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A Deployable Framework for Mobile Telemedicine Applications

N.A. Ikhu-Omoregbe[1], C.K. Ayo and S.A. Ehikioya
Department of Computer and Information Sciences, Covenant University, Ota, Nigeria

Abstract. In recent years, the shortage of medical specialists and access to medical information has necessitated a growing interest for cost effective and efficient telemedicine tools for healthcare delivery. Mobile telemedicine applications are aimed at meeting the mobility requirements of patients and doctors by integrating wireless communications for different health care services and education.

Although, telemedicine holds great promises in enhancing health care delivery in rural area and developing countries, only a few applications exist because of poor frameworks for their deployments. This paper, aims at providing a deployable framework for Mobile Telemedicine Applications for Tropical Diseases (MTATD).

MTATD presented here, provides access to a telemedicine unit via hand held devices over a PSTN/GSM and the Internet for a collaborative health care delivery and education between patients and care providers.

Keywords. Deployable, Framework, Health care, Telemedicine, Mobile

Introduction

Telemedicine aims at providing expert-based health care and medical information to rural or understaffed remote sites and to provide advanced emergency care through modern telecommunication and information technologies.

Telemedicine holds great promise to enhance healthcare delivery in rural areas and developing countries by allowing a physician or other healthcare specialists examine a patient while linked by video or other means to an expert consultant at a distant medical center [1]. Radiologists and other specialists can review medical images transmitted over telephone lines or the Internet. Similarly, a Pathologist in a developed world can review biopsies done in a hospital in a rural or developing country near real-time [1].

The rapid advances in digital and communication technologies have now made other media, particularly images and sound amenable to computer-based storage, manipulation, and transmission [2,3]. Medical diagnosis and management could be achieved with the use of textual descriptions and still images [4] over fax, telephone or email but most times, these do not provide sufficient information for correct diagnosis and prognosis by the experts during a telemedicine session [5]. Traditional telemedicine applications are associated with the use of expensive and bulky telecommunications infrastructures with substantial bandwidth of 128kbps or greater [6].

Significant researches exist in literatures demonstrating different clinical areas of telemedicine applications such as the use of Public Switch Telephone Network (PSTN), and the use of Integrated Services Digital Network (ISDN) for the transmis-

[1] corresponding author **stnics@yahoo.com**

sion of medical data and video images during telemedicine session. Many of these applications are still being deployed on fixed stations and thus do not meet the mobility requirements of patients and doctors who could be mobile [7]. In health care patients are the major player and they are mobile, applications deployed for them should be without mobility constraints.

The design and deployment of a telemedicine application, like any other application, assumes a systems engineering approach. Requirements engineering is highly significant in this process, since getting the requirements wrong would lead to a poor and unacceptable product. Requirements engineering therefore, provides the appropriate frameworks, and ensures that the proffered solutions are correct, complete, concise and unambiguously specified to guarantee an acceptable product [5].

Wireless and mobile technologies are currently having powerful impacts on the way different health care providers offer services to their patients [7]. Cellular digital networks, handheld devices such as PDAs and mobile phones are being used to extend the deployment and maneuverability of health care applications and content.

The remaining part of the paper is divided as follows: In section 2, we look at Telemedicine Applications and their Requirements. In section 3 we present the Architecture and a Deployment Infrastructure for MTATD, in section 4, we provide a prototype and a discussion of core functionalities in section 5. We conclude in section 6 with a brief summary.

1. Mobile Telemedicine Applications And Their Requirements

Mobile telemedicine is an emerging area, integrating wireless communication for different telemedicine applications. The emerging mobile and networking technologies such as 3G/4G, are fast opening new opportunities and introducing greater innovations to health care delivery [8]. Some benefits [9,10] offered by mobile telemedicine system using mobile network include amongst other:

- cost effective utilization of limited health care resources
- access to enhanced services, especially where cost and distances would have been constraints.
- allowance for patients to remain in their normal environment and maintain a normal lifestyle
- minimizes travel cost and risk for patients or physicians
- early diagnosis, intervention, and treatment in certain events
- provides for the mobility needs of the patients or physicians
- quicker turn around time for consultations

The communications infrastructures for handling the multimedia requirements for telemedicine applications are largely dependent on the type of telemedicine being addressed. Types of telemedicine include: teleconsultation, telediagnosis, tele-education, telementoring and Telemonitoring [1,6,7].

a) Teleconsultation: This involves the interactive sharing of images and other medical information in which the primary diagnosis is made by the doctor at the location of the patient. Generally, a teleconsultation is between a family practice expert located at a local medical center and the relevant specialist or subspecialties located in a remote medical center whose "second opinion" is required to confirm a diagnosis by the local expert [1].

cian/Server Support Unit. The patient unit, usually handheld device with capabilities to integrate medical devices uses the GSM mobile telephone or PSTN links It accepts and transmits clinical information such as; Heart Rate, None-Invasive Blood Pressure, Invasive blood Pressure, Temperature, Respiration etc to the Physician Support Unit depending on his complaints and the requirements for his/her diagnosis.

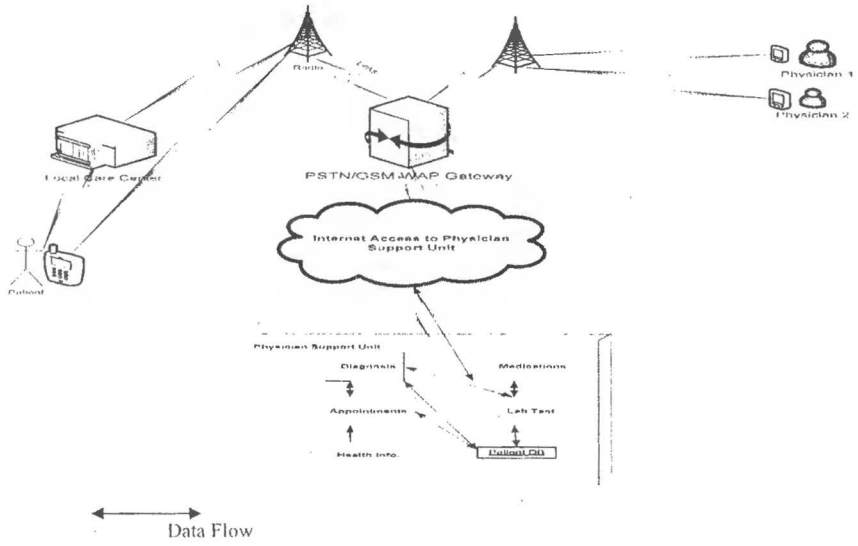

Fig. 3.1. MTATD Architecture and Deployment Infrastructure.

The Physician's unit enables him/her to receive, view and interpret the data from the patient's unit for possible diagnosis and therapy. The Physician Support Unit is supported by a database component to record relevant encounter and store relevant data for diagnosis and other clinical and administrative use. When further test or consultation is required, the patient is asked to visit a participating local health care center or hospital for adequate care.

3. Prototype of MTATD

Prototyping is considered a cure for the problems of understanding during requirements capturing [16]. We present a prototype of the core functionality to demonstrate executed versions of our requirement model.

The Client application was developed with Wireless Markup Language. The Server application was developed in java language because of its independent platform and security features and provides access to MS SQL 2000 Server. The database is equipped with graphical users interface to enhance its usability and shown in Fig. 4.1.

The server receives patients' electronic records via an API that returns diagnosis and treatments information in the form of XML document. The prototype application has been tested with openwave v7 simulator, which emulates the Wireless Application Protocol, gateway on a (3-tier) client-server architecture separated by a mobile network. The prototype has been tested on the covenant university Intranet in preparations for further stress testing and deployment at the Covenant University Health Center, Nigeria.

b) Telediagnosis: This is a most prominent application of telemedicine. It entails the sharing of images and medical information in which the primary diagnosis is made by an expert at a location remote from the patient [1].
c) Tele-education: This involves the provision of educational materials over a telecommunication network [1]. In telemedicine, it entails the dissemination of medical information, research and laboratory findings and results. In implementing Mobile Telemedicine Application for Tropical Diseases, patient can have access to relevant medical information for better living through tele-education.
d) Telementoring: This is similar to Tele-education. It is an education technique that involves real-time guidance of a less experienced practitioner through a procedure for which he or she has limited experience [6]. For example, guiding a less experienced physician during a surgical process in a local hospital by a more experienced surgeon at any another part of the world via telecommunications infrastructures.
e) Telemonitoring: Results from recent finding have shown that the number of patients receiving monitored treatment from home is on the increase [7]. Some patients prefer to remain within the comfort of their homes and to cut down hospitalization cost while their health conditions are being managed and monitored from a remote location via mobile infrastructures. This is possible by connecting camera or other medical devices (e.g. pulse oximetry) to personal digital assistance (PDA) or mobile phone such as Nokia 9000 which can relay information collected from patients to the healthcare provider via wireless network. Telemonitoring is suitable for different emergency health care scenarios such as monitory of an elderly, suffering from diabetes. With the right infrastructures in place, healthcare provider can continuously monitor a patient's physiological data regardless of the patient's location provided he is within the mobile coverage [11].

1.1. Telemedicine for Tropical Diseases

Numerous diseases such as malaria, cholera, yellow fever etc are prevalent in Africa with common symptoms. Malaria (a protozoan disease caused in human by four species of genus plasmodium) is the most widely spread amongst them. Malaria is characterized by extreme exhaustion, high fever, sweating, vomiting, pains and anemia. From statistics, it is African leading course of under-five mortality (20%) and constitutes 10% of the overall diseases in Africa. 30-50% of inpatients admission and 50% of outpatients visit in some areas such as Nigeria where more the 90 people per square kilometer are likely to be infected with the disease [12-14].

Nigeria and other developing nations of the world could embrace the opportunities offered by the emerging mobile technology to address malaria and other health issues. Nigeria has the fastest growing mobile coverage in Africa with teledensity of 15 as at the end of the year, 2005 [15]. The architecture proposed in this paper, utilizes the enabling mobile network infrastructures in the country for the deployment of MTATD.

2. Architecture

We propose a client/server architecture separated by a mobile network. The system consists of three main modules called Patient Unit, a Physician Unit and the Physi-

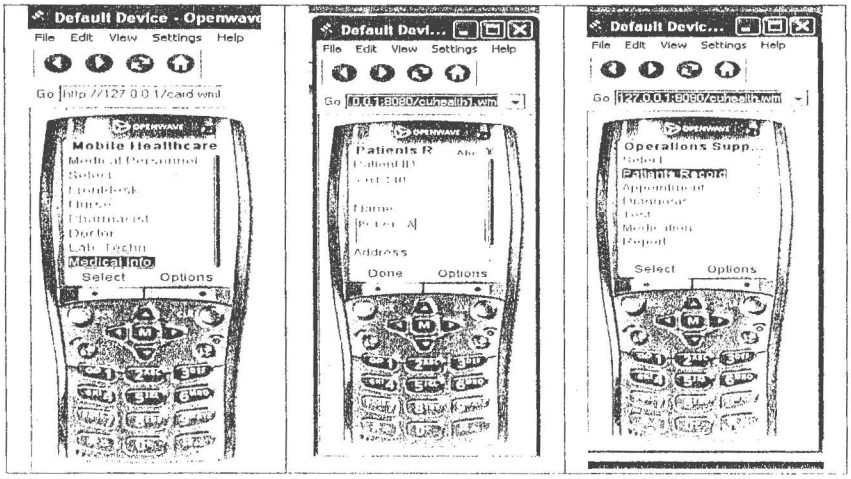

Fig. 4.1. User's Interfaces and Services in MTATD.

4. Discussion on MTATD

MTATD allows effective and efficient use of medical resources available at medical centers to support the medical practitioners. The application could be interfaced with a camera having the capabilities to connect various medical instruments, e.g. Otoscope, ophthalmoscope, sigmoidoscope, or any form which are necessary for viewing procedures performed at a remote site and facilitates consultations with the a medical center [17,18,19]. Doctors at one side may view, discuss cases, interview patient, and interact effectively with him to improve the quality of patient care via the WAP infrastructure. The MTATD is capable of transmitting clinical information from the client device to the server.

MTATD proposed in this paper could have a call center using IP-based Customer Relationship Management (CRM), which connects patients by telephone, 24/7/365 to the health information they seek. When a patient in need of medical services dials into the system she will have access to front desk information or an option of being connected to a medical specialist. If the caller (patient) selects a nurse for example, the nurse works through the patient's symptoms and recommends appropriate course of action [20] with the help of the telemedicine support unit which uses fuzzy logic and neural networks principles to arrive at conclusion. The function of the nurse is usurped by the system [21].

MTATD incorporates an Automated Speech-Controlled Customer Care Service system (ASR CCS) proposed in [21] to minimize Human-to-Human (H2H) interaction being replaced with Human-to-System (H2S) model to reduce response time [22].

MTATD has self-starting capabilities, which enables it to initiate dialogue with patients by mailing diagnosis and therapies through SMS (or via email) to patients who had earlier made complaints and could not have a consultation session with a specialist. In instances where a doctor's or laboratory visit becomes very necessary such as when a patient is infected with P.facliciparum malaria (where it is advisable to hospitalize and treat the patient as a medical emergency to prevent complexities) [20,22], the system books an appointment with the specialist in a participating health care center and reports to the patient when she can see the physician while automatically transferring the patient's record to the contacted specialist's attention.

5. Conclusion

The accessibility of prompt and cost effective medical services and educations could lead to life savings for rural dwellers and the inhabitants of the developing nations; Particularly, for the areas that are categorized as death zone by WHO, for lack of adequate manpower and facilities.

MTATD as described in this paper will go a long way in improving health care delivery by enabling patients with handheld devices book appointments and receive other medical services at their convenience. Furthermore, it will reduce the cost-implication of deploying telemedicine applications in least developed countries and developing nations of the world, where there is a high shortage of medical personnel and information.

Finally, as more Nigerians and Africans get connected to mobile services, the framework thus provided could act as a specification document for developing and deploying applications to address endemic diseases such as, HIV/AIDS, cholera, etc. across the world.

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