Development of a Cost-Effective Telemedicine Services for People Affected with Cardio-Vascular Diseases in the Rural Area: A Case Study of Iwo Local Government

Ibrahim Adenuga[1], Olufemi Akinyede[2] and Omoyele Akinsowon[3]

[1] Department of Information Technology, National Open University of Nigeria,
Lagos, Nigeria

[2] Department of Computer Science, The Federal University of Technology,
Akure, Nigeria

[3] Department of Computer Science, The Federal University of Technology,
Akure, Nigeria

Abstract

In rural Nigeria, the health system is in a disreputable state and this is attributed to several factors especially the flagrant underfunding of the health sector and shortage of skilled specialists at the primary health care (PHC) level - as a result of the migration of a number of physicians from the rural areas to urban centers. The impact of this rural-urban migration has led to the shortage of trained personnel or specialists in the rural communities. This research work aims at developing a cost-effective telemedicine solution that will bridge the gap created as a result of migration of trained medical specialists from rural areas to urban centers. Finally, an integrated portable electrocardiogram (ECG) device to provide the waveform required by the specialist to recommend a possible treatment to the rural medical practitioner is provided. The system was developed using Iwo local Government Council as a case study

Keywords: Telemedicine, medical health and services, rural access, primary health,

1. Introduction

Telemedicine is the use of telecommunication and information technologies in order to provide clinical health care at a distance [1]. Information and communications technology or information technology is better defined as the integration of telecommunications, computers and application software which enable users to access, store, transmit, and manipulate information. Information technology is not a magic formula that is going to solve all our problems but it is a powerful force that can and must be harnessed to our global mission of peace and development [2][3]. Information and Communications Technologies (ICTs) have the potential to improve the lives of people in rural communities [4]. The need to develop and organize new ways to provide efficient healthcare services has thus been accompanied by major technological advances, resulting in dramatic increase in the use of ICT applications in healthcare and e-health. The integration and assimilation of e-health into the everyday life of healthcare workers is becoming a reality in developing as well as developed countries, [5];[6]. Information and Communications Technology has made it possible for medical practitioners to discuss medical issues and diagnosis of complicated diseases. ICTs are widely perceived to have the capability, if used effectively, to bridge social and economic gaps that divide rural and urban communities, provides access to quality healthcare and enhancing the general well being of the underprivileged people of the remote areas [7].

[8] opined that computer literacy by both educated and uneducated have become the most important factor for improved standard of living. There is no effective health education anywhere in the world without the application of ICT. [9] perceived ICT as an unavoidable technology for the improvement of organization, team and people in the information age. According to [9], computer compliance has become the accelerator for productivity and economic growth. Rural dwellers in Nigeria need a wide range of qualitative health care. Just as we have service providers' Mast everywhere in the rural areas, so there is need to explore the power of ICT to bring such health care closer to their door steps. Most especially where it is obvious that treatment of chronic diseases like tuberculosis, leprosy, cardio vascular and other deadly diseases can only be seen

IJCSI International Journal of Computer Science Issues, Volume 11, Issue 6, No 2, November 2014
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

130

in the urban region. The need for the development and usage of cost-effective telemedicine services in Nigeria especially for the rural dwellers cannot be over emphasized as there is continuous need for a wide range of qualitative health care services especially for the rural area inhabitants.

The role of information communications and technologies can no longer be ignored within the healthcare industry [10]. In fact, for the healthcare industry to maintain and improve both clinical and business operations, it has to depend on Information technology [12]. Electronic health (e-health) describes the application of ICT across a whole range of functions that affect the healthcare industry. E-health can also be defined as any electronic exchange of health related data. The solutions that are provided through e-health initiatives within hospitals include Hospital information Systems(HIS), Telemedicine services, Electronic records and Internet Services [10]. Conclusively, most hospitals these days have begun a system in which the use of popular paper records and health information systems is being substituted with the use of electronic record keeping systems. Hence, there is reduction in the use of papers; patient files are easily accessed with the use of the computer.

2. Architecture of Telemedicine Client Server System

Telemedicine client-server is a software architecture model consisting of two parts, client and server systems, both communicate over a computer network or on the same computer. A client-server application is a distributed system consisting of both client and server software [1]. The client process always initiates a connection to the server, while the server process always waits for requests from any client. When both the client and server processes are running on the same computer, this is called a single seat setup [1]. The client-server relationship describes the relation between the clients and how it makes a service request from the server, and how the server can accept these requests, process them, and return the requested information to the client. The basic type of client-server architecture employs only two types of hosts: clients and servers. This type of architecture is sometimes referred to as two-tier. The two-tier architecture means that the client acts as one tier and server process acts as the other tier. On the other hand a three tier client server architecture has the client/server model expands to include a middle tier (business tier), which is an application server that houses the business logic. The middle tier relieves the client application(s) and database server of some of their processing duties by translating data from the database into client data in return [11]. The client-server architecture has become one of the basic models of

network computing. Most web application uses this model and in this study, our telemedicine web application is also based on this architecture. Many types of applications have being written using the client-server model. Standard networked functions such as E-mail exchange, web access and database access, are based on the client-server model. For example, a web browser is a client program at the user computer that may access information at any web server in the world. The figures below show the three tier client-server architecture and the network application architecture of the telemedicine system.

2.1 The System Architecture

There are three tiers of the system architecture:
2.1.1   Presentation tier/layer
This is the topmost level of the application. The presentation tier displays the medical information via the web browsers to both the specialist and the health workers at the rural primary health centre. It communicates with other tiers by outputting results to the browser/client tier and all other tiers in the network. (In simple terms it's a layer which users can access directly such as a web page, or an operating systems GUI).
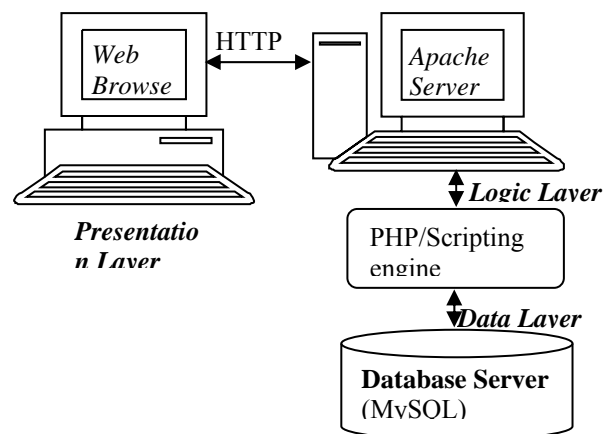

Fig 1 A typical Three-Tier Client/Server Architecture of Telemedicine System

2.1.2   Application tier/layer
Application tier (business logic, logic tier, data access tier, or middle tier) and the logical tier are pulled out from the presentation tier and, as its own layer, it controls an application's functionality by performing detailed processing.

2.1.3 Data tier/layer

This tier consists of database servers. Here medical information is stored and retrieved. This tier keeps data neutral and independent from application servers or business logic. Giving data its own tier also improves

scalability and performance. Their relationship is hereby shown in the figure below.

2.2 Algorithm for Telemedicine Client-Server System

The following steps apply to both TCP and UDP used in ensuring that what is sent by the client system is successfully delivered to that Server side.

Step 1: Create socket

Step 2: Binding to create socket

Step 3: Listen to connections

Step 4: Accept a connection

Step 5: Enter the password in the client

Step 6: If password is wrong the server will not grant access to database

Step 7: Authentication is accomplished by entering the password then client can access the database of server

Step 8: Patients visits the rural doctor

Step 9: Rural Doctor performs the necessary diagnosis and takes the patients data

Step 10: Rural patient information is accepted with a special key and sent to the specialist

Step 11: Specialist recovers the file and decrypts it using same key to recover the original file.

2.2.1 Telemedicine Flow Charts

The flowchart is a means of visually representing the flow of data through an information processing systems, the operations performed within the system and the sequence in which they are performed. The flow chart can be likened to the blueprint of a building. The flow process drawn below describes the sequence of steps between the patient, rural physician and the specialist or Cardiologist.
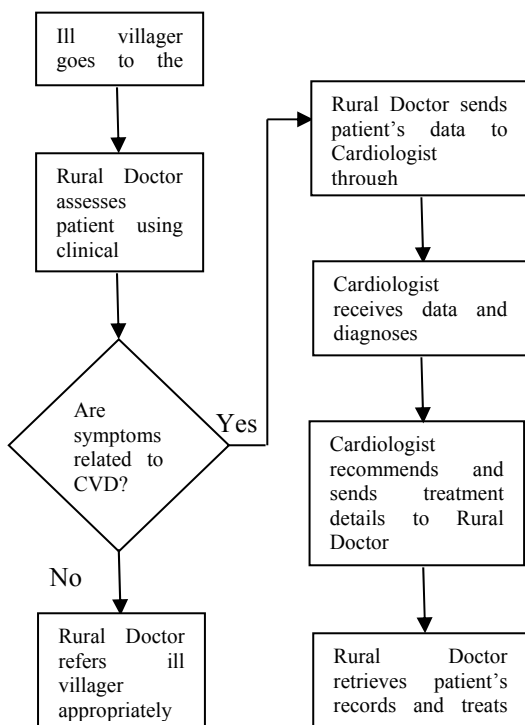

Fig. 2 Telemedicine Flow Chart

The algorithm flow processes are as follows:

1. An ill villager visits the primary health center
2. The Rural Doctor examines the patient and performs the necessary diagnosis using clinical devices and portable EKG device.
3. Rural physician logs in with his assigned username and password. Patient's data is taken and saved into the database. If illness is related to CVD, the data is sent to the Cardiologist via Telemedicine Interface.
4. Cardiologist receives the patient's data, examines, diagnoses and sends recommended treatment to the Rural Doctor.
5. Rural Doctor receives data and administers recommended treatment to the patient.

Fig. 3 System login page screen

After registration of users with the system, users can login as shown in figure above.

The user will log-in and the system will check the user name and password from the http request and matches the details of user from database (e.g. validation). If authentication is successful, the system will display a message box that informs the user that he can use the system. Otherwise, the system will display a message box that informs the user to go through the process again.
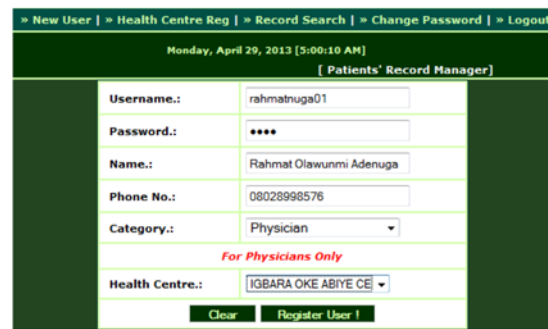

Fig. 4 New user Registration Manager

2.2.2 New User Registration Manager

IJCSI International Journal of Computer Science Issues, Volume 11, Issue 6, No 2, November 2014
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

132

This interface is used by the administrator to add new user to the telemedicine application. The category where the user belongs is chosen from the category list item as displayed in the fig. 4 above. The user must be assigned a username and his intended password for him to have access to the application. Also, details like full name, phone number, category of user and the health centre he is attending are necessary to complete the registration
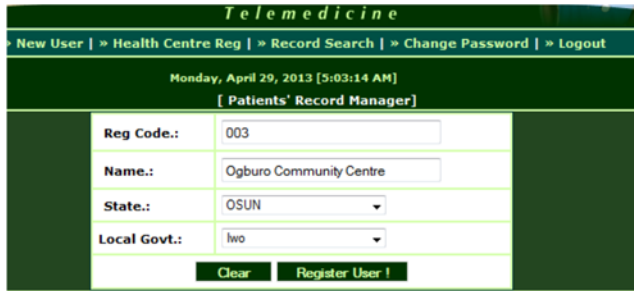

Fig. 5 Health Centre Registration Manager

2.2.3 Centre Registration Manager

This interface is used by the administrator to register the participating health centre. New health centre can be added to the application. This application can support many health centres and as many as medical practitioners in diaspora can parcitipate. Health centre registration is important so that the identity of any request made from the rural community can be known rather than giving the right recommendation to the wrong people. The health centre registration is often accompanied with system generated centre ID which also helps to distinguish one health centre from the other.
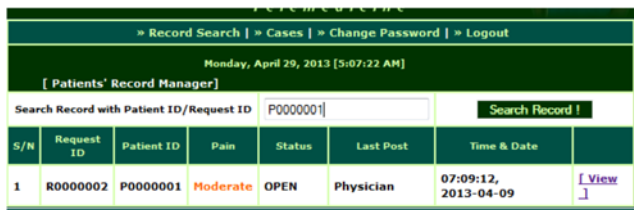

Fig. 6 Record Search Manager

2.2.4 Specialist Record Manager

The specialist searches for a patient record by simply using his or her patient ID which is already in the database. He can click of view the state of diagnosis. The patient ID helps him to know the present case he is handling and to know if he has attended to such case or not.
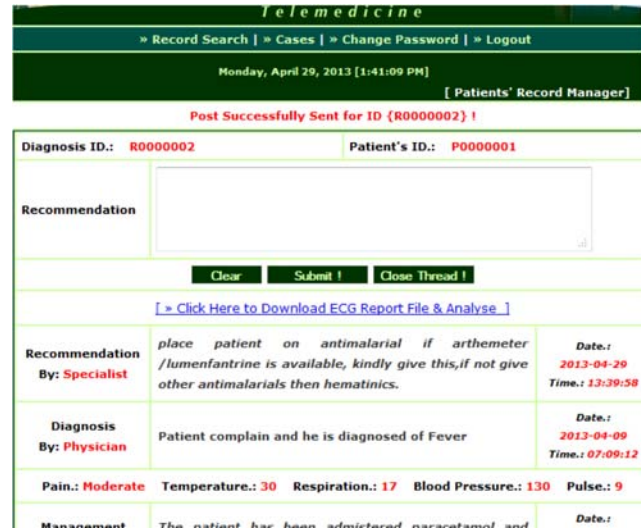

Fig. 7 Case Diagnosis Thread

2.2.5 Diagnosis Thread

This interface shows the discussion thread between the Physician at the rural centre and the cardiologist at the urban centre. All the tests and diagnosis are carried out by the rural physicians or health workers while recommendation on what to do is provided by the specialist via this sub system. This thread also helps both the specialist and the rural physician to know the last person to contribute to the thread.
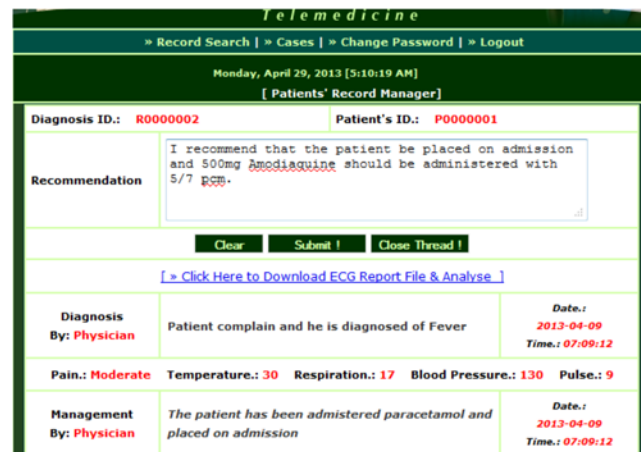

Fig. 8 Case Recommendations Thread

2.2.6 Specialist Recommendation Thread

The specialist advices or recommends the best treatment option for the rural physicians. The specialist view the uploaded ECG, checks all other medical data sent by the rural physician and recommend the next step to take. He also advice on possible referral to the urban specialist hospital provided the patient's case requires a surgical procedure.

IJCSI International Journal of Computer Science Issues, Volume 11, Issue 6, No 2, November 2014
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

133

Fig. 9: New Patient Registration Manager

2.2.7 Registration Manager

The rural physician ensures that a record is created for a new patient just like in the conventional hospital where a card number is issued for a patient. Though, this is different in the sense that instead of having to search manually for a particular patient case note, patients' id number assigned will be used for easier record or file retrieval. The rural doctor initiates the thread by the medical history of the prospective patient.

Fig.10 Medical History page

2.2.8 Medical History The medical history is often accompanied with other medical data like vital signs and ECG report which must have been generated by the portable EKG device and stored on the computer systems.

Fig.11 Rural Physician Disease Management

2.2.9 Disease Management

The rural physician explains in clear terms what management he has proffered for the patient as seen in the figure above.

Fig.12 Specialist Recommendation Interface

2.2.10 Specialist Recommendation The specialist reads through the medical data, the medical history and the management note prepared by the rural physician and therefore recommends the best treatment option available for the rural physician.

IJCSI International Journal of Computer Science Issues, Volume 11, Issue 6, No 2, November 2014
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
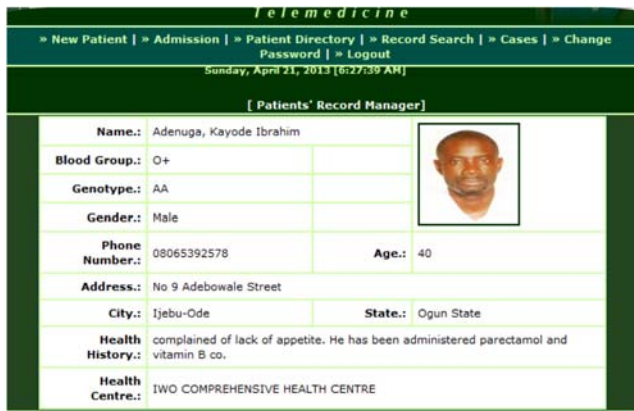www.IJCSI.org

134

Fig.13 Patient record output

2.2.11 Patient Record

The figure above describes the output of the record search manager. He displays the information on a patient bio data, health history and their community health centre where they reside.
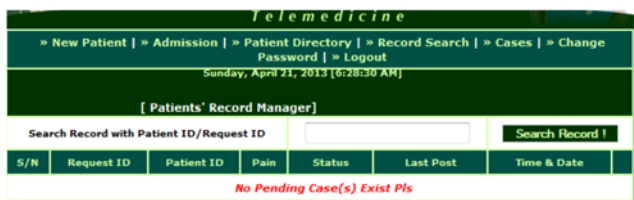

Fig. 14 View pending Cases Interface

2.2.12 Pending Cases Interface

This subsystem is used view the pending cases. This will be used by both the rural physicians and the specialist at the urban centre. This will help them to ensure that cases are being treated without any delay whatsoever.
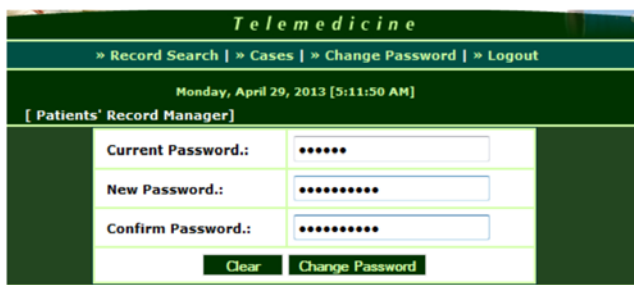

Fig. 15 Change Password Manager

2.2.13 Password Manager

The rural physician can change his or her password if he so desires. To change the password, simply type the current password into the current password column and afterwards type the new password and confirm the new password.

3. Conclusions

This project is based on the development of a web based telemedicine system that is cost effective for Iwo rural community, Osun state area of Nigeria. The research work describes a telemedicine application that could be used to provide tools for overcoming the unequal geographic distribution of medical specialists, establishing meaningful consultation between remote rural healthcare practitioners and specialist typically seen in the urban medical centers. It also provides opportunities for the rural healthcare practitioners to obtain real time information that can aid in the diagnosis of patient"s health situations. The system could as well be used in the urban hospitals as knowledge based support for medical practitioners, thereby allowing more reliable diagnosis, thereby ensuring a qualitative healthcare service delivery. The proposed system is at its embryonic stage and more contributions are still required from either private or government healthcare sectors in other to further fully maximize the benefits embedded in the application of telemedicine services for health care delivery. We employed a store and forward approach in this research (i.e a situation whereby an information is collected, stored and forward at a later time) due to the internet challenge in terms of bandwidth cost and the erratic nature of the internet connectivity. We hope in the nearest future more attention will be given to the real time teleconferencing or video conferencing that will ensure an interactive two-way remote consultation and diagnosis between the patients in the remote rural areas, rural health care workers and specialist in the urban cities.

A Click will request the customer to enter his user name and password. If the entry is *successful*, a *login* welcome page is displayed and customer will be allowed access to the system. The detailed security analysis of the login authentication is hereby presented.

properties.

References
[1] Wikipedia, (2013), Client-server. From Wikipedia, the free encyclopedia. http://simple.wikipedia.org/wiki/Client-server
[2] K. Annan, Kofi Annan's IT challenge to Silicon

IJCSI International Journal of Computer Science Issues, Volume 11, Issue 6, No 2, November 2014
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

135

Valley. CNet News.com, (online), 5 November 2002..
Available at http://news.com.com/2010-1069-
964507.html?tag¼lh, (accessed November 2004).

[3] H. Iain, "Postcolonial Practices for a Global Virtual Group:
The Case of the International Network for Learning and
Teaching Geography in Higher Education (INLT)". Journal
of Geography in Higher Education, Vol. 32, No. 1, 15–32,
January 2008,
http://www.geosci.usyd.edu.au/SEAASWP/Hay2008.pdf

[4] L. Nkqubela, E. Marlien and C. Pieter,
Conradie (2010). "ICT Applications as e-health Solutions in
Rural Healthcare in the Eastern Cape Province of South
Africa", Health Information Management Journal, Vol 39,
No 1, 2010, ISSN 1833-3583 (Print), ISSN 1833-3575
(Online).

[5] S.Y. Kwankam, "What e-Health Can Offer", Bulletin of the
World Health Organization, 2004, 10: 800–1.

[6] N.A.I. Omoregbe, "Development of a formal framework for
usable operations support in e-health based system", 2007,
http://dspace.covenantuniversity.edu.ng/bitstream/handle/123
456789/90/Full%20thesis.pdf?sequence=1

[7] M. Gurstein, "Tsunanmi warning system and the last mile",
The journal of community informatics, 2005, 1(2), 14-17.

[8] A.C. Benson, "Neal-Schumann Complete Internet
Companion for Librarians, 2001, New York: Neal-Schumann
Publishers, pp 24.

[9] W.S. Humphrey, W. S, "The Team Software Process",
(MM/SE/-2000-TR-023), Software Engineering Institute,
Pittsburgh, Pp 36-54.

[10] S. Ouma and M.E. Herselman, "E-health in Rural Areas:
Case of Developing Countries", World Academy of
Science, Engineering and Technology, 2008.
http://www.waset.org/journals/waset/v16/v16-96.pdf

[11] B. Morgan, "An Overview of Common Database
Architectures",http://www.windowsecurity.com/whitepape
rs/software_engineering/An-Overview-of-Common-
Database-Architectures.html, 2008.

[12] M.L. Bernstein, T. Mccreless and M.J. Côté, "Five
Constants of Information Technology Adoption in
Healthcare", Winter Journal, vol. 85, no. 1, 2007.

Adenuga Ibrahim is currently the head of Information Technology
Unit, National Open University of Nigeria, Akure Study Center. He
received his B. Sc (Hons) in Electronics and Computer
Engineering in 2005; and also had M. Sc in Information
Technology in 2013 from National Open University of Nigeria. His
research focus is in the area of Telemedicine and Expert System.

Akinyede, Raphael Olufemi is currently a lecturer at the
Department of Computer Science, the Federal University of
Technology, Akure, Ondo-State, Nigeria. He received his B. Tech
(Hons) and Ph. D degrees in Computer Science from The Federal
University of Technology, Akure. His research focus is in the area
of e-Commerce and Wireless (Mobile) Network Security. He has
published a number of articles in reputable journals. He is a
member of Nigeria Computer Society (NCS).

Akinsowon Omoyele is a member of some professional bodies
including the Computer Professionals Registration Council of
Nigeria (CPN), Oracle Certified Professionals, International
Association of Engineers (IAENG) and Organization of Women in
Science for the Developed World (OWSD).