Wireless Solutions Developed for the Australian Healthcare: A Review

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Abstract

Despite the emergence of innovative wireless solutions in healthcare, the current status of Health Information Systems (HIS) is primitive and a myriad of problems have crept into the development of these systems. Gartner research shows that the status of the HIS is about 10 years behind the expectation, and other studies have identified several issues in implementing IT healthcare applications. Wireless technologies and portable computing devices could be put into greater use in healthcare to provide timely and quality care and to remedy some of the organisational problems. In this paper, we present a review of wireless solutions in Australian healthcare. Our study reveals that, despite the sophistication and maturity of the wireless technology, healthcare organisations in Australia are far from deploying enterprise-wide wireless solutions, and this is in part due to complexities in deploying them and associated management problems such as the lack of broader vision and drive and support for new initiatives. We also provide some key recommendations for successful wireless implementation in healthcare.

Index terms – wireless technology, healthcare, m-health, e-health, technology management

1. Introduction

Wireless technology has started making in-roads in healthcare applications due to the mobility and flexibility it offers to healthcare practices. For instance, in Australia, many healthcare providers use PDAs and other hand-held devices that support wireless communications to solve 'local' problems at department or unit level. However, they seem to be ad-hoc solutions and don't address the needs and requirements at the entire organisational level. Examples of these wireless solutions can be found in Fremantle hospital in Perth, Government hospital in Western Sydney and Base hospital in Toowoomba, Queensland. Common driving factors of these and other similar wireless deployments in hospitals were: motivation or interest in addressing user needs at department level, enthusiasm exhibited by IT people working in these hospitals in trialling new technologies, push for innovative solutions to solve current problems, drive by the executive officer to trial innovative solutions (usually read in a magazine while travelling) and to test 'proof of concept'. Despite the fact that these drivers are common to the wireless development in the Australian healthcare, it appears that there is no organisation-wide initiatives and plan to implement wireless healthcare solutions. Several studies

in healthcare, specifically in telehealth, have clearly identified poor or improper management of technology as a major factor contributing to the failure of successful deployment of IT in healthcare.

Studies in telehealth reveal that technical solutions alone will not provide expected benefits. In addition to deploying innovative solutions, providing appropriate access to these new services and actual use of these services are more important [1]. The access includes access by medical practitioners as well as public, both in metropolitan and rural areas. Another study in the area of Internet-based palliative homecare concluded that technology alone will not solve the problems encountered in that domain [2] and proper management of technology is the key to success. For instance, the implementation of a web-based tele-radiology system did not deliver expected results and user input errors and procedural errors were cited as the main reason for its failure [3]. The management's attitude in assuming that hospital users are computer literate was also cited as a major reason of failure. Despite these and other findings, it appears that current implementations of wireless technology have ignored the aspect of user training. This has resulted in users finding these new wireless systems complex to comprehend and use.

While technology advancements provide many new solutions to problems and difficulties encountered in healthcare, proper management is vital for the successful implementation of these solutions. As evidenced by many studies in healthcare and that of the authors of this article [4], management of implementation of solutions appears to be a major concern in healthcare. Following a review of some wireless solutions in Australian healthcare, this paper provides evidence as how the current ad-hoc wireless solutions failed to address management problems and, as a result, failed to fully realise the potential benefits of these solutions, despite the availability of adequate infrastructure.

This paper is structured as follows. Following the introduction, section 2 provides a background on wireless technology and how this technology could be used to address some of the current problems in healthcare. Section 3 outlines some of the wireless technology solutions in Australian healthcare environments. It is followed by an analysis of why these innovative solutions did not provide expected benefits in section 4. Section 5 provides a discussion on what should be done to manage wireless solutions from a techno-management perspective and offers recommendations on successful wireless implementation

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in healthcare. The last section summarises the findings and offer concluding remarks.

2. Wireless technology in healthcare

In this article, wireless information technologies is used as an umbrella term that includes mobile and hand-held computers, personal digital assistant, mobile phones, pagers, wireless computer networks and mobile and wireless communications [4, 5]. They offer greater flexibility and mobility, beside several other benefits [5]. In healthcare settings, wireless technologies could be used to access data about a patient, to enter certain predefined data/information in order to process billing details or to capture patient data at the point of entry. Common to these activities is the ability to access patient information and diagnostic data from a mobile device at point of care anytime and the ability to transmit data to a central repository or to an existing legacy system [6].

Due to the ever-increasing costs and complexities in managing the patient data and associated information such as billing and pharmaceutical information, current healthcare systems are not functioning at the expected levels [7]. This has, in turn, compromised the level of service provided to the healthcare customers' organisations including patients and doctors. While it is possible that these problems can be resolved with proper integration and access to systems [8] using conventional technologies, wireless technology will be able to provide better access to data from anywhere at any time [9]. The benefits of these features have prompted healthcare organisations to consider wireless solutions in their information technology development and deployment.

There are two basic approaches to wireless networks, each using a different base technology. One is used to create a wireless LAN [10], and the other to establish wireless connectivity to the Internet [9]. The latter infrastructure also is referred to as the wireless Web, wireless telecommunications, or a wireless wide-area network [11, 12]. Both infrastructures can be accessed by means of portable, mobile-computing devices such as Web phone, PDA, pocket PC, or a laptop computer. The scope of this paper is limited to the WLAN.

Until recently, most vendors have focused on developing handheld mobile computing applications to support products such as wireless laptops that display data from the legacy information systems and PDAs used to collect patient vital signs. The past year, however, has seen the emergence of micro-Web browsers for handheld devices that can address very specific communication and data needs in addition to exisiting connectivity schemes (eg, writing a prescription using a handheld device that transmits the order via the Internet to the appropriate pharmacy).

Although wireless and mobile computing has made significant progress and is gaining widespread adoption, there are some obstacles to realizing their full potential [13]. Device limitations such as screen size, memory, and storage capabilities constrain the amount and types of data that can be displayed at a time [14]. Further, the most significant limitations of wireless networks are the slow data transfer rate and the lack of a single connectivity standard that enables devices to communicate with one another and to exchange data [15]. Other limitations are: wireless devices are still in their infancy stages and slower in speed compared with the desktop computers [14], high costs to initially set up wireless systems [16], lack of real-time connectivity due to the mobility of the device [6], the size of the screen and hence the problems that may be encountered to display data [17], little or no provision for high quality graphic display [18] and hard-to-see display [19]. These issues appear to be impeding the progress of wireless uptake in hospital settings.

Some of the current mobile computing applications in healthcare organizations are alert messaging [5], capturing time sensitive data [14], decision-support to applications [20], laboratory reporting [21], prescription order entry [6] and management [22].

Alert messaging and communication applications capture clinical alert messages issued by patient monitoring devices or legacy applications, or sent by telephone, and relay the information to the caregivers. These applications also can include two-way response and e-mail capabilities. Charge-capture and coding applications allow entry of diagnostic and procedure codes at the time of the visit [23]. These applications facilitate interactions with legacy systems, allowing a physician to receive information from a legacy scheduling or registration system and to send information to a billing system. Clinical-documentation applications facilitate template- or dictation-based recording of patient visit information. Decision-support applications assist physicians in determining and delivering the correct therapy to patients by providing [23], for example, drug-drug interaction checking, drug-allergy checking, dose checking, and duplicate therapy checking for prescriptions. Laboratory order-entry/results reporting applications facilitate ordering of laboratory or radiological/imaging tests and/or routing of test results for view and sign-off by users [24]. Prescription order-entry applications include a broad range of features, including custom order lists, adverse drug interaction alerts, drug reference information, pre-packaged prescription management, electronic prescription routing, and electronic claims submission.

Vendors are likely to introduce many new products, with richer functionality, as the market matures [25]. Technological advances are helping to simplify the use, increase the coverage area, and reduce the cost of these products, thereby securing greater user acceptance and fuelling development of the next generation of applications [26].

3. The development of wireless solutions in healthcare environment

In many healthcare organisations either PDAs or digital tablets are used for the wireless application as they appear to be the preferred choices [5]. In order to realise efficiency gains in the healthcare settings, three major issues in wireless development need to addressed: (1) appropriate development methodology that enables proper integration of the new wireless solutions with the

existing solutions, (2) data access and communication and synchronisation issues between the mobile devices and existing databases, and (3) suitable user interfaces in order to capture and access data that is accurate and timely.

Studies that examined healthcare wireless development found that the developers had adopted either a rapid prototyping or a waterfall method for development [4]. The design strategy, in projects examined, included top-level architectural issues rather than detailed procedural issues. The prototyping also ensured that the functionality of the system was kept separate from the implementation and the specification was encompassed with the operating environment[28]. Due to the relative newness of the environment - wireless deployment for healthcare - the specifications were kept localised and loosely coupled. This facilitated changes to the coding and module development. Where waterfall model was followed, procedural issues were given importance, followed by data flow considerations in order to realise a detailed design. The waterfall model allowed the sequential development as this was essential to mentally map various activities required to complete the project successfully. This is in conformance with current software engineering practices that recommend combining approaches in order to deliver better solutions and derive benefits of both the approaches.

The access control issues in many wireless developments include data access, validation, verification, data capture and transmission [23]. The data include patient details such as names, specific admission details, details of the doctors and other billing information. Due to the sensitive nature of the applications, many wireless solutions using hand-held devices, do not write or over-write any data that are available on the main healthcare database. Usually an intermediate tier is placed as a holding platform for the data for various purposes. These data are written onto the main database only when all the validations are performed. Data is verified by healthcare staff for accuracy and relevance prior to certifying their accuracy. As the data are written onto an intermediate tier, and not stored on the device, security issues associated with the theft of the wireless device are eliminated in some wireless solutions provided.

Choice of appropriate user interfaces is crucial for the success of wireless applications especially when used by different categories of people [29]. For instance, the wireless solutions are used by nursing staff, visiting consultants, resident doctors, relatives and patients, administrative staff and other management staff for a variety of purposes. Many wireless applications provided data capture in the form of optional buttons and context-sensitive predefined codes so as to enable users just to place a tick or choose an option. Users are provided with data from the main database to minimise any errors and have restrictions on what they could 'write' or input, depending on their level of access.

3.1 Practices and Experiences in Fielding Wireless Applications

While the prototypes were found to be successful in many healthcare solutions, they also posed a number of limitations with regard to the code, integration with existing applications, user interfaces and data transmission [4]. The code was written as generic as possible and parameters were kept as variables to allow flexibility. During real-time testing, some of these parameters caused run time errors, as the compiled code was not able to resolve certain data types prior to the run. This created the necessity to re-visit the code and examine every instances of the run in order to fix the problem. Integration with existing applications caused concern, as the healthcare industry did not have uniformity across all branches - applications developed by the national office followed national standards while local branches followed their own ad-hoc standards. The environment (Java libraries) used for the development was superior to actual (run-time) environment in hospitals and this caused problems while the product was tested in the healthcare setting, as some libraries were not available in the existing environment. These caused minor difficulties while integrating the wireless application with existing applications.

User interface created confusion as a number of staff were used to paper and pencil method [21]. During the testing some staff found the screen of the handheld device was not bright enough and encountered difficulties in reading the fields or forms displayed. The size of the screen of the PDA also prohibited the display of forms in their entirety and this introduced operational difficulties. Memory restrictions on the device also restricted certain operations.

Data transmission issues introduced certain limitations [30]. While the prototype was tested using the infrared technology in a closed environment, the 'line of sight' required by the infrared created some limitations as it was not be possible to guarantee the line of sight always due to the sensitive nature of the emergency department. On the other hand, Bluetooth technology (another wireless technology) did not provide acceptable levels of coverage. It was not be possible to transmit data using wireless technology alone, as some branches of the healthcare were about 400 KM from the national office. These issues are being investigated currently by some healthcare organisations.

3.2 Project Management Issues

Management problems also hindered adoption of solutions in healthcare. For instance, after examining a specific wireless solution in the Australian healthcare, Railsbag [31] questioned the planning methods and concluded that many current installations of wireless solutions in healthcare appear to have had inadequate planning. While this is a major source of failure, he also identified training to users to be a major factor contributing to success. The training management plan is a key factor for proper implementation of wireless in an organisational setting. According to Simpson [13], many studies revealed the lack of an enterprise perspective in wireless deployment, which essential as wireless technology could provide a radical shift in the way enterprise data are managed and accessed. Simpson [13] also warned the initial successes of wireless development in organisations were short-lived because of the lack of enterprise strategy for wireless solutions.

The aspects of management policy to integrate wireless solutions with enterprise systems were studied by [32]. They indicate that while there was support from middle management to the systems developed for the healthcare, there is no explicit reference to an organisational wide deployment of this wireless solution. Johnson [33] provides a comprehensive project management approach to organisations to realise value from technology solutions, subtly indicating the necessity for strong management policies for such development and proper integration and management of new solutions. Crow [34] provides details of a wireless solution developed in a hospital in Melbourne, Australia, and emphasises the need for management of this solution at organisational level, including developing policies and procedures to properly integrate this system with other existing systems.

Management issues of wireless in healthcare in terms of wireless capacity in rural areas, implementation process and methodologies for Quality of Service are highlighted in [35]. Specific issues relating to infrastructure were also addressed by prior studies in terms of growth and hence revenue prediction. A major criticism in this area appears to be the lack of knowledge by developers in terms of available technologies and proper planning of the development and deployment.

Recent studies indicate that while the technology infrastructure is available, management directive is still evolving in healthcare to integrate wireless solutions to realise benefits at enterprise level. The wireless solution provided to Australian healthcare addressed mainly software issues and limited organisational need. The solutions did not consider organisation-wide deployment and did not address policies at organisational level. It appears that the solutions were short-term fixes to existing problems and wireless technology was used as a trial.

4. Failure to provide expected benefits

We examined three wireless solutions/projects in Australian Healthcare to study the approach followed for their development and whether they provided expected or full benefits. As discussed below, the development approaches were ad hoc and had several limitations, and perhaps as a result, these projects didn't yield the full benefits.

A trial project [32] in Tasmania, Australia, addressed data capturing needs using PDAs. It, however, did not follow project management techniques, software development techniques, security and privacy issues, cost benefit analysis, software testing and software management. The implication of the development was that the wireless infrastructure was available with in the organisational context and hence a solution could be developed. The development team did not study the problem to establish that wireless was the solution for the problems encountered in data capture and did not provide any cost-benefit analysis of the new solution. Therefore, it is not possible to ascertain whether the new solution was superior in terms of performance, cost etc. While it is necessary to assess the demand, choose a

relevant solution, manage the solution at enterprise level in order to reap benefits of wireless technology, the solution provided by [32] did not follow these guidelines. Therefore, it should be assumed that the wireless solution, even though it met the objectives of the development, did not address the management principles and may not sustain in the long run. Further, this solution is not expected to provide organisational-wide benefits because the solution did not consider any of the organisational objectives.

Rao [34] had documented process by which a solution was provided. The wireless system, while addressed the user needs, did not incorporate any management practices that are essential at an enterprise level. For instance, users were able to access this wireless system from areas beyond the emergency department, where the system was expected to function. This immediately opened up issues associated with security and privacy of patient data. Further, there is no evidence to suggest that a proper cost-benefit analysis was conducted to demonstrate the wireless system is a better and a right solution. The change management was not included in the total design. While the software specifications were achieved to the satisfaction of the users, the management model was not considered in this development. Therefore, at enterprise level, this system is not known and hence considered to be not available. This leads to conclusion that this wireless solution did not provide expected or full benefits at organisational level. What is important to note is that it focused on provision or availability of infrastructure for wireless development and considered only the technical aspects, not the management aspects.

The wireless development project at the emergency department in Western Sydney [36] measured communication efficiency in terms of speed and reported satisfaction from users on this aspect. It met the objectives of the software development, as in other projects discussed above. It considered wireless infrastructure issues and developed a wireless local area network. This infrastructure was further linked with an innovative speech recognition system in conjunction with the local switchboard. Despite the clever use of wireless infrastructure, the project did not address change management, reduction in data error and other common themes identified in the healthcare literature. Further, the data that emerged from the wireless network was restricted to the emergency department and how this data were further integrated with the organisational database was not clear. The project did not state whether the wireless development was initiated by the management, and whether the project would be extended to other departments. Considering that there is no clear evidence as to the expansion of the wireless project to other sections of the organisations, one would assume that the project was a stand alone activity and did not address management objectives at the organisational level. Therefore, organisational wide problems could have not been addressed in this project.

As highlighted by Gururajan [4], the wireless solutions provided to both public and private hospitals while addressed data management issues, did not address

management difficulties encountered. The projects, while meeting the software development objectives as dictated by the users, did not address many of the management concerns which include: error in data capture, delayed billing cycles, work scheduling, data integration at organisational level, efficiency gains, Quality of Service (QoL) and mobility.

Thus, it appears that these wireless technology solutions in the Australian healthcare sector were developed without proper understanding the organisational level management issues. In the projects examined, the data/information security and privacy concerns were seldom addressed in detail. The data integration issues, integration of data from mobile wireless devices with existing organisational data, were not addressed. Further, the study shows the lack of project planning, cost issue discussion, demonstration of benefits to organisation as a result of wireless implementation and the change management plan in most of these projects. The healthcare issues that were identified in the literature and how wireless technology might offer solutions to address these issues were not give due consideration in all of these projects.

Based on the examination of current literature and the wireless projects developed in Australian healthcare, it could be concluded that the solutions were provided because of the enthusiasm of the technical and clinical people to resolve some of the local issues. These solutions appeared to be successful due to the relatively affordable cost at department level and the local expertise available within the department. While management appears to have supported these projects, there was no evidence that these projects were driven by management objectives. Therefore, these projects may be seen as answers short-term fixes to current problems supported by the availability of wireless infrastructure without proper consideration to management objectives and issues at organisational level.

In summary, the wireless solutions examined in study were developed by IT people and most of them appear to be initiated by senior clinical staff and not by the management. All the solutions were developed for an individual entity in an organisation such as the emergency department, as an ad-hoc solution without properly integrating the solution with organisational wide data. Many of them did not address organisational data issues concerned with security and privacy issues. Almost none of them addressed the privacy principles as mandated by the Health Department. Most of the solutions were 'proof of concept' without clearly thinking through how to progress the development further. All of them started without proper planning and none of them incorporated project management techniques at professional level. Many of the solutions provided a detailed cost benefit analysis.

5. Managing wireless solutions: A techno-management Perspective

Given that the wireless projects examined did not realise the expected benefits and failed to address

management and other issues, what could be done to resolve these and successfully manage development and deployment of wireless solutions in healthcare? We suggest a broad framework for deployment of wireless solutions in healthcare environment.

Any wireless deployment at organisational level should consider limitations of the hardware including network infrastructure, proper software architecture designs that can bind existing data model with the new wireless systems, user interfaces to accommodate different types of users, configuration of the wireless LAN, IP address assignment issues arising from the dynamic and mobile nature of users, security features of both data and network, authentication methods as users may use different types of devices and hence varied types of addresses, file sharing procedures as data can emerge from any mobile device including graphics and sound files, performance issues as wireless can become unreliable in certain conditions such as stormy weather, training as users may not be familiar with new devices and their functional elements and finally cost issues.

The development of wireless solutions calls for consideration to technical and management aspects and issues. However, the current projects, sadly, are developed to address some compartmental issues without a long-term view and hence fail to provide benefits to the organisation. Proper deployment of wireless solutions calls for an organisational-wide plan as it will affect the entire organisation. While detailed description of a plan or how to implement a plan is beyond the scope of this paper, the following recommendations would serve a starter:

Evaluate organisational needs: First, establish user needs in order to provide wireless solution. If a simple solution without wireless can be provided, go ahead with it. If wireless is a better solution, then study the impact of adding wireless to the organisational IT needs - once the wireless solution is provided, it may be difficult to remove it as users will demand more of it.

Plan organisational wireless needs: Evaluate the type of wireless technology that is most suitable to the organisational needs as this is when the cost figures will compound the problems. Also consider the long term sustainability of the chosen wireless technology in the organisation.

Plan a trial wireless rollout: Have a conceptual model to start with, develop a solution and trial it out before any big scale deployment.

Test the wireless implementation at enterprise level: Testing at organisational level is crucial, and unit level testing is not adequate, to reveal problems at the system/organisational level For instance, some wireless system did not function well when tested at another branch because the conditions were different in that branch due to State legislations [4].

Train users: User training is crucial as wireless interfaces may differ from traditional desktop computers and users may be confused with new interfaces. Further, paramedical staff appears to be intimidated by new technology.

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Implement a production rollout: This is the stage when all components of the wireless systems at organisational level are implemented at the same time. It is essential to integrate all systems at some point of time to change over from existing systems to wireless systems and the overall changeover may bring out some unexpected problems. One such problem can be traffic load. These issues should be considered well in advance and addressed.

Plan ongoing maintenance: Ongoing maintenance is crucial in wireless implementation for many reasons. For example, users outside the organisation may use different hardware and software platforms and it may be necessary for the organisation to provide support to these users. Devices need to be upgraded to meet industry standards. Security protocols may need upgrades. These are challenges to organisations and should be well thought about prior to full implementation.

6. Conclusions

This paper examined wireless solutions developed for three Australian healthcare providers and found that while these developments achieved their software development objectives, failed to address the acute issues of healthcare management in Australia. The wireless technology, which is hailed as the solution to some of the problems facing the healthcare industry, is implemented to address some local issues but not organisational issues. Therefore, it can be stated that despite the success of these wireless solutions, the management problems are not yet addressed by these solutions in a comprehensive manner. Further, The developments did not detail how the data emerging from the wireless solutions will be integrated with existing data, and how the change management practices will be implemented. As a result, the wireless solutions in these Australian healthcare organisations did not realise major gains. The paper provided recommendations to address these issues and to realise the potential benefits of wireless technology in healthcare. It is hoped that this paper helps developers and managers recognise and understand, as well as address these problems for the benefits of all - the organisation, patients and healthcare providers.

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