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Framework for Web-Based and Desktop-Based Telemedicine System

[1]Olayinka,T.C., [2]Olayinka A.S, [3]Oladimeji O.R.
[1]Computer Science Department, Wellspring University, P.M.B.1230, Benin City, Edo State,
[2]Physical Science Department, Faculty of Science, Edo University,Iyamho, P.M.B. 07, Auchi, EdoState,
[3]Department of Nursing, Delta StateUniversity, Abraka, Delta State, Nigeria
Corresponding Author: Olayinka

Abstract: *The continuous decline in quality medical healthcare delivery to rural communities in developing countries is what necessitated this study. Most patients in remote areas cannot afford transportation to the nearest healthcare facility providing the necessary medical services relevant to their situation. Provision of support services and continuous medical education for those healthcare professionals working in rural areas are extremely difficult. Telemedicine is a feasible tool to address these issues. In this paper, we proposed a framework for web-based and desktop-based telemedicine system were remote medical centre can access the medical resources available in urban medical centres through the internet. The web-based telemedicine application is database driven application while the desktop-based telemedicine application offers real time audio-visual communication between the remote medical personnel/patient and the medical experts in the urban areas. The proposed applications were tested with good latency which will in turn reduce cost of healthcare delivery.*

Keywords: *Patients, healthcare, audio-visual, ICT, framework.*

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I. Introduction

Many developing countries are facing various problems in delivering healthcare and medical services to their populace. This problem includes lack of funds as well as shortage of trained and experienced doctors and nurses which contribute to poor delivery of healthcare to their populace. In addition, poor roads, limited transportation facilities and long distances are severe obstacles for providing healthcare services to rural communities and remote areas.Telemedicine is not a telephone conversation or a fax. Classically, it involves the application of both video and audio technologies in support of healthcare delivery. Telemedicine enables another form of humanitarian aid whereby specialists from industrialized countries can offer part of their time and knowledge to assist doctors and other healthcare professionals in developing countries. For the development of medical services the collaboration with experienced professionals is often inevitable.In countries where healthcare facilities are rare and access to medical services is restricted by distance and poor transportation, telemedicine offers possibilities to distribute medical services more equally by utilizing Information Communication Technologies (ICT). ICT bridges the physical distance between patients and healthcare providers. Telemedicine is very useful in areas where there are shortages of doctors and specialists that can diagnose specific medical conditions.

Telemedicine literally means "medicine at a distance". Telemedicine was fundamentally born during the 'space race' between the United States of America (USA) and the former Union of Soviet Socialist Republics (USSR). The National Aeronautics and Space Administration (NASA), the USA military and USA Government funded many telemedicine projects. NASA was keen to build up a distant monitoring system to manage the health of American astronauts in space [1].

Telemedicine involves the use of telecommunication to provide medical information and services [2]. The World Health Organization (WHO) defines telemedicine as the practice of medical care using interactive audiovisual and data communications for medical care delivery, diagnosis, consultation and treatment, as well as education and the transfer of medical data" [3]. Generally, telemedicine involves the use of modern information technology, especially two-way interactive audio and video telecommunications, computers and telemetry, to deliver health services to remote patients and to facilitate information exchange between primary care physicians and specialists at some distances from each other [4]. Telemedicine provides patient medical care and consultation over a distance, using telecommunications technology such that the patient and healthcare provider do not have to be in close proximity. [5]. The real time transmission of image and voice of two partners has often been regarded as a key necessity for telemedicine consultations. In order to achieve these goals, we

have identified the functions that the telemedicine system must facilitate; patient registration and discharge, diagnosis and consultation, prescription and treatment, patient's referral to medical providers, medical providers' examinations, the storage and retrieval of information, administration and database management.There are several sub-specialties of telemedicine, the best known is teleradiology, but we also have telesurgery, teledermatology, telecardiology, telepathology, telehealth, teleconsultation, tele-diagnostics and telepsychiatry.

Over half of all United State hospitals use telemedicine, and this trend is rising. In fact, in a recent survey of healthcare executives found 90% had already begun developing or implementing a telemedicine program into their organizations [6]. Even healthcare providers in smaller, independent practices are starting to adopt telehealth to compete with local retail clinics and stop losing their patients.

II. Literature Review

2.1 Telemedicine in the Industrialized World

The industrialized countries like North America, Europe, Japan and Australia have a considerable amount of experience with telemedicine. It has been practiced in these countries to some degree for over 50 years. The Nebraska Psychiatric Institute for instance, in 1959 was one of the first in the world to use a closed circuit television link with the Norfolk Hospital 112 miles away. The link was used by doctors who consulted with each other on patient cases and also gave psychiatric consultations to patients on the other end of the link. Another significant early implementation of telemedicine was a microwave video link set up in April of 1968 between the Massachusetts General Hospital (MGH) and Bostons Logan airport. The link was established to provide immediate health services to airport employees and passengers. This eliminated the need to have physicians permanently assigned to the clinical facilities at the Airport, while avoiding the delays associated with patient transportation. Examinations at Logan included radiology, dermatology and cardiology [7].Telemedicine has advanced significantly in the developed world. It is now used in a wide variety of settings ranging from simple doctor-patient telephone and email consultations, to sophisticated Virtual Reality (VR) enhanced tele-surgery. Moreover, it is used in remote areas, correctional institutions in the military and in space projects. Telemedicine is commonly used in areas where there are shortages of doctors and specialists that can diagnose specific medical conditions.

2.2 Services Rendered By Telemedicine

- **Specialist Referral Services:** Here, the specialist assisting a general practitioner in rendering a diagnosis. This may involve a patient seeing a specialist over a live, remote consultation or the transmission of diagnostic images and/or video along with patient data to a specialist for viewing later. Routine applications of specialist referrals include radiology, pathology, dermatology, ophthalmology, cardiology and so on.
- **Primary Patient Consultations:** This takes place between a patient and specialty physician with the aim of rendering a diagnosis and treatment plans using transmission of audio, video and medical data.
- **Remote Patient Monitoring:** Here, thepatient can be monitored using devices to remotely collect and send data to a monitoring station for interpretation. For instance home telehealth applications might include a specific vital sign, such as blood glucose or a variety of indicators for home-bound patients and can also be used to support visiting nurses.
- **Consumer Health Information:**Theconsumer health informationincludes the use of ICT for consumers to acquirespecific health information and on-line discussion groups to provide peer-to-peer support.

2.3 Partners Involved in Telemedicine

The partners involved in telemedicine application are identified:

- **Specialist,**performs second opinion consultations, sub-specialty consultations, consensus diagnosis or joint research.
- **General Health Professional and Specialist,** referral to establish diagnosis and also educational applications and decision support.
- **Patient and Healthcare Professional,**involved in primary consultations, for instance, pre-clinical consultation over telephone.
- **Patients,**use ICT for exchanging information and knowledge. This will be increasingly used by self-help groups on issues about living with a certain disease or disability.
- **Specialist to Computer Applications,**theseare used for remote quality assurance, decision support and joint research.
- **Patient to Computer Applications,** health awareness web sites are used to disseminate information to patients and to provide preventive information.

2.4 Significance of the Telemedicine

Telemedicine requires the integration of technology, tools and training with medical care practices and problems. New developments in ICT provide a continually expanding array of tools for the implementation of telemedicine applications. In this study, telemedicine will:

1. Enable transmission of knowledge to the patient rather than to only transport patients to the healthcare centers where the knowledge is available. This has promising implications in particular for remote and under-served areas.
2. Offer possibilities for creating networks between the geographically separated healthcare providers.
3. Be possible to establish diagnosis and feasible treatment plan.
4. Offer opportunities for continuous medical education in remote areas which will ensure improved local healthcare delivery.
5. Give access to relevant and up-to-date health information and e-learning.
6. Help to improve the administrative process in healthcare centres.

2.5 Review of Related Literatures

Matusitz and Breen [8]presented telemedicine effects on health communication. In their study, they analysed telemedicine as the use of distant communication within the context of clinical healthcare and the effects it has on health communication. Telemedicine has both positive and negative ways of radically modifying face-to-face communication. They identified the advantages of telemedicine such as the ability telemedicine to transcend geographical boundaries, transcend temporal boundaries, reduce costs, increase patient comfort, security, and satisfaction, and to digitize health communication via web-based services. They also identified the telemedicine applications:Management of specific diseases, Use within specific specialties, Classification according to technology, andTypes of clinical problems.

Harnett [9] studied Telemedicine Systems and Telecommunication. In his study he stated that to have successful telemedicine systems, it requires the use of appropriate equipment, some telecommunication medium and also right people who are properly trained. In the study, he divided telemedicine practice into two distinct categories, real-time telemedicine (synchronous e.g video-conferencing) and store and forward telemedicine (asynchronous e.g. E-mail). Harnett concluded by identifying the robust state of telecommunication networks and video equipment which has made telemedicine readily available for users.

Demartines *et al* [10] studied Knowledge and Acceptance of Telemedicine in Surgery. In their research, they carried out survey using questionnaire sent to the chief surgeons at 141 Swiss hospitals to evaluate their knowledge and acceptance of telemedicne in surgery. The response rate was 69%. Ninety-three per cent of all surgical departments used computer technology, 85% regularly used the Web and 88% had an internal hospital network. Integrated services digital network (ISDN) lines were used in 58% of the participants' hospitals. While 35% of respondents had participated at least once in networking, only 8% regularly used telemedicine. The opinion was that access to therapeutic advice (87%) was a better use of telemedicine than was obtaining a primary diagnosis (24%), although the majority accepted the principle of making (91%) and receiving (94%) a remote diagnosis. The survey suggested that surgeons are interested in telemedicine and open to its development, although their experience and knowledge are limited.

Oguntola [11] reported University College Hospital (UCH), Ibadan, Nigeria commissioned E-radiology to improve their medical services. This will ensure that all radiological results, whether from X-ray, scan, ultrasonography, were kept on the hospital's website and could be downloaded when required and assured of the safety of the data, which can be downloaded from an intranet service that would be assessed with a password, the patient's name and hospital number.

Odeh [12] studied telemedicine centre brings affordable, high quality healthcare to Nigeria. Using, Nigeria as a case study for the telemedicine center would increase access to high quality healthcare services at affordable cost among Nigerians. He stated that the initiative rides on the availability of the broadband access fibre optics access provided by Nigerian Telecommunication firm. This will reduce the traffic of Nigerians travelling abroad for medical attention. Time and cost involved in patient's transportation can be significantly reduced.

III. Methodology

The existing method of healthcare delivery system in developing countries like Nigeria was analysed in order to identify major problems associated with healthcare delivery. There are major problems with the existing method to healthcare delivery; these include inadequate power supply, lack of infrastructure and poor education on the benefits of telemedicine. In this study, a framework for the development of telemedicine system is presented. This system is capable of providing basic medical consultations and delivering healthcare services via web-based and desktop-based telemedicine system.

3.1 Framework for the Telemedicine System

The framework of the telemedicine system in this study consists of web-based and desktop-based telemedicine system. The Fig. 1 illustrates the complete architectural framework for both web-based and desktop-based telemedicine system. The web-based telemedicine application is database driven which is hosted by the web server connected to the internet. The patient can access the web application through the internet to access the basic healthcare services and leave message for any doctor on the telemedicine system. The doctor in turn can access the web application through internet and respond to the patient's request. The desktop-based telemedicine application enables the general practitioner with the patient at the local hospital communicates in real time audio-visual with the specialist doctor at remote hospital over internet. The firewalls ensure the security of the local and remote networks of the hospitals respectively. The Fig. 2 shows the simplified framework for web-based telemedicine application whereby the patient can access the system on the internet, to register, login and send message about his or her illness to the doctor in the hospital without visiting the hospital or travel a long distance before he/she can communicate the doctor, then the doctor can make prescription immediately. At the backend of the telemedicine application the administrator manages the telemedicine database. Fig. 3 depicts the simplified architectural framework for desktop-based telemedicine application where the doctor with the patient in the local hospital and the specialist at remote location (hospital) can enter into one to one real time communication using the audio-visual facilities. In this mode, the doctor, patient and the specialist can see each other and talk to each other in real time.

The Telemedicine application was developed using HTML (Hypertext Markup Language), JSP (Java Server Pages), C#, MySQL (My Structured Query Language), Java Script and Flash. HTML was used for designing of the web pages with Java scripts embedded to enhance it with interesting elements. Java provided an interface to HTML pages. The second middle layer was developed using JSP while the backend layer, database was designed using MySQL. The least hardware requirements for the desktop-based application is Intel dual core processor, 2.0GHz, 1GB RAM, hard disk of 250GB, 32-bit operating system (OS) with relevant input devices such as keyboard, mouse, web camera, headphone with speaker. The system implementation was carried out using Java run-time environment 1.4 and Dot Net Framework 3.0. The web-based system can run on any internet compatible operating system with Flash Player and web browser while desktop-based application is for windows OS. The minimum requirements for the server system is Intel 2.13GHz Quad Core, 4GB RAM, 146GB SAS (Serial Attached SCSI (Small Computer Systems Interface)) HDD with Windows 2007 Server Operating System (OS).

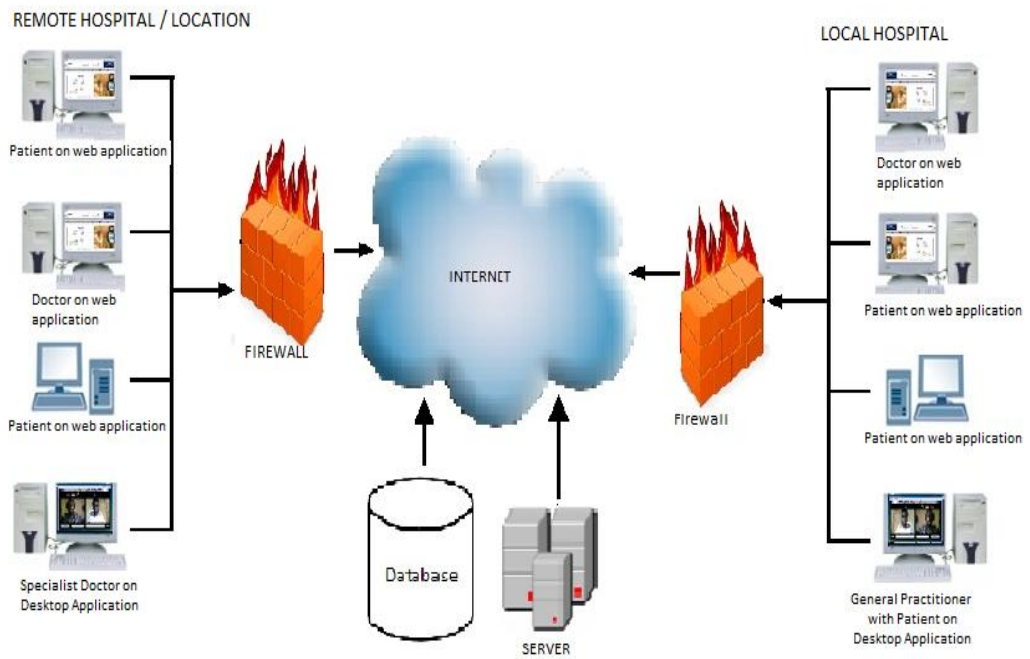

Figure1: Complete Framework for Web-based and Desktop-Based Telemedicine System

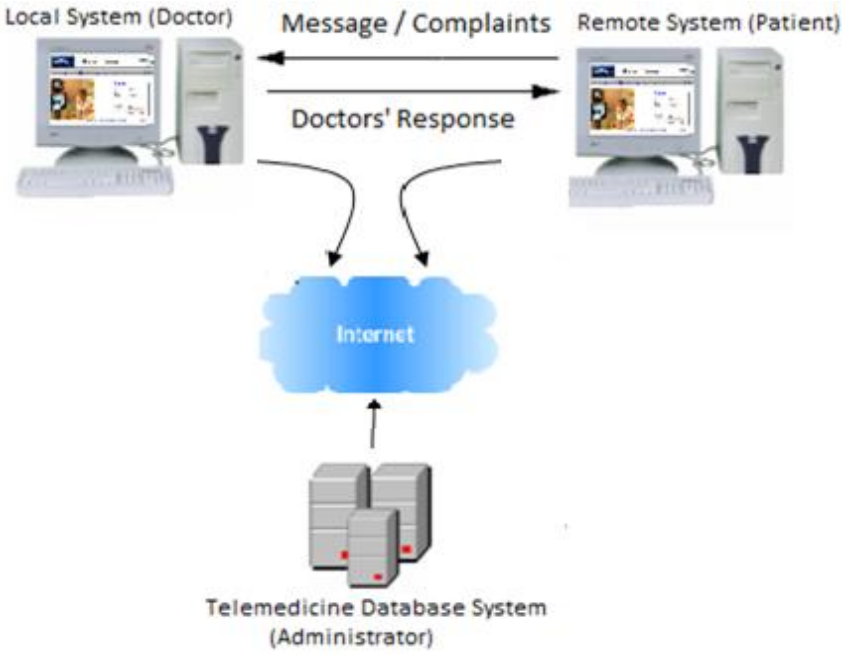

Figure 2: Simplified Framework for Web-based Telemedicine System

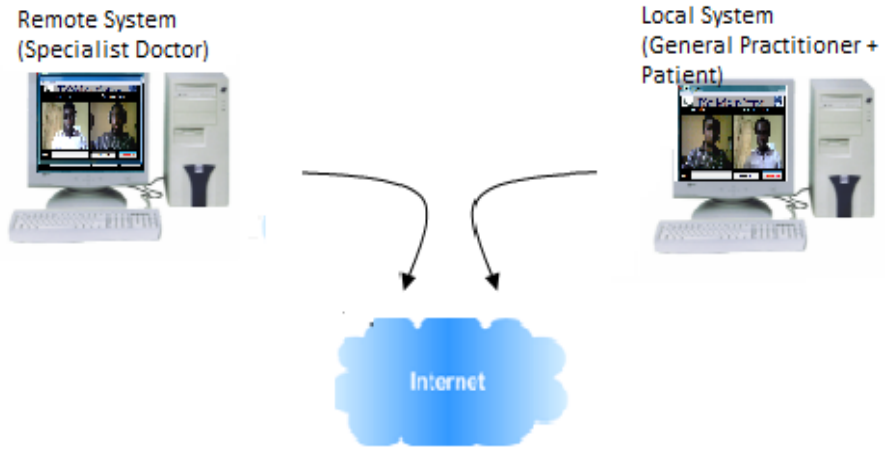

Figure 3*:* Simplified Framework for Desktop-based TelemedicineSystem

3.2 Results and Discussion

The ultimate goal of the telemedicine application is to create facilities for patient's registration, consultation, diagnosis, test recommendation and drug prescription without visiting the hospital or travel a long distance before he/she can communicate the doctor. The patient has the flexibility of choosing from a pool of experts (doctors) and seeks opinion from knowledgeable resources. The applicationachieves the task of providing a suitable platform for patients to address their consulting needs by a single click on each interface. MySQL database management system and Netbeans 6.9.1 integrated development environment platform was used in developing the web application. This application should be hosted on a web server for it to be available on the World Wide Web (www). The telemedicine application database layer is made up of 3-logical modules. The modules are patients' module, doctors' module and administrators' module.Patients' module deals with the patients' information, such that the patient can register on the telemedicine system and login for consultation with the doctor at any desired time. The patients' module enables patient registration, patient login, and patient visit. The doctor's module aids the doctors to effectively interact with the patients and it provides doctor registration, doctor login and patient details. The Administrators' module comprises of administrator's login, viewing database and updating database. The administrator has the right to view the database for patient's information, doctors' information and can also update database which includes updating all the patient profiles

and doctors profiles. The administrator manages the application database at back end.The desktop-based telemedicine application is an extension of the web-based system which provides a synchronous duplex audio-visual real time communication between remote doctor/patient and specialist doctor similar to video conferencing of Bellazzi *et al*. [13]. The telemedicine system is capable of carrying out telediagnosis, teleconsultation and teleprescription via video-conferencing[14].

IV. Conclusion

Telemedicine has been viewed as a solution to reducing costs and making healthcare services possible even to remote areas. With rapid advances in information and communication technology (ICT), makes it possible to transmit text, sound, video, image and other information from one location to another. Time and cost involved in patient's transportation can be significantly reduced.This paper presents a framework for both web-based and desktop-based telemedicine system to provide healthcare services to remote areas. The web-based telemedicine is database driven and synchronous duplex audio-visual communication was tested with good latency on desktop-based telemedicine system. In conclusion, telemedicine has the potential to change healthcare delivery especially in developing world thereby reducing the overall cost.

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