Development of a telemedicine model with low cost portable tool kit for remote diagnosis of rural people in Bangladesh

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Abstract – **In this paper we have developed a Telemedicine model with portable tool kit for remote patients to collect vital signs of patients which are used for Telemedicine services. This developed system is low cost, portable, and easily maintainable and can be integrated with any complex health system. We have used the GNU health where local doctors can communicate with a low cost terminal. Expert doctors can also take part through this terminal and deliver treatment to the patients. The patient's medical history is stored in GNU health database and accessed from the remote terminal. We have successfully designed the system and collected the patient's data. Through our developed android apps, the data will be stored in the staging server. From the staging server, any health system can collect the data and give the services to the rural people. Finally we can conclude that, Telemedicine service can be given effectively by using our portable tool kit in a cost effective manner which improves the quality and accessibility especially in rural areas.**

Keywords—telemedicine; gnu; ecg; spo2; glucometer

I. INTRODUCTION

Bangladesh is a small country with huge number of population. Most of the people in our country live in rural areas where health care facilities are poor. Most of the specialist doctors live in urban areas. In this scenario, healthcare facilities can be given to this huge number of populations through Telemedicine. Telemedicine is a promising cost- effective alternative method that has been shown to prevent deaths and improve functional recovery [1]. Telemedicine technologies have been proven to work, and are considered to be a viable option [2] in future healthcare delivery. Health professionals who used telemedicine in their work had more positive impression towards it [3]. According to Wootton, a successful telemedicine provides high quality care at low cost in comparison with an alternative such as regular care [4].

In Bangladesh, health service delivery in rural areas is extensively increased in absence of qualified human resources for health (HRH) [5]. In Bangladesh, the medical doctor to population ratio in urban areas is 1:1500, whereas the ratio is 1:15000 in rural areas [6]. Around 20% of physician positions and 22% of nurse positions at the sub-district or upazila health complexes are vacant. The vacancy rate is even higher for the specialist positions (52%) at the upazila-level health complexes [7].

It was found that early diagnosis and treatment are vital to ensure sustainable medical treatment and enhance survival rates [8]. Alongside the potential to lower healthcare costs, telemedicine services have the strength to increase the accessibility and quality of care [9-10]. The main aim of this research is to develop a telemedicine model through a newly developed portable telemedicine tool kit which will be cost effective for our rural people.

II. REVIEW OF LITERATURE

In order to carry out this research, related research articles are reviewed renounced journals, conferences, magazines, books and different sites. Most recent findings are analyzed in this section with their weaknesses and strengths.

A real-time heart monitoring system was developed by Priyanka Kakria, N. K. Tripathi, and Peerapong Kitipawang considering the cost, ease of application, accuracy, and data security [11]. In this paper, three types of wearable sensors are used to get heart rate, blood pressure, and body temperature from the patients. By using android phone, data were sent to the web server. Through the server, both doctors and patients are connected. Their developed system generates alarm and informs the doctor in case of emergency. The limitations of this research are to generate false alarm due to battery issues of sensors and smart phone.

M. Abo-Zahhad, Sabah M. Ahmed, and O. Elnahas proposed a system that can collect four different physiological signs of ECG, SPO2, temperature, and blood pressure. These signals are transferred to an intelligent data analysis scheme to diagnose abnormal pulses. The system has web-based interface for medical staff to observe immediate pulse signals for remote patient treatment [12].

The research was conducted by Meenu Singh and other's titled "Application of Handheld Tele-ECG for Health Care Delivery in Rural India" to identify heart conditions of the

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rural people. Patient satisfaction was reported to be about 95% in this study [13].

Another study was conducted by Fang Zhao, Meng Li, Yi Qian and Joe Z. Tsien. They described a process to get blood volume pulse and respiratory wave from a single channel images captured by a video camera. This research enables a much needed low-cost means to protect sudden infant death syndrome in new born infants and detect stroke and heart attack in elderly population [14].

The authors Gregorio L pez, Vctor Custodio, and Jos Ignacio Moreno developed a system which monitors several physiological parameters, such as ECG, heart rate, body temperature, etc., and tracks the location of a group of patients within hospital. This paper depicts the system architecture, deployment and validation of results from both laboratory tests and a pilot scheme [15].

The researchers named Md. Nazmul Hossain and others developed a portable health clinic tool that was used for the rural people of Bangladesh in collaboration with Kyushu University, Japan. The project was running as pilot basis in two districts of Bangladesh. Patients and doctors are getting health services through a website [16].

III. Materials and Methods

This research was carried out through mainly four modules: Portable telemedicine tool kit module for collecting the vital information from patients through different sensors, communication module that is android apps to collect data from the portable tool to the server module, server module consists of staging server primarily used for storing the patient data from the android apps and GNU health server module to fetch data from staging server for future use and management. Remote health professionals connect to the GNU server for the delivery of healthcare services. The activity diagram of our proposed telemedicine model is shown in the following figure 1:

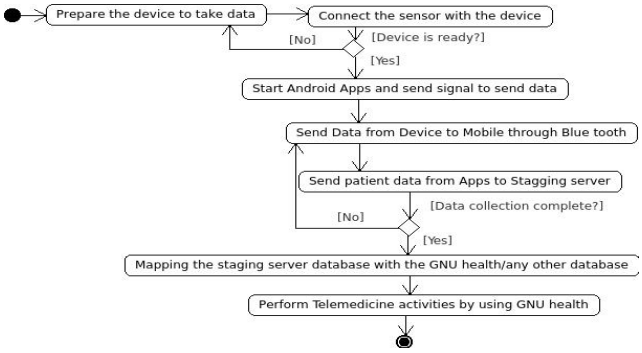

Fig. 1. The activity diagram of the telemedicine model

From the activity diagram we can understand the overall working procedure of the proposed telemedicine model. The activity diagram describes the starting to final activities of how the service is delivered through our proposed system.

Figure 2 shows the component diagram of the proposed telemedicine model. The major components of the diagram are sensors, telemedicine tool kit, android phone, staging server, GNU health server database and client module.

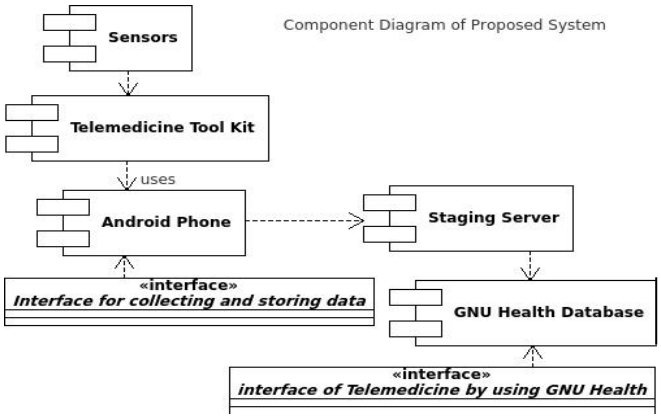

Fig. 2. The component diagram of proposed model

The deployment diagram is given in figure 3. The diagram consists of 1 to N number of remote telemedicine devices for collecting data from patients. Android phone is used to send data from the staging server. It is a repository of patient data. Our proposed system will fetch data from this server to GNU health server. After that a low cost client is made to connect to the GNU health server. The client is made of Raspberry pi, keyboard, mouse and monitor only.

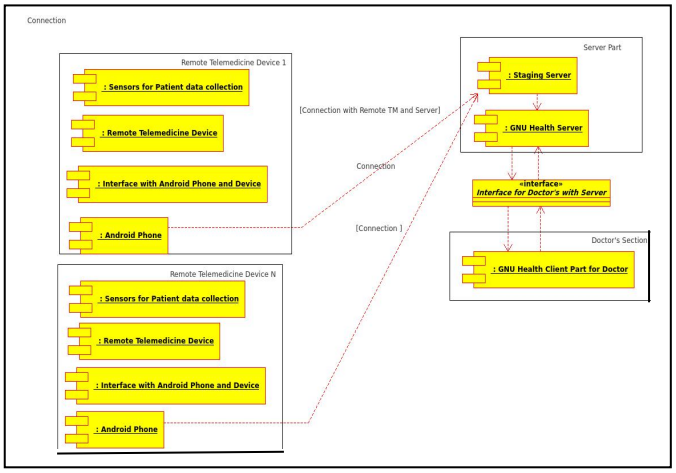

Fig. 3. Deployment diagram of proposed telemedicine model

The portable tool kit is composed of e-health sensor shield, sensors, arduino and Bluetooth module. After making proper connections with the sensors, the operating mechanisms are handled through code. After putting the sensors in the right position of the body, the data were collected from the kit through Bluetooth. By using the apps, we can send the data to the server.

The portable telemedicine tool kit arrangements are shown in the figure-4:

Fig. 4. Physical arrangement of portable tool kit

From figure 5, we can see that the SPO2 sensor sends data from the device. We can also format the data according to our desired format. The sensors are maintained through the command from the Android phone.

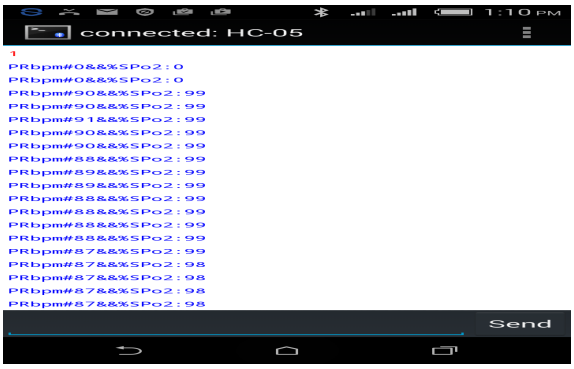

Fig. 5. Output from the SPO2 Sensor

IV. RESULTS

We have prepared the portable tool kit for collecting data through Bluetooth terminal to the app. We have installed GNU health server for storing the patient data. GNU health client module was implemented to connect remotely into the health system. The following sections show the results of different modules.

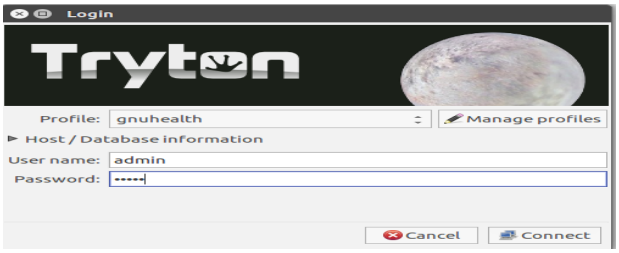

Fig. 6. GNU health client login window

Figure 6 shows the client login module. Client can use this section for connecting with the GNU health server. Remote health professionals use this module for telemedicine service. Valid user name and password is necessary to login the system and use the facilities of the health system.

The figure 7 shows the result of inserting the patient information into the system. At the time of registering a patient, an ID is assigned which is used in the system for different types of functions.

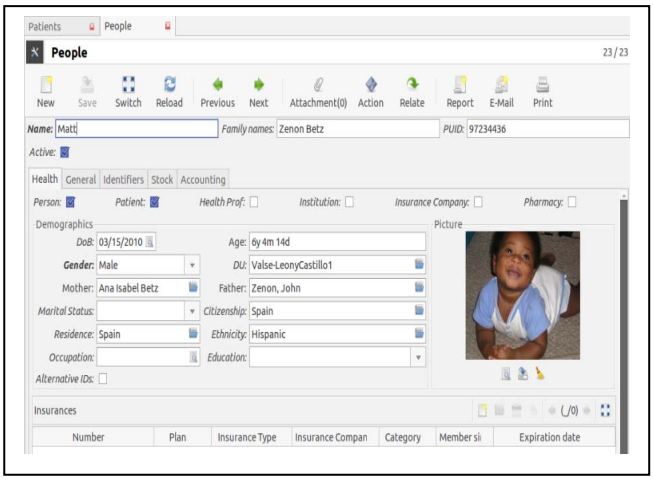

Fig. 7. GNU health patient information screen shot

Figure 8 depicts the prescription generated by expert doctors for different patients. Any patient can get his or her previous advices from the system easily. Doctors can also get the patient's history and treatment plan through this section. It is helpful for the doctors to make prescriptions of patients by investigating the patient's previous information.

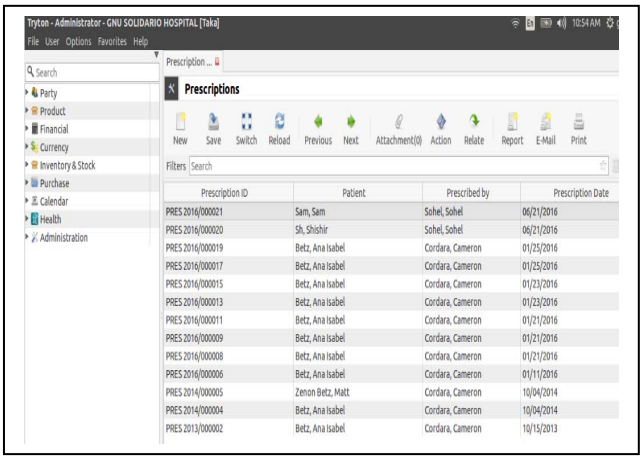

Fig. 8. Prescription of patient from the system

Figure 9 shows the lab test result generated by lab technician. Doctors send request for a lab test of a patient. The lab technician performs the test and inputs the values of the test in the prescribed format and saves it. Category wise lab test results are stored in the lab test result section. Doctors can easily search the patient lab test results from the system. The history of the results can be accessed and managed through terminal. After getting the lab result, doctors prepare the prescription of the patients.

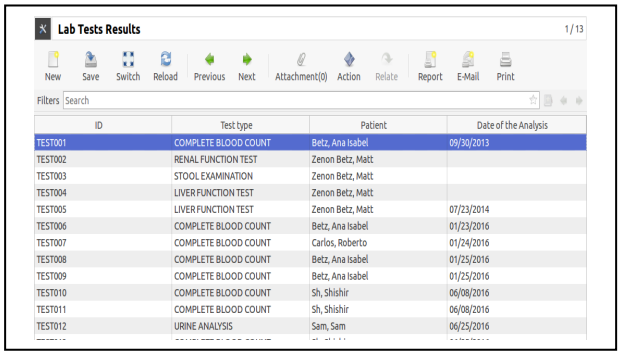

Fig. 9. Diagram of category wise lab test result

V. DISCUSSION

In this paper, we have developed our portable telemedicine tool kit for collecting seven vital signs of patients. The sensors used in the tool kit are SPO2, airflow, temperature, blood pressure, body position, glucometer and ECG.

We have tested the GNU health server through client for our telemedicine application. Patients will not face any difficulties due to the change of his geographical positions. Our telemedicine model will provide the facilities to its users.

In order to make this model cost effective, we have created a low cost client module by using Raspberry pi 3, monitor, keyboard and mouse only. This arrangement can reduce the expense about half of the cost of a computer system. This GNU health client module is portable and can be easily installed at any remote locations.

Our proposed model is superior to other models because this model is composed of a customized tool kit capable of collecting the vital sign of patients in a cost effective manner. This model includes staging server facilities which can be shared by any health system for their patient's data. Patient data is stored centrally and accessed through remote locations. All the healthcare centers find the same format and structure of patient data and record. Our model facilitates the health services to the remote people.

VI. CONCLUSION

Telemedicine is playing a vital role for giving the healthcare facilities to the poor people. We have implemented this telemedicine model to enhance the facilities of the services of telemedicine. Our developed portable telemedicine kit can collect seven vital signs of a patient in an automated manner. We have successfully collected the data from the kit to the server for permanent storage. From the GNU health, we have found that when any abnormalities are found from any test result for a patient, warning message is given to the test of the patients. Doctors can deliver the necessary treatment for the patient in the case of emergency. We have shown the low cost solution of telemedicine through a customized terminal. Health related services can be easily found and accessed through our developed model. Our proposed model can be used as a low cost standard model for the telemedicine services of rural people of Bangladesh.

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