E-Healthcare Systems and Wireless Communications:

Current and Future Challenges

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Chapter 10
Design and Deployment of a Mobile-Based Medical Alert System

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ABSTRACT

The use of wireless technology for health care delivery is having great impacts in the health care sector on a global scale. However, alert systems in medical institutions are rare. As a result of this, patients find it hard to keep track of scheduled meetings with medical personnel; they also find it difficult to keep track of prescribed medications. These could have adverse impacts on patients' health, especially for those with chronic diseases. This chapter therefore, presents the design, deployment and evaluation of a mobile-based medical alert system (MAS) for managing diseases where adherence or compliance is paramount for effective treatment. The system alerts the patients and medical practitioners about information and emergencies via text messaging on handheld devices such as mobile phones and PDAs. It also allows users to receive scheduled appointment and medication updates that will facilitate their treatment processes. The prototype application is developed by the incremental software process model and runs on a GSM network.

INTRODUCTION

At the end of this chapter, readers will understand:

- The meaning and importance of mobile HealthCare
- The meaning of medical alert systems
- Describe the components of medical alert systems
- The benefits of using Short Message System (SMS) in health care services
- How to implement and deploy medical alert systems
- How to evaluate mobile health care based systems

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BACKGROUND

Ubiquitous health systems which focus on automated applications that can provide HealthCare to citizen anywhere/anytime using wired and wireless mobile technologies is becoming increasingly important. Consequently, hand-held devices especially PDAs and smart phones have been reported to become increasingly prevalent for health care delivery (Trevor et al., 2004; Wickramasinghe et al., 2004; Baldwin, 2005). Research efforts and the use of wireless communications technologies to extend the reach, range and maneuverability of health care applications are covered in (Kyriacou et al., 2003; Voskarides et al., 2002; Mobile, n. d; James, 1996; MobilePoint, 2004); Kugean, 2002; Qureshi, 2005; Robert, 2005; Aura, 2006; Kim, 2005; Tang, 2004). Other research work that demonstrate the feasibility, convenience, and efficiency of using handheld devices in enhancing care delivering in areas such as transferring clinical data (Kim, 2005; Tang, 2004), electronic messaging systems (Wojceichowski et al., 2006; Wojciech et al., 2008; ng, 2007) have also been widely reported. The increasing adoption of mobile technology devices such as PDAs, cell phones, and laptops, for HealthCare (mobile health care) delivery is due to the flexibility and portability they offer to the physicians than some more computational desktop computers. In addition, hand-held devices and the applications bundled within them are significantly cheaper and require very little training unlike most PC-based alternatives. Furthermore, mobile devices support features that allow remote users to synchronize personal databases and provide access to network services such as wireless e-mail, Web browsing, and Internet access, thus meeting the mobility needs of patients or medical practitioners who are always on the move.

All across the world, the shortage of health care personnel continues to present great concerns for health care systems. However, in the developing world, the explosive growth and adoption of mobile communications over the last decade has provided new opportunities for the promotion of quality HealthCare. Mobile devices no doubt are having great impacts on the way we do things. Mobile health care systems allow the delivery of accurate medical information anytime anywhere by means of mobile devices (Rifat et al., 2009). In recent times, there have been a number of mHealth initiatives in public health being piloted and used from one country to another. Among these initiatives, Short Message Services (SMS) stands out as being the most promising in terms of its cost-effectiveness, scalability, convenience, broad reach, and widespread popularity in the developing world (Greifinger, 2009). SMS alerts have proven particularly effective in targeting hard-to-reach rural dwellers where the absence of HealthCare amenities, lack of HealthCare workers, and limited access to health-related information of major concerns. On a general note, mHealth initiatives promise to close the information gap that currently exists for patient data in the developing world, enabling health workers to measure the effectiveness of HealthCare programs, allocate resources more efficiently, and adjust programs and policies accordingly (Ramswaroop et al., 2010).

In spite of the advances in mobile HealthCare delivery, there are often situations where patients with certain medical conditions are unwilling or unable to reliably go to a physician. Obesity, high blood pressure, irregular heartbeat, or diabetes, HIV/AIDS are examples of such common health problems. AIDS (acquired immunodeficiency syndrome) is a disease caused by a virus called HIV (human immunodeficiency virus). Anyone of any age, race, sex or sexual orientation can be infected with HIV. In these cases, people are usually advised to periodically visit their doctors for routine medical checkups and regularly take some prescribed drugs. The provision of smarter and more personalized means through which patients are able to get medical feedback would certainly lead to life, time and cost savings (Rifat et al., 2009).

The monitory of patients' health has been a major issue in mobile health care delivery. One area that requires monitoring is that of medications. Adverse drug effects are a major cause of death in the world with tens of thousand deaths occurring each year because of medication or prescription errors. Many errors involve the prescription or administration of the wrong drug or dosage by care givers to patients due to illegible handwriting, dosage mistakes, and confusing drug names. With the use of mobile devices such as personal digital assistants and smart phones some of these errors could be eliminated because they allow prescription information to be captured and viewed in SMS rather than handwriting. For instance, common drugs for HIV/AIDS include; Abacavir, Zidovine and Luminvudine must be taken with compliance to the doctor's prescriptions.

Also, at the moment, alert systems in medical institutions are rare. As a result patients find it hard to keep track of scheduled meetings with medical personnel; they also find it difficult to keep track of prescribed medications. These could have adverse impacts on patients' health, especially for those with chronic diseases.

In view of the above, the contribution of this book chapter is to present the design and deployment of a Medical Alert System that will improve HealthCare delivery on a global scale. The system integrates the functionalities of core e-Health based systems with an Ozeki SMS server. The system supports real time transfer of prescription data to patient through SMS.

An incremental approach to software development is used for the development of the system. This approach allows a system to be decomposed into a number of components, each of which are designed and built separately allowing each component to be delivered to the client when it is complete. This allows partial utilization of product and avoids a long development time (Software Engineering, 2006).

OBJECTIVES

The objective of this chapter is to presents the design, deployment and evaluation of a mobile-based medical alert system for managing diseases where adherence or compliance is paramount for effective treatment. The system discussed alerts the patients and medical practitioners about information and emergencies via text messaging on handheld devices such as mobile phones and PDAs. It also allows users to receive scheduled appointment, medication and updates that will facilitate their treatment processes. The prototype application is developed by the incremental software process model and shall run on a mobile network.

This book promises to be a major contribution to the realization of the objectives of Information and Communication Technology (ICT) policies and the attainment of the millennium development goal for many countries. Specifically, a major component of the ICT policy of Nigeria (Nigeria, n.d.), is to deploy Information Technology to combat serious national health threats such as HIV/AIDS, etc. The final product is expected to run on GSM network in the country which presently supports more than 86 million subscribers (NCC, n.d.).

The rest of the paper is organized as follows. In section 4 we propose and implement an e-health solution by providing the architectural design of MAS. In section 5 we discuss the evaluation of the system and conclude the book chapter in Section 6 with some remarks on future work in section 7.

SOLUTION AND RECOMMENDATION

The usage of SMS is mainly to send short text only messages. SMS is built on GSM (Global System for Mobile communication) which is highly patronized in Nigeria. SMS contains a maximum of 160 characters. The operations supported by SMS includes: Message Originating (MO) and

Message Terminated (MT). The MO is used for sending SMS and MT is for receiving SMS. Once an SMS is sent from a mobile phone, the message arrives at Short Message Service Center (SMSC). SMSC generally follows Store & Forward rule, which means message is stored inside SMSC until it reaches the recipient. SMS messages do not have to be responded to. In addition, messages can be linked to various other services and can directly use their format. Both text and binary data of limited length can be transmitted by SMS and it can be automated (Mark Ridgeway, 2002) such that it is sent at a particular time such as in a medication alert system discussed in this paper

Systems Architecture

The SMS integrates with core e-Health based systems (Ikhu-Omoregbe et al., 2010). The e-Health system consists of the following modules:

Patient Medical Record Support Module (PMRSM)

This is the core support service in e-Health based systems. It provides functionality that maximizes the usage of the patients' medical information by serving as central sources of information for communications between health care providers, covering the patients' history, observations, and diagnosis.

This support service is not limited to only the interactions recorded in the patient-doctor encounter database but draw from numerous different facilities and support services such as records from the database of laboratory test, medications, and appointments, and diagnosis. This system allows an authorized user to view patient medical records real-time, in other to undertake treatment processes that are most beneficial and cost effective to the patients.

Laboratory Test Support Module (LTSM)

This support system aims at improving patient safety and efficiency in care delivery. A doctor may want to confirm the presence or absence of diseases by requesting that a patient undergoes a test. Laboratory test include blood, urine, sputum etc. After the test is performed, the result is given to the patient or captured and committed directly to the system for later use by the referring physician. Where X-rays or other forms of scan are required, the laboratory personnel and the X-ray specialist perform the respective tests and save the report separately on the server based system with the patient's identity. Especially where the client device does not have capabilities to store image files.

Pharmacy and Billing Support Service Module (PBSSM)

This module is a patient-centred, browser-based, integrated management medication system, providing drug therapy, billing and documentation for every step of medication treatment process. Its functionality includes: checks for drugs interactions, billing and allergic drug alert. The module helps to minimize medication errors and adverse drug effect on patients by allowing physicians send prescription information directly to the pharmacist after reviewing patient's allergic medication list real time via hand-held devices. The module helps to eliminates transcription errors and minimizes the time delays between the patient's consultation session with the physician and the collection and administration of drugs. By making patient medication information available electronically, accessible anytime, regardless of the location within the care network, cost of treatment is substantially reduced and lives are saved.

Security and Authentication Support Module (SASM)

In a hospital setting, several users access the patients' records to improve services to patients. These users include, doctors, nurses, laboratory personnel, pharmacist amongst others. A common way to give access right to hospital personnel is according to their functional and structural role which relates to their profession or specialty.

Ozeki SMS Server

The MAS forward a medical alert message to the patient's mobile phone using Ozeki SMS server. Such alert include the time to take drugs for an ailment. The architecture of MAS is depicted in Figure 1. The architecture contains 1) Client device such as cell phone and PDA, 2) MySQL database and 3) three servers: Ozeki SMS server, Application and Web Server. The screen shot for the configuration of GSM modem in Ozeki SMS server is shown in Figure 2. Figure 3 shows the SQL statements for sent messages and Ado connection script while Figure 4 shows the database content of MAS.

SQL Statement

Figure 3 contains the SQL statements of the messages sent from Ozeki SMS server, and the MySQL database Ado connection string.

Prototype Implementation

Figure 5 depicts a live deployment of the prototype MAS on a Nokia 6301 mobile phone. The screen shot represents a typical message that was sent from the MAS platform to the patient mobile phone. The application is executed by an automated scheduler which works with PHP, and integrated with Ozeki SMS server. The characteristics of MAS amongst others are 1) *Simplicity,* The system architecture of MAS is a simple one with no complex system or communication architecture, and 2) *Cost-Effective,* MAS is cost effective. The setup consists of some low cost components such as Ozeki message server which allows use of free evaluation and free and open source software (FOSS).

Figure 1. Architecture of MAS for HIV/AIDS patient

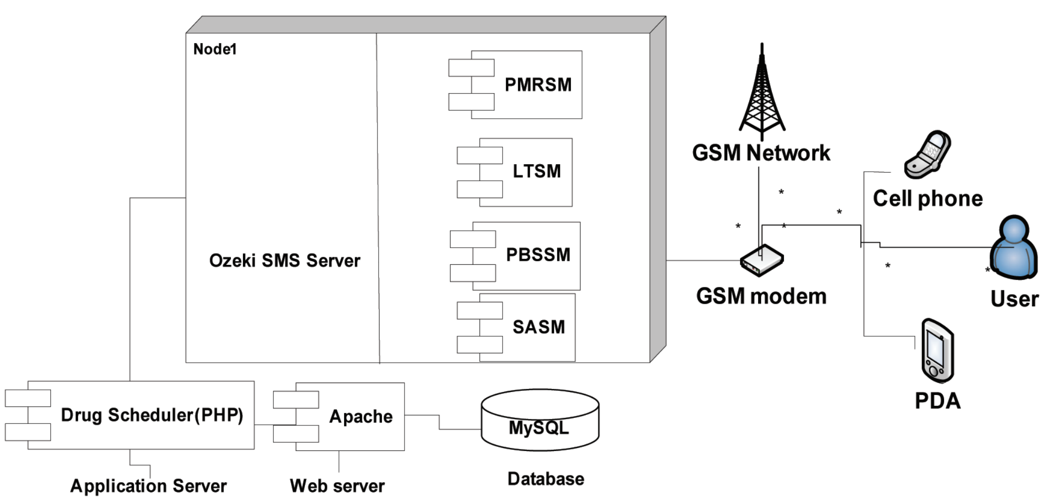
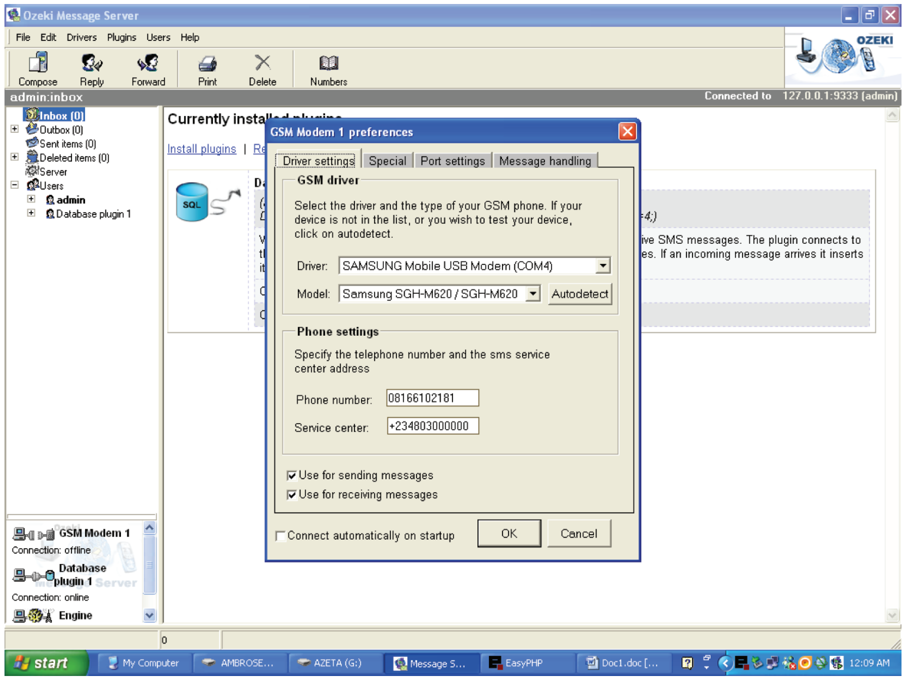


Figure 2. A configuration of GSM modem in Ozeki SMS server



EVALUATION

The method engaged for the evaluation of MAS is Cognitive walkthrough strategy. Cognitive Walkthrough Strategy (John Rieman, 1999) encompasses one or a group of evaluators who inspect a user interface by going through a set of tasks and assess its understandability and ease of learning. To evaluate our MAS, we followed this strategy. 1. Who will be the users of the system?

Figure 3. SQL statement for sent messages and Ado connection script

SQL statement for messages
Download new messages: select id,receiver,msg,operator,msgtype,sender,reference from ozekimessageout where status='send'
Update downloaded messages: update ozekimessageout set status='sent' where id='$id'
Update transmitted messages: update ozekimessageout set status='transmitted', senttime= '$senttime' where id='$id'
Update deleted messages: update ozekimessageout set status='deleted' where id='$id'
update ozekimessageout set status='received',receivedtime='$recvtime' where id='$id'
Receiving incoming messages: insert into ozekimessagein (operator, sender, receiver, msg, senttime, receivedtime, msgtype,reference) values ('$operator', '$sender', '$receiver', '$msg', '$senttime', '$receivedtime','$msgtype','$reference')
The Database Ado Connection String
Driver={MySQL ODBC 3.51
Driver};Server=127.0.0.1;Database=dblogin;User=root;Password="";Option=4;

2 Ph.D. students (Computer Science), 2 graduate students (Computer Science), 3 graduate students (Mathematics), 5 undergraduate students (Biology), 4 undergrad students (MIS), 2 Medical Doctors (Health Center), 2 patients with some technical knowledge and 3 patients without technical knowledge were chosen as the users. We have tried to cover all type of end users and both males and females having different ages. 2. What tasks will be analyzed? The services provided by our MAS were executed by the users. We have tried to select the tasks to be analyzed in such a way that no major task has been overlooked. 3. What is the correct action sequence for each task? First, we briefly explained the task sequences and process to get result. A questionnaire was given to the users. Table 1 shows the user's satisfaction rating [0 is the lowest value and 5 is the highest value].

This study makes a contribution in the field of mobile health care delivery. Researcher wishing to provide a patient monitoring technology that is based on SMS to complement existing e-Health systems will have something to gain also from the article. The analysis from the findings shows Overall (3.6), Ease of Use (3.9), Ease of Input (4.3), Interface Navigation (4.5) and User Satisfaction (4.0. The resultant average rating of (3.6+ 3.9+ 4.5 + 4.3+ 4.3/5 is 4.06 Several usability studies suggest that system with "Very Bad Usability" should have 1 as mean rating, "2 as Bad Usability", 3 as Average Usability, "4 as Good Usability" and "5 as Excellent Usability". It was proposed (Sauro, 2005) that "Good Usability" should have a mean rating of 4 on a 1-5 scale and 5.6 on a 1-7 scale. We can therefore conclude that the prototype MAS application presented in this chapter has "Good Usability" based on the average total rating of 4.06

CONCLUSION

In this work, we have illustrated how to enhance health care delivery on a global scale by developing and evaluating a medical alert system (MAS) which sends medical to patients via handheld

Figure 4. Database content of MAS

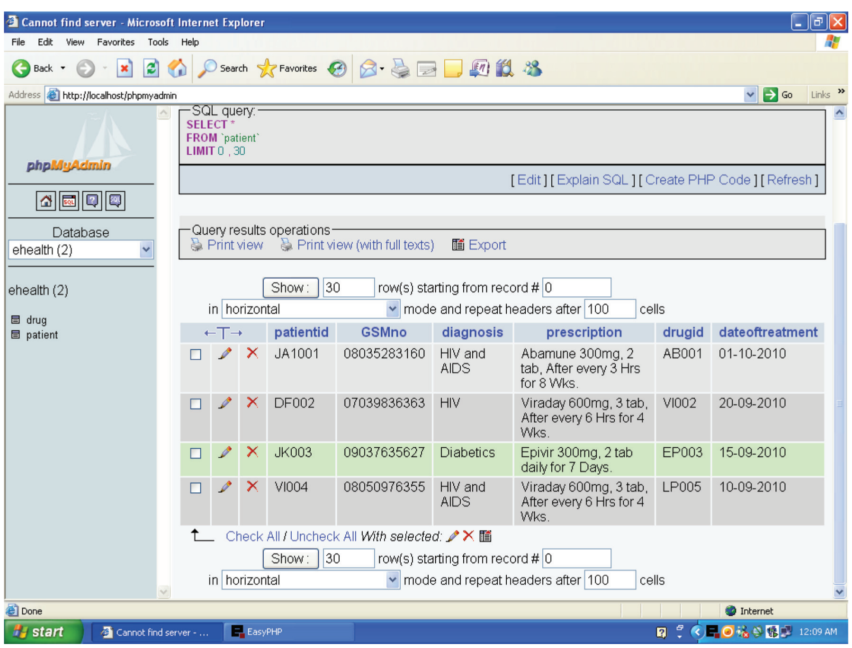
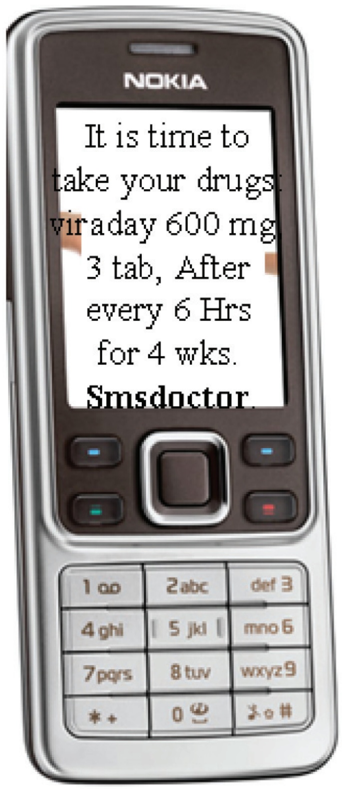


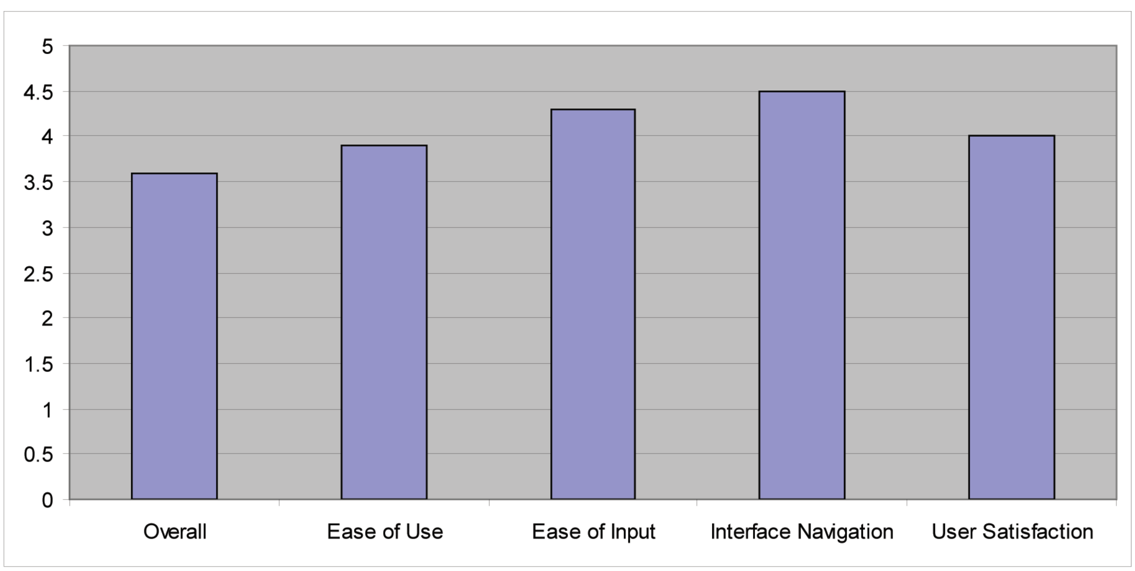
Figure 5. SMS message received by a patient



devices. The system runs on an Ozeki SMS server platform. The goal of the MAS is to remind patients having HIV/AIDS and other related health issues to take their drugs at the prescribed time. An obvious benefit of MAS is to save the patient from the danger of forgetting to take drugs that have been prescribed by the doctor. Experience has shown that when drug prescribed by doctors are abused or not taken as expected it may not function or provide the necessary cure in the human system. The system provided will no doubt help to address the millennium development goals that bother on health care delivery and also help in addressing the problems of HIV/AIDS and other prevalent diseases associated with people living in developing countries.

When the prototype system is fully deployed, it will complement the existing systems used in the domain of e-Health and enhance the quality of health care services provided by both the private and public hospitals in the country.

Figure 6. User's satisfaction rating



FUTURE WORK

To deploy the system on the nation-wide GSM network and to introduce some elements of natural language processing to include translation to local languages in order to increase the acceptability by the non literate people in the country. Security issues will also be critically examined. In addition, voice-alert SMS is being considered as part of the future works in this study, since our investigation shows that some visually impaired patient infected with HIV/AID will benefit from a system that will not only send SMS messages but also read the content of the SMS alert to the hearing of users.

REFERENCES

Baldwin, P., & Thomas, L. (2005). *Promoting private sector investment and innovation: InfoDev and Acatel*. Washington, DC: The International Bank for Reconstruction and Development / The World Bank, N.W.

Cabral, J. E. Jr, & Kim, Y. (1996). Multimedia systems for telemedicine and their communication requirements. *IEEE Communications Magazine*, *34*(7), 20–27. doi:10.1109/35.526884

Cheng, Q., Qu, H., Wang, Y., & Tan, J.(n.d.). Mobile health networks case: Unconfined mobile Bluetooth technology for e-medical services. In Tan, J. K. H. (Ed.), *E-health care Information Systems* (pp. 190–201).

Ganz, A., Istepanian, R. H., & Tonguz, O. K. (2006). Advanced mobile technologies for health care applications. *Journal of Mobile Multimedia*, *1*(4), 271–272.

Glinkowski, W., Wojciechowski, A., Golebiowski, M., & Gorecki, A. (2008). *M-Health implemented by multimedia messaging service teleconsultation in orthopedic clinic*. In Blobel, Pharow, Zvarova, Lopez, & Aka (Eds.), CeHR International Conference, Berlin.

Ikhu-Omoregbe, N. (2010). *Development of a formal framework for usable operations support in e-health based systems*. Saarbrücken, Germany: VDM Publishing House Ltd.

Istepanian, R. S. H. (2005). Wireless security for personalized and mobile health care services, In *Proceedings of the 29th Annual International Computer Software and Application Conference (Compsac'05)* (volume 1). Washington, DC: IEEE Computer Society.

Kim, D. K., Yoo, S. K., & Kim, S. H. (2005). Instant wireless transmission of radiological images using a personal digital assistant phone for emergency teleconsultation. *Journal Telemed Telecare, 2005*(11 Supl 2), S58-61.

Kugean, C., Krishnam, S. M., Chutatape, O., Swaminathan, S., Srinivasan, N., & Wang, P. (2002). *Design of a mobile telemedicine system with wireless LAN*. 2002 Asia-Pacific Conference on Circuits and Systems (APCCAS '02) (vol. 1, pp. 313-316).

Kyriacou, E., Pavlopoulos, S., Berler, A., Neophytou, M., Bourka, A., & Georgoulas, A. (2003). Multi-purpose healthcare telemedicine systems with mobile communication link support. *Biomedical Engineering Online*, *2*, 7. doi:10.1186/1475-925X-2-7

MobilePoint. (2004). *Mobile point-of-care solutions*. White Paper, Intel. Retrieved from www.intel.com/business / bss / solutions / blueprints / pdf / poc032106.pdf

NCC. (n.d.). *Nigerian Communications Commission, subscriber data*. Retrieved from www.ncc.gov.ng

Ng, W. H., Wang, E., & Ng, I. (2006). Multimedia messaging service teleradiology in the provision of emergency neurosurgery services. *Surgical Neurology*, *67*(4), 338–341. doi:10.1016/j.surneu.2006.10.056

Pfleeger, S. L., & Atlee, J. M. (2006). *Software engineering: Theory and practice* (3rd ed.). London, UK: Pearson Educational Inc.

Qureshi, A., Shoeb, A., & Guttag, J. (2005). *Building a high-quality mobile telemedicine system using network striping over dissimilar wireless wide area networks*. 27th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Shanghai, China.

Ramswaroop, G., Rao, M., & Rajasekhar, K. (2010). *Short messaging service (SMS) based diseases surveillance system under integrated disease surveillance project (IDSP) in Andhra Pradesh India (a case study)*. Retrieved September 20th, 2010, from http:// public. webfoundation.org/2010/04/trai_compendium/28.%20SMS%20based%20deseases%20survillance%20system.pdf

Ridgeway, M. (2002). *Net wireless programming*. Alameda, CA: SYBEX Inc.

Rieman, J., Franzke, M., & Redmiles, D. (1995). Usability evaluation with the cognitive walkthrough. In *Proceedings of CHI '95 Conference Companion on Human Factors in Computing Systems*. New York, NY: ACM Press.

Rohm, T., & Rohm, T. Jr. (2004). Evolving medical informatics: From diagnosis to prognosis. *International Journal of Electronic Healthcare*, *1*(1), 103–111. doi:10.1504/IJEH.2004.004660

Sauro, J., & Kindlund, E. (2005). A method to standardize usability metrics into a single score. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '05)* (pp. 401-409). New York, NY: ACM Press.

Shahriyar, R., Bari, F., Kundu, G., Ahamed, S. I., & Akbar, M. (2009). Intelligent mobile health monitoring system (IMHMS), *International Journal of Control and Automation, 2*(3), September 2009. Retrieved October 2nd, 2010, from http:// www. sersc. org/ journals/ IJCA/ vol2_no3/ 2.pdf

Tang, F.-h., Law, M. Y. Y., Lee, A. C. H., & Chan, L. W. C. (2004). A mobile phone integrated health care delivery system of medical images. *Journal of Digital Imaging*, *17*(3), 217–225. doi:10.1007/s10278-004-1015-5

Uneca. (n.d.). *Nigerian national policy for Information Technology* (IT). Retrieved from http://www.uneca.org/aisi/nici/Documents/

Voskarides, S., Pattichis, C. S., Habib Istepanian, R. S., Kyriacou, E., Pattichis, M. S., & Schizas, C. N. (2002). Mobile health systems: A brief overview. In R. M. Rao, S. A. Dianat, & M. D. Zoltowski (Eds.), *Proceedings of SPIE AeroSense 2002: Digital Wireless Communications IV* (vol. 4740, pp. 124-131), Orlando, Florida, USA.

Wickramasinghe, N., & Misra, S. (2004). Wireless trust model for health care. *International Journal of Electronic Healthcare*, *1*(1), 60–77. doi:10.1504/IJEH.2004.004658

Wojceichowski, A., Glinkowski, W., Gołębiowski, M., & Górecki, A. (2006). The use of multi-media messaging as supplement information of musculoskeletal injury cases. In E. Pietka, J. Leski, & S. Franiel (Eds.), *Proceeding of the XI International Conference on Medical Informatics & Technologies (MIT '06)* (pp. 246-253).