

FEASIBILITY STUDY OF INCORPORATING REMOTE HEALTHCARE
SYSTEM USING WIRELESS BODY AREA NETWORK
FROM THE SECURITY PERSPECTIVE

TAMIL CHELVI A/P VADIVELU

A project report submitted in the fulfillment of the
requirements for the award of the degree of
Master of Computer Science (Information Security)

Advanced Informatics School (AIS)
Faculty of Computer Science and Information System
Universiti Teknologi Malaysia

JUNE 2013

ACKNOWLEDGEMENT

I would like to express my gratitude to all those who have given me the possibility to complete my research. First of all, I would like to thank all the lecturers, my family members and friends for their valuable supports towards me and great helps during difficulty times.

I am deeply indebted to my supervisor Dr. Nurazeen Maarop whose help, stimulating suggestions and encouragement helped me in all the time of research and writing of this report. She showed me different ways to approach a problem and the need to be persistent to accomplish any goal. She also gave insightful and beneficial comments and reviewed my work. Her guidance gave me a high confidence in completing this report.

Last but not least, one of the greatest pleasures is acknowledging the efforts of many people whose names may not appear on the cover, but whose sincerity, cooperation, friendship and understanding were crucial throughout the process of this research.

ABSTRACT

The healthcare system in Malaysia has witness a tremendous change and there are many systems developed to provide a better healthcare system. A remote healthcare system using the Wireless Body Area Network (WBAN) is still new to public hospitals in Malaysia. The “Feasibility Study of Incorporating Remote Healthcare System Using WBAN from the Security Perspective” is a research to study the security aspects for remote healthcare system in public hospitals in Malaysia. The preliminary study of this research focuses on the security aspects to be considered for developing a remote healthcare system since such system is yet to be used in the country. Medical practitioners from Department of Cardiology from public hospitals are interviewed to know the incorporability of the remote healthcare system using WBAN from the security aspects identified. The security aspects identified are data confidentiality, data integrity, data privacy and data authentication. All these four aspects are identified to be crucial in for a remote healthcare system in Malaysia.

ABSTRAK

Sistem kesihatan di Malaysia menyaksikan pelbagai perubahan besar dan terdapat banyak sistem yang dibangunkan untuk memperkasakan perkhidmatan kesihatan di negara kita. Sistem kesihatan menggunakan Wireless Body Area Network (WBAN) masih baru di hospital awam di Malaysia. Kajian 'Feasibility Study of Incorporating Remote Healthcare System Using WBAN from the Security Perspective' merupakan kajian yang mengkaji isu-isu keselamatan dalam WBAN dan mengenalpasti set keperluan keselamatan untuk membangunkan satu rangka kerja etika. Kajian awal pelaksanaan kajian ini memberi tumpuan kepada ciri-ciri keselamatan yang perlu diambil kira untuk merekabentuk sistem sedemikian di negara kita. Pengamal perubatan dari Jabatan Kardiologi dari hospital awam ditemuduga untuk mengetahui kebolehlaksanaan ciri-ciri keselamatan yang dikenalpasti serta pelaksanaan sistem penjagaan kesihatan jauh menggunakan WBAN. Ciri-ciri keselamatan yang dikenalpasti adalah kerahsiaan data, integriti data, privasi data dan pengesahan data. Keempat-empat ciri ini dikenalpasti sebagai ciri penting dalam membangunkan sistem kesihatan jauh.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF ABBREVIATIONS	xii
	LIST OF APPENDICES	xiii
1	INTRODUCTION	1
	1.1 Overview	1
	1.2 Background of Study	2
	1.3 Problem Statement	6
	1.4 Research Aim	6
	1.5 Research Questions	7
	1.6 Research Objectives	7
	1.7 Research Scope	7
	1.8 Significance of Study	8
	1.9 Summary	9

2	LITERATURE REVIEW	10
2.1	Introduction	10
2.2	Healthcare System using WBAN	11
2.3	Security Issues and Features in WBAN	14
2.4	Summary	22
3	CONCEPTUAL FRAMEWORK	23
3.1	Introduction	23
3.2	Context of Conceptual Framework	23
3.3	Proposed Conceptual Diagram	26
3.4	Summary	30
4	METHODOLOGY	31
4.1	Introduction	31
4.2	Research Design	31
4.2.1	Unit of Analysis	32
4.2.2	Methodology Used	33
4.2.3	Techniques for Data Collection and Analysis	34
4.2.4	Deliverable of the Research	35
4.3	Instrument Design	36
4.3.1	Selection of Participants	36
4.3.2	Interview Instrument	37
4.3.3	Instrument Design for Interview	39
4.4	Summary	42
5	FINDINGS AND ANALYSIS	43
5.1	Introduction	43
5.2	Findings and Analysis of Research	43
5.3	Summary	50

6	CONCLUSION	51
6.1	Introduction	51
6.2	Conclusion of the Results	51
6.3	Contribution of the Research	52
6.4	Challenges and Future Works	52
6.5	Summary	53
	REFERENCES	54
	Appendix A	58 - 85

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	OSI Security Architecture Reference Model	15
2.2	Attacks and possible security approach based on OSI Model	15
3.1	Reference Categorization by Perspective	24
3.2	Aspects and Related Items	24
3.3	Inclusion Aspects in the Remote Healthcare System in Malaysia using WBAN	25
3.4	References Supporting Selection of Items for Security Aspects	26
3.5	Supporting Points for Aspect Categorization	29
4.1	Profile of the Participants	37
4.2	Inter-relation of Topics and Research Questions	38
4.3	Start-list Code for Interview Questions	38
4.4	Interview Question Design	39
5.1	Importance Level of the Security Aspects	45

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
3.1	Conceptual Framework of Security Features for Incorporating Remote Healthcare System using WBAN	28
4.1	Research Design	32
4.2	Steps Used in Literature Review	33

LIST OF ABBREVIATIONS

AES	-	Advanced Encryption Standard
BAN	-	Body Area Network
BP	-	Blood Pressure
ECG	-	Electrocardiogram
EEG	-	Electroencephalogram
GPRS	-	General Packet Radio Service
ICT	-	Information Communication and Technology
IT	-	Information Technology
MAC	-	Message Authentication Code
MMA	-	Malaysian Medical Association
OSI	-	Open System Interconnection
PDA	-	Personal Digital Assistant
RSA	-	Rivest-Shamir-Adleman
SHA	-	Secure Hash Algorithm
SSL	-	Secure Socket Layer
UMTS	-	Universal Mobile Telecommunication System
WBAN	-	Wireless Body Area Networks

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Sample Interview Results	58

CHAPTER 1

INTRODUCTION

1.1 Overview

Healthcare system has to undergo a drastic transformation due to new challenges of rapidly growing population of elderly and rising healthcare awareness [1]. The increase in average lifespan and cost of health motivates innovation in healthcare system. Recent technological advances in sensors and wireless communication have enabled the design of wireless sensor equipments for healthcare monitoring. Several new medical equipments are designed using wireless technologies to revolutionize the healthcare system to provide inexpensive, continuous and safe health monitoring. Medical devices such as wireless pulse oximeter, wireless single-lead Electrocardiogram (ECG) patch sensor, wireless blood pressure (BP) sensor and wireless Electroencephalogram (EEG) sensors are designed such that they can be worn or implanted to monitor psychological signals and transmit the data to specialized medical servers. This has led to the development of Wireless Body Area Networks (WBAN). The WBAN technology are mainly used in the Cardiology Department in any medical field as this field requires medical practitioners to obtain medical readings such as ECG, pulse rate, blood pressure, stress test and blood investigation. To do all these tests and readings, sensor equipments are used. WBAN can be used to design a remote monitoring healthcare system. The integration of wireless communication and computing system can deliver a more complete healthcare system [2]. This is in line with the 10th Malaysian Plan for Ministry of Health, which is to establish a comprehensive healthcare system and recreational infrastructure. The focus of this research is to identify the security

features for remote healthcare system using the WBAN for healthcare system in Malaysia.

WBAN is formed when one or more types of wireless sensors are deployed in environments that belong to the patient. It is a network of nodes that are deployed on the surface of a person's body. These nodes can send data to remote locations with use of any available networks. This network is then connected to a backbone network via a gateway. The gateway node could be connecting the sensor node to a range of telecommunication networks. These communication networks could be using public or private networks. A WBAN could offer a user to store its collected data on his/her personal device or any other portable device and then transfer that information to a suitable computer or centralized server. At the application level, medical practitioners can monitor vital health information using a graphical user interface. Typical application of WBAN in healthcare system for remote monitoring requires patients to wear body sensors on their body parts (wearable sensors) and whereby these sensors have capabilities of taking down the medical records. The data is then transferred to a centralized system using the Internet. For this to happen, patients will need to connect the sensor via wireless to any source of Internet. Medical practitioners on the other hand need to log in to the system to periodically check his or her patient's record.

1.2 Background of Study

The use of technology has increased work efficiency in many sectors. Medical domain particularly has adopted many technologies into their daily use in providing better healthcare system [3]. Tremendous changes in the use of technology have been reported over the years in medical industry. The integration of WBAN into the healthcare system is nothing new in the first world countries. Canada is one of the earliest countries that used the WBAN technology to provide remote healthcare system for their citizens. In Malaysia, the implementation of such systems

is still in the planning stage. Several private medical institutions are in plans to do such system.

The use of WBAN exposes many data vulnerability as Internet is often used for communication. Besides, medical data is considered to be very confidential and medical practitioners are tied to the code of conduct in performing their duty. Transportation, tourism, education, and others sectors are also rapidly evolving with the use and development of sophisticated systems, but medical system is still a little laid back as there is no proper guidelines and awareness on the data access[2]. Medical data can be misused for various purposes. Medical practitioners are believe to be the greatest threat to patients' data due to the access they have pose on the sensitive medical records [4]. Many patients are actually unaware that their medical records are exposed out of their consent. In fact, many patients disagree if their health records are shared by many for various purposes [5]. One of the purposes of electronic medical system is to improve the healthcare services. The use of remote healthcare systems will save cost and errors during treatment of patients but despite all these people are worried about the privacy and security of medical records [6]. Furthermore, processing data over the Internet may pose the treat of data modification. Therefore data integrity checks should also be included in any electronic health applications [3]. The shortages of medical professional to handle high risk factor patients are also insufficient. This is further supported by Dr David K L Quek, the President of Malaysian Medical Association (MMA), (2009-2011) who stated in news that the underlying logistical problems and manpower constraints appear to hamper the implementation of a more comprehensive cohesive healthcare system [7].

Healthcare sector in Malaysia witnesses vast changes over the period of time. The government of Malaysia has put quality healthcare as one of the main principles through varieties of network clinics and hospitals. Health is considered as a part of socioeconomic development as it involves large number of citizen. The chronological changes in the healthcare system prove that technology does play a role in influencing the operation of the healthcare system in Malaysia particularly. Nevertheless, a healthcare system without considering the security features will give

a bad reputation of the public hospitals in Malaysia [8]. Besides security, ethical component is one of the important components in developing a healthcare information system [9]. This is due to the need for the medical practitioners to follow the code of ethics outlined by MMA. The lack of enforcement of Information Technology (IT) policies and operational policies in managing patient data is also a concern when developing any medical system. This happens when some of the medical practitioners face ethical problems dealing with patient data. It is very important to balance patients' right to data protection or confidentiality because it is the central for trusting a relationship between patients and healthcare providers [6][3][5].

In the 1980s and 1990s, the healthcare system in Malaysia continued to attain a better and more equitable distribution of health services and facilities. Preventive and curative healthcare services were implemented whereby immunization, vaccination rural sanitation health education programme and family development were given importance. Priority was also given to provision of basic healthcare and specialist services. The reports by MMA [10] recorded that for man power development; there were only 4229 doctors, 249 specialists and 10,500 nurses in government hospitals. In 1990, the doctor population ratio for the nation was 1:2560 with having Kuala Lumpur and Pulau Pinang as above the target. To solve this problem, government hired many foreign doctors on contract basis. This scenario is not continued as it takes up lots of cost. To solve this government has taken many measures with the help of growing technology to save the cost and man power in daily healthcare monitoring. Electronic and wireless equipments are introduced to reduce the time taken to obtain reading from patients and this indirectly reduces the manpower needed to examine a patient. In the 10th Malaysian Plan, the Prime Minister has put a stress that by 2020, the number of old aged citizens in Malaysia would be 3.4 million. Therefore, this group of people will be given importance for healthcare by focusing on elderly friendly infrastructure and improving access to affordable healthcare. The use of Information Communication and Technology (ICT) in medical field brings new challenges and expectations to the society. In the 10th Country Health Plan, the inadequate integrated planning of health information systems, particularly the absence of policy and facility to empower access to secured

personal health information is highlighted. This motivates the implementation of integrated systems in public hospitals.

As technology evolves, people are also changing. Many departments are moving into e-services to provide a more mobile accessibility for the customers. For medical field, the implementations of e-services or remote services are still not widely used due to the dependability to the hardware equipments to get the medical data of the patients. Another factor that contributes to this reason is also the cost for implementation and the readiness of the patients and medical officers to commit responsibilities to handle the body sensor and to monitor the data remotely. With the invention of wireless body sensor equipments, medical departments can now go wireless: for monitoring the healthcare of the patients'. The current manual system of recording the patients' medical data is not efficient and resourceful. Using medical equipment, a medical practitioner needs to manually record the readings (medical data) of a patient and record it into a sheet for monitoring. When such system is used, patients are unhappy because their data is shared among the medical practitioners on duty in a particular department [5]. This is unethical and may raise the issue of data privacy and trust among the patients. Compared to paper files (traditional records), electronic medical data are more transferable [6] and therefore, stronger protections are needed to eliminate the violation of patient privacy.

Besides this, the demand for services for the aged is increasing. This trend is global whereby the number of population over the age of 65 is doubled from 357 million in 1990 to 761 million in 2005 [11]. According to the statistic provided by the Department of Statistics Malaysia on their website, Malaysia particularly has about 29 million citizens and the annual growth population for Malaysia is about 1.6%. Out of this statistic, around 1.5 million are over 65 years old [1]. Majority of this group of people are very highly in need of regular healthcare monitoring. The need of them to regularly visit the hospitals or clinics can be very troublesome and cost consuming. All these statistics shows that Malaysia also needs a major shift towards a more scalable and efficient healthcare system. With this, one of the best solutions is to go for a remote healthcare monitoring. Several factors need to be accounted if the healthcare monitoring system goes remotely. The assurance of data

security is very crucial. Medical practitioners are also tied to the code of ethics during performance of their duty. Therefore, this research discusses the security elements of remote healthcare system using WBAN to be fulfilled for developing such system.

1.3 Problem Statement

Implementing a remote healthcare system need to consider security features. Therefore, before deployment a remote healthcare system using WBAN, a feasibility study is crucial. WBAN technology has been used in other countries for medical purposes but in Malaysia, such projects are still under development. For public hospitals, such system is new and feasibility study provides relevant data on the implementation of remote healthcare system using the WBAN in public hospitals since it is not implemented. The issue of secure communication arises. Secure communication need to be achieved by employing strong security mechanisms to ensure non-disclosure of secret information, prevention of data alteration, proof of identity and non-contestable message origin. Medical data are very crucial and need to be protected as alteration in the records may results in an incorrect diagnosis and prescription. The research also find out opinions on to what extend such system can be used in monitoring healthcare of patients in public hospitals and the impact of such system on the work efficiency.

1.4 Research Aim

The aim of this research is to determine the feasibility of incorporating remote healthcare system using WBAN from the security perspective.

1.5 Research Question

The research questions for this research are as below:

- What are the security features for a remote healthcare system using WBAN?
- What are the security features that can be incorporated into the remote healthcare system in Cardiology Department in Malaysian public hospitals?
- Is the security features identified suitable to be used in remote healthcare system using WBAN for Department of Cardiology in public hospitals?

1.6 Research Objectives

Objectives of this research are:

- To identify the security features for remote healthcare system using WBAN
- To design a conceptual framework for incorporating security features for remote healthcare system using WBAN in Cardiology Department in Malaysian public hospitals.
- To determine the feasibility of incorporating remote healthcare system using WBAN in Department of Cardiology in public hospitals.

1.7 Research Scope

This research focuses on:

a. Security aspects

The security identified covers only the data security and some ethical issues. Security aspects are identified based on literature review.

b. Conceptual framework

A conceptual framework is designed based on literature review. Some of the security features are included in this framework for a remote

healthcare system using the WBAN technology. The inclusions of the features are based on critical success criteria of successful models and framework that have been developed.

Medical practitioners from Department of Cardiology in public hospitals are interviewed to get feedback on incorporating a remote healthcare system using WBAN based on the security features identified in the conceptual framework. Interviews are conducted in the hospital premises during working hours.

1.8 Significance of Study

This research will benefit medical practitioners, patients, hospital management, system developers and many others who are involved in providing healthcare system in various ways. In another word, it gives significance to field establishment or theoretical development and also significance to the organization. To develop a system using the Wireless Body Sensor Network, one needs to know the security issues that may arise concerning data.

This research can be used in as the first step to gather information about implementation of remote healthcare system using WBAN before the real implementation takes place. It will be an interest to system developers, patients and medical practitioners for having a feedback from the end users especially medical practitioners on execution of such system for healthcare monitoring in Malaysia. Furthermore, developing systems for medical isn't that simple as medical practitioners have their code of conduct to be complied. Thus, it is important to follow these codes of conduct so that patients are aware that their data is restricted for access.

The significant benefit of this research to the organization is that a more effective way of monitoring patients' medical data is designed. Besides, this cuts down the concern of patients about their data. Providing the medical practitioners

and patients a clear policy and guidelines on how data is accessed and shared is important to build the trust between patient and doctor. This remote healthcare system will be more convenient for both patients and medical practitioners as this saves their time. Hospitals will have a more systematic way of keeping patients record, on the other hand patients do not need to worry about their data being safe. Remote healthcare system will be an interest for Department of Cardiology since there are many sensory types of equipment used for obtaining patients' medical readings.

1.9 Summary

The use of WBAN in medical system exposes security threats for data. Several problem statements have been identified for the purpose of conducting this research. With that, objectives are outlined and the scope of study is also explained. The aim of this research is to give a significant knowledge of security features in remote healthcare system and how this system is to be accepted for implementation from the perspective of the medical practitioners. The next chapter discusses about the literature review and the methodology used to conduct this research. It is the most important chapter as it gives ideas, knowledge and resources about this research and these are important elements to produce a good research.

References

- [1] Department of Statistics Malaysia. <http://www.statistics.gov.my/> last visited 24th Sept 2012
- [2] Kementerian Kesihatan Malaysia. *Country Health Plan*. Bahagian Pembangunan dan Perancangan.
- [3] ETHEL. (2011). *ETHICAL Principles for eHealth : Conclusions from the Consultation of Ethics Experts around the Globe*. EHTEL Briefing Paper.
- [4] Baumer,D, Earp,B.J, and Payton,F.C. (2000). *Privacy of Medical Records : IT Implications of HIPAA*. ACM Computer and Society, v.30,n.4 pp.40-47.
- [5] Stone,M.A. (2005). *Sharing patient data : competing demands of privacy, trust and research in primary care*. The British Journal Of General Practice.
- [6] Miller, J.S. (2008). *Electronic Medical Records : How the Potential for Misuse Outweighs the Benefits of Transferability*. Journal of Health & Biomedical Law, IV:353-373
- [7] David,K.L.(2012). *Health Care Cost & Challenges in Malaysia*. Berita March Issue
- [8] Sulaiman,S., Alias,R.A. (2006) *Information Ethics in Malaysia Paperless Hospital*. Proceedings of the Postgraduate Annual Research Seminar 2006.
- [9] Samsuri,S., Ismail,Z and Ahmad,R. (2013). *Adopting a Knowledge Management Concept in Securing the Privacy of Electronic Medical Record System*. 7th International Conference on KMO, AISC 173, pp. 547-558.
- [10] Malaysian Medical Association (2002). *Code of Medical Ethics*. Adopted at the 41st Annual General Meeting, Negeri Sembilan.

- [11] Milenković, A., C. Otto, et al. (2006). *Wireless sensor networks for personal health monitoring: Issues and an implementation*. Computer Communications 29(13–14): 2521-2533.
- [12] Al Ameen, M. and K. Kwak (2011). *Social issues in wireless sensor networks with healthcare perspective*. International Arab Journal of Information Technology 8(1).
- [13] Germanakos. P, Mourlas. C, and Samaras. G. (2005). *A mobile Agent Approach for Ubiquitous and Personalized eHealth Information System*.
- [14] Harvard Sensor Networks Lab. <http://fiji.eecs.harvard.edu/CodeBlue>, Last visited 24th Sept 2012
- [15] Silva Cunha, J. P., B. Cunha, et al. (2010). *Vital-Jacket®: A wearable wireless vital signs monitor for patients' mobility in cardiology and sports*.
- [16] Zakaria, H.A (2007). *Development of Wireless Patient Data Management System*. Journal of Sustainability Science and Management 2007 Volume 2 (1):86-89
- [17] Xue Y., Yan, V.P., (2010). *Mobile Body Sensor Networks for Health Applications*
- [18] Mohanty, P., S. Panigrahi.,(2010). *Security issues in wireless sensor network data gathering protocols: A survey*. Journal of Theoretical and Applied Information Technology 13(1): 14-27.
- [19] Stallings, W., (2010) *Cryptography and Network Security Principles and Practice*, Cryptography Book, 5th Edition, Prentice-Hall

- [20] Somasundaram,M. and Sivakumar, R. (2011). *Security in Wireless Body Area Networks : A Survey*. 2011 International Conference on Advancements in Information Technology With workshop of ICBMG 2011IPCSIT vol.20, IACSIT Press, Singapore
- [21] Ragesh,G.K and baskaran,G. (2012). *Addressing the Need for Context Awareness and Security Requirements in Wireless Body Area Networks*. International Journal of Future Computer and Communication, Vol. 1, No. 3, October 2012.
- [22] Wandert, A. S., N. Gura, et al. (2005). *Energy analysis of public-key cryptography for wireless sensor networks*.
- [23] Meingast, M. and T. Roosta (2006). *Security and privacy issues with health care information technology*.
- [24] Yan, L. and C. Cui (2007). *Energy Comparison and Optimization of Wireless Body-Area Network Technologies*
- [25] Bilstrup, U. and P. A. Wiberg (2007). *A preliminary study of wireless body area networks*
- [26] Martineau,T and Willetts,,A.(2006). *The Health Workforce: Managing the Crisis Ethical International Recruitment of Health Professionals: Will Codes of Practice Protect Developing Country Health Systems?*. Health Policy 75, 358-367.
- [27] National Health and Medical Research Council. (2011). *An ethical framework for integrating palliative care principles into management of advanced chronic or terminal conditions*.
- [28] Robert M. Sade (2010). *Breaches of Health Information : Are Electronic Records Different from Paper Records?*. The Journal of ethical Clinical ethics 21, no.1 : 39-41.

- [29] Hamilton Health Sciences (2010). *Ethics Framework*. HHS Board of Directors.
- [30] Ng, H. S., M. L. Sim, et al. (2006). *Security issues of wireless sensor networks in healthcare applications*. BT Technology Journal 24(2): 138-144.