ADDIS ABABA UNIVERSITY
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FACULTY OF INFORMATICS
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DESIGN OF ARCHITECTURE AND IMPLEMANTATION ISSUES FOR A TERRESTERIAL AND VSAT BASED NATIONAL TELEMEDICINE NETWORK

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Abstract

For a developing country such as Ethiopia with a difficult mountainous terrain and limited transportation infrastructure coupled with one of the lowest patient-doctor ratios anywhere in the world (almost 30,000 to 1), telemedicine offers a cost-effective health-care system. This awareness is slowly gaining traction in the country with a pilot program entering a trial stage. Looking forward, however, we argue that telemedicine should play a more prominent role in the national health-care plan mainly due to its cost-effectiveness and the availability of a substantial number of Ethiopian physicians living abroad - in some accounts more Ethiopian physicians live outside Ethiopia than inside - whose expertise can be tapped.

To study the past and current effort on the application of telemedicine in Ethiopia, a survey of government, public and private hospitals was conducted. The survey included stakeholders of the health care system of the country through interviews and questionnaires. The result of the survey indicated that there have been few attempts to introduce telemedicine in Ethiopia. These efforts were found to be effective in creating awareness about the benefits of telemedicine; but with a limited scope. The study also investigates interests of the growing number of private hospitals that may have sufficient funds to implement telemedicine systems and identifies the specific area of telemedicine the private hospitals would be interested.

Further, we propose a comprehensive design of network architecture for a nation-wide telemedicine network that connects all regional hospitals and health centers with the urban public and government hospitals. Specifically, we propose a high level telemedicine network architecture, which can be implemented over the existing/emerging ICT infrastructure in Ethiopia to. The network connects all regional clinics with public/government urban hospitals for the purpose of data transmission in the form of text and images, as well as instantaneous access to patient information. We also propose a web based telemedicine system, which provides basic services for medical tele-consultation. The system can be used by health care providers to store and retrieve patient information, to write referrals and give feedback to referrals, by using a web based Graphical User Interface.

Since implementation of telemedicine could be challenged by factors such as medical ethics and medico-legal issues as well as user's resistance, we have

presented these challenges. In the long run, we propose that the success of telemedicine efforts in the country will depend on its financial and operational sustainability. Commercialization, as one possible vehicle of financial sustainability is investigated.

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Acronyms and abbreviations

AAU	Addis Ababa University
ADSL	Asymmetric Digital Subscriber Line
API	Application Program Interfaces
ASP	Active Server Pages
ATM	Asynchronous Transfer Mode
BMN	Broadband Multimedia Network
BMN	Broadband Multimedia Network
BTS	Basic Telemedicine Service
DDN	digital data network
EPR	Electronic Patient Records
ETA	Ethiopian Telecommunication Agency
ETC	Ethiopian Telecommunications Corporations
FoM	Faculty of Medicine
FR	Frame Relay
FTP	File Transfer Protocol
GP	General Practitioner
GUI	Graphical User Interface
HNS	Hughes Network System
HTTP	Hypertext Markup Transfer Protocol
ICT	Information and Communications Technology
ISDN	Integrated Service Digital Network
IT	Information Technology
ITU	International Telecommunications Union
JDBC	Java Database Connectivity
JSP	Java Server Pages
Kbps	Kilo bits per second
Kebele	Administrative division of Woredas
LAN	Local Area Network
Mbps	Mega bits per second
MEDLINE	A database of millions of documents in the medical field
MoFED	Ministry of Finance and Economic Development
MoH	Ministry of Health
MySql	An open source database management system
NASA	National Aeronautics and Space Administration
NGO	Non Governmental Organizations
NTCC	National Telemedicine Coordinating Committee
OGA	Other Government Agencies
ONS	Optical Network Systems
OO	Object Oriented
PC	Personal Computer
PSTN	Public Switched Telephone Network
SchoolNet	A VSAT network for secondary schools connectivity in Ethiopia
SSL	Secure Socket Layer
UML	Unified Modeling Language
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Education and Science Commission

VC	Video Conferencing
VLAN	Virtual Local Area Network
VSAT	Very Small Aperture Terminal
WAN	Wide Area Network
WHO	Health Organization
Woreda	Administrative division of towns in the regional states of Ethiopia
WoredaNet	A VSAT network for connectivity of Woredas in Ethiopia

Chapter 1

Introduction

1.1 Overview

Ethiopia is located at the horn of Africa, with a land area of approximately 1.1million square kilometer. Currently the population of Ethiopia is estimated to be about 69.1 million, out of which more than 80% live in the rural areas. The country is subdivided in to 9 regional states and 2 administrative states. The states are further divided in to Woredas and Kebeles.

The health care system of the country is underdeveloped. According to the latest Health and Health related indicator [1] published by the Ministry of Health (MoH), the health care system can only be able to provide basic services to 61% of the population. There are only 119 hospitals of which 83 are under the ministry and 36 owned by Non Governmental Organizations (NGO), private investors and Other Government Agencies (OGA). Physician to population ratio is one of the lowest in the world 1: 25,958[1]. Since most of the physicians are stationed in the urban areas the above ratio shows a large variation across the regions. The regional best ratio is 1:3179 of Harari' s region and the worst ratio is 1:72,764 of the Somali region. There are only 752 specialists among which more than 60% of them are working in the capital city Addis Ababa. On the other hand there is no specialist of any kind in the Afar and Somali regional states. **Appendix A** shows the number and distribution of nurses, physicians, specialists and hospitals across the country.

In most of rural areas traditional practices such as early marriage, circumcision, etc result in frequent medical problems and trauma on women and children. Child mortality and maternity problems are severe in rural areas when compared to the cities. Moreover, an estimate of 60 – 80% of the health problems is due to communicable but preventable diseases, as well as diseases that result from unhygienic environment and nutritional deficiencies [2].

[1] Ratio includes 631 health officers

Because of poor transportation and other infrastructures in the country, it has been challenging task to deliver heath care and educate the rural people. As a result the rural people have to travel long distance to get proper medical care. Their journey is difficult as the land is characterized by mountainous terrain and there is no adequate transportation. Other infrastructures like electric power, clean water, telecommunications etc are unknown to most of the rural people. This in turn worsens the problem of health care delivery to the underserved and un-served remote areas.

However uniform health care coverage requires that health care be readily available to all citizens, including those people living in smaller cities and rural areas. As one of the general policies: "Development of an equitable and acceptable standard of health service system that will reach all segments of the population within the limits of resources" was specified [48]. In this work, we submit that implementing an Information and Communication Technology (ICT) based solution could be considered to realize equal access to proper health care to all citizens, despite the limited resources. ICT applied to health care holds the promise of increasing access to health care to where it is underserved. An ICT based system, designed to allow physicians to consult a specialist about a case without sending the patient to the location where the specialist is working can increase access to medical care to rural areas.

Telemedicine can be a cost effective solution to fill the gap created by the lack of highly qualified experts in different fields of medicine in rural areas as well as in urban areas in Ethiopia. It allows medical personnel at the underserved areas to get specialist support from hospitals in the cities. By doing so, application of telemedicine addresses two of the problems facing the health care system of the country: *shortage of health care services and uneven resource distribution*. This is particularly important in rural areas that lack the means to get access to proper health care and unable to employ medical personnel. It is also important in the cities as a means to get access to advanced health care systems and specialist support from physicians living abroad.

In this research, we investigate the status and technical and business challenges of implementing telemedicine technology to the health care system of Ethiopia. We address questions such as:

- Can telemedicine be applied in the health system of Ethiopia?
- Would it be possible to implement cost effective but state of the art connectivity between regional clinics and urban hospitals?
- Which existing ICT infrastructure can be used to implement nation wide telemedicine network?
- Would the increasing number of private hospitals be interested to exploit the application of telemedicine?
- What factors are there to promote or challenge application of telemedicine in Ethiopia?
- Would it be possible to sustain telemedicine application in Ethiopia?

1.2 Purpose of Study

The main objectives of this thesis are:

- Conduct a survey of potential uses of Telemedicine in Ethiopia.
- To design a nation-wide telemedicine network architecture that connects all regional health care centers with urban public/government hospitals.
- To argue and demonstrate that telemedicine application can be implemented on the existing ICT infrastructure and bandwidth in Ethiopia.

The basic purpose of the network design is to achieve good quality communication between General Practitioner (GP) at underserved areas and specialists in urban hospital using a medical tele-consultation. This will ultimately results in improvement of patient care and help to reach underserved areas. The design should also provide ability for private hospitals to be able to join the network and also to interface with the substantial number of Ethiopian and non-Ethiopian health professionals living outside the country.

In addition to the network design, we have tried to address the following issues:

- Identify specific tele-health and telemedicine applications such as tele-opthalmology, tele-radiology, tele-dermatology, etc, which are very relevant and substantially useful to be practiced in the case of Ethiopia.
- Conducted a survey to find private hospitals, which may have funds and facilities to explore the use of telemedicine in other tele-health specific areas such as heart diseases.
- Investigated legal, ethical, and cultural issues that may promote or challenge applications of telemedicine in the country.
- Also investigate and propose commercialization possibilities, as the implementation and sustainability of telemedicine system will depend on the availability of financial resources.

1.3 Significance

It is envisaged that the results of this thesis would be used to implement an efficient and sustainable nation-wide telemedicine system, which would help to balance proper health care delivery in the country. The main beneficiaries of the results will be the public as a whole and the rural people in particular. Other beneficiaries include: Medical institutions in general, Policy makers, Researchers, ICT Organizations etc. The main beneficiaries and specific benefits of the result is listed below:

- **Policy Makers**: would be aware of the application of telemedicine to alleviate the problem of expanding health care delivery to underserved rural areas. It would also help them to see how better quality health care can be delivered to the relatively better served urban regions. The result of the thesis can also be an input to devise policies on the ethical, legal and cultural issues related to the applications of Telemedicine.

- **Medical Institutions**: Hospitals both private and public can use the result to make decisions on the use of telemedicine and medical statistics date collectors.
- **Researchers**: Researchers, from the medical science and IT fields can use the result of the thesis as an input to their study. It will also help them design a better architecture based on new technologies, and / or add security, efficiency etc features to the design.
- **ICT Organization**: will get market opportunity by providing communication services to those institutions that would implement telemedicine.
- **The Public**: would get access to proper medical care if the design could be implemented and its service can be sustainable.

In general it is believed that the study will play a significant and complementary role in the health care capacity building program of the country. The thesis tries to show ways on how uniform health care can be delivered to all citizens, by employing telemedicine services parallel to the expansion of ICT infrastructure in the country.

1.4 Methodology Overview

The method employed and the type of data required in this thesis depends on the nature of specific objectives. First the problem was classified in to two major parts, technical part and non-technical part. The technical part addresses the problem of designing the telemedicine network architecture and related issues such as User interface, database and application design. On the other hand ethics, medico-legal issues and commercialization are considered in the non-technical part.

The technical part was accomplished by using computer system development methodology. The data required for this part was collected using interviews and site observations. The application was then developed by using object orientated software development methodology, and the unified modeling language (UML)

tools [26, 27]. To design the network, hierarchical model was employed. The detail of the methods and actual works are presented in chapter 3.

For the non-technical part, both qualitative and quantitative research methodologies have been employed. In addition to a comprehensive review of the literature, real-time data was collected using questionnaire from private hospitals and (See Appendix B). Private Hospitals were surveyed about their use of ICT and their interest in exploiting telemedicine application. In total twelve private hospitals practicing in Addis Ababa were surveyed.

1.5 Assumptions and Limitations

In this study we are assuming that a nation wide telemedicine network and application can be implemented over the existing or emerging ICT infrastructures. An ICT infrastructure which covers as much area as possible across the country will be suitable for our purpose.

However, since this could be the first nation wide telemedicine application, we assume connectivity among public/government health care facilities. We also assume that private hospital will be interested to join such a network, in telemedicine specific areas of their interest.

The application to be designed in this study supports only doctor-to-doctor communications or any combinations of interactions between healthcare providers. No patient-to-doctor or any other combination of users including the patient is not considered. This is because of the low level of computerization in the country.

Since the available advanced medical instruments, which are capable of digital data acquisition are limited in the health care institutions, our application assumes data entry from instruments manually. User interface will be available to simulate the traditional paper forms to help health care providers/users in entering patient data.

Chapter 2

Background to Telemedicine Technology

The concept of telemedicine is not a new phenomenon. It has been practiced ever since the advent of telecommunication and postal services. The modern age telemedicine is more related to ICT and it is non-existence or in its infancy in developing countries such as Ethiopia [5]. 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 [3, 4, 20]. In this chapter we have summarized a review of telemedicine technology and mention some successful telemedicine applications when necessary.

2.1 What is Telemedicine

Literally, the term "telemedicine means medicine at a distance" [4]. In its simplest form telemedicine means enabling people in one geographical area to have access to a trained medical specialist in another geographical location. It involves the use of telecommunications technology for providing medical services to locations that are at a distance form the provider [4,5].

Many definitions can be found from different articles [3,4,5,11]. A more general definition of telemedicine adopted by a study group from World Health Organization (WHO) to draft a health telematics policy for WHO is [5]:

> ***Telemedicine*** *is the delivery of health-care services, where distance is critical factor, by health-care 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 health-care providers as well as research and evaluation, all in the interests of advancing the health of individuals and their communities*.

Telemedicine application can be a simple form of telephone conversation between a GP at a distance requesting a second opinion from a specialist. Or it can be an offline communication via two-way store-and-forward electronic mail (e-mail). On the other hand telemedicine can make use of high speed, wide bandwidth transmission of digitized signals in conjunction with computers, fiber optics,

satellites, and other sophisticated peripheral equipment and software, to have a real time videoconferencing involving doctors, the patient and the patient's family [6].

2.2 History of Telemedicine

Telemedicine has been in use in some form or another for long period of time. Medical advice through correspondence, letters, etc, has been in practice for several years. It is practiced by telegraph in the early 1900s and by radio shortly afterwards [5,10]. The first test of telemedicine in Sweden for example, took place in 1922, when the Sahlgrenska Hospital started to give medical advice to ill and injured sailors via radio [10]. Doctors providing tips on diagnosis or treatment of ailments through newspaper columns or through radio and TV broadcasts has also been practiced. But today telemedicine is not understood in this simple form. It does now mean a more interactive and more advanced in the use of new communication technologies.

The National Aeronautics and Space Administration (NASA) played an important part in the early development of telemedicine. NASA's effort in telemedicine began in the early 1960s when humans began flying in space. Scientist at NASA demonstrated successful that physicians on earth could monitor the physiological function of an astronaut. Other early telemedicine experiments were based on the use of television. A patient-physician telemedicine system was established in 1957, as part of a tele-psychiatry and medical education program in Omaha, Nebraska. [5, 11]

From its start, development of telemedicine was derived by the need to provide medical diagnosis for patients in remote areas, who are unable to travel. Its main focus was geographical distance. Recently however the growth in the use of telemedicine has been facilitated by several important factors such as, Lower cost and more widely available communications, higher performance computers, greater public confidence in the use of computer technology, greater acceptance of the technology by medical professionals, and emerging global standards in communications, video conferencing, and medical disciplines [53].

Telemedicine does not seem to have a long recorded history in Ethiopia. The Ethiopian Telecommunications Corporations (ETC) recognized telemedicine as one of its services only in June 1997, and organized a Division within its ranks to address this service [8]. On the other hand the Faculty of Medicine (FoM), at the Addis Ababa University (AAU), had attempted to create awareness about telemedicine and its benefits using brochures. To coordinate telemedicine related efforts in the country, there was a need to form a national committee composed of representatives from concerned government organizations. In February 1998, representatives from ETC, FoM and Ministry of Health (MoH) established a National Telemedicine Coordinating Committee (NTCC). What the committee has done in relation to telemedicine initiatives in Ethiopia will be discussed in detail in chapter 4 of this report.

2.3 Applications of Telemedicine

Application of Telemedicine has dramatically increased over the years. Its applications become faster and more widespread and more independent of geographic locations [20,29]. Among the various applications of telemedicine, the more common ones are listed below.

2.3.1 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.

In some cases tele-consultation is used to supplement the conventional face-to-face medical encounter. In other cases, when used as a patient-to-doctor communication and particularly for rural residents, tele-consultation can be used as a substitute for a face-to-face encounter [15]. Its importance is justified by the long distance between the patient and health care provider and health care service

centers [16]. It can overcome the distance and transportation barriers of the health care delivery.

2.3.2 Continuing Education

An on going education of health care professionals, on primary heath care and the public on diseases prevention method can be achieved by the use of telemedicine system. This application can take different forms including:

- Continuing distance education for GPs, nurses and community health personnel, which enable them to upgrade their professional knowledge. This service can be effective in transferring knowledge to GPs, as it can be implemented at the working place of the GPs, and may contain the information needed in daily medical practice [17].
- Community health education for the public, to apply health system, which focuses on hygiene, family planning, and in general prevention methods.
- Medical information exchange between medical professionals located at distant places.
- Support system for operation and maintenance of medical equipments [6].

2.3.3 Access to Medical information

This application allows physicians to get access to medical databases, local or international, which may help them to identify a problem or simply keep up to date with new developments in the field. There are many medical information databases in the world and there are telemedicine web sites in the Internet where physicians can get access to medical information. One of the biggest databases is MEDLINE, which contains about 11 million documents [18].

2.3.4 Remote Sensing

Remote sensing consists of the transmission of patient information, such as X-rays, or patient records from a remote site to a collaborator at a distant site. Vital Signs measurements can be sent from patients home to hospitals for follow up of patient's condition. A study was conducted to test a telemedicine service, for diagnosis of essential hypertension. It was concluded that, the telemedicine service, found to be better at detecting hypertension than the usual care [19]. 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 [20].

2.4 Benefits of Telemedicine

Some of the benefits of telemedicine are summarized below [6, 12]:

1. Better Access to medical care: Telemedicine can provide an improved medical access to previously un-served or under-served geographical areas.
2. Reduced cost: The travel cost of patients for specialty care, the travel cost of health care professionals for continuing education or consulting can be minimized. Telemedicine can also save cost of employing and keeping specialists in rural clinics. It is cost effective to have a telemedicine application that can help rural clinics to send x-ray images to a radiologist in cities than employing and keeping the radiologist in an isolated remote area clinic. Using such a setup, a radiologist may serve many remotely located health care centers.
3. Reduced isolation: Telemedicine provides a pear and specialist contact for patient consultations and continuing education. It has also been reported that color, full-motion video is critical to the health professional for simulating face-to-face communication between colleagues in consultations and between patients and physicians.
4. Improved quality of care: Telemedicine allows the consultation among the referring physician, the consulting physician, the patient, and the patient's family through interactive video with critical information of the patient available on-line. Also, the physicians or other personnel at remote location can be educated during the consultations with specialty physicians and other experts, increasing their ability to treat other similar cases in the future.

The benefits of telemedicine to developing countries are evident, as it allows better access to medical care. In a case study, it was reported how a patient in Nepal, (a developing country) whose health condition was improved by a tele-consultation with neurologist and neuroradiologist in Ireland [21]. The report also

raised a question as to how best the industrialized world can improve medical care for people in the developing countries. Developing countries can also benefit from the cost effectiveness of telemedicine as they have difficulties in providing health care to all of their citizens because of limited health care budget.

2.5 Risks of Telemedicine

There are also risks associated with the application of telemedicine that challenge its implementation. Misdiagnosis, security and confidentiality of patient's information raise ethical and medico legal issues. Physicians may misdiagnose a patient in the conventional medical practice. However the fact that a physician has to diagnose a patient with out physically examining the patient may increase the opportunity of misdiagnosis. Conventional radiology for example, allows the radiologist to examine the patients if necessary, but in tele-radiology the radiologist will not get a chance to examine the patient as they are separated geographically [22].

Patient records may be exposed, and their confidentiality violated. Alteration or elimination of records and vulnerability of computer data to accidental erasure are also concerns of security and confidentiality associated with telemedicine. Technology acceptance of health care providers is also another challenge facing the application and usability of telemedicine. Since health care providers are the most important users of telemedicine applications, their acceptance will be important to implement telemedicine [23]. It has been reported that some medical doctors tend to resist the concept of tele-consultation on the grounds that the images do not have efficient quality, that they are too busy and having personal policy against information technology [28].

The medical laws need to be improved and keep pace with the advancement of technology in order to balance the benefits and risks of application of telemedicine. However the legal and regulatory environment has not progressed as rapidly as the technology [20, 22, 24].

2.6 Telemedicine Technology Requirement: Case of Ethiopia

Application of telemedicine requires both telecommunications technology and medical equipment technology. A range of telecommunication technology is required to connect distant sites depending on the specific need of the application. Advanced medical equipment technology is needed to enable digital data acquisition. In addition to these, digital cameras, scanners, printers, TV sets etc are also required.

The required network technology depends on the type of telemedicine services employed. If it is for an asynchronous (offline) communication, a store-and-forward technique such as e-mail will be sufficient [12]. For example in a tele-consultation request, the referring physician can send a note describing the request along with the patient's record electronically. The patient record can be attached to an e-mail message. On the other hand, a synchronous (real-time) communication such as Video Conferencing (VC) may need a higher bandwidth technology such as Integrated Service Digital Network (ISDN) and satellite connection. Depending on the volume of data and the required data transfer speed, broadband networks such as Asynchronous Transfer Mode (ATM) should be employed.

Poor communication infrastructure has been a major inhibitor of telemedicine in developing countries. In such cases, it has been demonstrated that low cost satellite connections could offer a viable and economical solution. Very Small Aperture Terminal (VSAT), which can provide direct voice and data satellite connectivity, has become the best choice to build up telecommunication services to rural areas [33]**.** In addition to the telecommunication services VSAT connectivity can serve application such as telemedicine. Low cost satellite communication using VSAT was used to implement telemedicine system in Temasek Polytechnic, Singapore [12]. The Ethiopian Telecommunications Corporation (ETC) has already installed 470 VSAT terminals out of which more than 292 have been operational in extending communications services to rural areas [7, 33].

Recently, ETC signed a $25 million contract with Hughes Network System (HNS) for a nation wide distance-learning network, which is known by the name SchoolNet VSAT Network [13]. The network will be completed by 2005 and will connect all schools across Ethiopia through VSAT. As it was announced by HNS on Nov 13, 2003, ETC will be supplied with a broadband satellite network. ETC can use the network for a variety of applications including video conferencing, Internet/intranet and VoIP solutions [14]. Due to the success of VSAT in other developing countries, this study also considers the use of this ICT infrastructure as a backbone to the telemedicine network design [11, 12].

There is also a promising VSAT network under development by the government of Ethiopia. This network, known by the name WoredaNet is expected to connect all the 594 Woreda administration centers across the country. Its purpose is to form a kind of e-governance. Each VSAT terminal in a Woreda will have ability to give access to Woreda level government offices such as finance agricultural development offices, etc. In addition to the cascading ability, each terminal will have video conferencing equipments. It supports two way interactivity of 45Mbps down link to all terminals and 256kbps uplink [See Appendix C]. Connecting regional clinics with terrestrial means to WoredaNet should be considered.

ETC has also introduced a multi-service digital data network (DDN), which provides three data communication services combined in one, namely Frame Relay (FR), ISDN and digital leased line. It extends its services to 9 cities in the country, and 6 node stations within the capital Addis Ababa [7]. The DDN service provides all types of quality data communication services including dedicated and dialup Internet access, managed private networks and distance education. An interview with one of the ETC officials revealed that DDN can also be used to implement connectivity among hospitals [See Appendix C].

Another attractive ICT development in the country is the Broadband Multimedia Network (BMN), which is currently being implemented. BMN is a backbone infrastructure based on different kinds of technologies such as Optical Network Systems (ONS) and ATM core networks. It supports last mile access networks

through ADSL and fixed wireless Access networks. We assume that this new connectivity will also be favorable to connect urban area hospitals.

Chapter 3

Methodology and Actual Work

As it was briefly stated in the introductory chapter, chapter 1, overview of methodology section, the choice of methods to be employed in this research work was based on the nature of specific sub problems. After dividing the problem in to technical part and non-technical part, we have further divided each part in to specific tasks and identified activities to accomplish each of the objectives accordingly. The identified tasks were:

Task 1: Design and implement Basic Telemedicine Service

Task 2: Propose Telemedicine Network Architecture Design.

Task 3: Identify specific areas of telemedicine

Task 4: Investigate Ethical and legal issues

Task 5: Identify commercialization possibilities.

In the next paragraphs our actual work will be presented in more detail, sub-divided in to the above list of tasks.

3.1 Task 1: Design and Implementation of Basic Telemedicine Service

The Basic Telemedicine Service (BTS) is a software system which provides Graphical User Interface for doctors to communicate in a collaborative tele-consultation. It also provides access to patients' clinical information for authorized health care providers.

3.1.1 Task Objectives

Primary focus of this task is to develop a set of services for use in telemedicine application for health care providers. Specifically the following objectives were envisaged in this task.

- To design an easy to use GUI to be used by doctors (or health care providers) in the treatment of their patients.
- To enable sharing of x-ray files and medical multimedia data among distance sites (hospitals), using file transfer protocol (ftp).

- To design a database to back up the telemedicine system, and store all the information necessary in the telemedicine application.
- To support authentication and access control of users.

3.1.2 Approach

This task facilitates the software development for BTS, by designing and developing a software infrastructure. It also helps us to design basic architectural components and services as a base to the development of generic prototype application. To accomplish this task, we have fist selected a sample hospital to model and gathered the required information form the hospital by site visits, interviews as well as document analysis.

3.1.2.1 Sample Hospital

The first action taken was to select a sample hospital where we could gather user requirements and model the clinical information flow. For this purpose we have selected the Tikur Anbassa Specialized Hospital. The same hospital was considered to be central cite in the NTCC's telemedicine pilot project. We have selected this hospital for the following reasons:

- Since it serves both as a health care center and educational environment (Faculty of Medicine).
- The hospital is where better health care services are provided to patients both in kind and number
- The hospital or faculty has library and computer center which have been necessary for our work.
- We think that the personnel working in this hospital are not far form the education and, we expect more cooperation in providing us with the necessary information.

3.1.2.2 Site Visit

During the course of this study, we undertook a visit the selected hospital to observe the day-to-day activities. This helped us to understand the clinical information flow and define user requirements. The visit has taken few weeks to

completely study the structural organization and activities involved in the process of patient care in each department. We have also questioned physicians, nurses and lab technicians as well as employees of record offices to find out their information requirements.

However, it is instructive to remember that a hospital environment is such that on should not ask questions that violate privacy. Most of the information is sensitive patient information; nobody is allowed to see except concerned personnel. Regardless of this situation we have accomplished the following activities during our site observation:

We were provided with forms used by the health care providers, physicians, nurses and lab technicians. These forms include copy of an empty Out-Patient Card, a variety of Lab-Request forms, Referral-Request and Referral-Feedback forms, Blood Transfusion Request forms, and inpatient admission and follow-up data forms.

We also interviewed limited number of health care providers, as most of them are too busy to give interviews. The major questions we asked doctors and nurses are:

- What information do you need in the patient ward to develop treatment procedures?
- Why is the information important?
- From where does the information come and where does it go?

The physicians we have interviewed were helpful in providing us with information that we couldn't understand from the collected forms and given us the guide line they are using to build patient cases in a booklet [25]. The booklet contains all the information which must be included in the case report written by doctors.

The information gathered during this visit was used to model the clinical information flow and the hospital as a whole. It also helped us to define the major user requirements to our telemedicine service software.

3.1.2.3 Development of the Application

After defining the functionalities of the application, modeling the hospital's clinical activities is undertaken. The application is then designed and a prototype was implemented for demonstration purpose.

The software development method we have used is the Object Oriented (OO) software development method. The main reasons for this choice of method are that, OO approach facilitates reusability, and it supports powerful programming languages such as java and C++. It is also easy to maintain and expand the OO software.

The Object Oriented Unified Modeling Language (UML), which is accepted as a standard for OO design and development was used as a modeling language in this task [26, 27]. In UML analysts need to define use cases, class diagrams and interaction diagrams in the requirement analysis phase of software development. In the next phase, system design phase, UML required us to set forward design goals, and decompose the system in to sub systems, as well as to decide where to deploy each software component.

3.2 Task 2: Identification of Telemedicine Specific Areas

Since the ultimate goal of this effort is to play a role in minimizing the problem of health care delivery, specific areas of telemedicine had to be selected. These specific areas should address the health and health related problems, which cause most of the deaths in the country.

3.2.1 Task Objectives

The main objectives of this task are:

1. To identify major killer diseases in the country and identify which particular specific area of telemedicine are helpful in alleviating the devastation caused by these diseases in the country.
2. To look for private hospitals, which may have funds to explore telemedicine in other types of diseases such as heart diseases

3.2.2 Approach

The task focuses on information gathering form health and health related indicators and statistical reports. In addition it facilitates the process of identifying private hospitals' interest to exploit the application of telemedicine.

3.2.2.1 Identifying Leading Causes of Mortality

To identify the major killer diseases those cause most of the devastation in Ethiopia we had to collect information on hospital visits and deaths. Similar previous studies were also used. After collecting the documents, we had to analyze each document and compare their results in order to pick the major killer diseases.

3.2.2.2 Survey of Private Hospitals

The number of privately owned hospitals in Ethiopia is increasing. Most of them are in the capital Addis Ababa. These hospitals are employing a number of health care providers because they can afford to pay better salaries.

As the private hospitals employ more specialists, their contribution to the public becomes significant. Hence our design considers the possibility of letting these private hospitals join the network. In order to find out their interest in exploiting telemedicine applications, and their choice of specific area, we prepared questionnaires and distributed to them (See Appendix B). The questionnaire asked them about their IT / ICT usage, their interest to employ telemedicine and also if they have got funds.

3.3 Task 3: Propose Telemedicine Network Architecture Design

The telemedicine network is a cost effective, nation wide connectivity between all the public/government hospitals/clinics. It also includes intra hospital connectivity among the departments of sample site hospital. The nation wide network uses one of the existing ICT infrastructures in the country.

3.3.1 Task Objectives

The main objective of this task is to design Intra-hospital campus level LAN and nation wide telemedicine network, over a cost effective means of existing ICT infrastructure.

3.3.2 Approach

The task facilitates the process of gathering information required for the design of networks. The same hospital, Tikur Anbassa Specialized Hospital was used as a sample to get information. Particularly the organizational structure of the hospital was used to design the network. During the site visit in Task 1, the information collected from the hospital included what departments and units constituted the hospital.

3.3.2.1 Investigation of Existing ICT

In addition to hospital information, the network design required to collect information about the existing ICT infrastructure. The network is expected to be cost effective, interactive, and covers the country as much as possible. The WAN connection should support the requirements set by our telemedicine network design. When we try to select the WAN infrastructure, we considered the following characteristics.

1. **Cost of Connection**

The health care system of the country is known for its budget constraints. In the last few years health expenditure has been increasing [1], but still not enough to enable most of the rural people get access to proper health care. Unlike LANs, WAN connection cost is always there as long as the hospitals are connected. As a result we think the cost needed for WAN connection and rental should be minimized as much as possible.

2. **Coverage**

Since the network we are going to propose should connect all regional clinics / hospitals, the ICT infrastructure should have the wider coverage possible across the country. We measure the coverage based on the organization of the administration of regions as well as the organization of the health care facilities. Recalling form the overview of this report, the government administration body,

which goes down to the lower part of the hierarchy is Kebele then follows Woreda and regional state. Hence our measurement of the coverage is that, high coverage means the ICT has point of presence in each Kebele or Woreda.

3. **Interactivity**

Telemedicine applications such as tele-consultation requires that the network connectivity between remotely located hospitals, should support two way traffic. This is because health care providers must be able to exchange information over the WAN connection. Data in the form of text, image or audio/video need to be exchanged. Hence a two way interactivity is a favorable feature of a WAN that we are going to select.

4. **Bandwidth**

Real time applications that use video conferencing technology require a wider bandwidth than a store-and-forward telemedicine application. In any of the cases a better bandwidth is preferable as it directly affects the network performance. The telemedicine application should have the minimum response time and bandwidth should not be a constraint.

5. **Connection Requirement.**

The network technology requirement to join the WAN connection is the other characteristics we considered in the selection of WAN. This will help us to identify what kind of equipments or terrestrial connectivity need to be acquired in order to get access to the WAN.

Based on the above listed characteristics, we investigated each of the existing WAN infrastructures to select the one best suited to the telemedicine network design we planning.

3.4 Task 4: Investigation Ethical and Legal Issues

Application of telemedicine will help the public to get access to a better health care. But it is a new development, for which there is not any regulation to govern its practice. The laws that govern the practice of medicine have been written based on the conventional patient-doctor medical practice. In order to apply technologies such as telemedicine, the law has to incorporate statements to govern the practice.

Investigating the existing medical ethics and medico-legal issues was important to endorse additional regulations in relation to telemedicine

3.4.1 Task Objectives

To investigate legal, ethical and cultural issues that may promote or challenge the applications of telemedicine in the country.

3.4.2 Approach

This task facilitates information collection related to ethico-legal issues surrounding the application of telemedicine.

3.4.2.1 Literature from the Internet

Internet was used as the only source of information about telemedicine and the related ethical and legal issues. We have tried to search documents from the Internet and then tried to relate what we have found to the Ethiopian case. To do this we had to revise the statements from the legislation and regulations that govern the practice of medicine in Ethiopia.

3.5 Task 5: Identification of Commercialization Possibilities.

As it has been mentioned earlier, budget has been a known constraint which restricted new developments. On of the concerns of the pilot project was budget. It was planned that Internet connection would be provided to selected hospitals free of charge for one year pilot period. The main objective of this offer from ETC was to sustain the project at least for one year. We learned from one of the NTCC members that, it is not yet clear how the project would be financed after the one year pilot period. Therefore, the investigation of means for financing a telemedicine application in Ethiopia was considered as part of this thesis.

3.5.1 Task Objectives

To identify commercialization possibilities and business models to make telemedicine sustainable in the country.

3.5.2 Approach

The task was important to collect documents presenting other's experience in applying and sustaining telemedicine applications.

3.5.2.1 Literature from the Internet

Again the Internet was found to be the only source of information in the issue of commercializing telemedicine. The technology is commonly used in most of the developed countries. Documents related to financing telemedicine were searched from the Internet and they were analyzed to see its possibility in Ethiopian case.

Chapter 4

Current Telemedicine Efforts

Introducing telemedicine to Ethiopia is a cost effective means to improve delivery of health care to the rural areas. It also helps to educate the public on prevention methods. But, it requires creating awareness and working hard on building up of telecommunication infrastructure, to underserved regions. There have been some attempts to introduce telemedicine in Ethiopia. However none of the efforts could reach to the stage of implementing and utilizing telemedicine technology. The efforts can be categorized according to the owner of specific telemedicine activity.

4.1 Effort by NTCC

Introducing telemedicine to Ethiopia is a cost effective means to improve delivery of health care to the rural areas. It also helps to educate the public on prevention methods. But, it requires creating awareness and working hard on building up of telecommunication infrastructure, to underserved regions. There have been some attempts to introduce telemedicine in Ethiopia.

Efforts to introduce Telemedicine in Ethiopia started around 1997. In June 1997, the Ethiopian Telecommunications Corporation (ETC) recognized Telemedicine as one of its services [8]. During the same time, Faculty of Medicine (FoM) was attempting to create awareness of telemedicine and its benefits to concerned government and non-government organizations in the country, using brochures. This activity was supported by UNECA. In February 1998, a National Telemedicine Coordinating Committee (NTCC) was established with the objectives of organizing Telemedicine effort in Ethiopia. The committee was composed of representatives from three local partners namely: Ministry of Health (MoH), ETC and FoM.

Following ITU's commitment to support telemedicine pilot projects in developing countries in the first World Telemedicine Symposium for Developing Countries [5], NTCC prepared a telemedicine initiative project proposal and submitted it in July 1999. The project proposed to connect ten selected sites (hospitals and

medical institutions) to the Internet. The project considers medical consultation among the selected sites as a major objective. ITU accepted the proposal in August 1999, and promised to provide the telemedicine initiative by providing material and expert support. After 11 moths, following the promise, ITU expert arrived to Ethiopia to visit sites selected to be connected in the first phase of the project. The Expert's report, a Project Implementation Document [9], was sent to Ethiopia in April 2001. As it was specified in the document, the project would be implemented in the following three phases [9]:

- **Phase I**: Pilot program, involves connecting ten sites,
- **Phase II**: Expanding the telemedicine network to more hospitals and health institutions in the country,
- **Phase III**: Expanding it further to join International Telemedicine networks.

By the time of writing this thesis, the first phase of the pilot project is expected to be implemented. Testing the system's operation has been scheduled for November 2003 [8]. But as we learned from the ITU's regional representative, here in Addis Ababa, the digital cameras for the ten sites and a server to be installed at the central site have not been purchased yet [See Appendix C]. The ITU experts are expected to come to Ethiopia to implement the pilot project after the purchase of the necessary equipment.

Different local and international partners supported this pilot project. Each of them is committed to play specific roles for the successful Implementation of Phase I, the pilot program. These partners include from local: MoH, FoM, ETC and Ethiopian Telecommunication Agency (ETA). International partners include: ITU, World Health Organization (WHO), United Nations Economic Commission for Africa (UNECA) and United Nations Education and Science Commission (UNESCO).

The total cost of the project is estimated to be 76,122 USD from which 55,000 USD will be contributed by ITU, in kind, for the purchase of Telemedicine system

equipments and expert advice. A two party agreement was signed between ITU and Ministry of Finance and Economic Development (MoFED).

4.2 Effort by Private Hospitals

The survey of private hospitals ware conducted using a questionnaire and interviews. Using the questionnaire we have tried to investigate the IT/ICT usage in private hospitals. Then we have included questions to find their communication needs, particularly the communication with other hospitals. At the end of the questionnaire we have added questions about their attitude towards the use of telemedicine and choice of specific area of telemedicine.

The questionnaire was distributed to 12 private hospitals, practicing in the capital city Addis Ababa. Eight of the hospitals participated by completing the questionnaires. Out of the 8 participants 2 of them were willing enough to discuss questions with the researcher to give more information in the form of interviews. The next paragraphs and the tables presented the survey result.

4.2.1 ICT Usage in Private Hospitals

All of the 8 participant private hospitals indicated having computers to support their day-to-day activates. Among them half 50% of the hospitals reported having less than 5 computers, whereas the other half indicated having in the range of 5-10 computers, in their respective offices.

Table 1: Availability of computers in private hospitals

Number of computers	No. of Private Hospitals	Percent
None	0	0.00%
Less than 5 computes	4	50.00%
6 to 10 computers	4	50.00%

The hospitals use their computers for a variety of applications. Among the applications, Microsoft Office package the most commonly used to support their Administration and Finance routines. All the hospitals reported that they use their computers for supporting their administrative and finance routines. A mall proportion of the hospitals only 12.50% of them reported to use the computers for maintain Electronic Patient Records (EPR). A significant percent of the hospitals, 87.50% use their computers for recording patient visits at the front desk, which they call Reception - of the hospitals. Our observation also confirmed that, behind

the front desk of the hospitals receptionists could be seen using one or two computers.

Table 2: Use of computers in private hospitals

Use of Computers	No. of Private Hospitals	Percent
Administration and Finance Routines	8	100.00%
To Record Patient Visits/Schedules and Appointments	7	87.50%
To Maintain Electronic Patient Record	1	12.50%

The computer systems used in the majority, 62.50% of the hospitals are standalone computers. Only 37.50% of the participants reported that their computers are networked for file or printer sharing. None of the hospitals have networks for database access and sharing Internet connections. We have also observed employees taking files using diskettes from on computer to another for printing. The computers are equipped with Microsoft products, running on of the Ms-Windows version.

Table 3; Computer systems in private hospitals

Type of Computer Systems	No. of Private Hospitals	Percent
Standalone Computers	5	62.50%
Networked for File and Printer sharing	3	37.50%
Networked for Internet Connection	0	0.00%
Networked for Database Access	0	0.00%

Internet connection seems common in the private hospitals. A majority of them, 87.50% reported that they have a dial up Internet connection, provided by the Ethiopian Telecommunications Corporation. Only 12.50% reported not having Internet connection.

Table 4: Internet connection in private hospitals

Internet connection	No. of Private Hospitals	Percent
Have Internet Connection	7	87.50%
Have No Internet Connection	1	12.50%

In those hospitals with Internet connection, the popular application used 85.71% of them used their Internet connection to send and receive E-mail messages. Use of the Internet for web browsing and electronic document searching is reported by 57.14% and 28.57% of the hospitals respectively. Only 14.29% of the participant private hospitals have web presence (have web site).

Table 5: Use of Internet in the private hospitals

Used their Internet Connection	No. of Private Hospitals	Percent
For E-mail	6	85.71%
For Web browsing	4	57.14%

For searching electronic Documents	2	28.57%
Have Web site	1	14.29%

Few of the participant hospitals employ IT / ICT staff. 87.50% of them do not have IT / ICT staff employed in the hospitals. Only 12.50% employed 0 to 2 staff with the job titles related to IT / ICT. As we have learned from the additional interviews, these hospitals are also teaching hospitals, which do have nursing college along with the hospitals.

Table 6: Number of IT / ICT staff in the private hospitals

Number of ICT / IT Staff	No. of Private Hospitals	Percent
None	7	87.50%
0 to 2	1	12.50%
2 to 5	0	0.00%

4.2.2 Use of Digital Medical Instruments

More than half of the private hospitals do have one or more medical instruments which are capable of digital data acquisition. Among the digital medical instruments, Possession of Laparoscopy surgery unit is reported by one of the hospitals. CT scan, Endoscopies, Photometers, ECG, EEG and Ultrasound units are reported by 62.50% of the respondents. 42.86% of the hospitals reported not having digital medical instruments.

Table 7: Possession of digital medical instruments

Digital Medical Instruments	No. of Private Hospitals	Percent
Have none	3	37.50%
Have one or more	5	62.50%

4.2.3 Automation

The hospitals were also asked to state if they have any plan of automation, to facilitate their day-to-day activities. Only 12.50% of the hospitals have no interest in automating any of the operations. 87.50% do want to automate some of the operations in their hospitals.

Table 8: Interest to automate activities in the private hospitals

Automation Interest	No. of Private Hospitals	Percent
Interested to automate operations	7	87.50%
Not Interested to automate	1	12.50%

Among the 87.50% of the private hospitals, 42.86% of them want to automate their stock control system, particularly to control their pharmacies along with the finance and admin routines. Automating the front desk, Reception activities and their finance routines are reported by 28.57% of the hospitals. Only 14.29% of

them indicated interest in automating their activities in the laboratory, maintenance of patient record and to have general hospital management information system.

Table 9: Systems to automate in private hospitals

Type of system to automate	No. of Private Hospitals	Percent
Stock Control for their pharmacies	3	42.86%
Finance Routines	3	42.86%
Patient Appointment and Schedules	2	28.57%
Laboratory (Clinical Chemistry)	1	14.29%
Patient Record System	1	14.29%
General Hospital Information System	1	14.29%

4.2.4 Communication Needs

To survey the communication needs of the private hospitals they were also asked if they communicate with any hospital in the country or outside the country. All of them reported to have communicated with other hospitals. 37.50% of them reported to have communicated with other hospitals both local and abroad. The same percentage of the hospitals reported to have communicated with local hospitals only. A few percentage, 14.29% of the hospitals reported to have communications with hospitals outside the country only another 12.50% reported to have never communicated with other hospitals.

Table 10: Communication of private hospitals with other hospitals

Communicate with other hospitals	No. of Private Hospitals	Percent
None	1	12.50%
Local only	3	37.50%
Abroad only	1	12.50%
Both Local and Abroad	3	37.50%

Telephone is used by all of the participating hospitals to communicate with other hospitals. Second popular means of communication are postal services and e-mail, which are reported to be used by 71.43% of the hospitals. Web based applications is reported to be used by only 14.29% of the hospitals to communicate with other hospitals.

Table 11: Means of communications used by private hospitals

Means of communication	No. of Private Hospitals	Percent
Telephone	7	100.00%
Postal Services	5	71.43%
E-mail	5	71.43%
Web based application	1	14.29%

The frequency of communication by the private hospitals with other hospitals also varies. More than half of them, 57.14% reported to have communicated with other hospitals between 5-20 times in one month. 28.57% of the hospitals communicated less than 5 times in one month. Only 14.29% reported to have communicated more frequently, more than 20 times in one month with other hospitals.

Table 12: Number of communication by private hospitals with other hospitals

Frequency of Communication in one Month	No. of Private Hospitals	Percent
Less than 5 times	2	28.57%
5 to 20 times	4	57.14%
More than 20 times	1	14.29%

More than half of the hospitals, 57.14% wanted to employ computer networks for their remote communications with other hospitals. The purpose of communication need is reported to be medical consultation, referral and exchange of information by all of these hospitals. 42.86% of the hospitals do not show interest to employ computer networks to communicate with other hospitals.

Table 13: Interest to employ computer networks for remote communications

Computer Networks For remote communication	No. of Private Hospitals	Percent
Interested	4	57.14%
Not Interested	3	42.86%

When asked to give their opinion on a possible nation wide telemedicine network, which connects all regional hospitals and clinics with urban hospitals, 62.50% of them reported that it will be good to deliver health care to remote areas of the country. The same percentage of the hospitals believed that the network would help to improve quality of care in the urban areas as well. 25.00% of the hospitals reported that such a network is too far to be achieved in this country. 12.50% of the hospitals expressed their fear that such a system may bring about complicated issues such as privacy and security.

Table 14: Opinion of private hospitals on a possible nation wide telemedicine network

Opinions on possible Nation-wide TM Network	No. of Private Hospitals	Percent
Good to deliver health care to remote areas	5	62.50%
Good to improve quality of care in urban areas	5	62.50%
Too far to achieve	2	25.00%
May bring complex issues such as privacy	1	12.50%

The majority of the participant hospitals, 75.00% reported that cost of advanced electronic medical instruments and computers inhibit the development of

telemedicine in our country. 62.50% of them reported that ICT awareness and lack of computer skill of employees are also among the inhibitors of the development of telemedicine. Budget is reported to be one of the inhibiting factors by 57.14% of the respondents. Medical Ethics, Medico-legal issues and culture were considered as inhibiting factors by 25.00% of the respondents.

Table 15: Inhibiting factors of the development of telemedicine by private hospitals

Factors inhibiting development of TM	No. of Private Hospitals	Percent
Cost of computers and medical instruments	6	75.00%
ICT awareness and skill of employees	5	62.50%
Budget	4	50.00%
Medical Ethics	2	25.00%
Medico Legal Issues	2	25.00%
Culture	2	25.00%

All of the hospitals participated showed interest in joining a nationwide telemedicine network if it can be implemented. 50.00% of them strongly agreed to join, and the other half just agreed.

Table 16: Interest to join a nation wide telemedicine network

Interest to Join Nation Wide TM Network	No. of Private Hospitals	Percent
Strongly Agree	4	50.00%
Agree	4	50.00%
Uncertain	0	0.00%
Disagree	0	0.00%
Strongly disagree	0	0.00%

Considering the development of their own telemedicine system, half of the participant hospitals have chosen not to respond. Among the other half, none of them reported to consider it within one year. 25.00% of the hospitals consider introducing telemedicine systems to their hospitals within the next one to three years. The other half of the hospitals reported to have considered developing their own telemedicine system after three years.

Table 17: Developing telemedicine systems in private hospitals

Consider developing TM Systems	No. of Private Hospitals	Percent
Chosen not to respond	4	50.00%
Within one Year	0	0.00%
In the next 1 to 3 Years	2	25.00%
After 3 years	2	25.00%

Currently none of the participant hospitals indicated having funds for the development of telemedicine. Only 12.50% of them reported that the availability of fund for the development of telemedicine depends on the cost of installing and maintaining such a system.

Table 18: Availability of funds for the development of telemedicine

Have Fund to develop TM System	No. of Private Hospitals	Percent
Yes	0	0.00%
No (Not Now)	7	87.50%
Depends on the cost	1	12.50%

The last question asked to the private hospital was to choose among specific areas of specialization, on which they would be interested to apply telemedicine. A relatively higher percentage, 62.50% of them identified Cardiology as a major interest area. Oncology indicated by 50.00% of the participants and Gynecology / Obstetrics and Endocrinology were chosen by 37.50% of the hospitals. 25.00% reported to be interested by General practice / family practice, Pediatrics, Diabetic patient management, Gastroenterology / Endoscopies, Infectious Disease and Radiology. Among the list of specializations, Dermatology, Pathology and Psychiatry have not been chosen by any of the hospitals.

In addition to the list of specializations we have provided the respondents Laparoscopy Surgery, Surgery, Dentistry and Rheumatology were added by 12.50% of the hospitals as areas of interest. The following table shows the list and number of hospitals interested in each of the specializations.

Table 19: Choice of specific areas of telemedicine by private hospitals

Interest on specific area of telemedicine	No. of Private Hospitals	Percent
Cardiology	5	62.50%
Oncology	4	50.00%
Gynecology / Obstetrics	3	37.50%
Endocrinology	3	37.50%
General practice / family practice	2	25.00%
Pediatrics	2	25.00%
Diabetic patient management	2	25.00%
Gastroenterology / Endoscopies	2	25.00%
Infectious Disease	2	25.00%
Radiology	2	25.00%
ENT / Otolaryngology	1	12.50%
Nephrology / urology	1	12.50%
Neurology	1	12.50%
Ophthalmology	1	12.50%
Orthopedics	1	12.50%
Laparoscopy Surgery	1	12.50%
Surgery	1	12.50%
Dentistry	1	12.50%

Interest on specific area of telemedicine	No. of Private Hospitals	Percent
Rheumatology	1	12.50%
Respiratory Medicine	1	12.50%
Dermatology	0	0.00%
Pathology	0	0.00%
Psychiatry	0	0.00%

Before completing the questions, the private hospitals ware asked to express their feelings about the benefits of telemedicine systems. 62.50% of the participants expressed their feelings saying that, they could benefit from the application of telemedicine by:

- Getting up to date information
- Improve quality of services
- Update modes of patient management
- Get access to current development in various specializations
- Assist in the management of controversial cases
- Obtain information on results of research works related to medical discipline
- Exchanging information in a diversified forms (text, image, audio and video)
- Experience sharing
- References

Table 20: Private hospitals feeling on the benefits of telemedicine

Feeling about the benefits of TM	No. of Private Hospitals	Percent
Responded	5	62.50%
Not responded	3	37.50%

4.3 Other Efforts

In addition the efforts of NTCC and private hospitals, there have been some indications of interest to introduce telemedicine in Ethiopia. According to a published document from the Internet, ETC presented papers to international conferences showing interest to introduce this technology to Ethiopia [4].

A newly established ministry, Ministry of Capacity building has a program known as ICT capacity building program. As part the program the ministry plans to introduce ICT is in the health sector of the country. Recently the program has done a survey: “The Ethiopian Baseline Study on the Deployment and Exploitation of ICT, 2003.” As part of this study the deployment and exploitation of ICT in the Health sector was surveyed [45]. The study targeted both Teaching and Non-Teaching hospitals, as well as health posts/centers, clinics and pharmacies across the country. Lastly, there are some documents in the Internet that discuss specific cases of telemedicine trial [46], calling support for telemedicine projects [47], and so on.

Chapter 5

Design of Telemedicine Network Architecture

5.1 Introduction

People want to get access to proper health care, which meets their needs at affordable costs. Health care has to be available when they need it to their proximity. Physical separation between the people and health care facilities must not pose any limitation to the efficient health care delivery to remote areas. Information Technology (IT) is a best choice to offering access to health care service to the expectation of people, when there is limited access to health care. In this regard Telemedicine has developed during recent years with the development of technologies such as Integrated Services Digital Network (ISDN) and Asynchronous Transfer Mode (ATM) networks [29]. Both the health care providers and patient can benefit from those networks. In our country such technology are emerging. The development of telemedicine has to follow the same truck.

IT based horizontal and vertical communication between the health care facilities following the organizational structure of the health system is essential. It facilitates efficient information exchange and hence helps delivering health care to underserved rural areas. Such communication is possible by implementing a nation wide Telemedicine network, based on affordable telecommunications infrastructure. The network should connect all regional clinics to urban area hospitals in the country for the purpose of:

- Establishing a reliable horizontal and vertical communication between the health care facilities driving a quality and an improved health care delivery to all citizens.
- Achieving e-health commitment and bring health care closer to underserved and un-served rural areas.

- Strengthening collaboration efforts among hospitals and facilitating information exchange and experience sharing among medical professionals practicing in remotely located clinics.
- Minimizing long distance travels of rural people to urban areas or to the capital city seeking proper medical care during trauma.
- Providing medical information to the medical practitioners, which will help them to keep themselves up to date with the current technology.

Even if urban areas are relatively better equipped with adequate ICT technology such as Internet access and digital telephone networks, 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 emerging state owned, low cost VSAT networks such as SchoolNet and WoredaNet provide the rural areas with suitable means of communication to urban areas and further to the world.

5.2 Current State of the Network

The current telemedicine system considered is the National Telemedicine Coordinating Committee's pilot project [9]. In this project a telemedicine network is formed by connecting 10 hospitals across the country by providing them with dial up Internet connection. There is an existing LAN in the central site (FoM). The LAN is base on Ethernet technology, which is used to allow students of medical faculty get access to collection of journals, and publication electronically. The other use of the LAN is to share Internet connection. All the connected workstations are in one room (Computer Center). Students and physician have to go to the room when they want to get connected to the Internet or look for some electronic journals. A server in another room stores the publications. This LAN is serving only the faculty, for educational purpose. On the other hand a number of other standalone PCs are used in some of the department offices.

The over all network connection is not documented. The only diagram one can find about the WAN connection is attached in the Annex I of the component project document [9]. It shows how the 9 hospitals are connected to the central

hospital in a kind of star topology. However, it is the telemedicine application's logical view, which depict that the central site is where all the consulting specialists are stationed.

The conceptual network diagram of the existing telemedicine network, as understood by the researchers is shown in Figure 1 below. All the ten sites will have dialup Internet connection from the sole Internet Service Provider, ETC through the Public Switched Telephone Network (PSTN). Each hospital will be quipped with a digital camera and scanner for dermatology digital image acquisition. The national Gateway at the Sululta satellite ground station connects to Intelsat Indian Ocean and Atlantic Ocean regional satellites [33]. There are no firewall or internetworking devices such as switches involved in the current telemedicine network. The only device used to connect the 10 hospitals is the modems attached to each of the PCs [35].

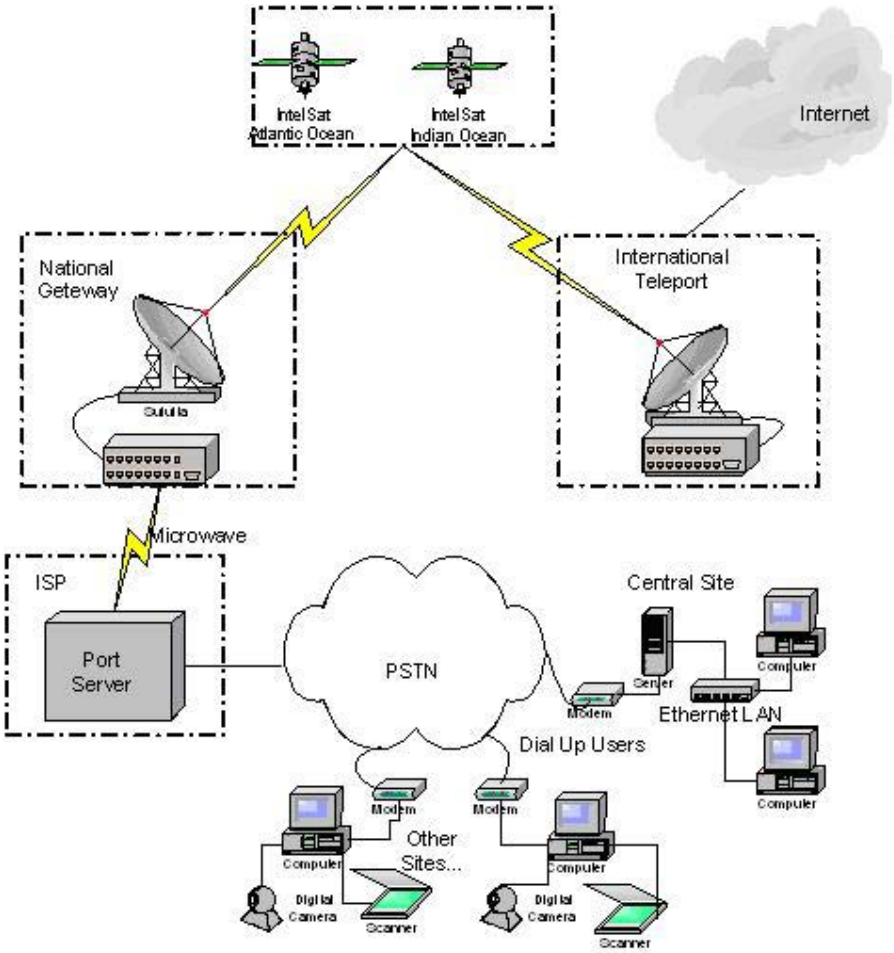

Figure 1: Conceptual network diagram of the pilot project

5.2.1 Drawbacks of the Current Network

The problem of the current system starts from the very fact that there was no design specific to telemedicine, used in the pilot project. This is because, the objective was to provide Internet service to the selected hospitals to enable doctors, communicate for consultation using e-mails. Providing hospitals with Internet connection cannot be considered as a telemedicine implementation. Some of the drawbacks of the pilot project are:

1. There is no GUI specific to telemedicine. This could be a problem because doctors will be obliged to use commonly available general-purpose email programs to communicate. It will be difficult for doctors to learn and understand the system easily and to distinguish telemedicine communication to the day-to-day emails.
2. There is no patient/physician database design considered in the pilot project. Storing patient data, for future use or physician data to identify the users is not possible if databases are not included in the system.
3. Expansion of the network, as it was planned in the phase-wise implementation plan of the project [8] is not visible, as there is no system design.
4. The project considers the use of e-mail and file attachment. This will be difficult if there would be a need to transfer larger files like medical images and x-ray files.
5. Using e-mail, it would be difficult to structure the information exchange among the doctors. Doctors will be forced to summarize the patient information every time they write referrals and give feedbacks.
6. It would be difficult to secure the patient information and the system as whole unless the PCs connected to the Internet are locked and used only for the purpose of telemedicine services.

Hence there was a need for new telemedicine system design that will have its own GUI, database and uses the existing ICT infrastructure for its network connectivity.

5.3 Telemedicine Network Design Considerations

5.3.1 Design Goal

The overall goal of the nation wide telemedicine network design is to provide a system which meets the needs as outlined in the previous paragraphs. The system implements connectivity among rural clinics and urban area hospitals to be used mainly for tele-consultation, and maintaining patient information.

As the main design goals, the network should be cost effective, expandable, secure which provides state-of-the-art ICT access scheme to rural area clinics. Existing ICT infrastructure will be given priority to minimize cost of implementing the network. In this design the following specific design goals were given priority.

5.3.1.1 Expandability

Expandable system is one in which additional inputs and outputs (such as the number of incoming data, the number of simultaneous users served, the number of clinics to get connected, etc) can be added without a major reworking of the network design. So the design should consider the network's ability to continue to function well as it is changed in size or volume to meet new traffic or application requirements [30]. In this regard expandability is a concern in the telemedicine network design for the following reasons:

- The number of hospitals built in the county is few in number. However there are more clinics being added to the health system of the country every year.
- There is also a chance to incorporate private hospitals in the nation wide telemedicine network as necessary, which will ultimately increases the number of sites to be connected in the future.
- The area of telemedicine applications will not be limited to some specific diseases, but will be expected to increase in type and number in the future.
- The network should also support advanced applications, which require real time connectivity such as video conferencing in the future.

5.3.1.2 Security

During consultation or patient referral, most of the data exchanged over the network is sensitive patient information. Confidentiality of patient information must always be respected. For a secure communication, protocols such as Secure Socket Layer (SSL) could be used. SSL permits users to conduct secure communication over web-based applications. This provides the ability to safely exchange patient information across the network.

When doctors exchange patient information, they should adhere to medical protocol that defines the rules to be followed during this process. In addition to these the network and involved servers should be protected by firewall against external invader. Firewalls could be software or hardware for the sole purpose of keeping digital pests such as viruses, worms, and hackers out of the network [31, 32].

5.3.1.3 Cost

Implementing a nation wide telemedicine network may seem to be more expensive than building clinics or equipping existing regional clinics with medical personnel and medical instruments. A cost benefit analysis, comparing various approaches has to be done, to come up with a lower cost solution to the problem of delivering proper health care to rural areas. However, network connectivity among the health care facilities, both in the urban and rural areas over an existing ICT infrastructure is considered as a cost-effective solution.

Considering the installation cost, our design will consider an already existing WAN, provided by the Ethiopia Telecommunication Corporation. Set-up costs depend on the type of WAN to be used in the telemedicine network design. But cost is taken as one of the selection criteria to choose from the existing/emerging ICT infrastructures in the country.

5.3.2 Design Requirements

Most of the inter-hospital communications used to be by telephone and hand delivered referral messages in this country. During referrals patients have to travel to one of the referral hospitals urban areas, carrying the referral messages written

by referring physician. Clinics located in the telephone coverage areas communicate using telephone to exchange information about availability of specialist or bed in another hospital. However, the communication needs of hospitals are beyond what have been practiced so far.

Geographically dispersed clinics need telecommunication technology for the following purposes:

5.3.2.1 Data Transmission

The data is in the form of both text and image about patients that need to be exchanged between clinics during remote consultations. Textual data may contain referral messages and feedback, clinical notes of patients etc. Medical image files such as x-rays and dermatology pictures acquired by digital cameras have to be accessed for remotely diagnosing a patient.

5.3.2.2 Instantaneous access to patient information

When consulting a general practitioner, specialists need to get access to patient information instantaneously. This requires a system, which maintains patient information in a standardized format and be accessible through a secure communication means by authorized users.

5.3.2.3 Access to Medical Information

Doctors need to get access to medical information databases to get informed on the current medical practices. This helps them to stay up to date with the new development in the field and get experience from similar cases when they come across difficult patient case.

5.3.2.4 Access to the Internet

In the Internet doctors need to visit web sites related to the medical field. Medical expert systems and Medical databases are some examples among the sources of information in the Internet. They can also use e-mail to communicate among themselves and benefit from sharing experience of senior specialists.

These and other communication needs of healthcare providers also require the development of telemedicine application software backed by electronic patient record systems. Design of such communication networks will also require the understanding of organizational structure of the clinics involved in the network. Since the government/public clinics are owned and organized under their respective regions, the WAN design should follow the organizational structure of the administrative regions in the country.

5.4 Proposed LAN / WAN Design

A detailed study about the inclusion of various clinics, their locations relative to the nearest access point to existing ICT infrastructure, traffic load and its characteristics, security, LAN/WAN protocol, topology and bandwidth requirements and utilization, allocation of bandwidth etc, have to be considered while trying to design telemedicine network. In addition to these, issues of communicating patient information electronically may raise question of medical ethics, and a need for developing medical protocol to be used in the day-to-day activity using telemedicine network.

In this section the proposed LAN and WAN for the nationwide telemedicine network are described. The necessary internetworking devices to be used will be presented in logical diagrams. The decision to make which specific internetworking device is yet to be identified. We will start with hospital LAN design.

5.4.1 Hospital LAN Design

To design the LAN for each hospital, we will consider the central site, Tikur Anbassa Specialized Hospital as a sample. The hospital is organized in to 16 departments. Each department will have units as necessary. For instance, the Internal Medicine department has units such as Renal Unit, Cardiology Unit, Neurology Unit, etc. The physicians in these departments/units need to communicate whenever a patient visits more than one of the units. The proposed LAN will follow the hierarchical structure of the hospital.

A variety of LAN technology can be employed. The decision to make the selection between the technologies depends on:

- Expected application to run on the network and their traffic patterns.
- Physical locations of the offices and users to be connected in campus.
- The rate of network growth.
- The abundance of the network technology in the market.
- Simplicity of installation and maintenance.

Currently we expect a web-based telemedicine application to run on the network. The application will use a central database server where all the user and patient information will be stored. The type of data to be transmitted on the network shall be in the text and image formats. Since all communication shall be through the server, the traffic pattern around the center is expected to be heavy. Higher speed devices will be used at the center of the LAN where there will be servers.

The sample hospital (Tikur Anbassa) is composed of 5 buildings (Block A-E). The blocks are not physically separated. They are built on a number Square meters area. All the departments and offices are located in either of the blocks. Having routers switches in each of the departments is ideal to design a high speed and expandable LAN, but makes it expensive. A cost effective choice is to put switches per building and then have the departments be connected and form groups by using Virtual LAN technology.

The rate of the hospital LAN growth depends on the level of computerization in the hospital. In this design it is anticipated that as the application is used and becomes familiar, there is a chance to add more applications and connect more computers and offices to the LAN. The switches/routers selected in this design should have many free ports to help cascade the growing number of connections in the future.

To design the LAN architecture we have selected the hierarchical model. It enables us to design and arrange the inter-network devise in layers. It is a model

preferred by most of network design experts for its ease of understanding, expandability and improved fault isolation characteristics [31]. The model required the following three layers

At the first layer – Core layer high performance switches that are capable of switching packets as fast as possible should be deployed. This layer connects the LAN backbone media. It also connects to the outside world to WAN via a firewall.

In this design the devices in the core layer will be placed at a central location in the hospital. The devices in this layer will be connected with high-speed cables such as fiber optics, or fast Ethernet cables. The servers necessary for the applications will be connected to switches in this layer shielded by a firewall.

The second layer – Distribution layer will contain switches and routers capable of VLAN switching and allow defining departmental workgroups and multicast domains. The devices should also support connectivity of different LAN technologies since they also serve as the demarcation point between the backbone connections in the core layer and the access layer.

In this hospital LAN design the distribution layer represents switches/routers at each building connected to the core layer on the on end and to the access layer on the other end. Use of redundant links will be used for maximum availability. The departments could be grouped forming their own Virtual LAN.

The third layer – Access Layer is where the end users are allowed in to the network. This layer contains switches/hubs from which PCs in each department get access to the Hospital LAN. Each department will have at least one switch/hub, which in turn will have redundant links to more than two of the switches in the distribution layer.

The following figure represents the hospital LAN design.

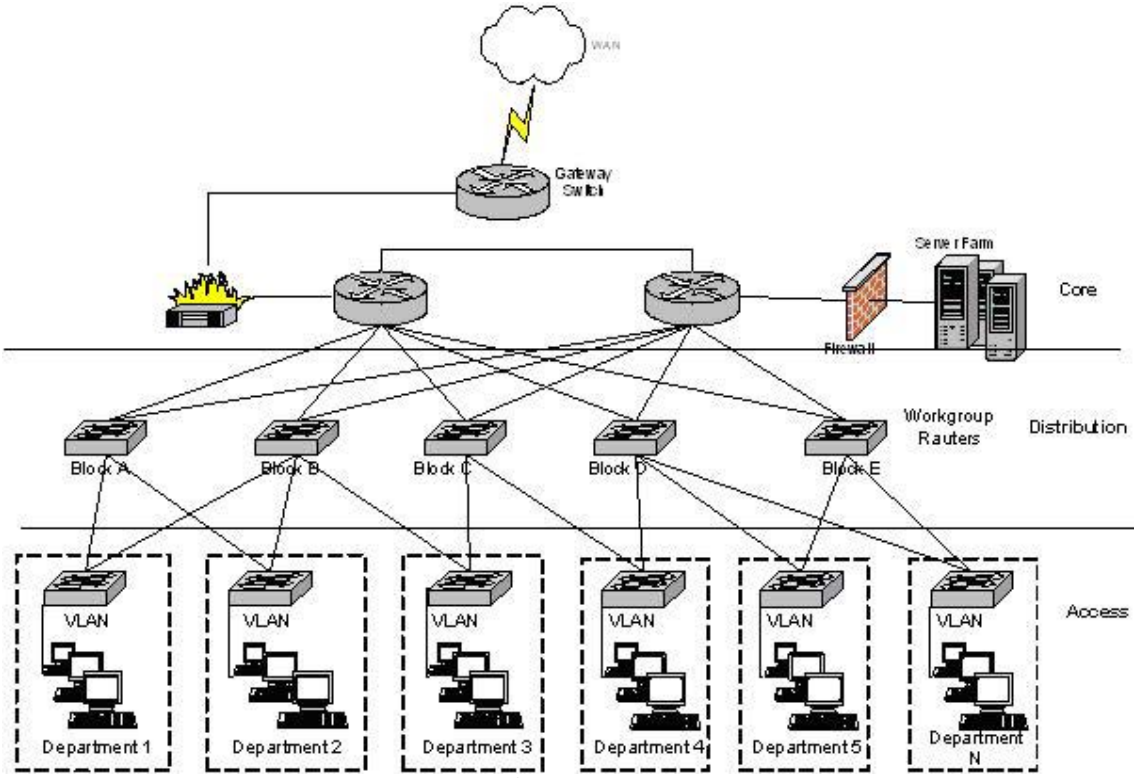

Figure 2: Hospital level LAN for Tikur Anbessa hospital

5.4.2 Telemedicine WAN Design

The design of the WAN for the nation wide telemedicine network raises the issue of WAN service provider. Unlike LAN, WAN connectivity depends on the availability of WAN infrastructure in the country. The sole WAN service provider is the Ethiopian Telecommunications Corporation (ETC). ETC provides a number of services [33] among which we have to select the WAN infrastructure that is suitable for the nationwide telemedicine network. The following services are considered in this design.

- Internet Services
- Digital Data Network
- SchoolNet VSAT network
- WoredaNet VSAT network
- Broadband Multimedia Network

5.4.2.1 Internet

ETC started providing Internet Services in 1997 using one gateway in Addis Ababa. Currently the server capacity is 10Mbps uplink and 4Mbps downlink [33]. The Internet service is provided to the customer in either by dialup or leased line connectivity.

5.4.2.1.1 DialUp

This connectivity is the cheapest Internet connectivity provided by ETC. It uses the exiting telephone line, which was originally setup for voice transmission. A maximum of 56Kbps bandwidth is provided to the dialup subscribers, but usually on can get 28 – 33Kbps in the daytime and 35 – 40 during the nighttime.

This service covers the telephone coverage areas in the country. The telephone network is concentrated in the urban areas in Ethiopia, with 505 exchanges, out of which only 159 are automatic digital exchanges. 58.6% of the exchanges serving the capital city Addis Ababa [3].

5.4.2.1.2 Leased Line

Unlike the dialup Internet connectivity, leased line subscribers can get access to the Internet on the 7 day 24 hour (7/24) basis, dedicated, fixed bandwidth connectivity [33]. Bandwidth can go up to 1Mbps [34]. The infrastructure used for leased line connectivity is a data network.

Currently there are very limited subscribers to the leased line Internet. As we have learned from engineers in ETC, the reason for this few number of customers is lack of awareness and high connectivity costs.

5.4.2.2 Digital Data Network

In 2001 ETC established a digital data network, which is capable of providing dedicated (leased line) Internet, ISDN and Frame Relay services. As it was announced by ETC, DDN supports digital lease at multiples of 64Kbps, to be used by a variety of applications [7, 33].

But still the DDN covers the urban areas where there are other means of WAN services such as dialup Internet service. The ISDN service is not matured and has

not been affordable. DDN is known to have a number of limitations as the provider itself specified them [34].

- It can only give up to a maximum speed of 1Mbps.
- It cannot provide bundle (voice, data, and video) services
- It does not support multicasting, etc

5.4.2.3 VSAT Networks

Very Small Aperture Terminals have been used by ETC as a means of transmission link to reach remote areas. So far 292 VSAT terminal stations have been operational and are being used by the telephone network [33].

In addition to these, there is a plan to install VSAT terminals in every secondary schools and higher learning institutions to form a broadcasting VSAT network called SchoolNet [13]. There is also another VSAT network to connect about 600 Woreda administration centers forming a government network called WoredaNet [Appendix C]. 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 selection.

5.4.2.3.1 SchoolNet

SchoolNet is a VSAT network, which is designed for broadcasting multimedia data to all secondary schools and higher learning institutions in Ethiopia. The network is owned by ETC. Though the network currently supports only one-way traffic, it can be upgraded to have up to 384kbps upstream, to support two way interactivity.

5.4.2.3.2 WoredaNet

WoredaNet is also a VSAT based network, which is designed for integrated services of voice, data and image. Currently the WoredaNet covers 571 Woreda administration centers.

The network supports two way interactivity of 45Mbps down to all the Woreda administration centers and 256kbps upstream from each Woreda. The network is

expected to scale up and include many government offices in each Woreda. The switches installed in each Woreda consist of more than 10 free ports to support more connections cascading out of the network point of presence.

5.4.2.4 Broadband Multimedia Network

A new Broadband Multimedia Network (BMN), which has been fully operational by the end of June 2004, is announced by ETC. The network interconnects the capital city with high speed Optical metropolitan Network and 13 other provisional towns using radio digital systems [33, 34].

As the name indicates, BMN is a high bit rate network, which supports voice as well as full motion video, on the same network infrastructure, with better quality and availability as well as relatively low price to customers [33, 34].

5.4.3 Summary of ICT Selection

To pick one of the infrastructures for telemedicine the following factors were considered:

- The geographical coverage
- The bandwidth
- Two way interactivity
- Rental cost of WAN connection
- The capacity to add more LANs

The following table summarizes the process of WAN infrastructure selection.

Table 21: Summarized comparison of existing ICT infrastructure

	Internet	DD N	SchoolNet	WoredaNet	B M N
Coverage based on the network's ability to go down to Woreda	Telephone coverage areas only	The capital and regional Urban areas only	About 500 schools covered. There are wordas that do not have schools	571 Woredas out of 594 are covered	The Capital city and 13 regional towns.
Bandwidth	Maximum of 56k dialup and 1Mbps in Leased line	Maximum of 1Mbps	Can be upgraded to 384k upstream	Downstream/ upstream 45Mbps/ 256k downlink	ADSL Services: Variable bandwidth Downstream/upstrea m: 512k/128k and 1024k/256k
Interactivity	Two way	Two way	One way broadcasting	Two way	Two way
Cost	0.11birr/min dialup 1000birr/month leased line		Free for schools	Free For Woredas	Not yet determined, under development
Capacity to scale	Not scalable	Not scalable enough		Will have more than 10 ports free at each Woreda	Can be expanded

5.4.4 Recommendation

Based on the comparison we have made WoredaNet will be best suited to the national telemedicine network, as long as the existing infrastructures are concerned. But as can be observed in the table, when the coverage is good the capacity is limited. BMN will be best for it represents state-of-the art service and higher bandwidth. However, it is centered in the urban areas only. It is also under development and we have considered it as a potential to be used integrated with the VSAT based networks to enhance nationwide telemedicine network. The SchoolNet needs to be upgraded to support two way interactivity.

The solution we propose is that of a nationwide telemedicine network that uses the combination of VSAT network that is cost effective and which goes down to the public even in the rural areas and urban area terrestrial network that provides modern but economical connectivity to hospitals. In this regard, we propose connectivity via the emerging BMN to connect urban area hospitals in the capital city and in the regions where the network can easily be accessible. And to use WoredaNet VSAT network to connect rural area clinics to the telemedicine network. **Figure 3** represents our proposed telemedicine network.

This WAN connectivity required that urban hospitals have two WAN connections. Getting more than one WAN connection may be more expensive. If the two WAN infrastructures could be integrated, an alternative WAN design will require only one WAN connection to the urban hospitals through which the hospitals will be connected to BMN and the rural are clinics to the WoredaNet. The second alternative of the WAN design is shown in **Figure 4**.

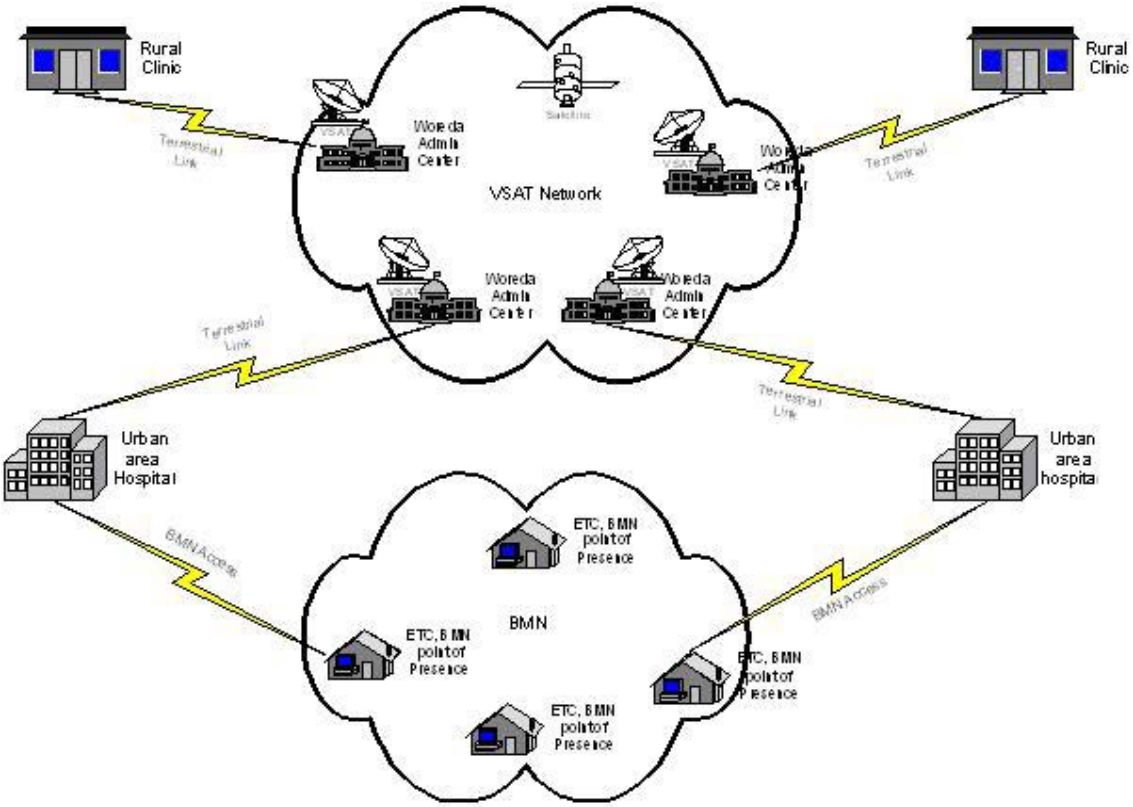

Figure 3: Logical WAN design based on BMN and VSAT networks alternative one

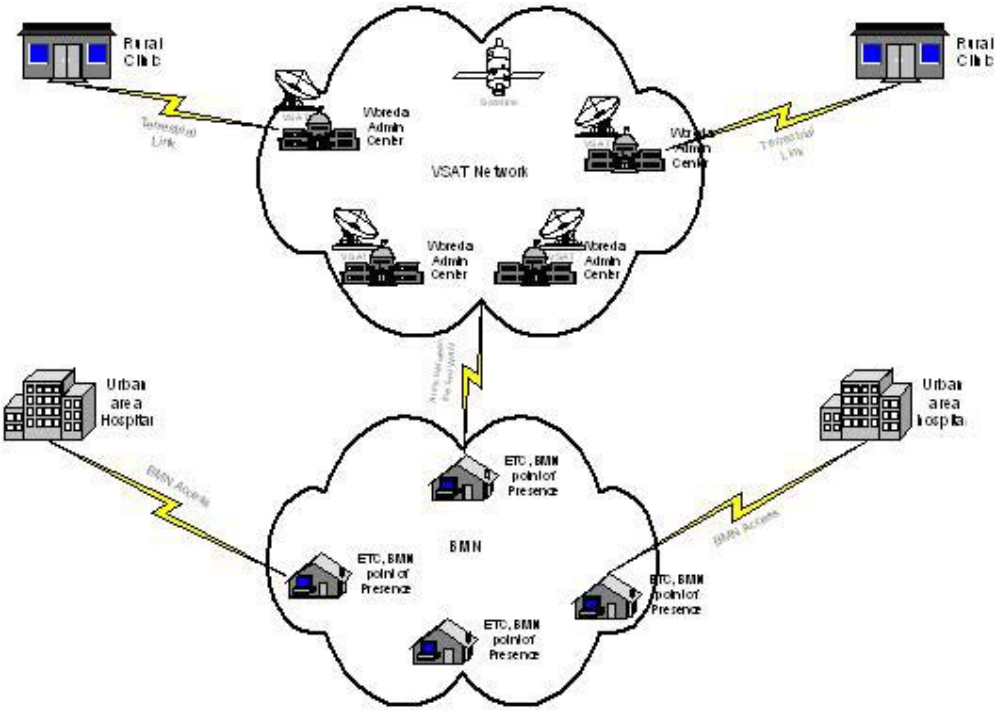

Figure 4: Logical WAN design based on BMN and VSAT networks alternative two

A typical simple scenario where the network is used for telemedicine consultation between a practitioner in the rural area clinic and a specialist in the urban hospital can be viewed in **Figure 5**. The practitioner inputs patient data and referral messages using the graphical user interface provided by a telemedicine application. On the other end a specialist reads the referral massage, displays the patient information, after which the specialist can input the referral feedback to advice the practitioner.

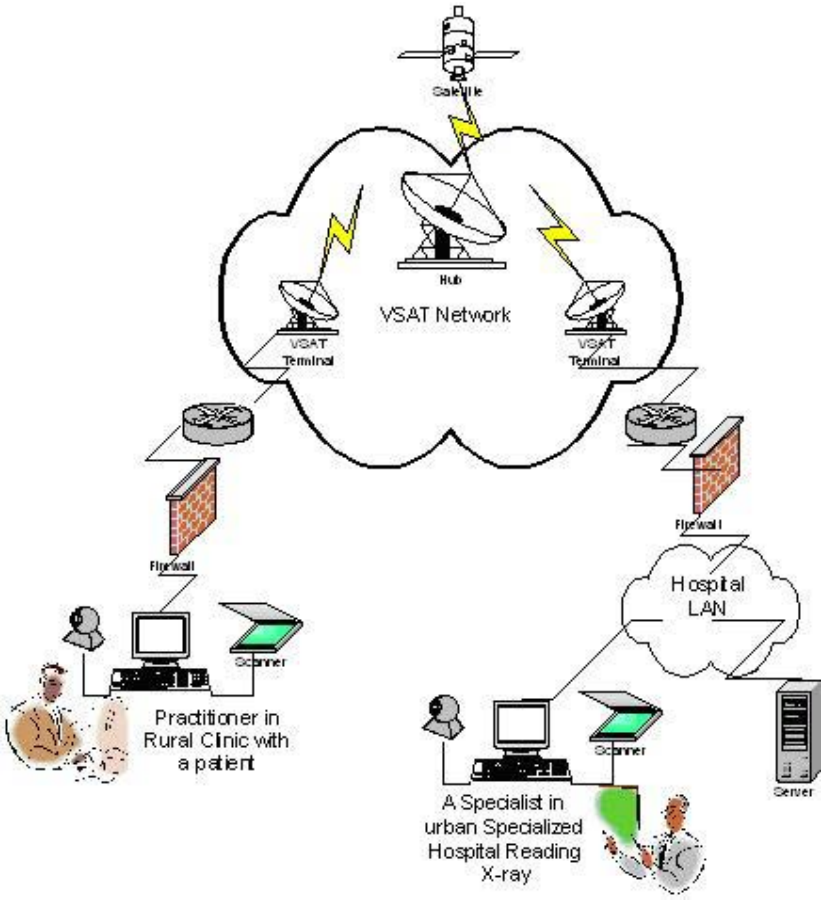

Figure 5: Scenario of the telemedicine network

Chapter 6

The Prototype

With the specified network requirements and architecture design, we have developed a working prototype for a national telemedicine network. The operations of the prototype telemedicine network are summarized below:

6.1 Overview

The prototype is a Basic Telemedicine Service (BTS), which provides a web based Graphical User Interface (GUI) for healthcare providers. BTS facilitates the information exchange between remotely located healthcare providers for the purpose of medical consultation, as well as for maintaining patient information. We have tried to reproduce electronically, the traditional paper based forms and patient cards used in the hospitals.

We have selected the web-based technology for its universality. Using web-based technology constitutes not only a network that can be used universally but also system independent platforms providing access to many different computer systems at client site [35]. The only requirement in the client site is web browser software installed and network connectivity.

To secure the system, we have used password protected system where the users have to login to get access to the functionalities provided by the system. In addition to that, user types are defined so that there will be a role based access to database and system functions in BTS. We have used a centralized database to store user and patient information. Unlike e-mails, this approach allows us to insure structured information exchange between the communicating healthcare providers.

6.2 Major Features of BTS

Basically BTS is a database driven web site, the major features of which can be described as follows:

- Provide user management services where administrator can register users, assign username and password, and define user type, as well as search and edit user information.
- Provide patient management services where health care providers can register patients, search patients and view patient information on a traditional patient card like interface, when necessary.
- Provide referral systems where physicians can write referral messages to a particular department and hospital, and on the other hand provides a system by which a physician can see the list of referrals forwarded to the department she/he is working and allow the physician to write feedback after examining the referral message and patient information instantaneously.
- Provides a system by which physicians can request lab test to any hospital laboratories so that patients can get tested in the clinic/hospital they are being treated.
- Provides list of lab test requests to laboratory technicians and allow them to input lab test results.

In the prototype we have tried to implement the above list of functionalities.

6.3 BTS System Architecture

The architecture of BTS is a three-tiered Client Server architecture. It is a web-based application, which will have a web server to provide all the interfaces of the system and database server to contain all information required in the system.

The prototype is constructed with a combination of open source products and freely available software components. The web server we have used is the Apache Jakarta's Tomcat web server [36]. The functionalities as well as the business rules necessary are programmed in Java [37]. The user interface and text of web pages are implemented by the Java Server Pages (JSP) [38]. Some scripting is included on the web pages in JavaScript. JSP has a capability to import java classes and run them from the web pages when the pages are downloaded to client machine [39].

Unlike other server side languages such as Active Server Pages (ASP), JSP makes the system platform independent. JSP also allows us to use the full power of java programming language which other scripting languages such as PHP lacks [39].

The database we have used is the open source MySql to back up our database driven application. MySql works on may different operating system platforms and is known for its speed of data retrieval [40]. It provides Application Program Interfaces (API) for many programming languages including Java. Passwords are secure because all password traffic is encrypted when connecting to the MySql server. For database connectivity we have used mm.mysql driver, which is a Java Database Connectivity (JDBC) driver, from MySQL AB, implemented in 100% native Java. [41]. **Figure 6** shows the BTS system architecture.

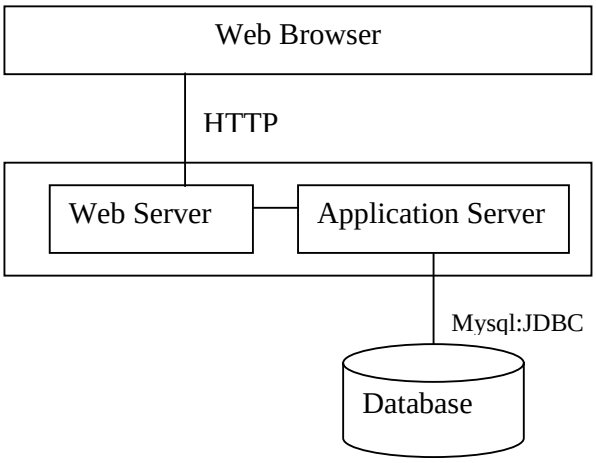

Figure 6: Architecture of BTS

The first layer is where the client machines run web-browser software. This layer is used to display the user interface (web-pages) of the system and send secure HTTP request to the web server in the second layer. Along with the web-server, application server resides in the second layer. This application server manages the clinical business logic. The bottom layer contains the persistent data of the system. All the data of patient's information, doctors and messages will be stored and maintained in this third layer. This layer runs the database management system software.

6.4 Database Design

Basic Telemedicine Service needs to keep track of information about patient and related medical records, user's information, and messages for both medical referral requests and feedbacks. A well-designed minimal database should be employed to manage this information. A relational database model is selected to store the persistent data of the system, as it could be easier to manage, and provides better management for complex query of such data [42]. Our database contains the following basic entities:

Person

The generic information of each person: user, patient or relatives are stored in the person entity. The generic information includes:

- Personal bio data such as Name, data of birth, gender, etc
- Address data such as: region, town, Woreda, kebele, telephone etc
- Occupation data such as: hospital, department, job title, etc

Users

This entity will contain user's information. Keeping users' information is needed for authentication and authorization purpose. User's type and authentication information such as username and password are stored in User entity.

Patient

This entity will be used to maintain patient record. It will be used to identify the patient. The patient medical information and associated medical record should always be available during consultation. Each patient is represented by a medical record entity.

Medical Record

This entity represents the medical information associated with each patient. It will contain Lab results; medical images such as x-rays, clinical notes written by doctors, follow up information and medical certificates as sub entities.

Each component of the medical record of a patient is composed of different type of data which are to be stored in the database. In the traditional paper based

system, medical record of a patient is identified by an Out Patient Card (OPCard) Number, which is usually called patent record number. OPCard is a four page hard paper card, which contains patient's generic information, such as name, sex, age, address on the first page and a table of two columns for date and clinical note to record chronological list of clinical notes. All other components such as Lab Test Results, x-ray reports, etc are stored inside the hard paper card referenced by the card number or name of the patient. The lab test results may contain zero or more test request forms along with the results for Urine, Parasitology, Blood Chemistry, Haematology, Serology, Bacteriology, Fine Needle Aspiration Cytology and Biopsy.

When a patient is admitted to the hospital, Admission and social data information is stored. The admission data includes identification information and name and address of next of kin, marriage and children information if any, occupational information etc. Then follow up data such as Vital Sign measurements, Fluid Balance information will be collected and recorded. Order sheet, which contains list of treatments to be ordered after admission is also part of inpatient medical record.

In addition to these, information about the hospitals, departments and laboratories are stored in respective entities. The entities and the relationship existing among them are presented in the following **Figure 7** below.

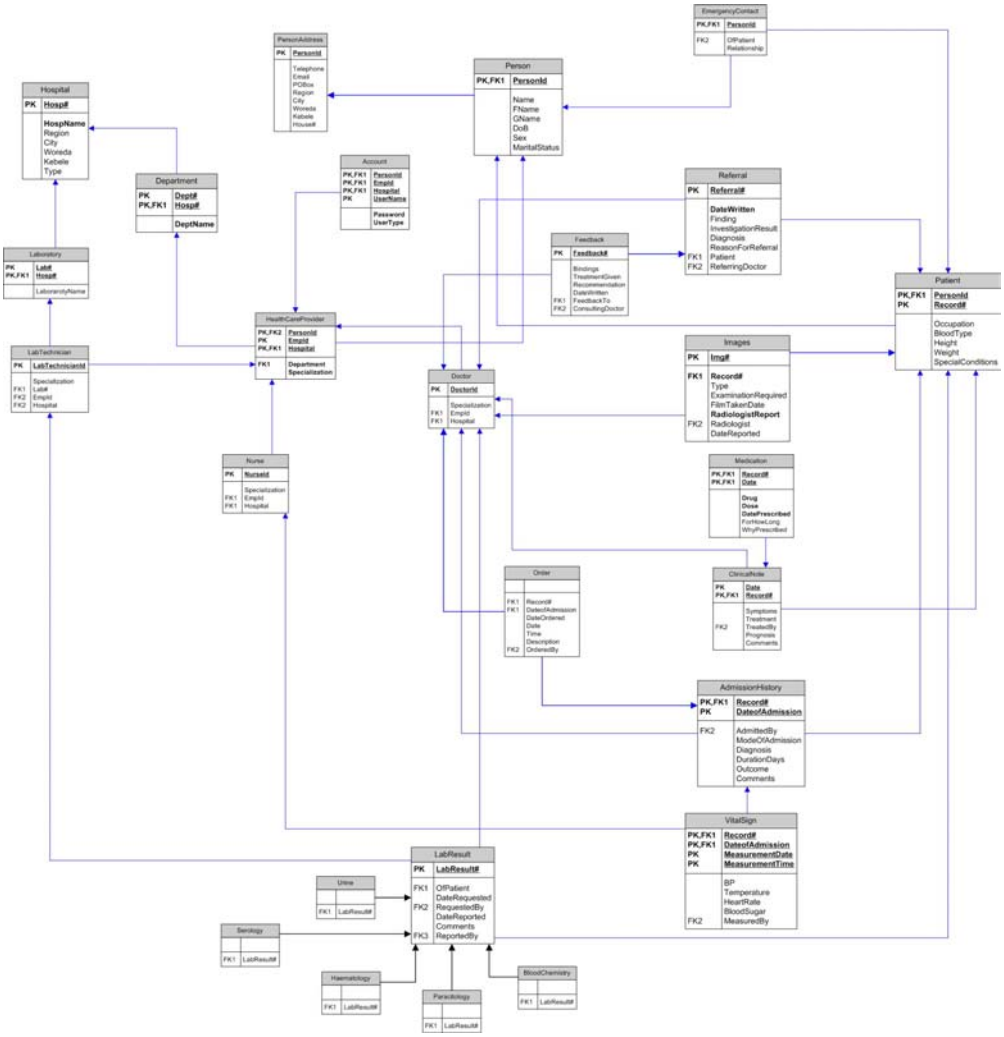

Figure 7: The database tables used in BTS

6.5 Graphical User Interface

BTS is accessed by opening the initial web page where user authentication is performed. The initial page contains a login screen to submit username and password of users. There is no need of menu or different buttons to be submitted based on the user types. Since the user types are defined in the database when the user registered, the page corresponding to the specific user type will be opened upon successful login. Currently Administrator, physician and lab technician user types are defined and all the user types will have their own main page as described in the following paragraphs. **Figure 8** shows the login screen.

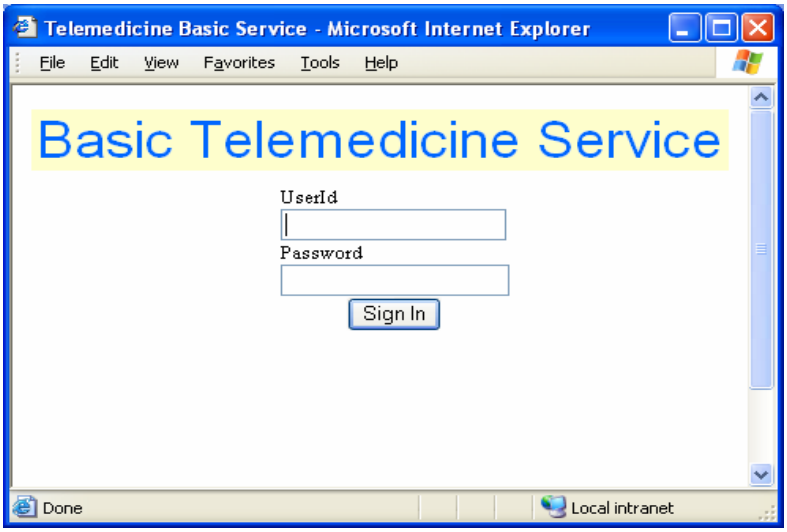

Figure 8: BTS login screen

6.5.1 Administrator's Main page

The administrator's main page is used for managing users. The functionalities accessible from this page are: **Register New User** and **Search User** by either or a combination of Name, Father Name, and User Name. **Figure 9** shows the Administrator's main page.

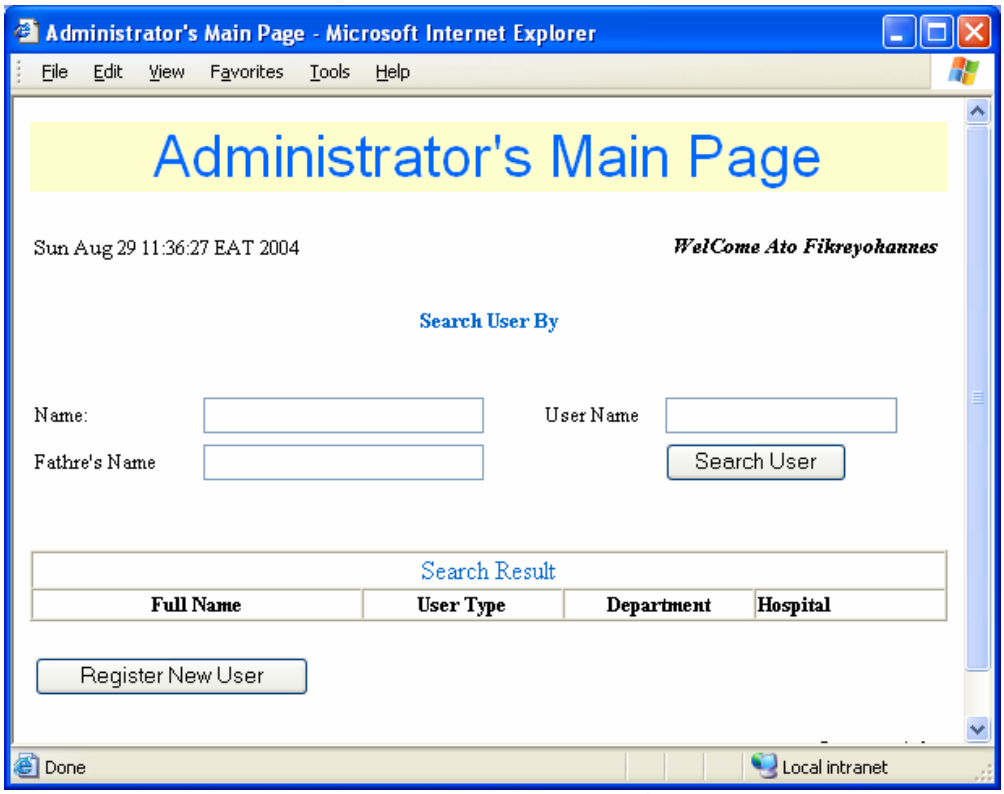

Figure 9: Administrator's main page of BTS

The registration function, invoked by clicking a button (Register New User), opens up a user registration form where the administrator can input all the information necessary about the user and define the user type. **Figure 10** shows the second half of the user registration page. The form is divided in to four parts where the admin can input the Generic user information, Address information, Profession information and Authentication information. One of the authentication information is the user type, where the admin can select from the list of user types.

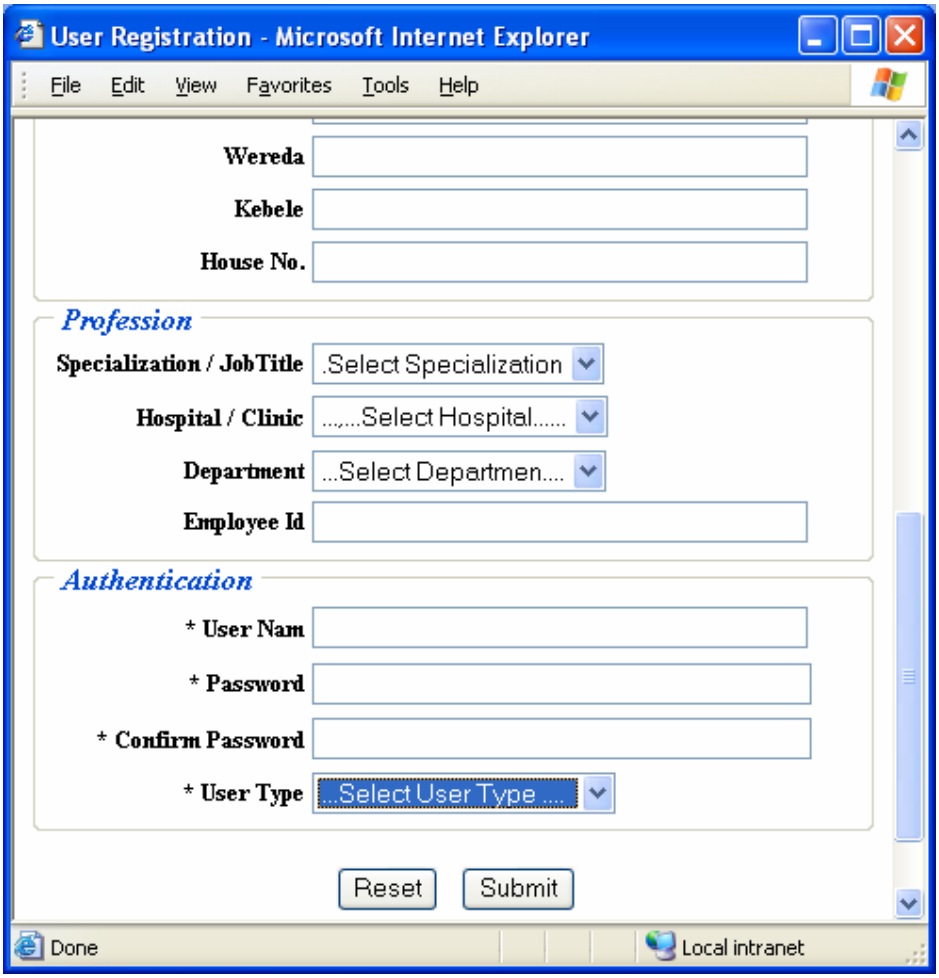

Figure 10: User registration page

The other function provided to administrators is the Search User function. It is possible to search users using any combinations of Name, Father Name and User Name. If username is provided, there is no need to search for users by name and father name. This is because username is unique in the user table.

The search result is displayed in the table below the search criteria input boxes. **Figure 11** shows the admin page after including a search result.

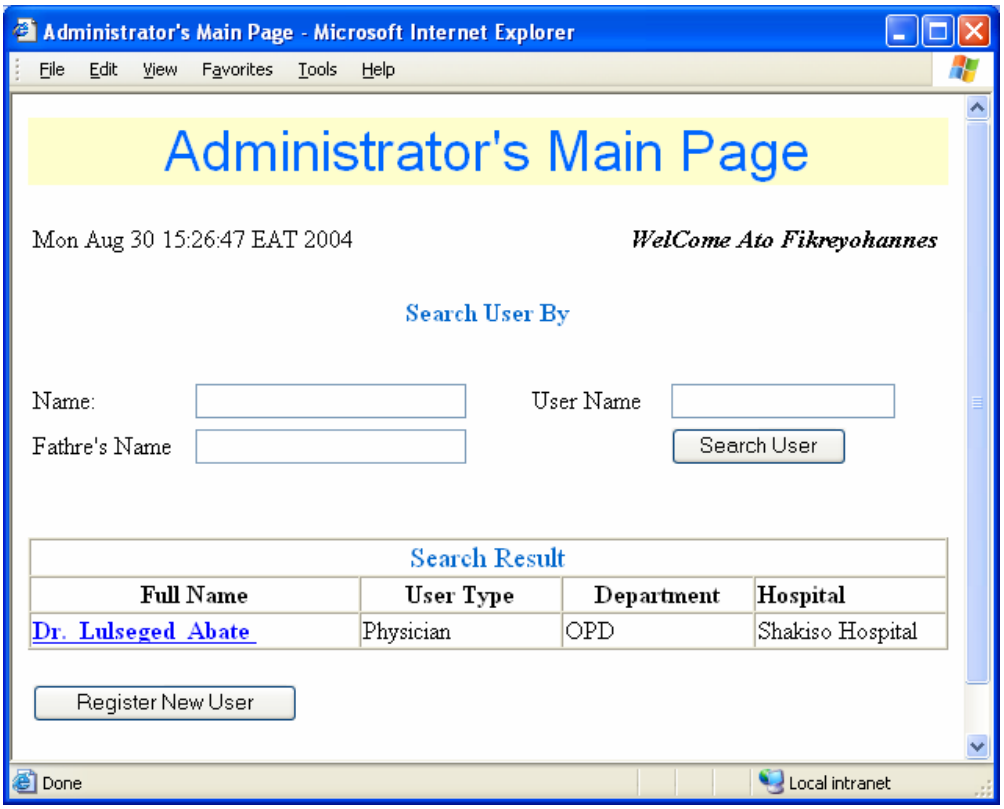

Figure 11: Administrator's main page showing search result

As it can be seen in the search result, the full name of the search result is a link. The link leads to a page containing user information from which the admin can edit that particular user.

6.5.2 Physician's Main page

The physician's main page contains a button to open Patient Manager Page, and list of referrals forwarded the department where the physician is working. The physician could either click the Manage Patients button or a link to one of the referrals. In each case new pages will be opened. **Figure 12** shows the physician's main page showing one referral forwarded to the department where physician called Dr. Aman is working.

If the physician chooses to treat the patients in the hospital where she/he is working or if there is no referral forwarded to the department she/he is working,

the physician can then open the patient manager page by clicking the 'Manage Patients' button.

The Patient Manager Page has two buttons namely, Register New Patient and Search Patient. The physician will have two options:

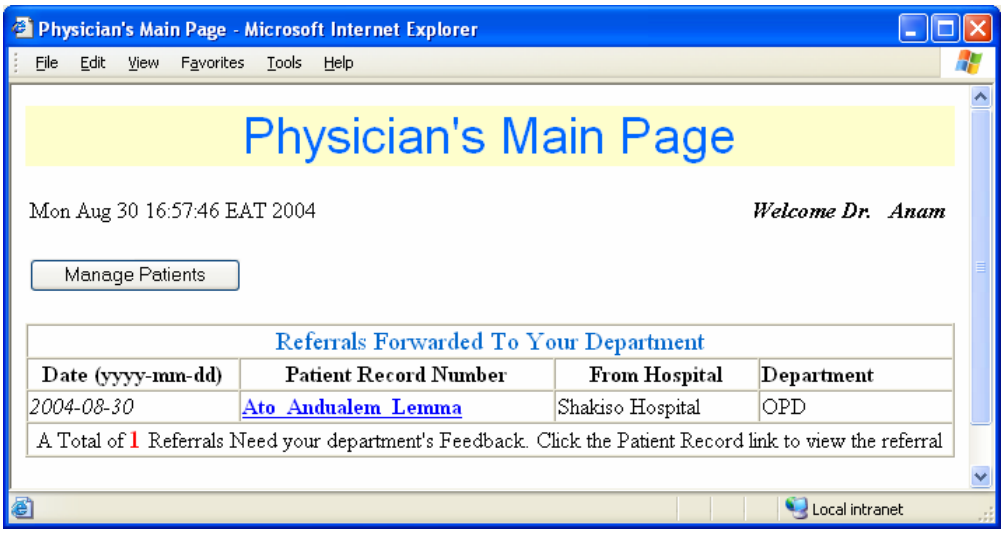

Figure 12: Physician's main page of BTS

- To register a new patient.
- To search a previously registered patient or

Figure 12 shows the patient manager page.

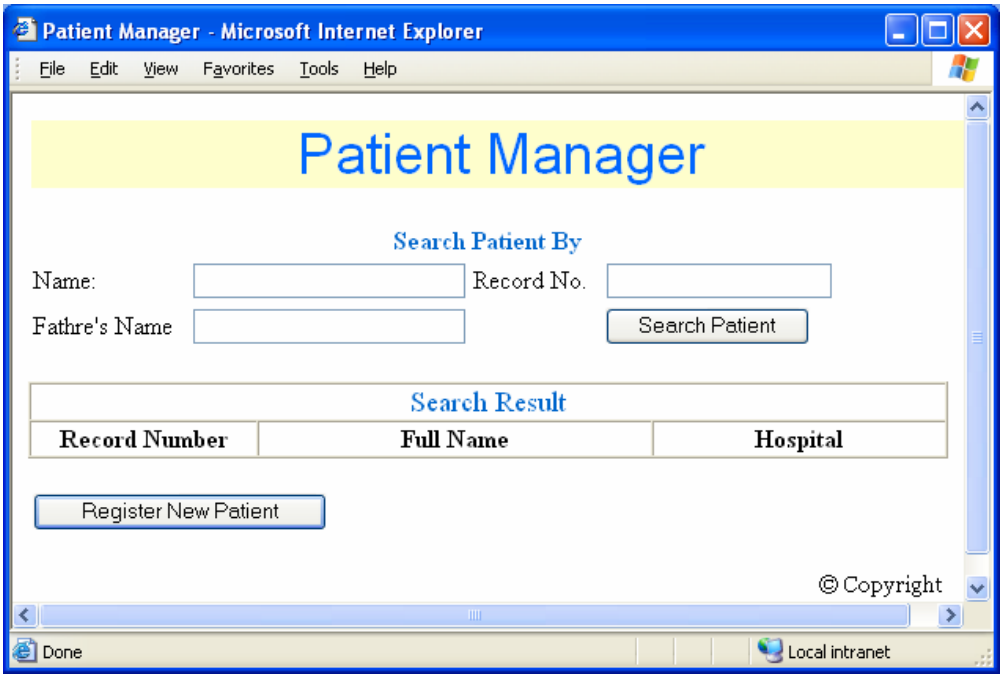

Figure 13: Patient manager page

When 'register new patient' is selected, a patient register form, similar to the user registration page will be opened. The patient information is grouped in to three categories namely: General, Home Address and Occupation information. **Figure 14** shows the first half of the Patient registration page.

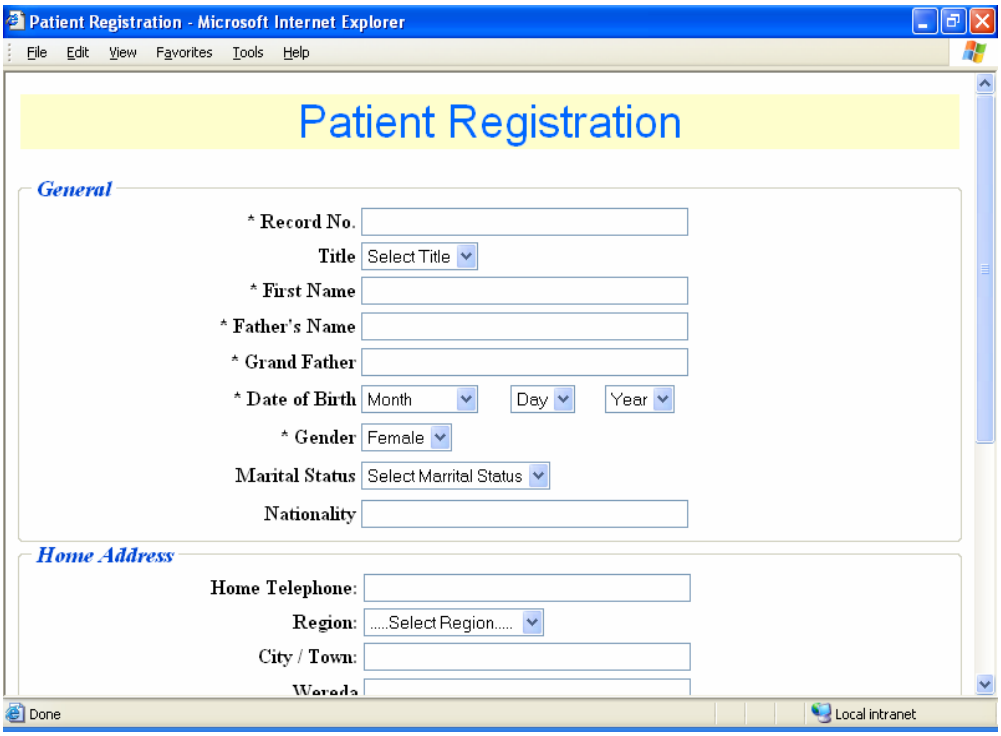

Figure 14: Patient registration page

On the other hand if the physician wants to look for a patient, she/he can input one of the search criteria namely Name, Father Name or Record Number of the patient. After providing the search criteria, the physician clicks the search patient button to display the list of search result. The search result contains the record number, Full name and the hospital where the patient was first registered. **Figure 15** shows the Patient manager page including a search result.

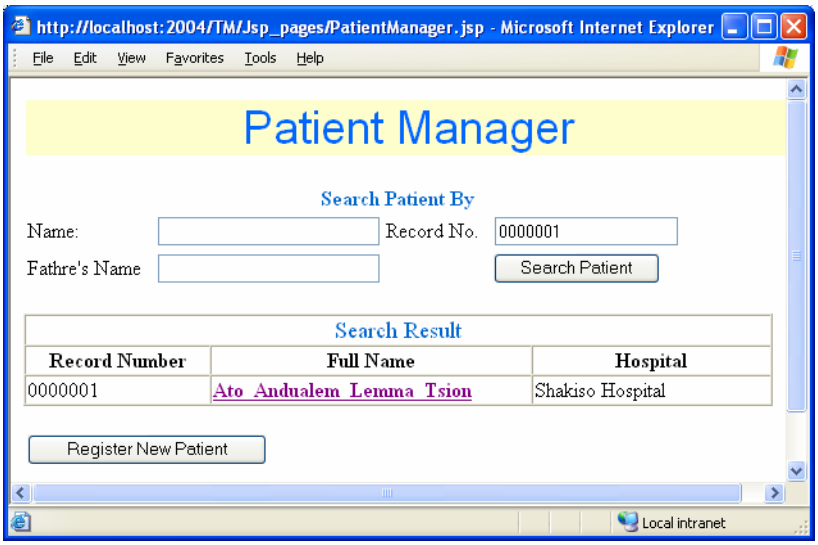

Figure 15: Patient manager page showing a search result

The patient full name is a link that leads to patient information page similar to the traditional Patient Card used in the hospitals. An example of the patient card, which opens up when the full name link in the previous interface is selected, can be seen in **Figure 16** below.

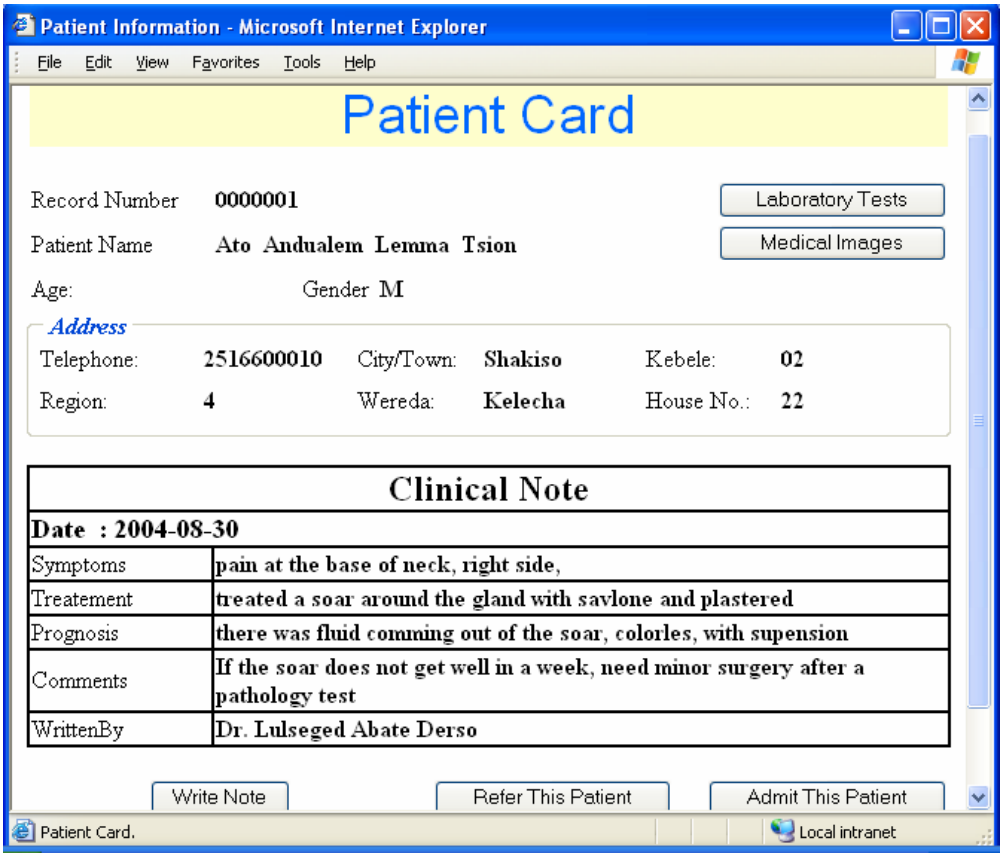

Figure 16: Patient card page of BTS

The patient card contains patient's general information, address information and clinical notes. The clinical notes ordered in descending order. In addition to the information displayed on the patient card, laboratory test results and medical images related to the patient are accessible by clicking corresponding buttons from the patient card interface.

The physician can add clinical notes or refer or admit the patient. All the functionalities are provided by buttons from the patient card. These buttons open the corresponding input pages.

From the physician's main page, the other option provided to the physician is to see referrals forwarded to her/his department. This is possible by clicking the link that opens a referral page corresponding to the patient. The patient referral page contains the referral messages and buttons that lead to patient information, as well as a button that lead to the feedback input page. **Figure 17** shows the patient referral information page.

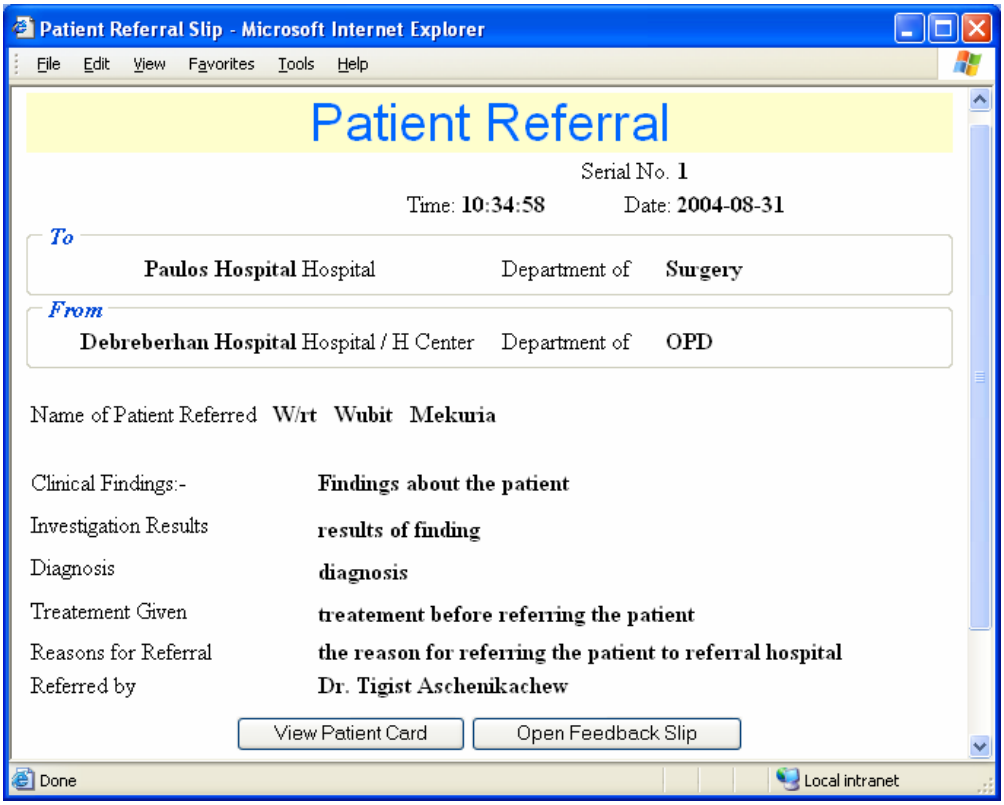

Figure 17: Patient referral information page

If the physician wants to view the patient information, she/he will click the View Patient Card button to open the patient card shown above in **Figure 15**. On the other hand the physician can give feedback to the referral using the feedback slip, which will be opened by clicking the Open Feedback Slip button. The feedback slip is an input form where the physician can input feedback information related to the current referral.

The physician can also request laboratory test after viewing the patient laboratory information page, which is accessible from the patient card page by a button called Laboratory Tests. The Laboratory information page and a parasitological test request pages are shown in the **Figure 18**. When a physician wants to request lab test, she/he need to click the button corresponding to the type of test required from the Laboratory Information page. The specific lab test request page provides the physician with dropdown list from which the physician can select where the lab test should be performed. This was found to be important in order to forward the lab test request to the other user types called, the Lab technicians.

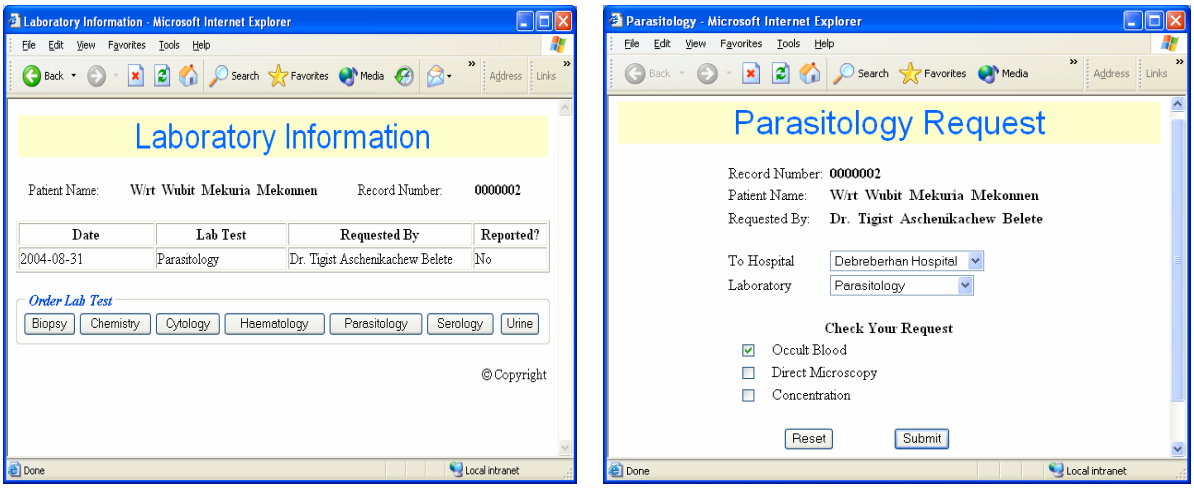

Figure 18: Laboratory information and parasitological test request page of BTS

6.5.3 Lab Technician's Main Page

The third type of user, Laboratory Technician sees a list of laboratory requests to the department she/he is working, on the Lab Technician's main page. The list contains a link to open lab test result input form where the lab technician can enter her/his report. See **Figure 19**, for the Lab Technician's main page.

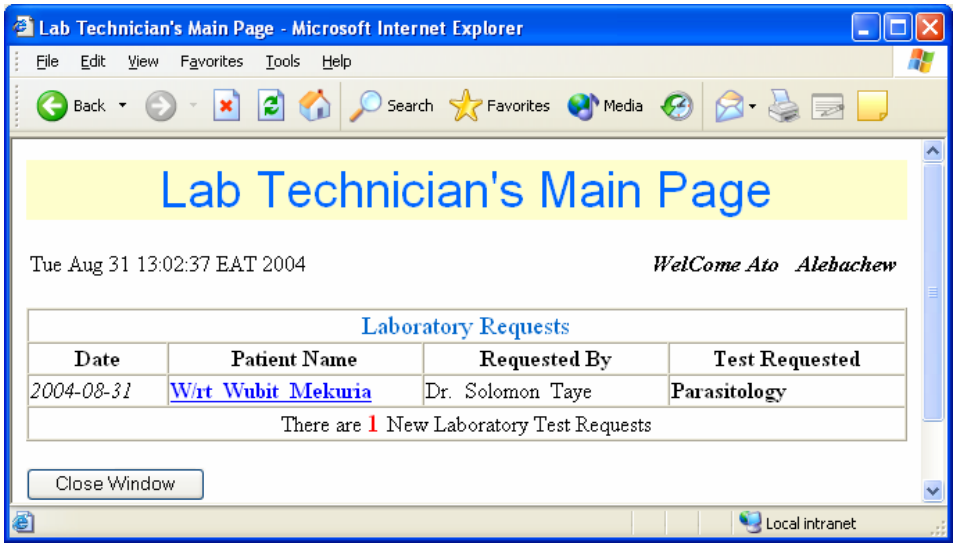

Figure 19: Lab technician's main page of BTS

The lab technician can either click the on of the links to report the lab request or close the window, if there is no request forwarded to her/his department.

In addition to these interfaces, the application consists of many other pages containing forms similar to that of the paper forms used in the hospitals.

Chapter 7

Implementation Issues

7.1 Overview

So far we have shown how telemedicine application can be introduced to Ethiopia. The existing ICT infrastructures and the emerging ones could be adopted by the health sector to utilize health care facilities at all levels and improve accessibility of care. The web based prototype can facilitate the communication needs of remotely located health care providers for medical tele-consultation. We believe that telemedicine has the potential to improve health care. We also believe that before trying to implement telemedicine, issues like medical ethics and medico-legal issues need to be considered. It is also possible to commercialize telemedicine once it is implemented, to ensure its sustainability.

For instance, it has been reported that, same faults of telemedicine in the developed countries are occurring [51]. As the report put it, the faults are:

- Excessive expectations
- Unsustainable funding models
- Lack of trials and evaluation data
- Lack of published results and sharing of expertise

We believe that we need to learn from the experience of others and implement a sustaining telemedicine system for Ethiopia. In this chapter we present some of the potential challenges of application of telemedicine in the Ethiopian context.

7.2 Medical Ethics and Medico-Legal Issues

The risk to patient privacy and confidentiality arising from the use of telemedicine system are easy enough to identify. These issues and their legal and ethical implications are emphasized in most disseminated research papers [20].

The advancement of telemedicine changes the way medical treatment is delivered. The information concerning medical treatment and health becomes more diversified. The volume of information and the media by which medical

information shall be exchanged increases. Although these changes for the betterment of the healthcare system, it could become difficult for the users to correctly understand the content. It could also be more difficult to confidently authenticate exchange and use of medical information.

Since ICT were designed to optimize information sharing than security, problems of security and confidentiality of personal information has been the biggest issue when individuals obtain medical or health related services by the use Internet and telemedicine [49]. Of all the kinds of personal information, it is particularly necessary to make known the importance of protecting information related to highly confidential personal medical treatment information. Our survey result has revealed that, more than 80% of the participant health care providers have expressed their concern of patient information security and confidentiality in remote consultations.

When transmitting patient information, it should be prevented from leaks, and falsification or misuse. This is because, information related to medical treatment and health affect the quality of care and the therapy provided by physicians to the patients [50]. Illegal modification of patient information may endanger the patient's life, and at present there is no clear legal action to take in such situations. These issues need to be resolved while trying to implement telemedicine. In a review article it was reported that, in the UK, there have been limited practice guidelines and legal issues relating specifically to telemedicine or tele-radiology [22]. In other articles the fact that, laws and regulations have not been upgraded in parallel with the applications of telemedicine is reported [20, 22, 24, 28].

To enable users benefit from the application of telemedicine, the application should be secure and reliable enough to keep the privacy and integrity of medical information. But in addition to that, there might be a need to create a code of ethics, which defines standards of conduct. Such code of conduct based on general regulations should serve to control the ethical challenges in the application of telemedicine. There is also a need to have individual laws, which support the use of telemedicine in Ethiopia based on the general law related to medical practice. 'Developing new rules and regulations to help in the implementation of the current

policy and addressing new health issues' is clearly stated as a general strategy 14.2 of the country's health policy. These new rules and regulations should consider new developments in the health sector such as the use of telemedicine, and include rules to address issues, which may arise with the technology.

7.3 Users Resistance

Users of telemedicine application constitute the health care providers: physicians, nurses, laboratory technicians etc. The information technology acceptance of these users will affect the success of telemedicine application. Most previous telemedicine researches have focused on the technological developments or clinical applications, not on the issues that include the physician's acceptance of the technology [23]. However, it was reported that un-cooperated healthcare providers represent the most significant obstacle to telemedicine. Busy clinicians showed strong tendency to refuse to use telemedicine systems, and surprisingly, physicians were found to be the least cooperative ones [28].

7.4 Commercialization

As it was specified in the overview of this chapter, one of the major drawbacks of telemedicine projects is lack of proper funding model, to sustain the application of telemedicine. In the case of Ethiopia, more than 80% of the patients in the public/government hospitals are non-fee-paying patients cost is covered by the government [48]. Looking for funds to expand ICT or telemedicine services can be challenging to urban and rural healthcare facilities.

When telemedicine is applied, there will be additional cost for ICT equipment, training and WAN connection, in addition to the treatment costs. A comprehensive design of funding model is a requirement to sustain telemedicine in Ethiopia. Funding need to be secured from variety of sources, both public and private, to supporting telemedicine applications.

Other countries experience showed that telemedicine systems are funded mostly by organizations, which are supported by funding agencies. Examples of such organizations include, the Californian Telemedicine and eHealth Center (CTEC) [53]. The other funding options are government-assisted programs [54]. The

majority of telemedicine activity in Australia is Government funded and occurs in public hospitals [55]. In other countries reserving exclusive special circuits or special WAN connection charges for health care sector, are used as an alternative to support telemedicine applications in the rural areas [28].

In the urban areas, patients may be able to pay for remote specialist consultation from specialized hospitals or from abroad. Private hospitals especially, can use their business liberty to implement telemedicine applications, which will help them get medical consultations in some specialties such as cardiology and then sell their service to those who can afford to pay. Similarly, if public/government hospitals can have telemedicine systems, the payments from those who can afford to pay may be used to subsidize the cost and support telemedicine systems in the rural areas.

In addition to these, even if most of the rural people are non-fee-paying patients, they will have to go to the cities to seek medical care. If telemedicine is applied and the patient from the rural areas does not have to go to cities, the transportation cost can be used to fund the telemedicine applications.

The government and the telecom company also need to support telemedicine applications by applying special WAN connection charges to rural area as well as urban area clinics, which are serving most of the non-fee-paying patients. In this regard the WoredaNet is expected to connect all the Woreda administration centers and their respective government offices. The health sector can also benefit from the WoredaNet, if the Woreda health offices (bureau) can be connected as well. For example the Woreda health offices could establish a second opinion centers, which provide tele-consultation serviced to the near by clinics. Such second opinion centers that are in charge of tele-consultation were used in Japan to reduce clinician's responsibilities [28]. In the case of the Woreda health offices, such tele-consultation centers can be established in the respective clinics or at least one in a Woreda and share the WoredaNet connectivity.

International organizations such as ITU, World Health Organization (WHO) and the Midjan Group are always there to support telemedicine activities in developing countries [56]. The ITU and WHO have signed an agreement in 1995

for the introduction of communication and informatics technology facilitating the provision of medical and healthcare services [5, 56]. Midjan Group wants to work in the area of distance education and technology transfer actions between developed countries and the developing world in the medical field [56]. In addition to these Non Governmental Organizations (NGOs) practicing in Ethiopia can also contribute to the health sector by finding funds specific to telemedicine from donor agencies.

However, an important way to achieve sustainable development of telemedicine is to establish new projects in a business manner. In Australia, the following Features business model for government funded projects are recommended from which our country can adopt [56]:

- The development of cost benefit analyses of the telemedicine project;
- A critique of the internal strengths and weaknesses of the organization in relation to telemedicine and of the external opportunities and threats;
- The use of targets and forecasts of usage levels and types of usage, in any one year;
- An appreciation of the market for telemedicine, and segments and trends in the market;
- The development of both objectives and strategies to achieve those objectives.

Chapter 8

Conclusions

This paper contributes to 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 exploit telemedicine technologies to provide basic health care to remote areas and improve quality of care, while protecting the privacy, confidentiality and integrity of sensitive patient information.

We have investigated the existing situation related to telemedicine effort in Ethiopia. Even if there are efforts to introduce telemedicine to the health system of the country, the actual design and implementation are found to be way far the schedule. We have also identified that, the planned pilot project had its own drawbacks, derived from its plan and use of ICT resources.

We have identified the network design considerations and designed a telemedicine network architecture that can be implemented over the existing/emerging ICT infrastructure in Ethiopia. We have also developed a web based prototype of Basic Telemedicine Service (BTS) to integrate with the network design. The system can serve to facilitate both the intra and inter hospital communications for information exchange.

Since we have used web technology, the location of users is not limited to the country. Users of web-based systems could be any where in the world. This means those Ethiopian and non-Ethiopian physicians, leaving in the country as well as outside the country can use the system to share their expertise. The prototype, if developed in to a full system and implemented, could be useful means to reduce the devastation in the remote area caused by lack of proper health care coverage in the country. It can also help to improve the quality of health care in the relatively batter served urban areas, by allowing physicians share their experience, increasing the possibility of getting second opinion, medical consultation from senior and more experienced specialists.

The open source and freely available technologies we have used to develop our web-based system makes it a low cost system that uses network connectivity and

desktop PCs. We have tried to upload our site on a free web-hosting site, which supports the technology we have used, just to test it with fake user and patient data. The site was successfully uploaded and we could test it by storing and retrieving the fake data.

We have also showed that, there are challenging issues in association to the applications of telemedicine. Medical ethical and medico-legal issues could challenge the implementation. A telemedicine system, which is as secure as possible, in addition to ethical codes of conduct as well as upgrade exiting medical laws could resolve some of the challenges.

To sustain telemedicine applications in Ethiopia the government needs to continue. However, other countries experience showed that one of the major challenges for telemedicine projects is to survive beyond the initial phases of government subsidies. Though it is not comprehensive, we presented different funding options, and business models of other countries to show stakeholders how telemedicine could be sustained financially.

8.1 Problems Encountered

We have encountered a number of problems during the course of the study. The major ones are described below.

8.1.1 Shortage of Documents

It was difficult for us to get published journal articles relevant to our research topic. The university has got some subscriptions to electronic journals. The subscription included selected topics and our topic was not included. Hence we had to depend on published and unpublished articles found freely on the Internet.

8.1.2 Shortage of Time

Time was too short, particularly in the first few months. We had to register to and take two courses in addition to the research work. Since the courses had their own course projects and takes up our time, most of the research work had to be postponed to the second semester.

8.1.3 Bureaucratic Offices

Since our study required us to talk to government offices, such as MoH, FoM, Capacity Building, and ETC, their bureaucracy caused some latency in the research work. In addition to these we could not have access to some technical documents, such as those on the WoredaNet, as the network is under development and that it is government network, which should be kept secure.

8.1.4 Busy Doctors

Most of the medical professionals are too busy to handle other matters in addition to treating thee large number of patients. Since we have assumed that doctors must be the major users of our system, we have to gather requirements form them. It was difficult to find doctors who answer our questions and even if we found to get some, they find it difficult to put the information the way we wanted to be presented.

This problem also raised a question on how the doctors may use the telemedicine application we are about to develop. Would they have time to use the application in addition to the traditional medical practice, which already have taken up their time?

8.1.5 Other resources

The other problems we have encountered were shortage/unavailability of resources such as stationary materials, printing, photocopying and binding services. The universities fund was too late and had too tight requirements we couldn't meet. As a result we had to use our own limited funds to support the research expenses.

8.2 Future work

As future work in the area of telemedicine we recommend the following issues:

8.2.1 A More Complete Telemedicine System

As this is supposed to be the first complete telemedicine system, including network architecture and database driven application, a store and forward system that supports only doctor-to-doctor communications were assumed. This is because; a store-and-forward system does not require higher bandwidth and scheduling among the consulting physicians. Because of the low level of IT usage

in the country, particularly in the rural areas, our system does not support patient-to-doctor communications.

In the future a more complete system which supports the following capabilities should be considered:

1. A System which supports real time tele-consultations via video and audio conferencing
2. That supports doctor-to-patient communication, in which case issues of localization will be a requirement.
3. That supports integration of the system with digital data generating medical instruments for automatic data entry.
4. A distance education/training system which can be used during epidemics to train rural clinic personnel and the public at large on the prevention and treatment of the epidemics.

8.2.2 Evaluation

As one of the future work, we recommend to evaluate telemedicine systems or projects base on the following criteria:

- Its cost effectiveness
- Its integration with the traditional system
- Its acceptance by providers, administrators and patients.

8.2.3 Distribution

Our system includes a central database, which stores all the information used in the Basic Telemedicine Service. The web server is also assumed to be single, central web server to be maintained at a central site. This approach is good to implement consistent system. The centralized system is a bottle neck for expansion and also will be a point of failure.

A more complete database design and system design shall include distributed database, where all the hospitals should keep their own databases, which can be treated as one database.

8.2.4 Standardization

When we tried to identify the clinical information flow in the hospitals, we have identified that, most of the public/government hospitals use similar forms.

Whereas the forms used in private hospitals differ in content and type among each other, and with the public hospitals. Since telemedicine leads to information exchange among hospitals, public or private, the information flow should be standardized.

A future work, which tries to generate standardized information content and flow to be used by all the health care providers, shall be important to facilitate inter-hospital communication.

8.2.5 Expert Systems

As the patient database get more reach in information about patient cases, expert system such as case based system where doctors can query the database to get experience from previously stored similar cases should also be considered. Such a system shall help future physicians working anywhere in the country to learn from the specialists success and/or failure, when they come across difficult patient cases.

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Appendix A: Number and Distribution of Health Care Facilities

The table below is an excerpt from the latest Health and Health related indictor, showing the Distribution of nurses, physicians, specialists, clinics and hospitals across the country

Region	Population		Physician & Health officers		Specialists	Hospitals
	Total	Urban (%)†	No.	Ratio		
Tigray	4,006,008	17.8	140	28,614	31	14
Afar	1,301,001	8.6	25	52,040	0	2
Amhara	17,669,006	10.9	291	60,718	24	17
Oromia	24,395,000	12.5	401	60,835	47	29
Somali	4,002,000	16.0	55	72,764	19	6
Benishangul	580,000	9.3	40	14,5000	2	2
SNNPR	13,686,002	8.1	310	44,148	21	14
Gambella	228,002	18.0	18	12,667	0	1
Hareri	178,000	61.2	56	3,179	13	5
Addis Ababa	2,725,002	100.0	207	13,164	73	22
Dire Dawa	357,000	73.1	47	7,596	14	2
Central	-	-	252	-	164	5
National	**69,127,021**		**2,663***	**25,958**	**752****	**119*****

Source: Health and Health Related Indicators, Ministry of Health, 2002/2003

† Population and housing census of Ethiopia, August Report, 1994

* Number contains 631 health officers

** Sum contains specialists working for NGOs and Private hospitals.

*** Sum contains NGO, Private and other government agency hospitals

lPopulation to physician ratios of some countries:

Liberia 43,000 to 1
Ethiopia 35,000 to 1
Nigeria 5400 to 1
Egypt 495 to 1
Italy 180 to 1
WHO Standard 10,000 to 1

Appendix B: Questionnaires

Addis Ababa University, Faculty of Informatics
Department of Computer Science, Postgraduate Program

Questionnaire to be completed by officials of Private hospitals

Introduction

The health vision for the 21st century is being shaped by global and national trends, which influence policies and plans for the future. Studies show that health systems of countries need to use Information and Communications Technology (ICT) more effectively in order to facilitate information sharing. The use of ICT in the health system, for diagnosis, treatment, education, consultation, etc. is in general called Telemedicine.

Telemedicine has been in existence since the time medical practitioners consult with one another over the old telegraph or telephone to discuss on medical cases. This can be considered as the 1st generation practice of telemedicine. With the convergence of computer and telecommunications technologies, the amount of information and interaction that can be shared during a medical consultation has changed. This includes exchange of information in the form of text, image, audio, and video.

Telemedicine is utilized by health providers in a number of medical specialties including: cardiology, pathology, radiology, pediatrics, orthopedics, dermatology, psychiatry, pharmacy, surgery, obstetrics, diabetic patient management, ophthalmology, otolaryngology, neurology, etc.

This questionnaire aims to find out something about your hospital's interest in exploring telemedicine and to identify specific telemedicine areas in which your hospital will be interested. The result is solely used for academic purpose. If you are interested, we will provide you with the result of this survey.

To save your precious time, we presented most of the questions with the possible answers. Please choose **one or more** answer which best explains your situation by putting check mark in the corresponding box, or write your answer in the space provided for each question.

Private Hospital Name: _____

Established in: _____ (EC or GC)

Telephone: _____

P. O. Box: _____

Town: _____

1. Do you have computers in your hospital?

☐ Yes ☐ No

If Yes: How Many? _____

1.1. For what purpose do you use the computers:

☐ To record patient visits, and / or schedules, and / or appointments.
☐ For Administration and finance routines
☐ To store and retrieve electronic patient information
☐ Others please specify:

_____
_____
_____
_____

1.2. Are the computers networked or do you have a LAN?

☐ Yes ☐ No

If Yes: for what purpose do you use the LAN?

☐ File and printer sharing
☐ Sharing Internet connection
☐ Database access
☐ Other please specify

_____
_____
_____
_____

1.3. Do you have Internet connection?

☐ Yes ☐ No

If Yes: for what purpose do you use the Internet?

☐ E-mail
☐ Browse the World Wide Web (WWW)
☐ Search electronic documents
☐ Others please specify

_____
_____
_____

1.4. Do you have a web site?

☐ Yes ☐ No

If Yes: Your web site address:

_____

1.5. Do you have IT / ICT staff in you hospital?

☐ Yes ☐ No

If Yes: How Many? _____

2. Do you have medical instruments capable of digital data acquisition?

☐ Yes ☐ No

If Yes: Please list some of them:

_____
_____

3. Do you have Computer Aided medical instruments? (Instruments attached to a Personal Computer, PC).

☐ Yes ☐ No

If Yes: Please list some of them:

_____

_____

3.1. Do you use the PCs attached to the instruments for other purpose in addition to its use to manage the instrument?

☐ Yes ☐ No

4. Have you ever thought of automating the tasks both administration and medical in the hospital?

☐ Yes ☐ No

If Yes: List services automated:

_____

_____

5. Do you communicate with other hospitals, or specialists in other hospitals both in Ethiopia and abroad?

☐ Yes ☐ No

If Yes:

☐ Local ☐ Abroad

5.1. What communication means do you use?

☐ Telephone
☐ Postal Service
☐ E-mail
☐ FTP,
☐ Web based applications.
☐ Others please specify:

_____

5.2. How frequent are these communications in a month?

☐ Less than 5
☐ 5 - 20
☐ More than 20

5.3. Do you have a plan to use computer networks to communicate with remote hospitals?

☐ Yes ☐ No

If Yes: What will be the main purpose of communication?

☐ Medical consultation
☐ Referral
☐ Exchange of Information
☐ Others please specify:

_____

_____

_____

6. What do you think of a possible Nation-Wide Telemedicine Network, which connects regional clinics with urban hospitals in Ethiopia?

☐ I think it is good to deliver clinical care to remote areas
☐ I think it is good to improve quality of care in the urban areas
☐ I think it may bring many complex issues such as privacy, security
☐ I think it is too far to achieve.
☐ Others please specify:

_____
_____
_____

7. What factors do you think inhibit the development of telemedicine in our country?
   - ☐ Cost of advanced electronic medical instruments and computers
   - ☐ ICT awareness and skill of employees
   - ☐ Budget
   - ☐ Medical Ethics
   - ☐ Medico Legal issues
   - ☐ Culture
   - ☐ Others please specify:

     _____
     _____

8. Would your hospital consider joining a national telemedicine network if it can be implemented?
   - ☐ Strongly agree
   - ☐ Agree
   - ☐ Uncertain
   - ☐ Disagree
   - ☐ Strongly disagree

9. If not your hospital will consider developing telemedicine system in about:
   - ☐ 1 year
   - ☐ 1-3 years
   - ☐ After 3 years
   - ☐ Depends on.... Please specify:

     _____
     _____

10. Do you have the fund to develop telemedicine system

    ☐ Yes ☐ No

11. For which specific diseases (areas) do you think your hospital needs outside consultation and be economical to get one? Pleas select and write the letter form the list below (Question 12) or list your own here.

    _____
    _____
    _____

12. Which specific area of telemedicine would your hospital be interested?
    - a. ☐ Cardiology
    - b. ☐ Dermatology
    - c. ☐ Diabetic patient management
    - d. ☐ Endocrinology
    - e. ☐ ENT / Otolaryngology
    - f. ☐ Gastroenterology / Endoscopies
    - g. ☐ General practice / family practice
    - h. ☐ Gynecology / Obstetrics
    - i. ☐ Infectious Disease
    - j. ☐ Nephrology / urology

k. ☐ Neurology
l. ☐ Oncology
m. ☐ Ophthalmology
n. ☐ Orthopedics
o. ☐ Pediatrics
p. ☐ Pathology
q. ☐ Psychiatry
r. ☐ Radiology
s. ☐ Respiratory Medicine
t. ☐ Others please specify:

_____
_____
_____

13. How do you think, you would benefit from a telemedicine system?

_____
_____
_____
_____
_____
_____

Thank you for spending time to complete this questionnaire. If you would like to contribute further to our thinking by discussing your views with us please complete your contact details below. We would be pleased to have a more detailed discussion with you through an interview.

Name:_____ Telephone: _____

Contact Person: Fikreyohannes Lemma
A Postgraduate student, Department of Computer Science
Addis Ababa University
Telephone: (09) 615261
Email: fikreyohannes@yahoo.com

Appendix C: Interview Results

Interview with the NTCC members

Infrastructure

The pilot project will use the dial up Internet service provided by ETC as its platform. As a result there was no need to have a design of network architecture. As Ato Asfaw put it, this pilot project involves providing the selected sites with Internet service so that medical specialists could communicate by e-mail and attachments to share files.

Since ISDN is not yet a full-fledged service in the country, we cannot say that it is used in this project. ISDN is practiced in Addis Ababa and is successful but it is not yet practiced outside Addis. He also added that, ETC recommended the use of Digital Data Network (DDN) or leased line Internet connection as a better infrastructure for Telemedicine, though these could be more expensive than the intended dialup Internet service.

VSAT is one of the emerging facilities in Ethiopia. It is used to provide telephone service to remote area. Currently ETC has installed about 470 VSAT terminals, for telephone service, not data transmission. For the SchoolNet program about 1110 VSAT terminals will be installed at schools and Weredas in the country. These may be used to expand the Telemedicine infrastructure in the future.

GUI

There is no special GUI designed to interface with the users in this project. Since it was intended to help the specialists to communicate through email, they will use email programs. Users may also need to use programs provided with devices such as digital cameras, scanners and printers or those provided by the respective Operating systems.

Bandwidth Availability

The maximum bandwidth from user to ISP (ETC) is 56Kb for dial-up access. Real time operation is not anticipated in this pilot project. There will only be offline operations, which involves email attachments. As a result, there was no high bandwidth requirement.

Expandability

There is no definite plan to interface physicians abroad, or to allow private hospitals to join the network. The question of expandability is a question of possibility. This project is part of developmental goal, not business goal. It requires a lot of subsidy from the government. That was why only public hospitals and universities were selected. If private hospitals are willing to provide free medical service and consultation, to underserved areas, they can easily join the current infrastructure. As to physicians abroad, the NTCC expects specialist support from associations around the world.

Database

We also discussed about database development. It is highly related to the development of Medical protocol, which defines patient data privacy and security, the way specialists should share information, etc. MoF was expected to develop the Medical Protocol, but not yet done. So there is no database involved in this project.

Interview with Engineers at the ICT Capacity Building

The interview to the ICT personnel was supposed to find out about the newly emerging ICT infrastructure called WoredaNet, a government VSAT network which is under development. We also wanted to know if there was any telemedicine initiative that the capacity building is aware of.
The questions we have asked to the personnel in charge at the ICT capacity building was:

Information required from the ICT Capacity Building Program:

1. Is there any activity related to Telemedicine in the program
2. If there is one:
    a. What kind of activity (is it a project, survey or other)?
    b. When was it started?
    c. What is its objective?
    d. Are there any local and / or foreign partners involved?
    e. Does the activity assume any ICT infrastructure existing in the country?
    f. Is there a technical document associated with the activity?
3. If there is no telemedicine activity:
    a. Does the Program consider application of Telemedicine or e-health in Ethiopia? Or do you have a plan to introduce Telemedicine in the health system of the country?
4. Are there any activity related to Telemedicine, which your program is aware of?
5. Does the program have fund to support thesis / projects in the area of telemedicine.

The summarized report of the response to these questions is presented below:

Currently there is no activity related to telemedicine by the ICT capacity building program. But as on of the objectives of the program, Introducing ICT in the health system of the country is considered. However, the ICT capacity building program should support projects, or initiatives that promote the application of ICT in any field possible to facilitate and create modern working environments in every corner.

Again there was no plan to implement telemedicine in Ethiopian by the ICT capacity building program. And the program has not been aware of any existing project related to the application of telemedicine in Ethiopia.

Even if there was no activity related to telemedicine owned by the ICT capacity building program, the respondent engineers ware willing to give us information about the VSAT network which is under development.

The network is called WoredaNet, and it uses VSAT terminals to be installed in all the Woreda administration centers to form a kind of e-governance. Since the network is under development and is a government network, no technical document can be provided to the public, at least not yet. However the following information about the network could be obtained from the interviews:

Network coverage:

The WoredaNet will have a point of presence in every Woreda administration centers, where VSAT terminals will be installed, already 571 Woredas were covered by the time of we conducted the interviews. Along with the VSAT terminals, Video conferencing equipments, tow telephone lines are expected to be provided to each Woreda site.

The objective is to create a wide are connectivity schema to regional and central government offices such as finance and agricultural offices. The various Woreda level offices are expected to be connected to their respective Woreda administration centers through a terrestrial means, such as cables, radio links depending on their distance from the administration centers. The switches at the Woreda administration centers have enough free ports to enable cascade connectivity to the various government offices.

Bandwidth

The band width used by this network is 45M downlink to all the Woreda administration centers and 257k uplink from each site. It provided two way traffic unlike that of the SchoolNet which provides only one way, broadcasting traffic. The responding engineer also added that the SchoolNet VSAT network can be upgraded to support up to 384k uplink.

Cost

There is no issue of connection cost as the infrastructure is owned by the government and it is expected to serve government offices. The government body which owns the infrastructure is ETC. This is so because ETC is the only organization that have the mandate to provide telecommunication services in the country. But in the case of SchoolNet and WoredaNet, the users are those Woreda government offices and schools across the country.