



Email based Real Time Cardio Telemetry System of Patient Monitoring through Internet

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Abstract— *In this study we developed a email based system for remote real-time tele-monitoring of patient with abnormal heart activity that helps doctors for detecting potential problems earlier, providing emergency health care, improving the quality of patient health and minimizing healthcare costs by reducing number of hospitalizations of patients. This paper initiates to develop a system for facilitating the accessibility of information about the patient's health both in hospital and home by reducing the physical movement of clinical staff to each patient. The study focuses on the key issues and challenges regarding the design and implementation of cost effective remote patient monitoring system and introduces the integration of pulse oximetry transducer based cardio-telemetry system with windows based software interface for real time data acquisition, risk calculation, and finally wireless transmission using the Internet as communication platform for implementation of an email based patient records management system. Using this system a specialist doctor can telematically 'move' to the patient site and instruct the patient depending on their vital signs. This cardio-telemetry system is equipped by two types of data base like local data base that is maintained by zonal or remote hospital and master data base that is maintained by administrative hospital, allowing the system to store and manage the data simultaneously.*

Keywords— *Cardio-telemetry, real-time, remote monitoring, low cost, email, emergency health care, pulse oximetry transducer, wireless transmission, Host-Client Protocol, MySQL DBMS*

I. INTRODUCTION

Heart disease is the leading cause of death for both men and women. According to World Health Organization (WHO) estimates, 16.7 million people around the globe die of cardiovascular diseases (CVD) each year. 80% of CVD related deaths being reported from low and middle income countries like India [1]. Emergency treatment is the necessary step to save the life. Thus the provision of effective emergency in real-time remote monitoring of the patient vital signs is a growing area of interest [2]. In understaffed rural or remote area and also in home monitoring the availability of prompt and expert medical care can meaningfully improve health care services [3]. Advancement of wireless network technology provides an opening of new technologies in varieties of applications including health care system [4]. The continuous monitoring systems are mainly used in hospitals, consists of sensors to be hardwired to nearby beside monitors, confining the patient to the hospital bed. The advent of wireless technologies like wifi and blue tooth enhance the mobility of patient while being continuously monitored by breaking the cable connection between patient sensor and beside equipment by a wireless connection [5]. One of the most advance and also possible trends that allow medical application is mobility- aware health care system that means home monitoring [6-8]. This system also allows the people to stay in their home environment and feel secure and live as a normal life as possible that is more important for recovery. The contemporary and emerging developments of wireless technology made a significant impact on current e-health and telemedical system and it also plays a crucial role for data transmission through internet [9]. In this context a remote system has been developed aiming to provide enhance information of patients to healthcare profession and also enabled higher mobility.

The objective of this dissertation to create e-mail based continuous heart beat monitoring system, detecting the critical condition exists or not by analyzing the risk factors and storing the record of heart beat as well as other vital signs. After that corresponding instruction from the specialist doctors has been forwarded to the patient through master database to local database using server client protocol. This cardio telemetric system allows the health professionals to access the patient information without need to move to patient site, home based elderly patient monitoring without requiring the use of any kind of terminal or application but instead allowing the use of a simple Web browser on a desktop computer or mobile device.

II. METHODOLOGY AND RESULTS

The cardio telemetry system being developed includes (A) The design and implementation of microcontroller (ATmega16L) based pulse oximetry system that measures the heart beat and transmit the corresponding data to the

computer over a USB to UART serial TTL communication module, followed by a Darlington transistor array (IC ULN2803A) to enhance the current gain for further operations.

(B) The integration of the data emanated from the sensor network with the software interface of the zonal hospital. The zonal interface is also capable to manage the multiple patients' information physically.

(C) Wireless Transmission of the vital sign in critical condition is performed over email to the doctor. The patient condition can be monitored in real time through a Web browser.

(D) The remote visualization of vital signs of one or more patients as well as management of the patient information are performed at administrative hospital using web based host client architecture. The overall architecture of the system is represented in Figure 1.

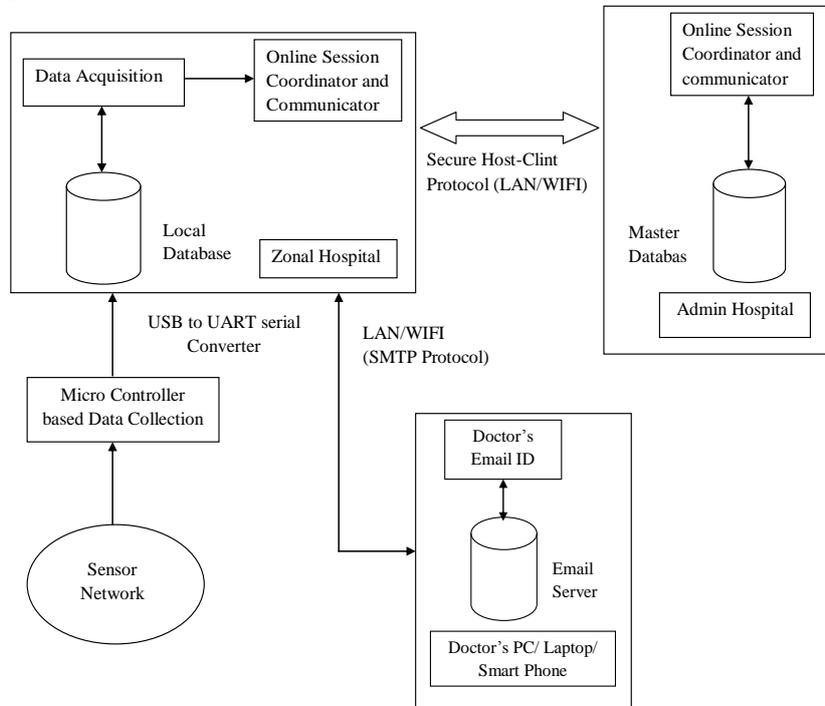


Fig. 1 System Architecture

This paper only addresses parts B, C and D of the entire telemetric system. The entire cardio-telemetry system has been developed initially to demonstrate how the healthcare cost can be minimized and patient comfort can be maximized using a simple device which integrates the hardware and software components together. The hardware is the combination of pulse oximetry transducer, Darlington transistor (IC ULN2803A), ATmega16L microcontroller and UART (Universal asynchronous receiver/transmitter) converter. The principle of pulse oximetry is based on the infrared and red light absorption characteristics of oxygenated and deoxygenated hemoglobin. The heart rate is also reflected by this principle. The analog bio-signal (information about heart), is emanated from the pulse oximetry transducer, fed to the pin 40 of the ATmega16L micro controller (with baud rate at 9600Hz and default internal clock at 1MHz) followed by the Darlington transistor (IC ULN2803A). The operation of both Port A (0th bit) and ADC (Analog to Digital Converter) can be performed by the pin 40 of the microcontroller depending on the set value of the internal register [10]. Analog value is being digitized to one byte packet data by internal ADC of the microcontroller and transmits it using USB to UART serial TTL communication module through pin 15 of the microcontroller by initializing it as Tx serial port. The sequence of operation at zonal hospital is depicted in Fig 2a and corresponding interface of zonal hospital presents in Fig 2b.

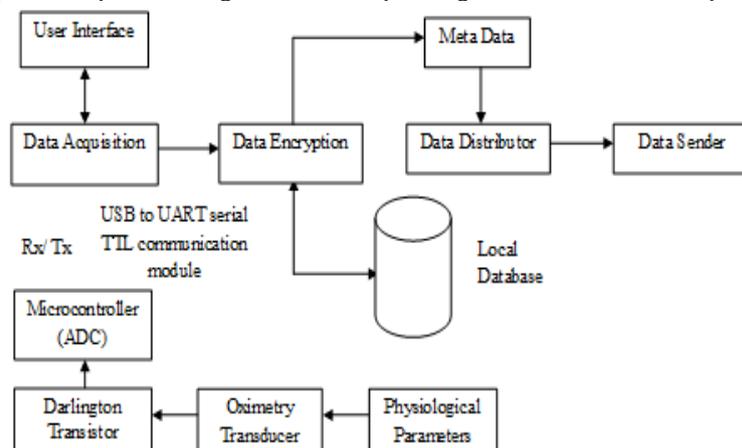


Fig. 2a Communication between sensor network and the zonal hospital interface

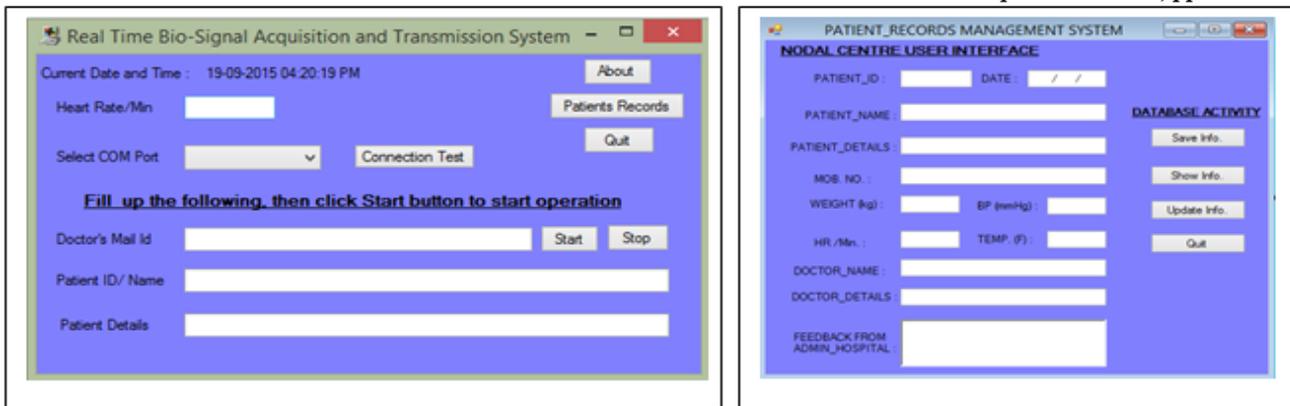


Fig. 2b Zonal Hospital Interface

The user interface of the zonal hospital is a windows based application, designed in such a way that it can receive digitized biosignal, count the bit per minute and finally analyze the risk factors. Intimation mail has been sent by configuring SMTP (Simple Mail Transfer Protocol) and SSL (Secure Sockets Layer) protocol to doctor's email id when the heart rate is not between the normal ranges. A potential role has been performed by the system (zonal site) simultaneously to store the multiple patient information (such as ID, Name, Weight, Heart Rate, Temperature, Blood Pressure etc.) to the local hard disk in a document file (.doc) as well as transmit the information of individual patient to the master database of the administrative hospital using satellite or POTS (Public old telephone service) communication. The admin interface is a web-based application, referred to as end user having the total control over data and programs accessing those data and is also responsible for querying, updating and generating reports. This interface provides the feature like authentication; access the information that has been sent by the zonal hospital, management of the patients' record, consultancy feedback from specialist doctor for each patient. HTTP has been considered as final choice since it is capable to block firewall or proxy efficiently and this interface supported by any web browser. Fig 3a represents the flow diagram admin hospital activity and Fig 3b depicts the corresponding interface of admin hospital.

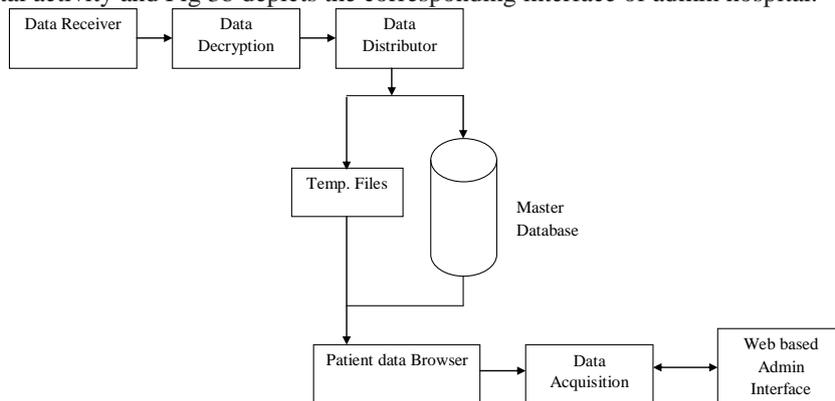


Fig. 3a Flow diagram admin hospital activity



Fig. 3b Interface of admin hospital

The admin interface has been implemented using C# programming language at ASP.NET platform. MySQL has been used as database management System (DBMS) [11], for being multi-user, multi-tasking and robust to store large amounts of data. It manages two separate tables like admin which is responsible for maintaining administrative data and automail which keeps the information about patient and doctor.

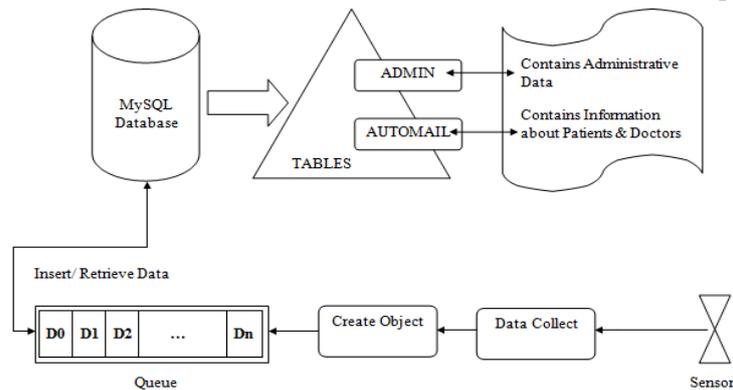


Fig. 4 Database activity of the entire system

III. CONCLUSIONS

In recent years research and development of remote telemetry based system are gaining momentum to maximize patient comfort and minimize the health care cost. The cardio telemetry system has great potential for early detection of bradycardia and tachycardia which improves the emergency response and quality of life. This system is cost effective, secure and also has less possibility of loss of data because data are storing in three different locations like local hard disk drive as doc file, inbox of doctor's id and finally to the SQL database of admin server. There are some limitations of this system like available memory size, network speed and TCP/IP configuration. This development is mainly targeted for home-based care, remote zonal hospitals those deal with very few facilities. In future, this work has immense scope for further development such as on chip hardware and software implementation, wireless interface between sensor and laptop or smart phone.

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