

## IMPACT OF MOBILE AND WIRELESS TECHNOLOGY ON HEALTHCARE DELIVERY SERVICES

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### **Abstract**

*Modern healthcare delivery services embrace the use of leading edge technologies and new scientific discoveries to enable better cures for diseases and better means to enable early detection of most life-threatening diseases. The healthcare industry is finding itself in a state of turbulence and flux. The major innovations lie with the use of information technologies and particularly, the adoption of mobile and wireless applications in healthcare delivery [1]. Wireless devices are becoming increasingly popular across the healthcare field, enabling caregivers to review patient records and test results, enter diagnosis information during patient visits and consult drug formularies, all without the need for a wired network connection [2]. A pioneering medical-grade, wireless infrastructure supports complete mobility throughout the full continuum of healthcare delivery. It facilitates the accurate collection and the immediate dissemination of patient information to physicians and other healthcare care professionals at the time of clinical decision-making, thereby ensuring timely, safe, and effective patient care. This paper investigates the wireless technologies that can be used for medical applications, and the effectiveness of such wireless solutions in a healthcare environment. It discusses challenges encountered; and concludes by providing recommendations on policies and standards for the use of such technologies within hospitals.*

**Keywords:** healthcare, mobile/wireless solutions, mobile architecture, healthcare portal, 3G Medicine

### **1. INTRODUCTION**

Healthcare is prominent throughout the world. It represents a significant percentage of many countries' GDP and is growing steadily. But the increasing demands on healthcare systems are too often accompanied by shortages in clinical staff. Mobile technology and WLAN solutions promise to transform the healthcare industry. Patient-centered care, e-pharmacy, asset tracking, mobile voice and rich media systems are just a few of the solutions that are enabled by WLAN technology. Healthcare is one of the few verticals aggressively developing and extending applications and business processes to the WLAN, making the industry a hotbed of WLAN innovation [3]. In one perspective, the significant advancement and proliferation of wireless data technologies create entirely new areas of applications. Of particular importance is the potential impact of next generation wireless technologies on healthcare delivery. The major challenges of healthcare management in the 21st century include the commonalties of a global and apparent terminal malady of exponentially increasing costs, an informed and empowered consumer, the need for e-healthcare adaptability, and a shift from focusing on primarily curing to the prevention of

diseases [1]. These technologies provide a variety of opportunities to address public healthcare challenges such as universal access for the uneducated, counter-bioterrorism, telemedicine, distance education, and home care. These opportunities present new challenges such as: surveillance, privacy/confidentiality/security of personal information which will affect all of our lives [4]. One of the advanced information technology solutions gaining popularity is the wireless access to patient records and other healthcare services. This really is the third generation of wireless in healthcare. Doctors and other healthcare professionals have progressed from pagers to basic cell phones and now to data-enabled "smartphones". Physicians have been trading in their old, disconnected PDAs for modern PDA smartphones with cellular integration and built-in Wi-Fi and Bluetooth wireless functionality for use within the clinical environment [5].

It has become necessary to evaluate performance of protocols for wireless medical devices in clinical environments to achieve improvement in the safety and efficiency of medical device wireless communication and operation. Nowadays healthcare providers such as doctors and nurses can directly communicate with one another via wireless infrared beaming in their PDAs. In particular, modern healthcare institutions can benefit from more extensive use of mobile devices for pervasive and ubiquitous access to healthcare information systems to deliver healthcare services, such as general surgery and emergency services [6]. With a large mobile population of doctors, nurses, physician's assistants and other caregivers, wireless LANs bring the ability to access the latest patient charts, medical records and clinical decision-support data at all times, anywhere in the healthcare organization. And as caregivers travel among different facilities, wireless network allows for easy connectivity at each site [7].

## **2.0 TECHNOLOGY AND HEALTHCARE SERVICES**

### **2.1 Handheld Devices, Wireless Communications, and Real-Time Clinical Information Systems**

Handheld portable computing devices promise to be strong catalysts in bringing the full power of information technology to the **point-of-care**. Personal digital assistant-type devices can significantly increase caregiver productivity and efficiency while preventing errors. These devices can be supported by wireless network and/or speech recognition Web-based and/or electronic data interchange (EDI) connectivity with all major suppliers to provide a more natural, easy-to-use interface for the clinician. In addition, they combine multiple functions (address book, scheduler, note pad, email, calculators, scanners, etc.) thus eliminating the need for multiple devices. A physician could access his or her patient schedule; document the clinical visit; order laboratory test, imaging, and medications; and generate data for billing purposes all from a single handheld wireless interface device. In the nearest future, the availability of ubiquitous, reliable wireless connectivity will provide anytime, anywhere access to information and messaging through highly portable or even wearable systems with speech interfaces and natural language command and control. In addition, cell phone-like devices for accessing the Web are poised to revolutionize Internet use. The use of point-of-care decision support will leapfrog physicians' and hospitals' efforts to improve patients' safety and reduce the occurrence of medical errors [8]. Mobile devices are becoming increasingly popular across the healthcare field, enabling caregivers to review patient records and test results, access charge captures, enter diagnosis information during patient visits and consult drug formularies. Reduced medical errors, elimination of duplicate entries, increased accuracy of data, improved patient care, provision of the most up-to-date patient information available and the ability to update this information, and decreased operating costs are some of the benefits [2].

## **2.2. Mobile telemedicine**

Pervasive healthcare has the potential to reduce long-term costs and improve quality of service, but it also faces many technical and administrative obstacles. Unique capabilities of emerging mobile device, wireless networks and middleware technologies can support a wide range of applications and services including mobile telemedicine, patient monitoring, location-based medical services, emergency response and management, pervasive access to medical data, personalized monitoring, and lifestyle incentive management.

## **2.3. Patient monitoring**

Wireless LANs and personal area networks make it possible to continually monitor patients almost anywhere and immediately notify healthcare workers, the nearest hospital, or an emergency service of any critical change in status. Such networks can quickly route biomedical and environmental data from sensors deployed on the body, in a room, or throughout a building to a central computer system for processing [9]. Wireless technology enables ambulance personnel to send real-time data about a patient's condition to a hospital while en route.

## **2.4. Maturing Telemedicine Technologies**

Maturing telemedicine technologies, struggling mobile networking revenues and increased personal healthcare awareness have provided the foundations for a new market niche for '3G Medicine'. During the last 5 years, telemedicine (based on internet and web technologies) is becoming a reality both in terms of developing technologies and supportive legislation. Within Europe, wireless infrastructures (3G Networking) has received a huge investment and although not well defined on how it would be achieved, healthcare has been identified as a major stream of revenue with personal healthcare being a key issue especially for the handset manufacturers. Combined with an increased awareness, not only for outpatients but also for the "well-worried" (healthy and health conscious), 3G Medicine Services will play an important role in personal healthcare management [10]. Wireless telemedicine is a new and evolving area in telemedical and telecare systems. Healthcare personnel require realtime access to accurate patient data, including clinical histories, treatments, medication, tests, laboratory results and insurance information. With large-scale wireless networks and mobile computing solutions, such as cellular 3G, Wi-Fi mesh and WiMAX, healthcare personnel can tap into vital information anywhere and any time within the healthcare networks. The recent introduction of pervasive computing, consisting of radio frequency identification (RFID), Bluetooth, ZigBee, and wireless sensor networks, further extends the potential for exploitation of wireless telecommunications and its integration into new mobile healthcare delivery systems [11].

# **3. ADOPTING WIRELESS SOLUTIONS IN HOSPITALS**

## **3.1 Wireless Technology and Medical Applications**

Healthcare providers look up to wireless solutions for a variety of reasons. Among the desired goals are reduced risk when monitoring patients, better patient outcomes, increased staff efficiency and continuity of care, improved response time, decreased costs associated with the care process, and compliance with government regulations and standards. Another goal is to reduce the cost and complexity of network management by leveraging existing wireless infrastructures and by deploying clinical and other value-added applications [12]. Point-of-care applications offer tremendous potential for today's healthcare industry as they enable healthcare providers to deliver service when and where it is needed, while still providing timely and secure access to all the critical information

required. A wide variety of healthcare applications with industry-leading mobile and wireless technologies provide solutions such as:

- **Mobile Care Delivery:** Record patient information at the point-of-care; Gather patient history; Monitor vital signs; and Ambulatory care.
- **Physician's Orders and Results:** Prescription writing; Drug administration monitoring; Drug interaction monitoring; Laboratory specimen collection; Track samples from bedside to lab; Review test results; and Charge capture.
- **Intelligent Devices:** Diagnostic Devices; Kidney dialysis, anesthesia delivery; Patient monitoring; Blood glucose monitoring; Medication dispensing devices; and Home disease management.
- **Sales Force Automation:** Pharmaceutical sales; and Medical equipment sales.

Bluetooth technology has become a wireless technology well suited to use in battery-powered commercial electronic devices, such as PDAs, cell phones, and a variety of other mass-produced electronics [9].

### **3.2. Wireless Patient Monitoring**

As hospitals deploy mobile applications to improve operational efficiency, wireless networks will be installed initially for high patient throughput areas, including emergency rooms, critical care wards and nursing care floors. Today, the adoption of wireless standards such as IEEE 802.11b/g (also known as Wireless Fidelity or “Wi-Fi”), and the use of mobile computing platforms form the basis of this wireless revolution. At the same time, clinical caregivers want to do more on a mobile basis and have grown accustomed to receiving information in real time via cell phones, pagers and PDAs. These factors have converged and are providing the impetus for a wide acceptance of wireless technologies within the healthcare industry [13].

## **4.0. CRITICAL WIRELESS INFRASTRUCTURE’S VULNERABILITIES**

### **4.1. Access Point (AP) Vulnerabilities and Mobile Trust Model**

Software that runs critical wireless infrastructure can suffer from vulnerabilities just like any complex system - often with devastating effects. A single vulnerability may compromise a host or a group of hosts, but a vulnerability in an infrastructure device can lead to much more damaging effects. Many access point (AP) vulnerabilities are caused by problems with the access points' administrative interfaces. A great way to protect yourself from vulnerabilities that might crop up is to disable access to APs on the wireless side and employ packet filtering on the wired side to limit access to a few select management workstations[14]. The movement towards Web-based services, and the increasing dependency on the Web have also made reliability a first-rate security concern. From malware and spyware, drive-by downloads, typo squatting, denial-of-service attacks, to phishing and identity theft, a variety of threats make the Web an increasingly hostile and dangerous environment. By undermining user trust, these problems are hampering commerce and the growth of online communities [15]. Given that systems will be transmitting highly sensitive information namely patient data, implicit in their use is a need for high level of end-to-end security, confidentiality and privacy. Mobile trust model can be incorporated into any wireless healthcare initiative that will enable healthcare organizations to meet the necessary security standards. By utilizing a well designed trust model in the structuring of a mobile or wireless initiative, it will only then be possible for these organizations to maximize the benefits from wireless technologies as well as minimizing their risks; thereby, enabling the benefits of cost- effective, quality-healthcare to those who are most critical; namely the patient [16].

## **4.2. Wireless sensor networks in healthcare applications**

With the proliferation of handheld and mobile computing devices, it is important for management and information security leaders to be aware of the overriding security issues that accompany the use of these devices, and to ensure the users of these devices use them in a secure, and approved, manner [17]. Moving to a fully pervasive system would be a complex transition requiring several steps and incremental budgetary increases to create the necessary infrastructure [9]. The flexibility and richness of the Web architecture have come at the price of increasing complexity and lack of sound overall security architecture. The emergence of wireless sensor networks (WSNs) in healthcare applications is gaining momentum through the increasing array of wearable vital sign sensors and location tags which can track both healthcare personnel and patient status/ location continuously in real-time mode. Generally, WSN devices are extremely limited in terms of power, computation, and communication. They are often deployed in accessible areas, thus increasing security vulnerabilities. The dynamic ad hoc topology, multicast transmission, location awareness, critical data prioritisation, and co-ordination of diverse sensors of healthcare applications further exacerbate the security challenges [18].

## **5.0. EFFECTIVENESS OF WIRELESS HEALTHCARE SOLUTIONS**

### **5.1. Security with Trust**

The effectiveness of wireless healthcare solutions will be a function of security with trust and the appropriateness of the wireless trust model to a particular healthcare environment. Mobile healthcare needs security. In other words, wireless trust environment closely relates to individual intention to adopt wireless technology. Mobile healthcare security embraces confidentiality, authentication, and message integrity, and must also be seen in the broader context of e-healthcare systems. Since mobile devices can be lost or stolen more easily than their fixed counterparts and a guaranteed physical protection of mobile devices such as PDAs is not very practical, a systemic solution is needed to establish identity of the provider even if the provider is using a preauthorized device. A provider who is interested in engaging in a trusted transaction needs to meet two tests irrespective of access location: (1) The provider must be able to identify his or her identity; and (2) The provider must be able to demonstrate the ownership of the mobile device being used for the transaction. Mobile devices carry hardware-based Subscriber Identification Modules (SIM) that can be used to authenticate the device [16]. End-to-end security of a mobile transaction requires intervention at multiple points since none of the individual technologies and devices offer a complete security solution.

### **5.2. Protecting patient confidentiality**

While the promise of better healthcare through better access to medical records is beguiling, it also creates a new layer of responsibility for physicians. When it comes to technology, it is imperative that physicians use only those devices that employ the very highest standards of security available. Privacy and security are also potential problems. Healthcare data should be available anytime anywhere, but only to authorized persons. Confidentiality in a mobile transaction is possible if the content of the transaction can be protected through end-to-end encryption. Not only the content must be encrypted in the mobile device itself, it must be transmitted in an encrypted form to the hospital's application gateway and vice versa. This requirement should not be confused with the radio path encryption since the content of a transaction uses media beyond the radio path [19]. Pervasive healthcare information could be abused by corporations in deciding who should



be promoted, by insurance companies in refusing coverage for people with poor health, and by spouses and their attorneys in divorce cases. The large-scale introduction of wireless technology in healthcare has legal and regulatory implications [9].

### 5.3 PROPOSED SYSTEM FOR HEALTHCARE SERVICES

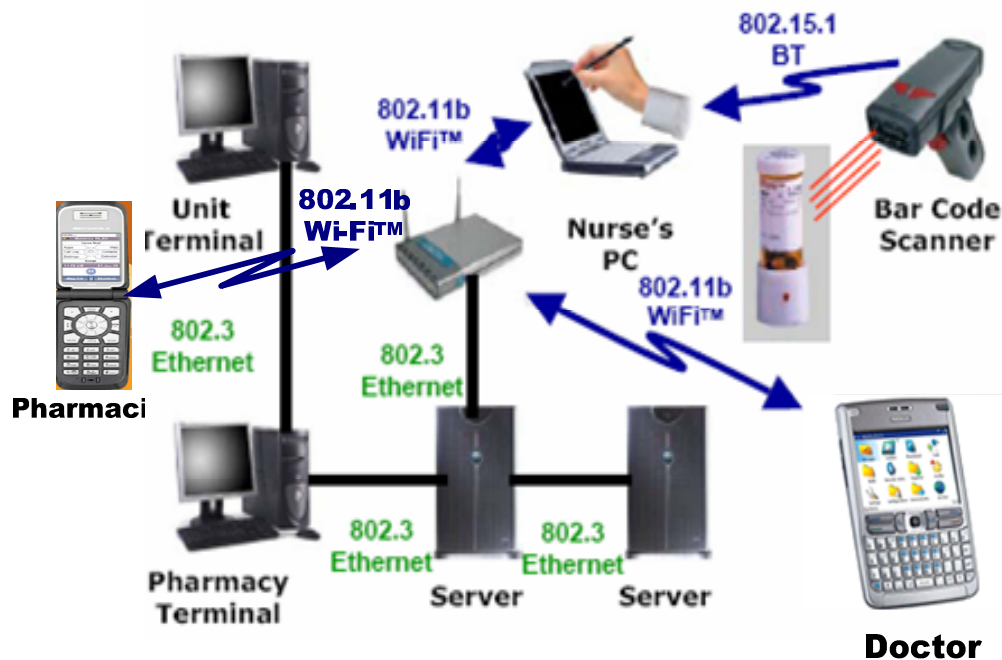


Figure 1 Wired/Wireless System for Healthcare Delivery Services

The IEEE standard 802.16, also known as Worldwide Interoperability for Microwave Access (WiMAX), is viewed as a powerful enabler for the massive deployment of high performance metropolitan area networks. Medication errors are the most significant and pervasive result of patient mis-identification. Poor patient identification can seriously affect the health of patients, as well as hospital bottom line. Patient identification problems in hospitals are particularly distressing because most of them do not have to happen. Using bar codes or RFID technology for positive patient identification is the fastest, easiest way to ensure accuracy in labeling drugs and patient samples, preparation and distribution of prescriptions, and administering correct medication dosages. The 802.11b standard is the first standard to make WLANs usable in the general workplace by providing robust and reliable 11 Mbps performance, five times faster than the original standard. Pharmacists can send prescription requests without the need to return to the dispensing department and doctors can sign patient prescriptions remotely. Surgeons can plan operation schedules and resources directly as a result of a consultation, allowing them to spend more time on operations, rather than administration. From the theatre itself, a timetable can be generated, and the required nurses, anaesthetists, and equipment sourced instantly, something that traditionally requires a lot of phone calls and meetings to co-ordinate [20].

## 6.0 CONCLUSION

Healthcare requires a new way to manage current challenges and to provide cost-effective quality care to all. Wireless technologies can reduce medical costs and improve quality of service. Provision of seamless mobility and connectivity to patients and frontline caregivers across the continuum of care through wireless patient wearable vital signs monitors, productivity tools, IP phones, PDAs, seamless enterprise coverage, robust fault tolerant WLANs, and integration of biomedical and IT systems on a single network infrastructure, conventional Telemetry and New Telemetry Offerings, Communications

systems (Paging, In-building phones, Asset tracking), and Standards: 802.11 constitutes the Wireless Networks Solution offering the required comfort on the impact of mobile and wireless technologies on healthcare services delivery.

In this paper, numerous benefits have been highlighted with the adoption of wireless technologies in healthcare delivery. The adoption of wireless standards (e.g. IEEE 802.11b/g); use of mobile computing platforms; access to information in realtime via cell phones, pagers, and PDAs through availability of ubiquitous, reliable wireless connectivity; have demonstrated the suitability and wide acceptance of wireless technologies in healthcare. One major obstacle in mobile adoption of and development in healthcare is trust as there is a need for high level of end-to-end security, confidentiality, and privacy. The security gap existing between wireless sensor networks (WSN) and the requirements of medical applications needs to be resolved. On-demand encryption of wireless and communication protocols used to connect a mobile device to a base station offers a partial solution. A comprehensive security strategy that guarantees confidentiality, authenticity, content integrity, and nonrepudiability must be put in place to combat the vulnerabilities of wireless technologies in healthcare.

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