

Telecommunication Network Architecture for Telemedicine in Ethiopia and its Applicability

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Abstract:- In developing countries like Ethiopia, there is a high shortage of medical health professionals affects the quality of healthcare of people especially in remote area. Due to this and lack of adequate guidance and treatments as well as lack of awareness on the prevention and treatment of various type of disease, a patient may suffer tremendously to the extent of losing life. Regarding to this reality, there should be a means to exploit the health professionals in the country in order to give the effective services. To solve these problems partially, using nationwide telemedicine technologies for efficient and effective communication on health care service in the existing infrastructure of the country is one means of efficient use of resource.

On this study the discussion of an important and as yet not fully solved, challenges of health care system of the country, and tries to show how to implement telemedicine technologies for efficient and effective communication to provide basic health care service on the existing ICT infrastructure of the country. to implement the telemedicine technology specially in remote area we designed nationwide telemedicine network architecture based on identified criteria like cost of connection, bandwidth of the network, interactivity, and coverage area.

We have also developed simple Telemedicine system (TMS) to integrate with the network design. The system can serve to facilitate both the inside and outside of hospital communications for information exchange. Using the developed system, health professional can share, access, and refer patient's information easily as far as network is available. it also used to share professional experience if patients' case is beyond the capacity. It can also help to improve the quality of health care in the relatively better served urban areas, by allowing physicians share their experience, increasing the possibility of getting second opinion, medical consultation from senior and more experienced specialist.

Keywords: *Telemedicine, Wide Area Network, Information Communication Technology, Local Area, Network*

I. INTRODUCTION

The American Telemedicine Association (ATA) defines telemedicine as the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status. Telemedicine includes a growing variety of applications and services using two-way video, smart phones, wireless tools and other forms of telecommunications technology. Starting over forty years ago, with demonstrations of hospitals extending care to patients in remote areas, the use of telemedicine has spread

rapidly and is now becoming integrated into the ongoing operations of hospitals, specialty departments, home health agencies, private physician offices, as well as consumer's homes and workplaces[1].

Telemedicine is an upcoming innovation which is expecting to minimize the hole between medical experts and patients. This framework not as it were permits communication of patients with the specialists, but plays a really vital role in the diagnosis, administration, and follow-up of patient across landmasses. Telemedicine is additionally playing an important part within the preparing of the medical professionals and clinical inquire about through video broadcasting and teleconferencing. Telemedicine integrates demonstrative advances, restorative information management assets and broadcast communications into a unified and clinically valuable framework.

Ethiopia is found at the horn of Africa, with a arrive zone of approximately 1.1million square kilometer. As of now the population of Ethiopia is assessed to be around 110 million, out of which more than 82% live within the provincial ranges. The country is subdivided in to 9 regional states and 2 authoritative states. The states are encouraging partitioned in to Zone, Woredas and Kebeles [14].

According to Ministry of Health nowadays in Ethiopia doctor to patient ratio is one of the lowest in the world 1: 28,000. Most of the physicians are stationed in the urban areas. The ratio shows a large variation when you go to across the regions, zones and woredas. In most of rural areas traditional practices such as early marriage, circumcision, etc. result in frequent medical problems on women and children [2]. In expansion to this, due to poor transportation and other frameworks within the nation, it has been a challenging errand to convey health care administrations the country individuals; moreover, medical experts may not be spurred to allow health care benefit for farther individuals. As a result, the rural individuals have to travel long separations to urge appropriate healthcare benefits [3]. In this scenario, telemedicine is a very useful way to disseminate health facility to rural Ethiopia utilizing its limited resources. The productivity and usability of telemedicine data depends on the availability of high bandwidth. Last few years, information and communication infrastructures in Ethiopia have experienced a huge development. Ethiopia government has given immense importance to ICT sector

for development for economic growth. Giving better health care for the people using the existing ICT infrastructure with

other emerging technology is the better solution for the country. Even if urban areas are relatively better equipped with adequate ICT technology such as Internet access and digital telephone networks (3G, 4G), the communication infrastructure is not as developed in many other rural regions. These regions have to be equipped with an access to urban areas. In this regard the newly owned, low cost VSAT networks such as School Net and WoredaNet and other wireless mobile network coverage is good in the country to provide the rural areas with suitable means of communication to urban areas and further to the world [4][]. We have proposed a telemedicine network framework for Ethiopia in this paper.

A. Overview of Telemedicine

The concept of telemedicine isn't a modern wonder. It has been practiced ever since 1950 using telecommunication and postal administrations. Nowadays telemedicine is more related to ICT and it's in the lower level in creating nations like Ethiopia [3]. On the other hand, telemedicine has advanced to the extent of virtual reality in developed countries, where a surgery could be performed remotely using high-speed network technology and robots [5].

Telemedicine is the delivery of health-care services, where distance is critical factor, by healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, and for the continuing education of healthcare providers as well as research and evaluation, all in the interests of advancing the health of individuals and their communities [6],[13].

A simple telemedicine framework is shown at Figure 1. The integration of multi-sciences into the telemedicine framework permits building of a health a network between therapeutic offices of different locations of a city or a nation or indeed a locale to exchange medical data, which incorporates but not limited to radiological images, laboratory data, and clinical discoveries together with a sound acknowledgment.

Around the world, individuals living in provincial and inaccessible areas have exceptionally restricted to get quality health care when necessary, since the specialist doctors are more likely to be found in regions of the concentrated urban areas [7]. Due to innovations in computing and telecommunications technology, many elements of medical practice can be accomplished when the patient and health care provider are geographically separated [7].

This exchange of electronic medical data may utilize an assortment of telecommunications technology counting, but not constrained ordinary telephone lines, ISDN, ATM, the Web, intranets, and satellites. Telemedicine is utilized by wellbeing suppliers in a developing number of medical

specialties, counting dermatology, oncology, radiology, surgery, cardiology, psychiatry, and health care supplier [8].

B. Application of Telemedicine

The application of Telemedicine has expanded over a long time. Its applications have gotten to be quicker and more widespread and freer of geographic areas [9].

Remote Consultation

Remote consultation involves a simple form of telephone or e-mail contact between remotely located health professionals. It can also use highly sophisticated network communication connecting remote health institutions for consultation among doctors using video conferencing. Physicians can use this application for requesting expert advice that can contribute to their patients' diagnosis from remote hospitals where specialists are concentrated. Remote consultation, sometimes called tele-consultation, can take place between doctor and patient or between any combinations of remotely located health care providers [10].

Continuing Education

We could use ICT technologies for remote education of health professionals on health care service and disease prevention method can be achieved by the use of telemedicine technology. This application can take different forms including [39, 38, and 35]. Distance (remote) education for doctors, health officers, nurses and community health personnel, which enable them to upgrade their professional knowledge. This service can be effective in transferring knowledge among them Community health education for the public, to apply health system, which focuses on hygiene, family planning, and in general prevention methods.

Access to Medical Information

This application permits doctors to access the databases, local or international, which may offer assistance them to recognize an issue or essentially keep up to date with modern improvements within the field. There are numerous therapeutic databases within the world and there are telemedicine web sites in the Web where doctors can access to therapeutic data. One of the biggest databases is MEDLINE, which contains more than 20 million archives [11].

Remote Sensing

Inaccessible detecting comprises of the transmission of quiet data, such as X-rays, or patient records from a farther location to a collaborator at a far-off location. Imperative Signs estimations can be sent from patient's domestic to clinics for take after up of patient's condition. A think about was conducted to test a telemedicine benefit, for determination of basic hypertension. It was concluded that, the telemedicine benefit, found to be superior at identifying hypertension than the normal care. The application of remote sensing is particularly important for gathering of clinical information from patients in inaccessible sites, such as ships, aircrafts, and geographically remote regions [12].

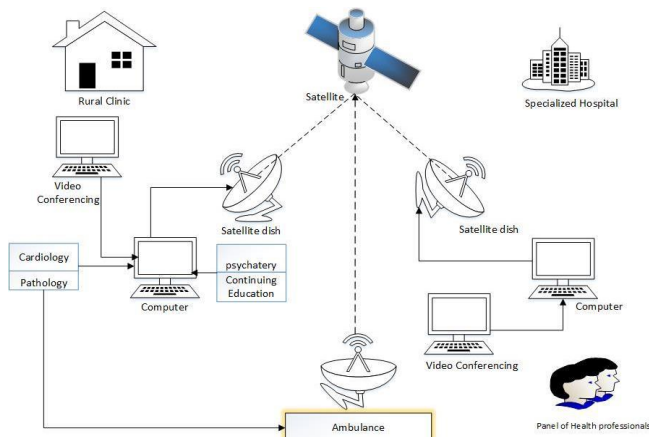


Figure 1 : A Simple Telemedicine Framework

C. Components and Methods of Telemedicine

The main components which need to establish the Telemedicine system are Telemedicine Workstation, Telemedicine Peripherals, Telecommunication Network Architecture, Software Architecture, Human Intervention. There are three ways to implement Telemedicine system these are: store and forward, Teleconferencing, and videoconferencing.

In **Store and forward** method, is a method where patient's information or Electronic Medical Record (EMR), like medical history, diagnostic images, medical scans, diagnostics reports and clinical findings along with other relevant demographic information are stored in any suitable telemedicine system. (EMR) is at that point transmitted to a medical expert or better medical office for conclusion and treatment advices. Store and forward overcomes the boundary of coordinating diverse doctors plan for consultation. Any specialist can go the understanding record and view detail of the condition to supply his or her expert opinion at his or her comfort [17],[21],[18].

Teleconferencing was continuously a portion of teleconsultation between colleagues for appropriate management of patients from the early days of the last century after the development of the phone framework. Still doctors are exceptionally utilized to this mode of teleconsultation among themselves [17],[20].

Videoconferencing is the most appropriate mechanism to have teleconsultation but it needs an expensive set of equipment and in conjunction with high bandwidth necessity, which is the most expensive item to purchase specially in developing country like, in Ethiopia.

D. Telemedicine in the case of Ethiopia

The concept of telemedicine is almost new in Ethiopia, though it has been in use for more than 35 years for human civilization. This developing field can increase productivity in health care; thereby diminishing costs, improving quality care, empowerment of consumers and patients; provide continuing medical education for health professionals and health education for consumers, bridging the urban-rural health facilities.

Ethiopia, as a developing country, has a huge population (above 110 million) with inequitable distribution of health care resources. Approximately 82% of its population lives

in rural areas whereas 65% of qualified consultants practice in urban centers. Due to the inaccessibility of health facilities in remote areas, a large health benefit looking for individuals may need to travel for their fitting health care in a few specialized health centers generally arranged in a capital city or big cities. The utilize of Data and Communication Technology (ICT) within the health division is very restricted in Bangladesh, in spite of the fact that its utilization will make a significant contribution to the change of health segment and change the situation.

To face these challenges, different efforts are made in the Ethiopian context to realize telemedicine in the nation. An attempt to introduce telemedicine started around 1997 when the Ethiopian Telecommunication Authority (ETA) recognized telemedicine as one of its services and Addis Ababa University Faculty of Medicine (AAUFOM) attempted to create awareness among stakeholders. To organize telemedicine efforts by these varying bodies, in February 1998, a National Telemedicine Coordinating Committee (NTCC) was established having members from the then Ethiopian Telecommunication Corporation (ETC), Ministry of Health (MOH), and AAUFOM [13]. Following International Telecommunication Union (ITU) commitment to help telemedicine pilot initiatives in developing countries, NTCC became prepared a proposal and submitted it.

Ethiopia Telemedicine pilot undertaking that connects the vital referral medical institution to nine of rural sites Tikur Anbessa hospitals is supposed to practice teleradiology and tele dermatology, Gonder and Jimma university hospitals are intended as specialty center for radiology consultation and ALLERT hospitals for dermatologic consultation. As reported in NTCC, this pilot project stayed for one-year practicing technology and tele dermatology [11].

II. PROPOSED TELEMEDICINE NETWORK ARCHITECTURE FOR ETHIOPIA

The design of WAN for telemedicine network architecture depends on the existing infrastructure of WAN availability in the country. Ethio telecom is the only WAN provider in the country. It provides a number of services for the country from remote to urban areas, among those we have seen those suitable for telemedicine framework [10]:

A. VSAT Network

Nowadays in Ethiopia there are very small aperture terminal (VSAT) networks for means of transmission of data for remote areas. There are more than 400 VSAT terminal stations used for telephone networking. In addition to this there is established VSAT network to connect more than 570 woreda administration centers forming a government network called WoredaNet. Since our focus in this design is to have low cost but wide coverage connectivity among the regional clinics and urban hospitals across the country, these VSAT networks were considered as candidates of our WAN infrastructure [12],[16].

B. Internet Services

ETC is started providing internet service only in Addis Ababa through dial up and leased line method. The dial-up connectivity is provided by ETC on

the existing telephone line it supports up to 56 kbps bandwidths. On the other hand, the leased line subscriber can get connection in 24/7 basis with fixed bandwidth. Bandwidth can go up to 1Mbps. The infrastructure used for leased line connectivity is a data network. But now a days there is 3G technology which covers 9 regional cities including Addis Ababa and Deridaw for mobile data (mobile internet service). There is also cellular network which covers almost 70% of the country which address the remote area of the country. ETC is also implemented 4G technology for high speed bit rate in Addis Ababa for mobile internet service. by integrated all this internet service it's possible to design nationwide telemedicine network which improves the balance of health care between urban and remote area of the country [19],[10].

C. Broad band Multimedia Network (BMN)

The broad band multimedia network is implemented by ETC since 2004. the network is designed to connect Addis Ababa with other 13 major towns in high speed bit rate optical network. It has high bandwidth which supports the transmission of image, text and motion videos easily [4].

Selection Criteria

To Selected the proposed telemedicine network architecture, we considered the geographical coverage area, bandwidth, two-way interactivity and cost of WAN connection. Based on the criteria BMN is best fit in the case of high bandwidth; however it established in urban areas only. VSAT network is good in terms of coverage area especially in remote areas in the country. Based on scenario we proposed a telemedicine network architecture that integrated VSAT network that is cost effective and which goes down to the public even in the rural areas and BMN to connect urban area hospitals in the capital city and in the regions where the network can easily be accessible as we have seen the following figure 2,.

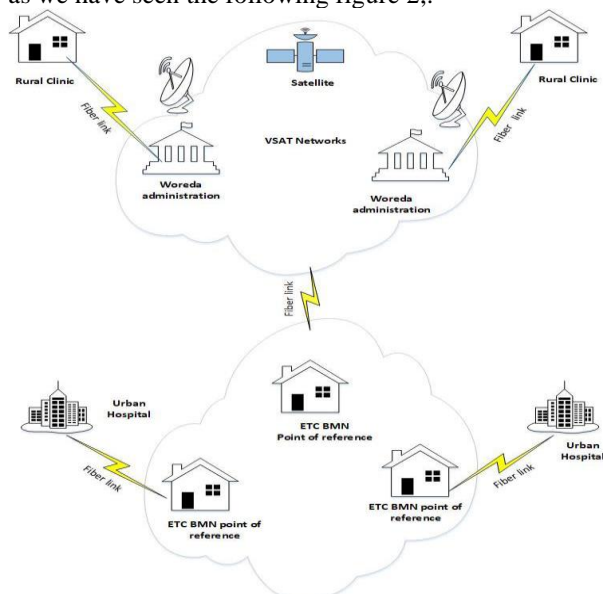


Figure 2 : Proposed Telemedicine Network Architecture

III. SIMPLE TELEMEDICINE SYSTEM FOR THE PROPOSED NETWORK ARCHITECTURE

Telemedicine is all about communication between patients and doctors. Hence, a simple telemedicine system has to be implemented and to be maintained to store the profile of these two members. The patients complain and the complete treatment process needed to be preserved in the system. Major functionalities of the system are described below and are shown in figure 3.

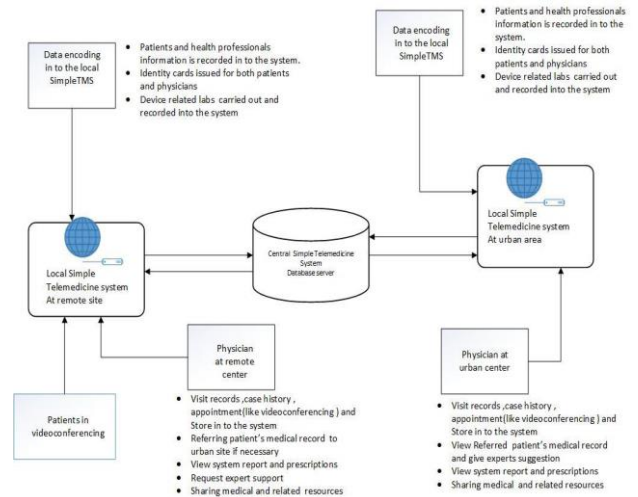


Figure 3: Proposed Simple Telemedicine System

In this simple telemedicine system patients and physicians registered with the given privileged as son as at their first visit. The specific Electronic Medical Record can be discovered by means of various selection criteria in a while. Based on the information patient's identification card automatically generated that contains a unique number which express the patient following visit uniquely. All patient's Electronic Medical Records stored in simple telemedicine system against the patient id. Once the patients and physicians profile registration completed on the treatment of telemedicine the local medical officer at remote health center will decide whether a second opinion from a specialist doctor is required or not. The patient's advised prescription along with complains, available medical records should be entered in the telemedicine system. If the second expert advisement is needed specialist doctors facilitate their opinion on the simple telemedicine system based on patients Electronic Medical Record.

A. Services of proposed Simple Telemedicine System

Simple Telemedicine System provides different medical services for health care providers to handle doctor to doctor and doctor to patient's consultation among clinics/hospitals over the proposed nationwide network architecture in the country. For the sack of system manage we divided the services in to different module.

User Management

In this module all authorized health professionals are registered with required profile and expert identification number is generated which express medical experts uniquely nationwide. During registration the role of the users should identified and assigned to each registered health professionals. Once registration is finished all health professionals had an account to get the all services of simple telemedicine system based on the privilege given during registration remotely.

Patient Care Management

Our proposed simple telemedicine system provides nationwide medical services. The main services provided in this module stated as follows:

Diseases Management: all patient's Electronic medical records managed from diagnosis to treatment plan including updating patients' profile from the simple telemedicine system. If extra expert opinion needed the system allows specialists to put their opinion on the assigned patients medical record.

Teleradiology: The system allows to deliver medical images like x-rays, MRIs, ultrasounds and CT records that can be viewed and interpreted for further diagnosis, treatment and consultation by a radiologist.

Patient Referral: the system provides to refer patients among any public or government health center with in the country easily.

IV. BENEFITS OF THE PROPOSED SIMPLE TELEMEDICINE SYSTEM

The proposed system has many benefits typical in developing countries like Ethiopia where more than 82% of the people lives in remote areas with inadequate health care centers, lack of health professionals, limited budget, and poor transportation infrastructure. Even urban hospitals are not good enough to serve huge number patients coming from remote areas, due to lack of resources management and medical experts. The idea of telemedicine system helped the country to balance rural and urban health care service particularly in Ethiopia. It is also a more comfortable approach to seeking health care for those who feel daunted by both medical professionals and their associated environment. As the medical information is exchanged in strict confidence this can also encourage a good relationship to develop between patients and healthcare professionals.it provides an interface to share medical and related resources among professionals in a distance during every phase of patient treatment.

The system enabled medical expertise to be accessed by local medical practitioners from district and central hospitals using proposed telemedicine network as well as opening the possibility to allow access to national health information. In general, the system provides virtual consultation, making virtual awareness on preventable approach about different diseases like HIV, COVID_19, tuberculosis and bad cultural practices.

V. CONCLUSION

In this paper we proposed telemedicine network architecture and its applicability using the existing infrastructure of telecommunication in Ethiopia. The proposed model is essential and effective to balance the gap between remote and urban health care services in the country. Its applicability is implemented with simple telemedicine system which provides an interface for doctor to patient communications.

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