to use the system. This meant that the interface on the handheld had to be as easy to use as the paper form the doctors currently use. Some time was spent in the Emergency Department of SJOG observing and talking to medical and clerical staff to understand various user issues involved. This has resulted in a prototyping of the interfaces, allowing for user input, so that the final solution was acceptable to the Emergency department staff.

The data for the diagnostic items on the handheld is held in one table in the Oracle database. The doctors specifically requested that the items be categorised into lists to match the paper form. There was insufficient data in the database to do this automatically so the items had to be hard coded into the handheld application. This was acceptable to the client because the handheld only stores the name and code for the items and this is rarely changed. The price for each item is stored in a different table in the database and any processing of prices is carried out in the middleware.

The client insisted on using a handheld device running the Palm OS. This meant there were some restrictions on the type of interface and the way data was to be transferred and stored on the handheld. Java 2 Micro Edition was used to develop the application on the handheld. J2ME has limited support for data storage and transport protocols. HTTP protocols were recommended by a number of sources (Yuan & Long, 2002) and were selected for this project. The data were transported in XML format as this allowed for structured data that mirrored the tables in the database to be transported. J2ME does not have built in support for XML so the KXML libraries were added to the project.

The current patient list that is displayed on the handheld requires data from 3 tables. As the processing power on the handheld is limited the data was processed and formatted for display before being sent as a view to the handheld. This has resulted in efficiency and effectiveness.

7. LIMITATIONS

The solution will work with infrared or modem equipped handheld devices. It will also work with a serial cradle connection. The connection protocols would have to be adapted for Bluetooth or 802.11b connections. Due to the small size of the screen it is not possible to display all the patient data in the patient list that is available on the main screen in the department. While the solution displays a list of current patients in the system all other screens are for data collection only, it does not display any of the diagnostic test results or treatments the patient has already had. However, the solution developed will enable ED staff whether the patient has already been seen by a doctor or nurse.

REFERENCES

- Athey, S., & Stern, S. 2002. The impact of information technology on emergency health care outcomes. *RAND Journal of Economics*, 33(3), 399 - 388.
- Atwal, R. (2001). *The wireless office: Evolution, Revolution or Bust* (No. PCIS-EU-DP-0101): Gartner Research.
- Bevan, N. 2001. International standards for HCI and usability. *International Journal of Human-Computer Studies*, 55, 533-552.
- Craig, J., & Julta, D. 2001. *e-Business Readiness: A Customer Focused Framework*. Boston: Addison Wesley.
- Davis, R. 2002. Pursue front end solutions to revenue problems. *Healthcare Financial Management*, 56(8), 30 - 36.

- Dornan, R. 2001. *The essential guide to wireless communication applications*. Upper Saddle River, NJ: Prentice Hall PTR.
- Foong, K., & Desai, K. (2001). *Wireless Services: India* (Operational Management Report No. DPRO-90802): Gartner.
- Johnson, C. 2004. *Realising value from health technology investments: Improving the selection and delivery of a portfolio of projects*. Paper presented at the HIC 2004, Brisbane, Australia.
- Kasper, C. E. 1996. Personal Digital Assistants and Clinical Practice. *Western Journal of Nursing Research*, 18(6), 717-721.
- Rogoski, R. 2005. Wireless by Design. *Health Management Technology*(January), 1-7.
- Shah, M. 2001. Grassroots Computing: Palmtops in health care. *The Journal of American Medical Association*, 285(13), 1768 - 1769.
- Shroeder, S. 1999. Wired for business. *Risk Management*(March), 12-22.
- Simpson, R. L. 1996. Wireless communications: A new frontier in technology. *Nursing Management*, 27(11), 20-21.
- Skiba, D. J., & Cohen, E. 2000. Case management and technology: a necessary fit for the future. *Nursing Administration Quarterly*, 25(1), 132 - 141.
- Smith, D., & Andrews, W. (2001). *Exploring Instant Messaging*: Gartner Research and Advisory Services.
- Stevenson, S. 2001. Mobile computing places data in the palm of the hand: Devices deliver real-time access to information. *Ophthalmology Times*, 26(4), 15 - 18.
- Stowe, B. 2000. Wireless networking looks attractive, but what about the cost of keeping it secure? *Infoworld*(May), 92.
- Stuart, D., & Bawany, K. (2001). *Wireless Services: United Kingdom* (Operational Management Report No. DPRO-90741): Gartner.
- Toms, G. E. 2000. Understanding and facilitating the browsing of electronic text. *International Journal of Human-Computer Studies*, 52, 423-452.
- Turisco, F. 2000. Mobile computing is next technology frontier for health providers. *Healthcare Financial Management*, 54(11), 78 - 82.
- Wisnicki, H. J. 2002. Wireless networking transforms healthcare: physician's practices better able to handle workflow, increase productivity (The human connection). *Ophthalmology Times*, 27(21), 38 - 41.
- Yacano, F. 2002. Monitoring air quality: handhelds and wireless tools from efficient links. *R & D*, 44(5), 42 - 46.
- Zhu, F., Mutka, M., & Ni, L. 2005. Facilitating secure ad hoc service discovery in public environments. *Journal of Systems and Software*, 76(1), 45-54.