A Novel Hierarchical Semi-centralized Telemedicine Network Architecture Proposition for Bangladesh

Choudhury, Samiul; Peterson, Carrie Beth; Kyriazakos, Sofoklis; Prasad, Neeli R.

Published in:
International Federation for Medical and Biological Engineering Proceedings

DOI (link to publication from Publisher):
10.1007/978-3-642-21683-1_44

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

A Novel Hierarchical Semi-centralized Telemedicine Network Architecture Proposition for Bangladesh

S.H. Choudhury, C.B. Peterson, S. Kyriazakos, and N.R. Prasad

Center for TeleInFrastruktur (CTIF), Aalborg University, Aalborg, Denmark
{samiulhc,cbp,sk,np}@es.aau.dk

Abstract— **One of the major functions of telemedicine is the prompt delivery of modern healthcare to the remotest areas with reduced cost and efficient use of communication resources. The establishment of a well organized telemedicine system is therefore exigent for the developing countries like Bangladesh where there are extreme paucities of efficient healthcare professionals and equipments, specifically in the rural areas. In this paper a novel, hierarchical and semi-centralized telemedicine network architecture has been proposed holistically focusing on the rural underdeveloped areas of Bangladesh. The model utilizes the existing fiber optic backbone and wireless telecommunication infrastructures to connect the remote healthcare centers with the urban specialized hospitals. The proposed network is of low cost, flexible and faster as well as more concrete than the existing healthcare organogram of Bangladesh. Finally, some features and services associated with the model have also been proposed which are pragmatic and easily implementable.**

Keywords— **Bangladesh, e-Health, Telemedicine, Tele-infrastructure, Tier, Upazila.**

I. Introduction

Telemedicine is one of the most promising branches of Information and Communication Technologies (ICT) and is possibly the most prominent e-business service that can have a major visible effect on the development of healthcare sector. It can reduce mortality, morbidity, expenses and psychological strains by catering healthcare services to the remotest parts of a country. In countries where access to medical services is restricted by distance and poor transportation, and where health care services are inadequate, telemedicine offers a great opportunity and possibilities to distribute medical services by utilizing ICT. Developing countries like Bangladesh are still striving to provide minimal health services to all citizens due to the insufficient number of health care professionals and medical services available, economic regression, geographical hindrance, inadequate transportation system, political instability and improper healthcare management. Telemedicine, therefore, may be an effective solution of the health care predicaments of Bangladesh.

Telemedicine activities were first materialized in Bangladesh in the mid of 1999 [1]. Henceforth different potential projects on telemedicine have been undertaken [2,3]. But none of them is commercially well established due to the lack of efficient workforce, technical limitations, high cost, discrete choices of location and services, illiteracy in technical knowledge and the absence of a concretely defined telemedicine policy. Moreover, the rural areas which consist of about 50,000 villages [4] and accommodate 80% of the total population of Bangladesh [5] get lower priority in healthcare sector due to the excessive healthcare demand of the urban areas.

In this paper, we have proposed a novel tele-infrastructure based integrated telemedicine network architecture that focuses primarily on the extensive but deprived rural parts of Bangladesh and is compatible with the existing telecommunication infrastructure, economic, social and geographic condition.The paper is organized as follows: the next part describes the methodology that has been followed in developing the paper. The succeeding section delineates the prospective areas of telemedicine of Bangladesh. Finally, the proposed telemedicine network architecture has been portrayed with its features and services.

II. Methodology

In this research work, we have studied a considerable number of scientific articles on telemedicine network architecture and applications in the developed and developing world. Necessary data and other information have been accumulated from the reliable official websites, newspaper articles, and up-to-date publications. The undeveloped rural parts of Bangladesh have been chosen as major concern. The applicability of the establishment of an organized telemedicine system in Bangladesh has been scrutinized. Comprehensive discussions with pertinent professionals, such as doctors and IT professionals have also been conducted and a network model has been developed on the basis of the outcomes of research and discussions.

III. Background Study: Health Sectors of Bangladesh and Prospect of Telemedicine

Bangladesh has made significant progress in health sector, specifically in primary healthcare since the Alma Ata

K. Dremstrup, S. Rees, M.Ø. Jensen (Eds.): 15th NBC on Biomedical Engineering & Medical Physics, IFMBE Proceedings 34, pp. 176 – 179, 2011.
www.springerlink.com

Declaration in 1978 [6]. Infant, maternal, and under-five mortality rates have decreased over the last decades, with a marked increase in life expectancy at birth [6]. But the progress is insufficient compared to the demand. In Bangladesh, there are 7 divisions, 64 districts and 482 upazilas which are the administrative units [7]. Each Upazila has an existing governmental Upazila Health Complex (UHC). According to the monthly statistical bulletin of Bangladesh Bureau of Statistics (BBS, 2008) the statistics of UHC is provided in Table 1. The statistics represents the impoverished healthcare infrastructures of Bangladesh. Moreover, around 75% of the professional physicians work in the urban areas [5]. There is a huge disparity in health care distributions between rural and urban areas. Rural people have to spend a higher proportion of their limited income to receive specialist's advice, because they have to travel long distances to go to the urban areas. It often becomes impossible to transfer a patient with a critical health condition to the urban hospitals due to the poor transportation systems in the rural areas. So, telemedicine may be an easier and cheaper way to disseminate healthcare facilities to the rural areas of Bangladesh. Compared to developed countries, telemedicine activities are still in the primary level in Bangladesh. So there is a huge window open for advanced and organized telemedicine system development in Bangladesh.

Table 1 Statistics of upazila health complex in Bangladesh

Parameters	2002	2003	2004	2005	2006
No. of hospitals	1,362	1,384	1,676	1,676	1,683
No. of hospital beds	45,607	46,125	50,655	50,827	51,044
Person per hospital bed (No.)	4,109	2,801	2,550	2,736	2,732
Person per Physician (No.)	4,043	3,532	3,213	3,317	3,125
Registered Physician (No.)	34,502	36,678	40,210	41,933	44,632

IV. Proposed Telemedicine Network Architecture

In this section, we have presented our proposed telemedicine network architecture. The objective of the proposed telemedicine model architecture is to develop a link between remote healthcare centers and the mainstream centralized urban healthcare centers utilizing the existing telecommunication infrastructures, incorporating government and private organizations in building up the panorama of an effective telemedicine network.

A. Network Model Description

The network architecture is shown in Fig. 1. The entire medical infrastructures will be partitioned into *four tiers*. The tier-1 health centers will be some specific, internationally recognized, government and non-government hospitals situated at the Capital and some big cities of Bangladesh. Tier-2 health centers are the district level hospitals while the Upazila Health Complexes (UHC) will lie in tier-3. The remote health care units will be designated as tier-4 medical units. The tier-1 units will communicate with the tier-2 units using the high speed fiber optic backbone network of BTTB covering all the districts of Bangladesh [2] while the communication between the tier-2 units and tier-3 units and also between tier-3 units and tier-4 units will be accomplished by wireless internet using the network covered by the mobile phone operators [8].

The Tier-1 medical units, adorned with the expert professsionals will be responsible for developing and maintaining the online telemedicine network and central server system and will regulate the overall telemedical activities throughout the country. The units will form a *fully connected mesh network* for quicker and safer performance. The logical central server system will be the integration of all the physical servers located at different tier-1 units for data protection, decentralization, and security reasons. The iPath software solution can be used as the online telemedicine platform [9]. The tier-2 units will directly regulate the operations of tier-3 units while providing some additional services such as mobile medical units, post disaster medical service units, etc. A tier-3 unit will be the one where the local people will sign themselves up for the online server system. It will communicate with the tier-4 units and provide the common medical treatments and diagnoses. The tier-4 units will be either rural government healthcare centers or NGO (Non-Government Organization) healthcare units affiliated with the central system. These units will be organized by cheap telemedicine kits and tablet PCs or simple ham radios.

In Bangladesh, the remote healthcare centers (mentioned as tier-4 units) are still not well developed; therefore, the tier-3 units (UHC) have got the primary focus in our model. Each tier-3 unit will be provided sufficient telemedicine equipments (desktop or laptop computer, broadband internet connection, etc.) with trained medical officers, nurses, pharmacists, and IT operators depending on the population density of the respective area.

B. Storage and Archive Subsystem

In order to develop a compact telemedicine network, a well organized data storage system is essential. The data base and server system of the proposed telemedicine network architecture is depicted in Fig. 2. Due to the large population, the centralized server system is hierarchically stratified into division level servers and district level servers. Each district level server will contain the information related to every citizen under that district.

In medical system, each patient will be identified by a unique *'National Health Card' (NHC)* number. Recently, Bangladesh Government has successfully implemented the

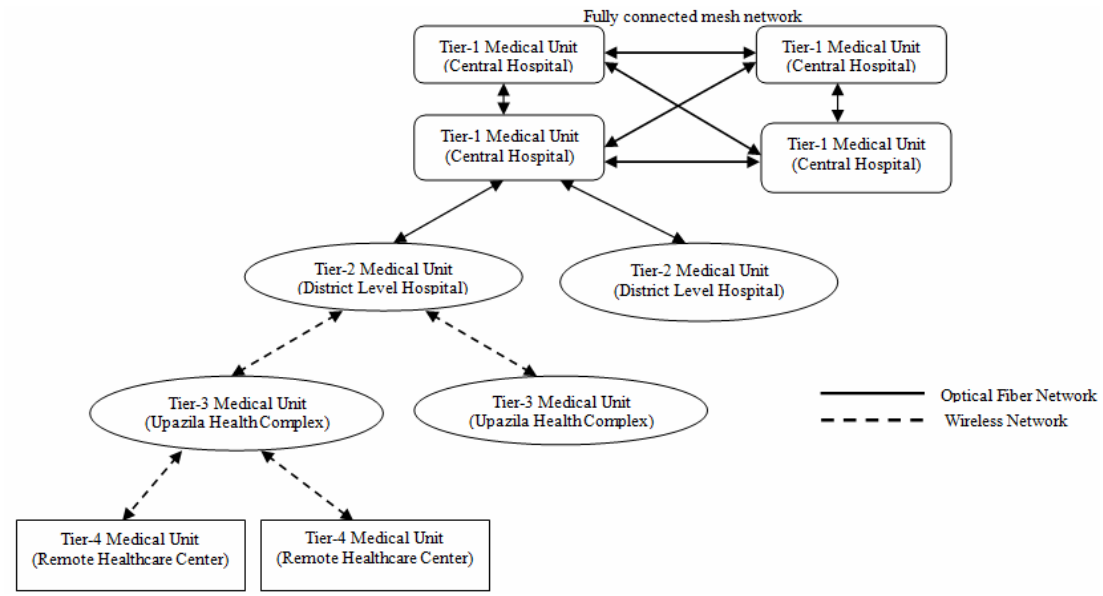

Fig. 1 Proposed Telemedicine network architecture

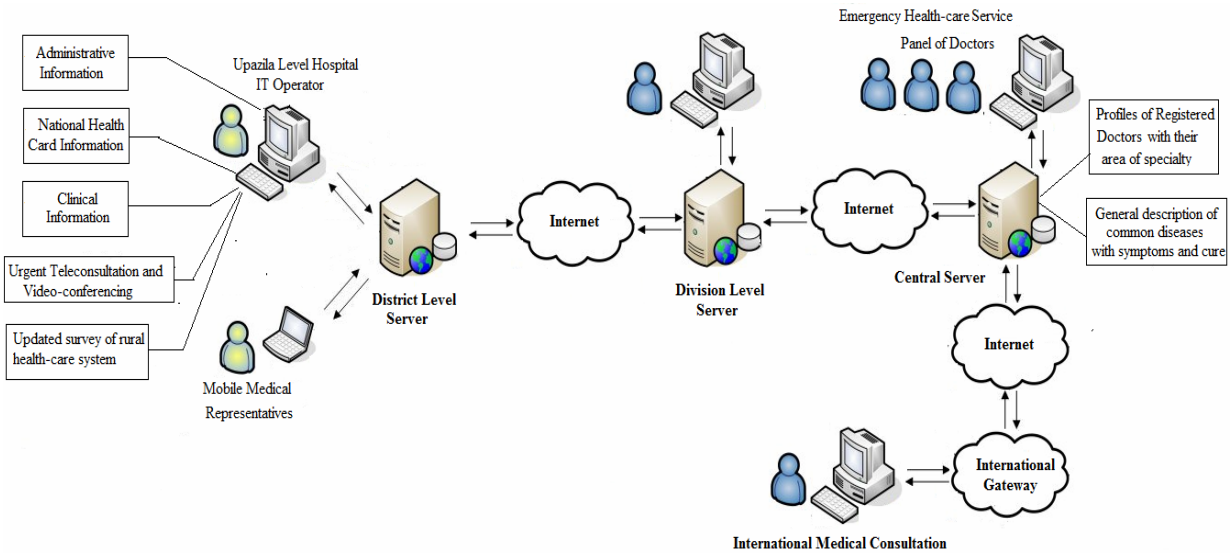

Fig. 2 Storage and Archive system of medical information for the proposed architecture

National ID card consisting of a 13 digit unique number for every single person of the country. The unique number of national ID card can be concatenated with the 'Date of Birth' to form the unique NHC number. The patients will be signed up in the e-health server with their NHC number and the online profile will contain the complete medical records and treatments. On the other hand, the registered doctors all over the country will have their own registration numbers and against these attributes, their profiles will be displayed which will contain their backgrounds, areas of specialty, experiences, and professional affiliations.

Apart from NHC information, the district level server will contain the hospital administrative information, patients' clinical information, and rural periodic health survey information. The central server will contain the NHC information, doctors' profiles, general descriptions of the common and chronic diseases with symptoms, and treatment options and links to medical journals and literatures.

When a patient will be moved to the UHC (tier-3), the local operator will find out the corresponding profile from the server and print a prescription form containing the NHC number and other required information for the patient. Then

the patient will be moved to the tier-3 medical officer who will primarily observe the condition of the patient and analyze the information along with the symptoms to prescribe the patient for medicine or further diagnosis. If the physical condition of the patient is complex enough to seek a second opinion or improved consultation from a specialist doctor, the tier-3 medical officer will inform the specialist doctor in tier-2 unit through a mail or any other messaging service with special emergency codes (e.g. 'Red' for critical condition, 'Yellow' for moderate condition, etc.). After scrutinizing medical records and physical condition, the experienced doctor will provide expert opinion. If the tier-2 unit doctor justifies the case as critical, then he/she will suggest the tier-3 medical officer to arrange a video conferencing with the experts in the central tier. In case of rare diseases or epidemic level diseases, international teleconsultation or medical knowledge and information sharing will be accomplished via internet using the international gateway.

V. Features and Services Offered by the Model

The following features and services can be incorporated with the proposed network model.

(1) Mobile medical and diagnostic unit Monthly Diagnosis Day: Mobile medical and diagnostic units consist of expert doctors and portable telemedicine kit will visit each area once in every month. The visiting day will be announced as '*the Monthly Diagnosis Day'* and people will be encouraged to join the program spontaneously with the help of local and national media. The mobile units will use bus or launch where the telemedicine equipments will be deployed. The prime functions will be to provide basic healthcare to the deprived people and collect organized health records from the patients.

(2) Emergency rescue team with telemetry equipment and transportation: The tier-3 medical units will be equipped with 24 hour emergency rescue team and ambulatory units, such as ambulances and specially equipped boats as roads are not available in many of the rural places and waterways are the only means of transportation.

(3) Pre and post disaster medical services: As Bangladesh is a disaster-prone country, pre and post disaster healthcare services are of prime importance. Pre-disaster services include the training and educating general people about disaster management. Post-disaster services include rehabilitation and providing of medicine and emergency treatment for diseases like malaria, diarrhoea, skin diseases, etc. that occur in an epidemic range in the rural areas after the natural disasters.

(4) Immediate Teleconsultation via mobile phone: Leased Helpline: This facility will be provided in the remotest areas where the austere people cannot afford to manage even a mobile phone. The gross networks of the existing mobile phone operators cover proximately the entire area of Bangladesh except the hilly and forest areas. These networks can be utilized here. The village phone program of Grameen Phone is an example of the solution [10]. The people will feel more comfortable to discuss directly with the doctor via cell phone. All of the mobile operators can dedicate some common *leased helpline* for emergency medical calls.

(5) e-Library facility: e-learning concept: E-mail and internet access for urban and rural health-care centers will facilitate the doctors in all tiers to access to the recent medical literatures and update their knowledge.

(6) e-Medical board for critical cases: In case of rare and chronic diseases or accidents occurred at any places throughout the country, special medical board of specialists will be formed in the tier-1 units to provide medical support for the victims.

(7) Special sections for mother, child, and aged people: Mother, child and aged people are vulnerable to diseases and death. Therefore medical units in each tier can contain intensive care sections for these groups of patients.

VI. Conclusion

In this paper, we have proposed a contemporary and pragmatic telemedicine network architecture with some services that are innovative for Bangladesh. The proposed system merges all the active government and non-government organizations and utilizes the existing telecommunication and medical infrastructures and is therefore readily implementable, cost effective and more compact, multifaceted, reliable and faster than the existing telemedicine systems. We have also proposed the organogram of a simple but complete medical data storage system that is compatible with the network architecture. The model will certainly facilitate the promulgation of the modern telemedical application to the remotest regions of Bangladesh.

References

1. Ministry of Health and Family Welfare, http://www.mohfw.gov.bd /health _policy.htm, Last Visited 2008. (2)
2. A. Nessa, M. A. Ameen, S. Ullah, and K. Kwak, "Applicability of Telemedicine in Bangladesh: Current Status and Future Prospects," The International Arab Journal of Information Technology, vol. 7, no. 2, April 2010. (3)
3. M. S. Chowdhury, Md. H. Kabir, K. Ashrafuzzaman, K. S. Kwak, "A Telecommunication Network Architecture for Telemedicine in Bangladesh and Its Applicability," International Journal of Digital Content Technology and its Applications, vol. 3, no. 3, September 2009.(4
4. http://www.reb.gov.bd/about_reb.htm.(5)
5. Encyclopedia of the Nations, http://www.nationsencyclopedia.com/ economies/Asiaand-the-Pacific/Bangladesh.html, Last Visited 2009.
6. http://en.wikipedia.org/wiki/Bangladesh
7. http://en.wikipedia.org/wiki/Upazilas_of_Bangladesh
8. http://www.bdgateway.org/ict_mobile_phone_operator.php?directores=MobilePhoneCom
9. http://sourceforge.net/apps/trac/ipath/
10. http://www.grameenphone.com/index.php?id=79