

## Remote Patient Monitoring- An Implementation in ICU Ward

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**Abstract.** The problem found in most hospitals is that the physician has to frequently visit the patient and assess his/her condition by measuring the parameters such as temperature, blood pressure, drip level etc. In case of emergencies, the nurse intimates the doctor through some means of communication like mobile phone. A growing selection of innovative electronic monitoring devices is available, but meaningful communication and decision supports are also needed for both patients and clinicians.

The aim is to develop a reliable, efficient and easily deployable remote patient monitoring system that can play a vital role in providing basic health services to the patients. This system enables expert doctors to monitor patients in remote areas of hospital. Mobile phones or personal digital assistants (PDAs) with wireless networking capabilities may serve as gateways that process, store, and transfer measured parameters to clinicians for further analysis or diagnosis. The timely manner of conveying the real time monitored parameter to the doctor is given high priority which is very much needed.

**Keywords:** Patient Monitoring, ICU, Mobile interface.

### 1. Introduction

Telecommunications has the potential to provide a solution to medical services to improve quality and access to health care regardless of geography. The advances in information and communication technologies enable technically, the continuous monitoring of health related parameters with wireless sensors, wherever the user happens to be. They provide valuable real time information enabling the physicians to monitor and analyze a patient's current and previous state of health. To remove or minimize cables, a robust wireless link with low power capabilities is required. Although many wireless standards can be used, there are important considerations such as range, throughput, security, ease of implementation and cost. Bluetooth is quickly becoming the preferred technology for wireless patient monitoring (Noel Baisa [7], 2005). A major motivation for reducing the number of cable or for doing away with the cables completely is to eliminate the potentially harmful currents to the patient. The patient monitoring involves handling of sensitive data. These data should be transmitted securely without any intrusion. Even a Bluetooth enabled gadget can try to participate in the network which introduces risk.

### 2. Related Approaches

- V.Thulasi Bai [1] et al (2006) presented "Wireless Tele Care System for Intensive Care Unit of Hospitals Using Bluetooth and Embedded Technology" in Information technology Journal at Asian Network for Scientific Information.
- V.Thulasi Bai [2] et al (2008) presented "Design and implementation of mobile telecardiac system" in the Journal of Scientific & Industrial Research Vol. 67, December, pp. 1059-1063. This paper presents design and development of portable cardiac telemedicine system that continuously acquires.

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ECG signals from high risk cardiac patients who can move around anywhere by a mobile phone using Bluetooth technology.

- K. E. B. Wallin [3] et al (2004), from the Department of Anesthesiology and Intensive Care, Karolinska Hospital, Sweden presented their work on the topic “Evaluation of Bluetooth as a Replacement for Cables in Intensive Care and Surgery”.
- Michaël Setton [5] et al (2006) presented a “Bluetooth sensors for wireless home and hospital healthcare monitoring paper” which explain about flexible and modular low power platform has been developed for health and lifestyle monitoring.
- Emil Jovanov [6] et al (2002), from Electrical and Computer Engineering Department, University of Alabama in Huntsville 301 Sparkman Drive, Huntsville presented a paper on “Patient Monitoring Using Personal Area Networks of Wireless Intelligent Sensors”.
- M. Schwaibold [4] (2003) presented “A WIRELESS, BLUETOOTH-BASED MEDICAL COMMUNICATION PLATFORM” explained the development of information technology in medical technology, since mobile applications in this area mean increased safety and quality of life.

### 3. Infrastructure Requirement

A rapidly increasing number of health care professionals now believe that wireless technology will provide accurate data with improved patient care. A wireless telecare system is needed along the patient bedside to provide good health care. The system must be interactive. The physician is needed to send the suggestion back about the patient to the nurse so that nurse can take immediate action. The proposed system consists of three main blocks. They are mentioned in the block diagram shown in Figure 1

The system is constructed such that it measures the biomedical parameters at the patient end without any intervention and then transmits the data acquired to the remote station. Sensors play an important role in monitoring the parameters. The precision at which the handheld device is to be operated is decided by the sensor that is used. Vital parameters such as temperature, glucose level, ECG, drip level; pulse rate can also be measured. The measured value is then transmitted to the base station via Bluetooth. The Temperature sensor is used for sensing the temperature. This system is constructed with low power consumption so that it would not cause much hindrance to the patient. The device is constructed such that it transmits the vital information periodically say 2 minute.

#### 3.1. Working Model

Each patient is connected with a temperature sensor. Measured parameters of patients are interfaced with the system at the patient end. The patient end system is connected with server and doctor mobile via Bluetooth. The server stores the central database of all the patients. The status of the parameter is decided in the patient end system. If the status is normal, the parameter is transmitted to the server and entered in the database. If the status is abnormal, then the parameter is immediately intimated to the doctor end the data is stored in the database of the server and is depicted in Figure 1

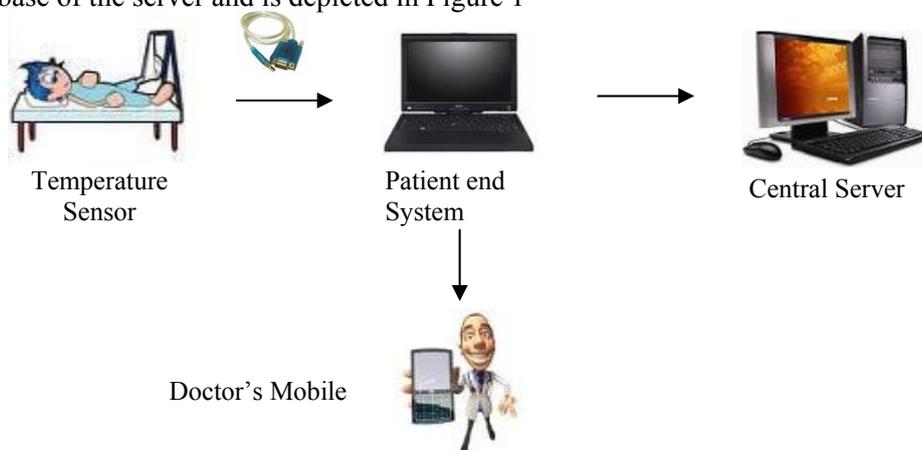


Fig. 1: Working Model

### 3.2. Temperature Sensor

The LM35 series are a precision integrated circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature.

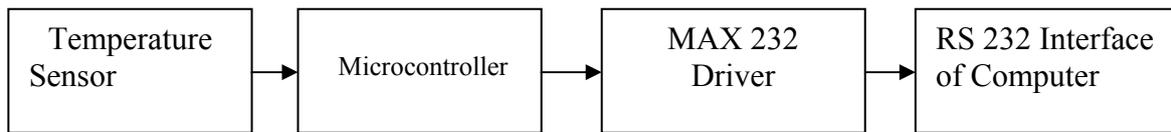


Fig. 2: Block Diagram of Temperature Sensor Module

Figure 2 shows the block diagram of temperature sensor module. The measured temperature is in analog. The analog value is converted into digital value for further processing using microcontroller. The digital data is transmitted to the PC through MAX 232 driver and RS 232 serial interface. The recorded temperature is saved in a database.



Fig.3: Recording Setup

Figure 3 shows the recording setup. The LM35 sensor is attached to the patient. The data is received from the patient end in ASCII form. The 'Bluetooth Hospital Client' does the conversion of ASCII values into decimal values. The application reads from the serial communication (COM) port.

### 3.3. Patient End System

Each patient at the Intensive Care Unit (ICU) is provided with a computer system, that has 'Bluetooth Hospital Client' application. This application reads the temperature sensor through the interface. The patient parameters like patient identification number (PID), temperature, heart beat, sugar, inhale, exhale and blood pressure can be transmitted to the server from the patient end system. The user interface of the patient end system is inferred in Figure 4.

The Bluetooth Hospital Client application has two menus: File and Client. The File Menu has a sub menu 'Exit'. Exit submenu is used to close the application. Client has two submenus: 'ServerIP' and 'Start'. 'ServerIP' submenu is used to connect with the central server and 'Start' submenu initializes the connection. Authentication is done after clicking the start submenu and entering a valid pass key. This pass key is a secret shared between client and the server. This process is needed to pair the client with the server. The various patient parameters are given in the user interface. The status of the patient is displayed in the user interface.

Figure 4 shows the various parameters of the patients with the status displayed as normal or abnormal. The unique ID of the patient is displayed in PID field. The temperature of the patient is displayed in Fahrenheit. If the temperature of the patient is less than or equal to 99 o F, then the status of the patient is normal. If the temperature of the patient is greater than 99 o F, then the status of the patient is abnormal. The readings recorded at 2 minute intervals are displayed in Figure 5. This work can be extended to measure other parameters by interfacing the respective sensor.

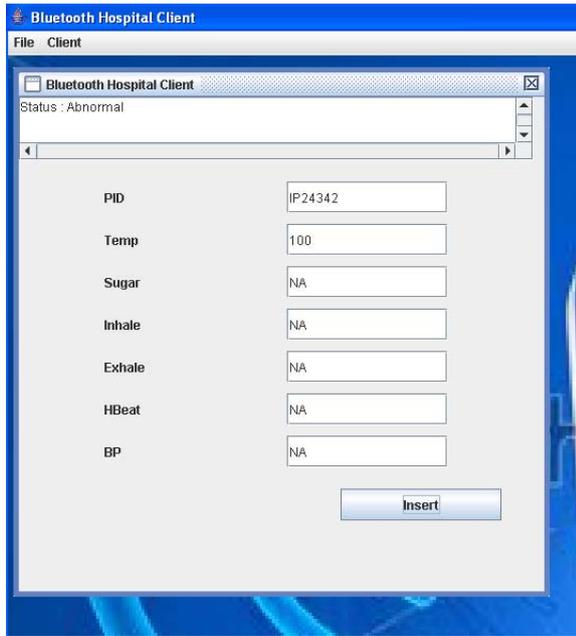


Fig.4: Status Window

Date	PID	Name	Time	Temp(Deg/Fahren)	Status
12-02-2010	IP24342	Hari	4.00 pm	99	Normal
			4.02 pm	99	Normal
			4.04 pm	99	Normal
			4.06 pm	99	Normal
			4.08 pm	99	Normal
			4.10 pm	99	Normal
			4.12 pm	99	Normal
			4.14 pm	100	Abnormal
			4.16 pm	100	Abnormal
			4.18 pm	100	Abnormal
			4.20 pm	100	Abnormal
			4.22 pm	100	Abnormal
			4.24 pm	100	Abnormal
			4.26 pm	100	Abnormal
			4.28 pm	100	Abnormal
			4.30 pm	101	Abnormal
			4.32 pm	101	Abnormal
			4.34 pm	100	Abnormal
			4.36 pm	100	Abnormal
			4.38 pm	100	Abnormal
			4.40 pm	100	Abnormal
			4.42 pm	99	Normal
			4.44 pm	99	Normal
			4.46 pm	99	Normal
			4.48 pm	99	Normal
			4.50 pm	99	Normal
			4.52 pm	100	Abnormal
			4.54 pm	100	Abnormal
			4.56 pm	100	Abnormal
			4.58 pm	100	Abnormal
			5.00 pm	99	Normal

Fig.5: Database in Patient System

The work in this thesis is done only for temperature so other fields are displayed as NA. The data collected for a period is stored in client database. The database consists of patient ID, patient name, time, temperature and the status.

### 3.4. Server

An application 'Bluetooth Hospital Server' is present in the server. This application is used to store the various details of the patients. Server updates the patient details from each patient end system. The server application has two menus namely 'File' and 'Bluetooth'. Their operations are similar to the patient end system application.



Fig.6: Server Interface

The server displays as 'Bluetooth Started' when server become active. The data is encrypted in the patient end system (client system). The encrypted information is transmitted to the server via Bluetooth. Server decrypts the data and the decrypted information is stored in the server. The message is displayed in the server window as shown in Figure 6.

The display consists of a block that displays the received patient information. IP24342 is the Identification number of the patient. 100 ° F is the measured temperature of the patient. NAs are other patient parameters which are not applicable in this work. The server database stores the parameters of all patients in ICU as shown in Figure 7 which displays the recent updates of each patient

PID	PNAME	Temp(Degree)	Sugar	Inhale	Exhale	HBeat	BP	Status
IP24342	Hari	100	NA	NA	NA	NA	NA	Abnormal
IP12345	Raj	99	NA	NA	NA	NA	NA	Normal
IP14327	Ram	98	NA	NA	NA	NA	NA	Normal
IP34216	Ravi	98	NA	NA	NA	NA	NA	Normal
IP24561	Vignesh	99	NA	NA	NA	NA	NA	Normal
IP32451	Prakash	100	NA	NA	NA	NA	NA	Abnormal
IP54632	Prem	99	NA	NA	NA	NA	NA	Normal
IP65437	Raghu	101	NA	NA	NA	NA	NA	Abnormal
IP82627	Gopi	101	NA	NA	NA	NA	NA	Abnormal
IP65368	Vishnu	98	NA	NA	NA	NA	NA	Normal

Fig.7: Server Database

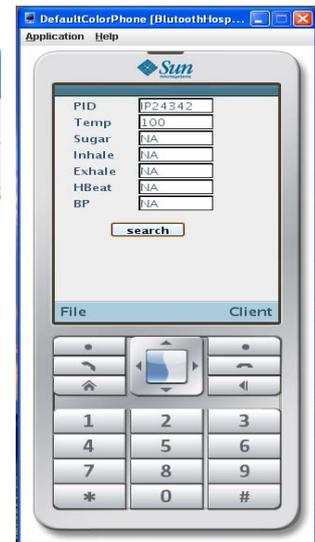


Fig.8: Mobile Interface

### 3.5. Mobile of Doctor

An application ‘Bluetooth Hospital Mobile’ is present in the Bluetooth enabled mobile of the doctor. This application presents the critical information of the patient. This mobile application has two menus, namely ‘File’ and ‘Client’. ‘File’ is used to close the application. ‘Client’ has two sub menus: Server IP and Start. The server IP submenu is used to connect with the server. Start submenu is enabled after providing server IP address, and now the mobile is connected with the server. Start menu starts the application and the details of the patient with unique ID are displayed. Search option is also provided in this application. Doctor can use the search option to know the details of the patients.

The mobile displays the PID and the monitored parameters. Temp is the temperature of the patient measured in Fahrenheit. The analysis is made at the patient end system. If abnormal, the doctor receives the patient information in his mobile.

### 4. Conclusion

The field of telemedicine has seen a tremendous technical development in the developed countries. Sustained efforts are also underway in the developing countries like China, Egypt and India in this field. The timely manner of conveying the real time monitored parameter to the doctor and providing 24 hours per day supervision increases the costs of treatment. A real time patient monitoring system implementation is exercised only for ICU ward. The concept is worthy but the difficulties stand when we go for bulk implementation.

### 5. References

- [1] V.Thulasi Bai et al, “Design and implementation of mobile telecardiac system” in the Journal of Scientific & Industrial Research Vol. 67, December 2008, pp. 1059-1063, 2008.
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