UNIVERSITY OF MAURITIUS RESEARCH JOURNAL – Volume 15 – 2009
University of Mauritius, Réduit, Mauritius

Research Week 2007

Pervasive Electronic Medical Record

Lolldeo Koossool
C-DAC School of Advanced Computing, University of Mauritius
Email: vineshk12@yahoo.co.uk

Yuvraj Ghura
C-DAC School of Advanced Computing, University of Mauritius
Email : yuvrajghura@yahoo.com

Paramasiven Appavoo
C-DAC School of Advanced Computing, UoM
Email: vara@csac.mu

Paper Accepted on 09 February 2009

Abstract

Everybody knows the significance of the golden-hour after which the majority of emergency cases are fatal. Besides, technologies like m-health and ubiquitous computing are emerging to enable the provision of a pervasive health care. In this paper, we propose PEMR, Pervasive Electronic Medical Record, which is a mix blend of disciplines like computational science, medical observation, record-keeping and security. In the proposed architecture, Radio Frequency IDentification (RFID) and wireless LAN will underpin the smooth running of the operations. PEMR will mitigate the grief and stress of both patients and physicians in emergency environment by maintaining the required information as patients are transported. The patient's information can also be sent to the hospital by radio link using General Packet Radio Service (GPRS) for recommendations from specialists. Wireless networks ease access to the latest patient medical records and clinical decision support data at all times, anywhere inside the healthcare organization. Moreover, medical data can be accessed using either Internet to a platform independent web service connected to database of medical records or Worldwide Interoperability for Microwave Access (WiMAX) technology whenever connection to an existing cellular network is unavailable. Apart from the designed architecture, this paper also highlights the challenges and implementation issues in PEMR.

Keywords: Pervasive medical records, telemedicine, security, wireless network

**For correspondences and reprints*

1. INTRODUCTION

All societies have undergone an irreversible radical change with the Information and Communication Technology during the past decade. Communication is in fact the basis for the smooth running of emergency operations and can at the same time mitigate the stressing environment of rescue or law enforcement. Timely access to the required information may be vital during the critical mission of emergency rescue.

Wireless communications have become very pervasive. However, wireless technologies are still in their infancy. When it comes to wireless hospitals, J. Morrissey of Motorola (2007) said that despite the proliferation of wireless networks like Wi-Fi (Wireless Fidelity), ZigBee and Bluetooth in hospitals, he is still wondering if wireless transport will be as reliable or predictable as the traditional wired network

PEMR is a sub-set of healthcare organization actual medical record, which is maintained in an electronic record format shared by a large mobile population of doctors, nurses, physician's assistants, emergency medical technicians and other caregivers. PEMR, a platform-independent solution, integrates RFID and other wireless networks to provide the required infrastructure for transmitting critical medical information anywhere and anytime using either existing network or ad hoc network. It also has the potential to reduce long-term costs and improve quality of healthcare service. This architecture will underpin a wide range of medical applications and services on emergency sites and hospitals.

2. RELATED WORK

Many researches are being done to realise the benefits of wired and wireless communication technologies in the medical world. The E-Health architecture proposed by Sharma et al. (2006) allows access to a multitude of electronic medical services from different sources via a distributed e-health portal. Von Lubitz et al. (2006) proposed a multidimensional communications network, World Healthcare Information Grid (WHIG). WHIG allows data/information collected from a wide range of sensors (that includes scientists, research labs, hospital, databank, etc.) to be accessible via an E-portal. Upkar Varshney et al. (2003) shows how wireless networks is used to improve communication among medical staffs and patients by providing accurate medical information anytime and anywhere. It also shows the use of advance wireless technologies, such as intelligent mobile devices and wearable networks in a pervasive healthcare environment. David Malan et al. (2004) proposed the Code blue architecture which allows wireless monitoring and tracking of patients and first responders using sensor nodes and other wireless devices in a disaster response setting and providing facilities for ad hoc network formation. MET (Mobile Emergency Triage) System, proposed by Wojtek Michalowski et al. (2004), is used by physicians in the Emergency Department to use a system that supports emergency triage of various types of acute pain at the point of care through the use of handheld computers. Shang-Wei Wang et al. (2006) showed the potential of RFID applications in a

Taiwan hospital in not only reducing operating costs but also in improving medical services and patient safety.

Moreover, for the assessment of a country's or region's e-health potential, Wickramasinghe et al. (2005) has put forward a framework, with four main pillars, namely (1) Information Communication Technology Architecture/Infrastructure, (2) Standardised procedures, protocols and policies, (3) User access and accessibility policies and infrastructure and (4) governmental regulations and roles.

3. PEMR

The aim of PEMR is to mitigate the stress of patients, paramedics, physicians and rescuers in emergency environments. The objectives of PEMR are (1) to make patients and medical information pervasive; this will allow for a more accurate diagnostic at the time of service and (2) to allow the transmission of critical information about victims to the nearest hospital during transportation; as such the appropriate treatment, from specialists from the hospital, can be recommended to patients in critical state. Also, at the same time the required medical resources are put in place to save the victim.

3.1 A scenario

During accidents, using biometric measurements, policemen can access medical records of victims. Same information will be sent to the ambulance on way to rescue the victims. On the spot, after the emergency rescuers diagnoses the victim whose nature of injury is forwarded to the hospital for the appropriate recommendation from specialists. As a consequence, the difference between life and death can be made as patients are given the most appropriate treatment on the way to at the nearest hospital. At the same time, the paramedics can be better prepared as they know exactly the kind of the emergency case they will be treating.

3.2 PEMR Architecture

Through GPRS technology, biometric data will be the input allowing the system to search through the online platform-independent web services for any related medical record for the injured patient. If the record exists, the patient identification number with critical health information will be transmitted to a RFID tag which is then slipped onto the patient's wrist or ankle. The patient's health status can relayed to the hospital by using General Packet Radio Service of 2G networks or 3G services. Ambulance can also be equipped with WiMAX (IEEE 802.16 standard) transceivers, as shown in figure 1., to stay connected in suburb areas or in places where the public radio infrastructure is poor.

Once the patient arrives at hospital's entrance, the RFID wrist strap allows for proper identification. The required personnel will be informed via their PDAs (Personal Digital Assistant) using the Wireless Local Area Network (WLAN) of the hospital. At the hospital the patient's information is also delivered instantly to different departments' terminals (operation theatre, medical and administrative) through WLAN.

As the patient enters operation theatre, the RFID tag is automatically scanned. A digital photograph of the patient from the electronic patient record is displayed on the monitor and all the required information is downloaded on the terminal to improve accessibility. Also, wearable vital sign wireless sensors can be also used to track patient status during their convalescence.

4. MAIN COMPONENTS IN THE PEMR ARCHITECTURE

The main components in the PEMR architecture for information transmission and storage technologies are RFID, Wi-Fi, WiMAX, GPRS, Internet, web services with online database.

4.1 RFID

The RFID strap will store the identity of the victim and it will be attached to the latter's hand or ankle. This will allow for an automated means of identifying the person at different places (in the hospital) with required related information being displayed on the terminal (for e.g. the doctor's PDA). As such RFID reduces operational costs and minimises administrative duties. Moreover, patients locations' can also be carefully monitored thus improving safety. Passive RFID tags are relatively cheap to use and work without any battery.

4.2 Wireless network (ad hoc and infrastructure-dependent)

Wi-Fi, the IEEE 802.11 b/g standard for wireless network communication, is used both at the hospital and on the emergency spot. At the hospital, the infrastructure-dependent and infrastructure-independent (ad hoc) wireless network for communication and electronic document transmission will co-exist. Doctors and/or paramedics may collaborate on ad hoc basis when the need arise under certain special condition to fulfil any emerging task. While on the emergency areas, a hybrid network will be set up using WiFi (ad hoc network on the emergency spot) with GPRS (to connect to the web services over Internet) or alternatively Wi-Fi with WiMAX (when the GPRS infrastructure is missing.)

4.3 Internet, web services and online database

Web services are accessible using SOAP (Simple Object Access Protocol). SOAP is an XML/HTTP-based protocol for accessing services, objects and servers in a platform-independent manner. This allows the set of existing heterogeneous application software on non-homogeneous devices to gain access to medical records and other services that may be required anywhere and anytime to save a human life. The online database, connected to the web service, contains crucial information pertaining to individuals living and visiting the country. Moreover, access to the Internet also allows other means of communication possible (unicasting and multicating text and visual messages) efficiently and reliably in an interactive manner.

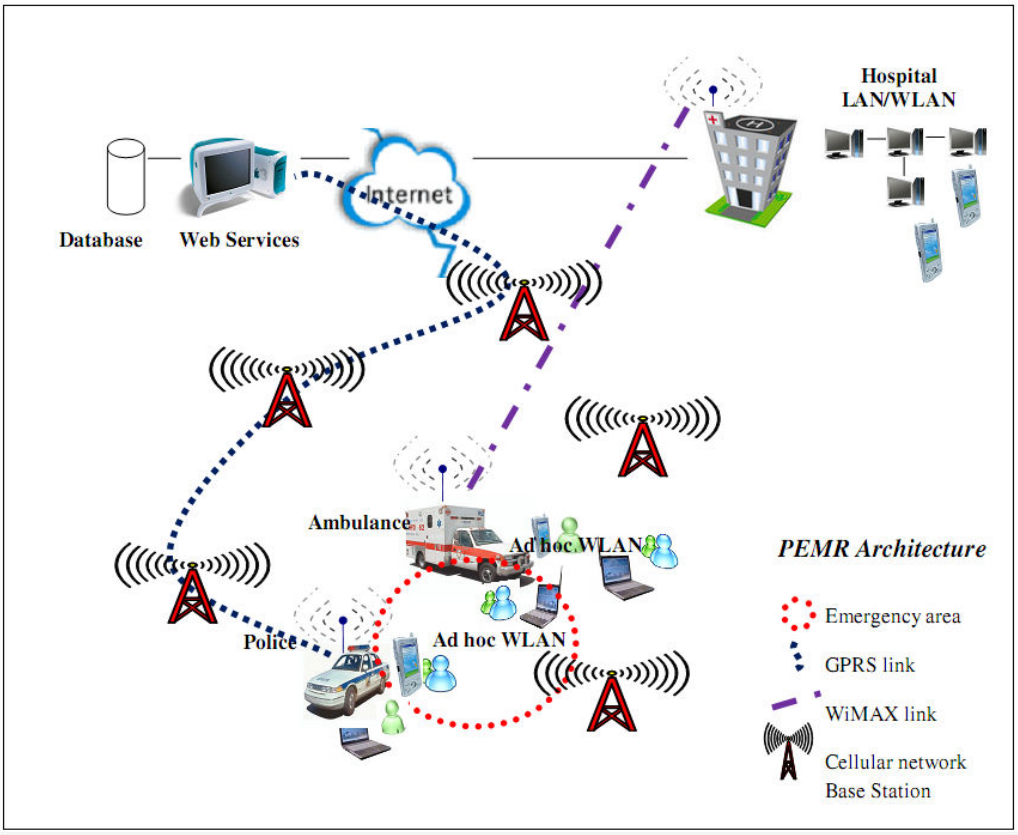

Figure 1. PEMR Architecture.

5. PEMR AND TELEMEDICINE

PEMR also supports telemedicine. In cases of emergencies in remote areas, telemedicine may decide between the life and death of victims in desperate conditions. It is possible to transmit victims health conditions (blood pressure, ...) and medical documents, that can be generated electronically with the appropriate medical devices in the ambulance, to the hospital where life-saving recommendations is sent by both local and foreign specialists within seconds. In the near future, ambulance may be well equipped to perform minor operations by remote specialists.

6. CHALLENGES AND IMPLEMENTATION ISSUES

6.1 Security and privacy

The basis of PEMR is efficient transmission of patient information which relies on both wireless and wired network. Along with data transmission, there are active and passive attacks on the network. Moreover, Network spoofing can indirectly cause more harm to victims instead of relief. All these network security threats arise mainly from (1) RFID tags, (2) Internet and (3) Wireless Ad hoc Network.

6.1.1 RFID tags

Unprotected tags may be vulnerable to eavesdropping, spoofing or denial of service attacks. Moreover, tags with protected contents are still susceptible to tracking thereby violating the "location privacy" of patients. Weis et al. (2004) proposes a number of feasible measures that must be taken to prevent RFID tags from being hacked.

6.1.2 Internet

Connecting the database of medical records to the Internet is done only with the installation of firewalls and proper authentication mechanism. Moreover, secure protocols, like s-http, use hybrid cryptographic methods like the use public/private key to exchange a secret key which is then use to speed up encryption and decryption. This method allows resource-poor devices, like a PDA, to access information efficiently. Another secure way of accessing resources connected to the Internet is by using a Virtual Private Network (VPN).

6.1.3 Wireless Ad hoc network

Secure routing in wireless ad hoc network can be established using a secure key management service proposed by Zhou and Haas (1999), which uses private and public keys. Moreover, the WEP (Wired Equivalency Privacy) is a security standard designed to provide wireless LAN (IEEE 802.11 b/g standard) with a level of security and privacy which is expected in a wired LAN. WEP provides two levels of security using a shared network security key in versions of either 40-bit or 128-bit which is more powerful. Using WEP, all data transmissions between computers in the wireless network are encrypted. An alternative to WEP is the Wi-Fi Protected Access (WPA). However, apart from encrypting communication channels between computers, WPA authenticates users accessing the wireless network. Moreover, WPA is also designed to work along with the 802.1X authentication server, which allows the distribution of keys to authorised users.

As mobile devices resource-poor, public key encryption is not attractive. Along with the Code Blue architecture proposed by David Malan et al. (2004), a lightweight public key infrastructure based on elliptic curve cryptography, David Malan (2004), was developed.

6.1.4 Confidentiality

The disclosure of patient data to authorised personnel only on an emergency spot is desirable but the same information in the hand of a passer-by may also aid in helping victims. The system can function in two contexts of privileges: one within the paramedical circle of trust, where it is allowed to query institutional resources such as hospital information systems; and a second one allowing access to a skim of critical information, which the patients decided beforehand, that others can access. This also gives control to the level of desired privacy.

6.2 Scalability and bandwidth

Ad hoc network used in emergency areas works fine with a sparse population of nodes. But as the number of wireless devices increases with the coming of other rescuers in different discipline, bandwidth availability decreases proportionally, if

not exponentially. This will degrade performance drastically. The routing protocols should include features like (1) building up a list of resources downloaded by mobiles nodes of the ad hoc network such that a virtual local database is build on the spot with all information available locally, (2) allowing offline operations as mobile node is getting weak connection to the network, and (3) building multi-hop routes using context information like nodes mobility to make route reconfiguration less frequent.

6.3 Resource management

Proper design and use of wireless technologies requires detailed planning and coordination. Good management includes successful deployment, installation, and troubleshooting of wireless systems for all wireless stakeholders throughout the hospital and the PEMR architecture. Wireless planning services are to help establishing wireless policies allowing coordination and collaboration at the level of (1) intra-organisational, i.e. within a hospital, or (2) multi-jurisdictional, i.e. hospitals and clinics at different locations working together, or (3) multi-disciplinary, i.e. paramedics working with the police.

7. CONCLUSIONS

PEMR supports patient care and enhance productivity of health care professionals while reduce the administrative costs associated with health care delivery. As a complement to the E-Health architecture proposed by Sharma et al. (2006), PEMR also incorporates ad hoc wireless networks which create opportunities to save life in emergency areas. PEMR infrastructure allows heterogeneous devices to access required information using platform independent solutions with the advent of web services.

Although the introduction of PEMR has immediate benefits for a care provider, there will be many issues that have to be overcome. After all, not every advantage of electronic record is immediately apparent. Electronic reporting will initially require a lot of effort and motivation from the care providers. During the implementation process, considerable commitment will be required from the care providers who will eventually have to work with the PEMR.

Our paper demonstrates the availability of patient information and efficient use of an integrated emergency care delivery system that encompasses the whole mission of emergency care to promote better provision of care than the current traditional system. Finally, the challenges and implementation issues are highlighted.

8. REFERENCES

DAVID MALAN, 2004. *Crypto for tiny objects*, Technical Report TR-04-04, Harvard University.

DAVID MALAN ET AL., 2004. *An Ad Hoc Sensor Network Infrastructure for Emergency Medical Care,* Workshop on Wearable and Implantable Body Sensor Networks.

J. PLATT, 2007. The Institute, IEEE, Vol. 31, No. 2.

LIDONG ZHOU AND ZYGMUNT J. HAAS, 1999. *Securing Ad Hoc Networks*, Network Journal, IEEE.

SHANG-WEI WANG ET AL., 2006, RFID applications in hospitals: a case study on a demonstration RFID project in a Taiwan Hospital, in *the proceedings of the 39th Hawaii International Conference on System Sciences*.

SHARMA S.K., XU H., WICKRAMASINGHE N. AND AHMED, N., 2006. Electronic healthcare: issues and challenges, Int. J. Electronic Healthcare, Vol. 2, No. 1, pp.50-65.

STEPHEN A. WEIS ET AL., 2004. Security and Privacy Aspects of Low-Cost Radio Frequency Identification Systems, *Security in Pervasive Computing: First International Conference*, pp. 201.

UPKAR VARSHNEY, 2003. Pervasive Healthcare, Computer, vol. 36, no. 12, pp. 138-140.

VON LUBITZ, D., WICKRAMASINGHE, N. AND YANOVSKY, G., 2006. Networkcentric healthcare operations: the telecommunications structure, *Int. J. Networking and Virtual Organisations*, Vol. 3, No. 1, pp.60–85.

WICKRAMASINGHE N. S.ET AL., 2005. A framework for assessing e-health preparedness, *Int. J. Electronic Healthcare*, Vol. 1, No. 3, pp.316 - 334.

WOJTEK MICHALOWSKI, ROMAN SLOWINSKI AND SZYMON WILK, 2004. MET System: A New Approach to m-Health in Emergency Triage, JOURNAL ON INFORMATION TECHNOLOGY IN HEALTHCARE, vol. 2, no. 4, 237-249.