Advances in Wireless Communications and Networks
2024, Vol. 9, No. 1, pp. 1-12
https://doi.org/10.11648/j.awcn.20240901.11

Research Article

Telehealth Support System Using Wireless Technologies: The Case of Ethiopia

Tsgaynesh Mogose Lefebo[1, *], **Mulugeta Libsie**[2]

[1]Department of Computer Science, School of Computing and Informatics, College of Engineering and Technology, Wachemo University, Hossana, Ethiopia

[2]Department of Computer Science, College of Natural Science, Addis Ababa University, Addis Ababa, Ethiopia

Abstract

The explosion of wireless technologies including wireless networks, large flat displays, sensors, personal digital assistants (PDA), smartphones, and embedded devices are playing a great role in the communication and service delivery of daily life. Nowadays it is possible to extend different applications such as providing voice calls, remote consultation, remote discussion, remote health service, access other applications, and so on wirelessly to anywhere in the world over short or long distances. In consideration of the various advantages of wireless technologies, in this work, the aim to explore the use of wireless technologies in the health domain for remote health domain. The main objective of this work is to design and implement a telehealth support system that helps improve the quality of the existing health system. The system allows health professionals to have adequate access to patients, to medical information, to give health-related services remotely, remote consultation, and remote education to patients/people anywhere and anytime. This telehealth support system is developed using a Java programming language with different editions for different purposes such as J2EE to develop both server-side and client-side applications of the system, JSP to design the web interface for the server-side application of the system, J2ME CLDC/MIDP platform which ships with J2ME wireless toolkit emulator to develop and demonstrate MIDlet applications on the target small computing device, and MySQL database for data storage management.

Keywords

Telehealth, Telemedicine, Telecare, Health Education, Ethiopia, Wireless Technology

1. Introduction and Background

The explosion of wireless technologies including wireless networks, touch panels, large flat displays, sensors, personal digital assistants (PDAs), cell phones, and embedded devices has the potential to transform traditional habits and ways of living [22]. This enables people to communicate, access applications, and transfer information over short or very long distances without wires as well as physical movement. This provides freedom of movement and the ability to extend applications anywhere in the world. The term "wireless" most often refers to telecommunications [1], which can be facilitated with various Wireless Protocols including: Bluetooth, UWB, ZigBee, Wi-Fi, and so on [24, 27]. Nowadays, it is uncommon

*Corresponding author: tseganeshM@wcu.edu.et (Tsgaynesh Mogose Lefebo)

Received: 25 June 2024; **Accepted:** 16 July 2024; **Published:** 29 July 2024

to see the involvement of this wireless technology in various instances to facilitate different developments in human society. The involvement of wireless technology in the health domain plays a pivotal role in improving the provision of healthcare [28, 29, 30]. This work explores the use of wireless technologies in medical applications for remote health education.

The use of wireless technology is on the rise in hospitals, medical offices, assisted living facilities, and homes with a number of advantages, which created new possibilities known as telemedicine, telecare, and telehealth in healthcare fields [10, 11]. Most of the time these three terms are used interchangeably, when in fact they are different depending on the coverage and application.

Telemedicine specifically refers to medical information exchange over a distance using telecommunication technology [12]. Telecare refers to a technology that allows patients at home to stay safe and healthy through the use of telecommunication technology [9]. However, telehealth is the broad term that refers to providing healthcare services, health education, health management, and health information services over a distance via telecommunications technologies [5, 23] and it is the expansion of telemedicine [2]. It allows remote doctor-patient consultation, remote monitoring of vital parameters, remote health education, and teleconferencing between specialists, and enables practitioners to evaluate and diagnose patients remotely or it is available at home, in the clinic, and in the hospital [25]. Telehealth application offers an effective means of improving the quality of health for any country, especially for developing countries like Ethiopia which have several health-related problems and a shortage of medical doctors and specialists.

Therefore, due to the recent technological advances various researchers are interested in studying the establishment and usage of wireless technologies as a vehicle for improving the quality of healthcare provision in healthcare fields. Recent efforts include mobile technology to monitor biosignals, follow up patients, and advise patients on sexually transmitted infections respectively [12, 17, 18]. Other work focuses on collecting, sharing, and managing medical information as well as medical news based on different mechanisms like wirelessly using PDA, and using Service Oriented Architecture (SOA) [4, 6]. Some are also designed and implemented specifically in a special area called cardiology/tele-cardiac [13, 15, 16]. However, the aforementioned existing systems and the other efforts [3, 19] are focused on achieving remarkable improvement in healthcare services specifically on the curative aspect of the patients and less attention is given to health education on disease prevention and control, health management, and provision of health information services. The importance of health education on disease prevention and control is more effective than getting everyone sick and treating/following them individually. In consideration of this importance, this work focuses on health education, health management, and health information services of telehealth applications.

Health education is a means to teach and counsel one or more people on the proper way of healthy living in order to improve one's health. By this people are able to learn how to prevent the spread of various kinds of diseases which can be categorized as communicable diseases, Sexually Transmitted Infections (STIs), non-communicable diseases, diet-deficiency diseases, and so on through the training and methods being taught in education. People are able to have better access to information regarding general prevention of diseases, including the knowledge of what to do and how to act during the increase of diseases. Therefore, this work focuses on developing a generic telehealth support system using wireless technologies, which can enhance the existing healthcare applications by introducing remote health education on disease prevention (pre-disease), and disease control or reaction (post-disease) as well as enhance the provision of health information services to the public at large.

The system developed provides a platform for interaction between doctors and patients in remote locations, enabling health professionals in distinct locations to share information as well as to monitor patients remotely and give them timely health information and support. The proposed system would even include a situation in which a doctor in one hospital can get/give support from/to a doctor somewhere in another hospital via digital imaging between professionals. Patient charts, X-rays, and other diagnostic materials can be transmitted digitally between doctor’s offices/smart devices. This potentially supports the extending of health information services available at anytime and anywhere.

2. Statement of the Problem

In Ethiopia, the government is the main healthcare provider which have a number of hospitals, health centers, health posts, health stations, clinics, pharmacies, and drug shops [33]. However, the healthcare system of Ethiopia is among the least developed in Sub-Saharan Africa and at present it is not able to effectively handle the significant health problems facing the country [35]. According to [20, 21], out of the total population 85% live in rural areas which makes Ethiopia one of the least urbanized countries in the world. The rapid growth of the population with a low ratio of health professionals exacerbates critical gaps in basic health services [14]. The healthcare system in Ethiopia can only be able to provide basic health services to 72% of the population [14]. The ratio of medical doctors to the population is one of the lowest in the world [32], which is a big problem that affects the health of people in the country up to the extent of losing of life.

The other health related problem is that resulting from lack of awareness and education on infectious diseases, communicable diseases, and nutritional deficiencies. In most of the rural areas an estimate of 60-80% of the health problems related with such kind of problems [8, 14]. Also the most common diseases that cause mortality among many Ethiopians are HIV/AIDS, tuberculosis, malaria, and various com-

municable diseases that occur due to improper sanitation and malnutrition [7]. In addition to this, due to poor transportation and other infrastructures in the country, it has been a challenging task to deliver health services and educate the rural people; also health professionals may not be motivated to educate remote people. As a result, the rural people have to travel long distances to get proper healthcare service and their journey is difficult as the land is characterized by mountainous terrain and there is no adequate transportation. But, uniform healthcare coverage requires that healthcare be freely available to all citizens.

In addition to this, issues such as widespread poverty, low education levels, inadequate access to safe water, poor nutritional status, poor sanitation facilities, and poor access to health services have contributed to the high burden of the ill health situation in the country [34]. Indicators such as infant mortality (97 per 1000), under-5 mortality (140.1 per 1000), and maternal mortality (871 per 100,000) speak more about the health and the general socioeconomic situation of the country [34]. Generally, life expectancy at birth is currently about 54 years and is expected to decline to 46 years if the present HIV infection rates are maintained. According to government statistics, 3.5% of the population in the age group of 15-49 in 2005 were reported to have HIV/AIDS [35]. Malaria is the primary health problem in the country. In total, as much as 80% of the health-related problems in the country are due to preventable communicable and nutritional diseases [35]. These are the major challenges the country is facing in its effort to reach the goal of universal coverage [33]. The government has chosen to strengthen primary healthcare as a strategic approach to solve the problems and to address a major gap in the country's healthcare system; lack of physical access to even basic healthcare facilities in rural areas. However, the healthcare delivery in primary healthcare facilities has been highly affected by the lack of skilled manpower and finance.

The country not only has a limited number of health centers but also a big shortage of health professionals to cover the health services for the nation at large [32, 33]. This influences inadequate treatment for many people, especially in remote areas.

In current working experience to get health service, the patient has to go to the nearby health center and consult the health workers at the centers irrespective of whether the workers are specialized in the area of his/her disease or not. Particularly, this problem is more challenging for patients with chronic diseases, which need continuous follow-up as well as specialized professional consultation on how to prevent and manage the disease. Additionally, the patients must go to the health center early in the morning and get registered to get a card for medical services. Since the number of health workers is limited in numbers, the user is expected to stay at the center and wait until his/her turn comes to see the health workers. This process may consume many times of the patient as well as the time of the health professionals. In addition to the time wastage, the patient might be asked for a costly service fee which he/she might not afford. Due to the aforementioned and related problems, the existing health system is not a motivating system for patients to diagnose from time to time and to consult health professionals when needed.

Proposed Solutions

A preferable solution to this problem is to effectively utilize the existing professionals and enhance the existing health system using wireless technologies to deliver and access health services for all populations living in both rural and urban areas. According to [26], the Ethiopian government had the initiative to implement the pilot project of telemedicine in a few selected Hospitals. Hence wireless technology is a powerful tool to use, by considering the problems in the current system and the advancements in wireless technology, this study aims to design a Wireless Telehealth Support System that addresses the following objectives:

1) Enhances the existing healthcare system by introducing various telehealth applications including remote health education on disease prevention and disease control/management.
2) Enhances the provision of health information services to the public at large.
3) Recommends the patients to get more sophisticated treatment or consultation from specialized professionals.
4) Also recommend any health professionals to get support from other specialists by informing where the specialized person is working/located and by allowing mailing or teleconferencing with the specialized person.

This helps the patients to save time and money as well as allows them to get the services easily at home or anywhere with low or no cost and high privacy, providing the ability to healthcare providers to save patient history and valuable information in their system. The system also provides a chance to make communication between health professionals and allows them to have adequate access to patients, to medical information, to give health-related services remotely, remote consultation, and remote education to patients/people anywhere and anytime. It also enables patients to send video and high-resolution images between two distant locations, doctors can easily examine patients in offices thousands of miles away. As a result, rural patients do not need to make long trips to urban centers to get proper health services as well as to consult specialists. In addition to this, the system is user friendly by providing the users with some easily selectable features to select as they need and send it to the specialist or to any health professionals to get any support easily in different manner.

3. Objectives

3.1. General Objective

The general objective of this thesis is to design and implement a telehealth support system using wireless technologies.

3.2. Specific Objectives

In order to achieve the aforementioned general objective, this work has the following specific objectives;

1) Study the existing system and identify its problems with appropriate propose solutions of problems.
2) Identify the functional and non-functional requirements of the system.
3) Design a prototype model for the system based on identified requirements.
4) Implement and demonstrate the proposed system.
5) Finally test the validity of the system.

4. Methodology and Tools/Software Usage

The different methods that used to design telehealth Support System at various phases are as follows:

4.1. Data Source and Data Collection Methods

Conduct literature review and related works: various reviews and assessments were done on different kinds of literature including books, research reports, journal articles, and written documents. The literature review deals with the review of important concepts that are related to this work as well as used in this work in order to identify the existing techniques and analyze the current situations of the area. The reviews are categorized into three categories:- first, they provide general information on various wireless technologies and the use of wireless technology in the health domain. Secondly, some telehealth-related terms including health telematics, e-health, telecare, telemedicine, and telehealth were discussed. Lastly, it provides information on the use/status of telemedicine/telehealth applications in Ethiopia. Also based on various related work this study tries to identify the usage and gap of the existing works and try to design and develop a telehealth support system that improves the quality of the current healthcare system by incorporating health education for disease prevention and management in the existing health system. This helps the patients to have a better awareness of how to prevent and control the spread of communicable diseases. Also, it allows patients to connect directly to their doctors or health professionals and enables them to access their medical history as well as their health progress from anywhere.

Interview and Questionnaires: in order to get various information about health and health education delivery, different stakeholders of the health-providing systems in the country including Ministry of Health (MOH), AAU Faculty of Medicine (FOM), and Ethiopian Public Health Institute were contacted. Also ethio-telecom stakeholders was interviewed in order to know current status of telehealth services in Ethiopia.

Observation: - some of the existing health service providing centers were observed physically.

4.2. System Analysis and Design Methods

System analysis is the part of the system development life cycle that determine how the current health system functions and assess what the user would like to see in the new system. During system development, there are expected levels of capabilities like functionality of the system that are expected by the users of the system. The system analysis model is used to correct and capture all functionalities as well as to eliminate unnecessary requirements. The analysis model mainly contains three models [36, 37]. The first model is a functional model that can be described by a use-case diagram, the second model is an object model that is described by class diagrams, and the third one is a dynamic model that can be described in terms of sequence diagrams, state charts, and activity diagrams. Regarding to this fact, this study aim to construct the model analysis based on formalized requirements of the system. In this work, the analysis model will be described in terms of a functional model, object model, and dynamic model using use case diagram, class diagram, and sequence diagrams respectively.

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements [38]. During the design phase, the analysis model was transformed into a system design model. The objective of design is to model the system with high quality and it discusses the details that need to be defined to run the requirements stated for final implementation, i.e., there is a shift from the application domain to actual implementation.

The task of system design includes the definition of the design goals of the system, decomposition of the system into subsystems which refers to the process of breaking down the system into manageable pieces to understand the complexity of the system, hardware/software mapping which shows the deployments of the components, and persistent data model that describes the database structure.

4.3. Development Environment and Programming Tools

To develop the proposed system the following tools and technologies were utilized.

Java 2 Enterprise Edition (J2EE): is used to develop both server-side and the personal computer client-side application of the system.

Java Server Pages (JSP): is used to design the web interface for the server-side application of the system.

Java 2 Micro Edition (J2ME): is a CDLC/MIDP platform which is used to develop and demonstrate MIDlet applications running on mobile clients. In order to run MIDlet applications on the target small computing device, the .JAR and .JAD files are installed in mobile devices.

Wireless Toolkit 2.5.2: is used to facilitate the development of the mobile client-side application of the system. It is also

used as a standalone Integrated Development Environment and provides the byte code pre-verification tool, implementation of API class libraries, and a device emulator [39].

NetBeans 8.2: is an IDE which used as an integrated development environment for both the client side and server side applications of the system.

MySQL: is used for developing a database that stores information about system users, maintained requests, healthcare providers, and others [31].

Microsoft Visio: is used for designing different UML diagrams that are used during different developing phases of the system.

5. Significant/Beneficiary of the System

Health is one of the basic or critical things for human beings. Regarding to this, there are different organizations that provide health services. The MOH is one of the responsible organizations in Ethiopia which has a responsibility in controlling various health sectors. So, in order to keep the quality of life of the population as well as to improve the delivery of health and health related services this system contributes a lot. As a result, by using the system MOH and various health centers, health professionals can improve the quality of health services. It also allows patients to get proper medical support. For each of them, the system benefit is as follows:

The system shall allow the health professionals including health extension workers, clinicians, nurses, specialists, medical doctors, etc. to:-

1) Send requests for support on cases that they want a specialist's or other professional's support/advice.
2) Update or delete the previous request.
3) Receive the recommendations/advice made by a specialist for the request.
4) Give/get support to/from other specialists and discuss concerning a certain case if the case is somewhat difficult as well as if the available data cannot lead to definitive diagnosis in real-time interaction using teleconferencing or in-store and forward telehealth system.
5) Exchange the patient's medical data securely for more clarification.

The system shall allow:-

1) The users register themselves with the telehealth system through means of Internet facilities either at home or at anywhere, at anytime with their mobile/wireless devices.
2) Any registered user gets the privilege of accessing the telehealth system for any service like health education on disease prevention and management, consultation, accessing any clarification related to different diseases, etc.
3) A registered user to maintain any requests using their devices.
4) Patients based on their request to get the response that suggests suitable tests which have to be carried out by the patient through the Internet.
5) Patients with the assistance of a health professional to undergo the prescribed test.

The system shall allow the Coordinator (may be MOH or Administrator) to:-

1) Manage announcements of different information.
2) Manage user accounts.
3) Maintain detailed information on health professionals.

6. Application Results of the System

6.1. System Architecture/ Framework of the System

The system architecture shows the overall organization and communication between the users and the system. The main components of the system architecture include a mobile client, web client, and system server. The following figure shows the general architecture of the system.

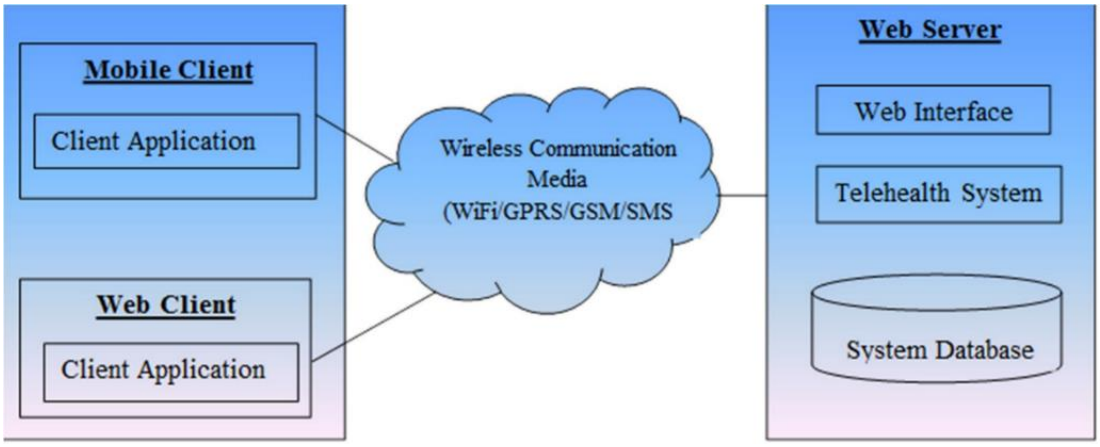

Figure 1. *The General Architecture of the Proposed System.*

Mobile Client

The mobile client component is the client side application of the system which runs on small wireless hand-held devices like mobile phones.

Web Client

This is the other client side application of the system which helps the users of the system who use laptop or desktop computers to get telehealth services.

Web Server

The server side application of the system including web interface and database application resides on the web server. This also contains the telehealth application which is the heart of the system.

6.2. Hardware/Software Mapping

The hardware/software mapping model of the system describes the relation between the hardware and software components and nodes as well as the communication technology that can be used for the system. The following figure shows the hardware/software mapping (deployment) of the telehealth support system.

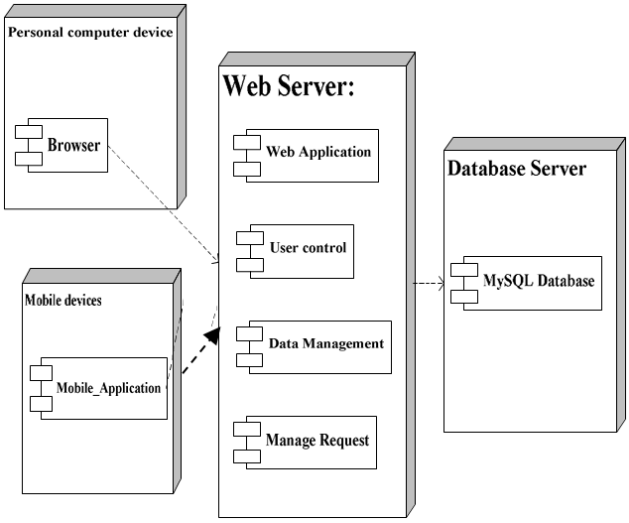

Figure 2. *Deployment diagram of Telehealth Support System.*

6.3. The Prototype

The prototype of the system is composed of a mobile client application running on small wireless computing devices like mobile phones, a web client application running on personal computers and a server side application capable of handling the user requests.

Mobile Client Application Interface

The mobile client application interface is an interface for the mobile client application that can run on mobile devices. When the application is started on mobile devices, it displays the login form that requires users to enter their username and password and verify the user's authentication. The login form of mobile application is shown in Figure 3.

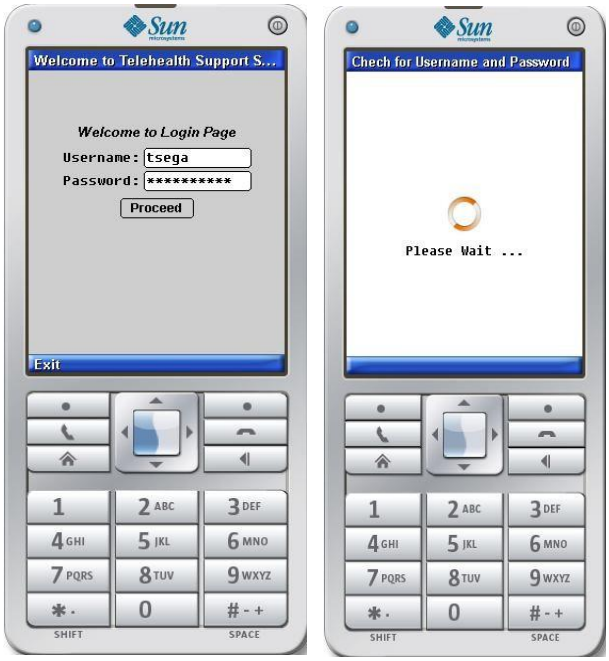

Figure 3. *Login Form for Mobile Client Application of Telehealth Support System.*

On a successful login to the system, the system displays the main menu of the system with different options. From the listed application let the user selects the registration form, then the system display the form which contains various information about the requester which are used for future process.

Figure 4. *Registration Form for Mobile Client Application of Telehealth Support System.*

After the user is registered for the request, the user can send, update, and delete the request by selecting from the given options. The following figure shows the request sending form with different list of options, list of symptoms with check boxes, list of the methods of communication, option for telehealth education.

Figure 5. *Maintain Request for Mobile Client Application of Telehealth Support System.*

The result is sent to the mobile client after sending the symptoms and receiving a sent request confirmation message. Figure 6 shows the result of the request based on some selection of the user. If the user needs details about various diseases s/he can click on the "Disease information" link to get more understanding of how to prevent, and control the disease, symptoms of the disease and other information from the system.

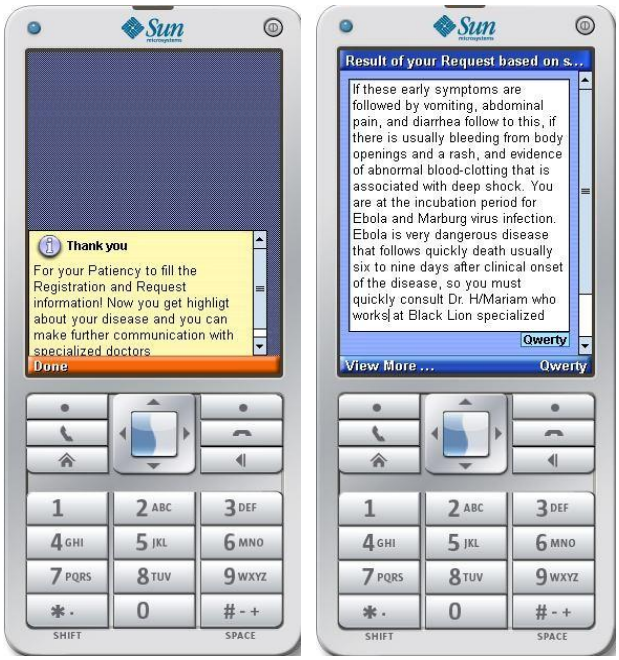

Figure 6. *Result of the Request for Mobile Client Application.*

Web Client Application Interface

The web client application interface is an interface for the web client application that can run on personal computers (laptop or desktop). When the application is started on these devices and if the user clicks on the login button, it displays the login form that requires users to enter their usernames and passwords and verify the user's authentication. If the user selects another operation like "Maintain_Request", the application takes the user to the maintain page that allows him/her user to register for sending requests and allow the user to update and delete the existing request as shown in Figure 11 and Figure 12 respectively.

Figure 7. *Login Form for Web Client Application of Telehealth Support System.*

After the users have selected and filled in the fields of login form with correct login credentials, the system displays the respective pages based on the selected and filled login credentials. On successful login, let the user is logged as an Administer, application takes the user to Admin page which contains different tasks that s/he performs as shown in Figure 8. On the other hand, if the patient or health professional wants to look at and get consultation or support from specialists, s/he can simply view some information by clicking on view professionals profile button.

Figure 8. *Admin page of Web Client Application of Telehealth Support System.*

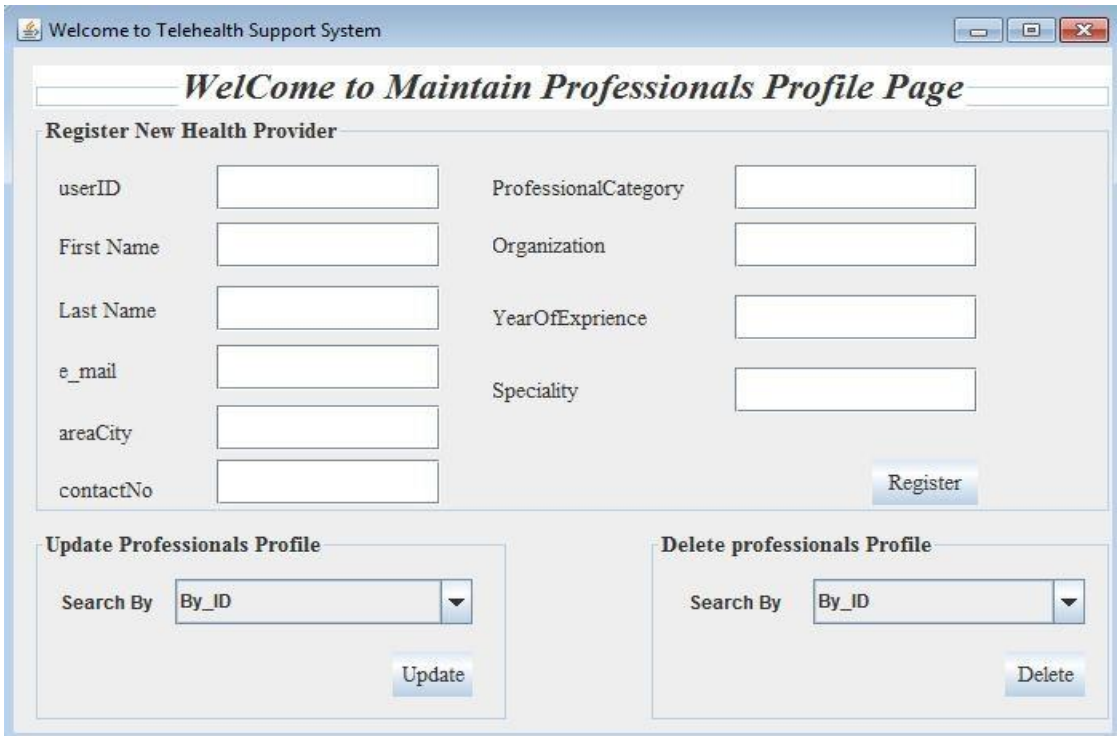

Figure 9. *Maintain professionals profile page for Web Client Application.*

Figure 10. *Maintain Account Page for Web Client Application of Telehealth Support System.*

Similar to mobile client application, the user can maintain request using web client application first he/she clicks on "Maintain Request" button, then follow the respective steps.

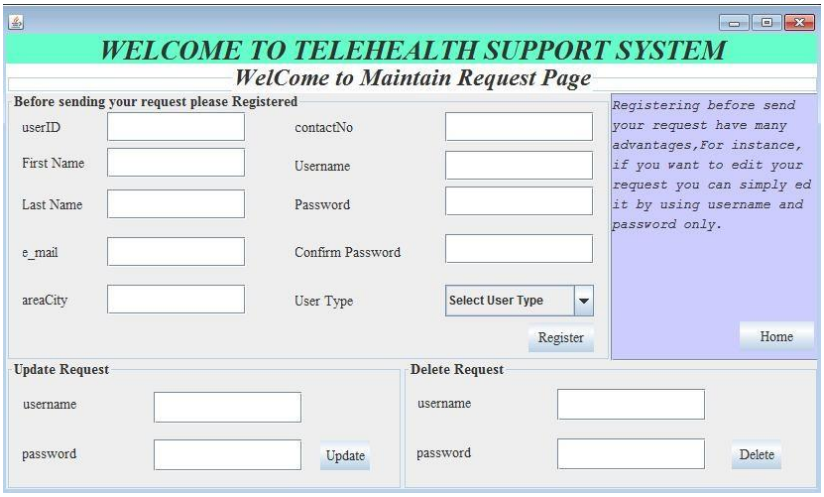

Figure 11. *Maintain request page for Web Client Application of Telehealth Support System.*

Figure 12. *Send Request page for Web Client Application of Telehealth Support System.*

After completion and sending the selected options as well as receiving a confirmation message, the result is sent to the web client. Also, if the user needs details about the disease s/he can click on the "Disease information" link and get more awareness on how to prevent manage, and/or control the disease and other information from the system including the symptoms of the disease.

Server Side Application

The server-side application of the system contains database applications reside on the web server. It is responsible for containing patient medical history, system user information, various profile information of the health professionals, general disease information, and request information.

7. Conclusion and Future Works

7.1. Conclusion

In developing countries like Ethiopia, there is a high shortage of medical health professionals that affects the quality of healthcare of people. Due to this as well as lack of adequate guidance and treatments, and lack of awareness on the prevention and control of various types of disease, a patient may suffer tremendously to the extent of losing life. Regarding this reality, there should be a means to exploit the health professionals in the country in order to give effective services. To alleviate these problems, using wireless technologies a telehealth support system that supports the existing system by incorporating health education and related services on disease prevention and control is proposed in this work.

Using the developed system, both health professionals and/or patients can access health services while on the move or while they are away from their living or working site to give and/or get better treatment and guidance. This is very important and practical in the areas with a very high shortage of medical professionals. The researchers believe that this empowers health professionals to have adequate health services access from anywhere and to give effective services to patients. Therefore, this helps to effectively utilize the insufficient resources, infrastructure, and health professionals in the country. Also, this improves the quality of patient care, and awareness around the people, since it enables both health professionals and patients to have adequate access to health services and information.

In order to achieve the advantages of these wireless technologies the Telehealth support system was developed. In the development phase of the prototype, MIDlets applications are executed using a J2ME CLDC/MIDP emulator. A J2ME CLDC/MIDP emulator is an important tool that ships with the standard J2ME wireless toolkit and allows the demonstration of MIDlet based applications in web browser applet as well as emulates a physical mobile device. This emulator is also enables us to run MIDlets on mobile devices such as mobile phones and laptop as well as on desktop PC and to simulate how the MIDlet will run on a physical device.

7.2. Future Works

As mentioned in the previous section due to the limitations of material resources, in the development phase of the prototype, emulators are used to demonstrate the prototype in a physical mobile device. However, the developed telehealth support system allows health professionals and/or patients to access health-related services from wherever they are.

This developed system is particularly applicable only for health education on disease prevention and control, health management, and health information services for communicable diseases and diet-deficiency diseases. In the future works, this health education service will be extended with other telehealth applications to various types of health problems like medical prescription as well as for all types of disease.

Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
APIs	Application Program Interfaces
CLDC	Connected Limited Device Configuration
FOM	Faculty of Medicine
HIV	Human Immunodeficiency Virus
J2EE	Java 2 Enterprise Edition
J2ME	Java 2 Micro Edition
JAD	Java Application Descriptor
JAR	Java Archive
JSP	Java Server Pages
MIDP	Mobile Information Device Profile
MOH	Ministry of Health
SOA	Service Oriented Architecture
WHO	World Health Organization
WLAN	Wireless Local Area Network
VSAT	Very Small Aperture Terminal

Author Contributions

Tsgaynesh Mogose Lefebo: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing

Mulugeta Libsie: Supervision, Validation

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Wireless, available at http://en.wikipedia.org/wiki/Wireless last accessed on Nov 12, 2020.

[2] Telehealth, available at http://en.wikipedia.org/wiki/Telehealth last accessed on Nov 14, 2020.

[3] Fikreyohannes Lemma, "Design of Architecture and Implementation Issues for a TERRESTERIAL and VSAT Based National Telemedicine Network", Master's Thesis, Addis Ababa University, published and available at: https://www.researchgate.net/publication/228393506

[4] Dejene Hunde, "Medical Data Access with a PDA-based Client", Unpublished Master's Thesis, Addis Ababa University, Ethiopia.

[5] Alonso, S. G., Marques, G., Barrachina, I. et al. Telemedicine and e-Health research solutions: a systematic review. Health Technol. 11, 257–266 (2021). https://doi.org/10.1007/s12553-021-00529-7

[6] Guillén, Edward Paul, Jenny K. Ubaque, Leonardo J Ramirez and Yaneth Cardenas. "Telemedicine Network Implementation with SOA Architecture: A Case Study." Proceedings of the World Congress on Engineering and Computer Science 2012 Vol I WCECS 2012, October 24-26, 2012, San Francisco, USA.

[7] Ethiopian Population, available at http://worldpopulationreview.com/countries/ethiopia-population last accessed on April 26, 2021.

[8] Awoke Misganaw, "Progress in health among regions of Ethiopia, 1990–2019: a subnational country analysis for the Global Burden of Disease Study 2019"; Published Online March 13, 2022, https://doi.org/10.1016/S0140-6736(21)02868-3

[9] Anne Rogers, Sue Kirk, Claire Gately, Carl R. May, and Tracy Finch, "Established Users and the Making of Telecare Work in Long Term Condition Management: Implications for Health Policy, Social Science & amp; Medicine", Vol. 72, Issue 7, April 2011, pp. 1077-1084.

[10] Khurrum M, Asmar S, Joseph B. Telemedicine in the ICU: Innovation in the Critical Care Process. Journal of Intensive Care Medicine. 2021; 36(12): 1377-1384. https://doi.org/10.1177/0885066620968518

[11] Taleb H., Nasser A., Andrieux, G., Charara N., Cruz E., "Wireless technologies, medical applications and future challenges in WBAN: a survey. Wireless Netw 27, 5271–5295 (2021). https://doi.org/10.1007/s11276-021-02780-2

[12] Biosignal Monitoring Using Wireless Sensor Networks, Available at https://www.intechopen.com/chapters/12898 last accessed on April 4, 2021.

[13] Benslimane Mohamed, Anas Bouayad, Abdelali Ibriz, and Harti Mostafa, "Architecture of a Telemedicine System for Monitoring Sick Heart Remotely", Journal of Theoretical and Applied Information Technology, 10th August 2013. Vol. 54, No. 1.

[14] Health in Ethiopia, available at https://en.wikipedia.org/wiki/Health_in_Ethiopia last accessed on April 15, 2021.

[15] Serhani MA, T El Kassabi H, Ismail H, Nujum Navaz A., "ECG Monitoring Systems: Review, Architecture, Processes, and Key Challenges." Sensors (Basel, Basel, Switzerland), published 2020 Mar 24; 20(6): 1796. https://doi.org/10.3390/s20061796

[16] V. Thulasi Bai and S. K. Srivatsa, "Design and Implementation of Mobile Telecardiac System", Journal of Scientific & Industrial Research, Vol. 67, December 2020, pp. 1059-1063.

[17] Daniel Abebe, "Design and Implementation of Mobile Based Patient Follow-Up System", Unpublished Master's Thesis, Addis Ababa University, August 2011.

[18] Zukriya Abdella, "Mobile Health Advisor System: For Sexually Transmitted Infections (MoHA System)", Unpublished Master's Thesis, Addis Ababa University, June 2011.

[19] Fasil Terefe, "National Telemedicine System with a Multi-Criteria Doctor's Unit Selection", Unpublished Master's Thesis, Addis Ababa University, June 2008.

[20] Telemedicine Pilot Project in Ethiopia Health and Social Care Essay, available on https://essaylead.com/telemedicine-pilot-project-in-ethiopia-health-and-social-care-essay last accessed on March 20, 2021.

[21] Ethiopia Demographics Profile 2021, available at http://www.indexmundi.com/ethiopia/demographicprofile.html last accessed on March 31, 2021.

[22] Wireless Network, available at, http://en.wikipedia.org/wiki/Wireless_network last accessed on September 2021.

[23] Telecommunications Network, available at, http://en.wikipedia.org/wiki/Telecommunicationnetwork last accessed on September 2021.

[24] Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou Shen, "A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi", The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON), Nov. 5-8, 2017.

[25] Types of Telehealth, available at, https://telehealth.va.gov/types-telehealth/ last accessed on, September, 2021.

[26] National Telemedicine Coordinating Committee, "Telemedicine Pilot Project in Ethiopia", available at, http://www.itu.int/ITU-D/fg7/case_library/case_study_2/Africa/Ethiopia.pdf last accessed on August 2021.

[27] Wireless Application Protocol, available at, https://en.wikipedia.org/wiki/Wireless_Application_Protocol last accessed on, September 2021.

[28] HealthCare, available at, http://en.wikipedia.org/wiki/Health_care last accessed on Nov 2021.

[29] George Elote, "The Impact of Wireless Local Area Network in a Healthcare Sector", Journal of Information Technology & Software Engineering, March 14, 2022, https://doi.org/10.35248/2165-7866.22.12.294

[30] Magalhães, Bruno, Carla Fernandes, Juan Miguel Martinez-Galiano, and Cédia Santos. "Exploring the use of Mobile applications by cancer patients undergoing chemo-therapy: A scoping review." International Journal of Medical Informatics 144 (December 1, 2020): 104293. https://doi.org/10.1016/j.ijmedinf.2020.104293

[31] MySQL vs. Microsoft Access, available at, http://dba.stackexchange.com/questions/62851/mysql-vs-microsoft-access last accessed on Oct 2014.

[32] Ahmat A., Okoroafor SC., Kazanga I., Avoka J., Jean A., Millogo S., Mahaman M., Illou A., Mwinga, K., Nyoni J., "The health workforce status in the WHO African Region: findings of a cross-sectional study. BMJ Global Health May 1, 2022; 7: e008317. https://doi.org/10.1136/bmjgh-2021-008317

[33] Health Facilities and Human Resources, available at, http://cnhde.ei.columbia.edu/healthsystem/facilities_capacity.html last accessed on Nov 20, 2020.

[34] Health Problem, available at, http://cnhde.ei.columbia.edu/healthsystem/health_problems.html last accessed on Jan 15, 2021.

[35] The Health System, available at, http://cnhde.ei.columbia.edu/healthsystem/ last accessed on Jan 28, 2021.

[36] Dathan, Brahma, and Sarnath Ramnath. Object-Oriented Analysis, Design and Implementation. Undergraduate Topics in Computer Science, 2015. https://doi.org/10.1007/978-3-319-24280-4

[37] Douglass, Bruce Powel. Agile Model-Based Systems Engineering Cookbook. Packt Publishing Ltd, 2021. http://books.google.ie/books?id=HekmEAAAQBAJ&printsec=frontcover&dq=Agile+Model-based+Development+Using+UML-RSDS&hl=&cd=6&source=gbs_api

[38] System Design, available at, http://en.wikipedia.org/wiki/Systems_design last accessed on, January 16, 2022.

[39] The Sun J2ME Wireless toolkit, available at, http://www.ibm.com/developerworks/library/ws-devwsconsum/ last accessed on, January 2021.