Power Competent Health Monitoring System for a Disaster Hit Area

Rajesh Kannan Megalingam
Department of Electronics and Communication
Amrita School of Engineering, Amrita University
Amritapuri, Kerala, India
rajeshm@am.amrita.edu

Savya Sugunan
Department of Wireless Network and Applications
Amrita School of Engineering, Amrita University
Amritapuri, Kerala, India
savyasugunan@gmail.com

Abishek Thekkeyil Kunnath
Department of Wireless Network and Applications
Amrita School of Engineering, Amrita University
Amritapuri, Kerala, India
abishektk@am.amrita.edu

Abstract—**Quick advancement in wireless communication devices and systems like mobile phone technology has had a significant impact on the health care industry. One such important application is to monitor patient's health status at anytime and anywhere [1]. In this paper we propose an emergency medical service system which can be used for DHA (Disaster hit areas). The proposed system can measure the vital parameters of the patient without the requirement of an elaborate patient monitoring system which consumes a lot of power, time and space, also need experts to setup the system. The system is designed such that it is easily portable, power efficient and user-friendly mode of operation for the ease of usage in a disaster hit area. Also for the communication with far away expert doctors the system needs wireless network connection (WNC) namely GSM (Global System for Mobile Communication). One of the paramount considerations in the design is to make the device compact and portable as well as to minimize power consumption.**

Keywords-health monitoring; global system for mobile communication; power efficient.

I. INTRODUCTION

Disasters are a crisis situation that far exceeds the capabilities as they are unpredictable and one of the major threats to the existence of human life. Even though they are unpredictable, it is possible to reduce the effects of disasters using efficient disaster management techniques. In this paper we are introducing a health monitoring system for DHA which provides a first aid treatment for the injured and save their life. Unlike treating people in hospitals, this task is challenging and tedious. The major problem faced by the population in a DHA is the lack of good medical facilities like the service of an efficient doctor, since soon after a disaster strikes it takes time for doctors to reach DHA. The aim of the system is to help expert doctors even from a far away distance to serve the injured and save lives in a DHA by giving necessary medical advises. One of the highlighting features of the proposed system is portability. The major problems faced in the monitoring of injured people in DHA are time, space, network and power. With the design of the proposed system we aim to solve these problems. In this system mobile phone is used to monitor the vital parameters of the patients. The system is designed to monitor the vital parameters of the patient and to send those data to the mobile phone through the Bluetooth module. The data from the mobile phone is then routed through a GSM to a base station by which authenticated doctors could get connected and suggest necessary prescriptions.

II. PROBLEM STATEMENT

Telemedicine provides health care when distance separates the medical professionals from the patients. This system is not an end solution for affected people in a disaster hit area. The system helps to provide a first aid treatment for the injured people just after a disaster strikes because there will be delay in doctors reaching the DHA. Even after they reach DHA, it takes time for setting up the medical facilities.

III. RELATED WORK

The health monitoring system in [1] focuses on the development of a wireless health monitoring prototype system with the initial emphasis on measuring the electrical activity of heart. One application in such a device would be in the monitoring of electro cardio gram activity in sleep apnea patients. They also dealt with a wireless health monitoring prototype but not applicable for a DHA, also it gives only limited information about the present condition of the patient. Paper [2] deals with a prototype of a wireless health monitoring system capable of sending SMS related to the health status of the patient. Here they monitors only the heart beat, it does not use any other sensors for monitoring other biological parameters like blood pressure and temperature. Also the system is not portable and thus would be difficult to use in disaster affected areas. Paper [3] presents a pervasive mobile health device that can help patients with life threatening allergies to manage their health in normal life and in emergency scenarios. In paper [4] they have proposed a mobile grid based health content delivery service, which can be useful for vital sign monitoring from a remote location. Even though this paper is based on web grid for monitoring biological signals in disaster affected areas the authors haven't given any details about the sensor module which can detect the body parameters of the affected person. The authors have given more importance for data transfer rather than data acquisition.

IV. PROPOSED ARCHITECTURE OF THE ENTIRE SYSTEM

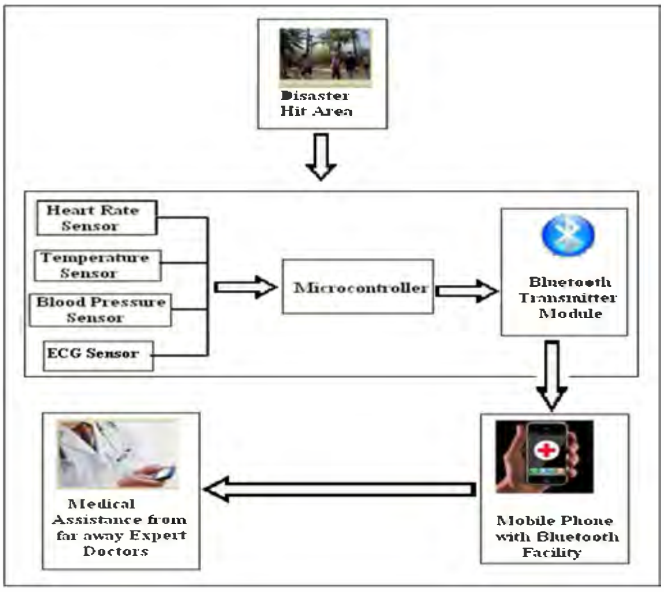

Figure1. System Architecture

The proposed system mainly has three components namely sensors, a microcontroller and a Bluetooth module. The sensors sense the vital parameters of the patient. The microcontroller, which is the core part of the entire system, is preprogrammed to directly receive the data sent from the sensors and to transmit to the Bluetooth module. The Bluetooth module plays the wireless part of the system by sending the data to the mobile phone (with Bluetooth facility) which is programmed, with a Health Monitoring Application (HMA), to receive the data send from the Bluetooth module. The mobile phone then sends the data to far away expert doctors for better medical assistance with the help GSM. The proposed system mainly considers two cases. First case is considered as worst one where WNC is not available and the second one is with the availability of WNC. The proposed system can work efficiently in both the cases [5].

A. *Two Cases in consideration*

1) *Case-1: No Network Connectivity*

This is the worst case where there is no WNC and insufficient number of doctors in the DHA to monitor and treat the affected people. In this situation the doctors can mainly monitor only the vital parameters of the patients, here with the help of sensors. The microcontroller and a Bluetooth module are being integrated to form a small system, and this system sends the data to the mobile phone through the Bluetooth transceiver. The mobile phone accepts the data wirelessly via Bluetooth which is already present in it, with the help of HMA. The HMA developed is capable of processing the data and displaying it in the phone itself. In order to send this data to far away doctors for better medical assistance we need WNC. But in this worst case condition we don’t have WNC, so we can use a mobile dish antenna that helps to communicate directly through satellites.

2) *Case-2: With Network Connectivity*

In this case network connectivity is available, so after sending the monitored data to far away doctors, they can even video chat depending on the facility of the mobile phone used, for providing better treatments for the patients. The system is easily portable. The portability of the system helps to monitor a large number of affected people in a very short span of life. Also when considering the case with heavily injured people they may need to take to hospitals. So initially they need to be provided with first aids. The proposed system could provide a better first aid based on the prescription provided by the far away doctors.

V. INTEGRATED PARTS

A. *Heart Rate Sensor*

Heart rate is the number of heartbeats recorded per minute typically recorded as Beats per Minute (BPM). The proposed system can have a reflective sensor which has the technique called Photoplethysmography (PPG). PPG is a simple and low cost optical technique that can be used to detect the blood volume changes in the micro vascular bed of tissues [6]. HLC1395 sensor is a miniature infrared sensor designed to sense reflective objects at short distances. The sensor is configured with the IRED cathode and the phototransistor emitter connected to a common lead [7]. The output voltage is of 0.50mV. Thus gets the voltage variation corresponding to the blood flow through the tissues. The heart rate is related to the blood flow and is counted with the help of a microcontroller.

B. *Temperature Sensor*

The body temperature is an important measure in determining the health status of the patient, so the temperature sensor must be sensitive to even a very small rise or fall in temperature. The proposed system uses DS18B20 which is a Digital Thermometer and Thermostat provides 9-bit to 12-bit temperature readings, which indicate the temperature of the device as in [10]. The data can be read from/written via a one-wire serial interface. The temperature value of the patient is read using the microcontroller at regular interval of time.

C. *ECG Sensor*

An ECG sensor is important for patient monitoring system because their analysis give clear information about cardiac regulation and well insight about pathological conditions. Also, the system should be user friendly, simple, reliable and of affordable cost. The three electrodes of the ECG sensor will be connected to the body. The signals pass through protection and selector circuits for protecting the sensitive amplifier from transients and ambience. These signals are then passed through multiplexers followed by a differential amplifier and band pass filter. This amplified signal is then connected to the analog input of the microcontroller, which calculates the digital equivalent of the input signal. Also a Bluetooth controller is interfaced to the microcontroller for transmission and receiving the data, commands etc from the cellular phone.

D. *Blood Pressure Sensor*

Blood pressure is an important parameter in determining the health status of patients, which leads to heart attacks, strokes and aneurysms. So diagnosing and monitoring of blood pressure is deadly important. However, it is not that easy to get reliable readings. Traditional blood pressure monitoring requires a cuff, wrapped around the upper arm and inflated until blood flow is completely cut off [6]. The examiner then gradually releases the pressure, listening to the flow until the pulse can be detected. With the new monitor no cuff is required; instead the device takes advantage of a method called pulse wave velocity, which allows blood pressure to be calculated by measuring the pulse at two points along an artery [6]. Comparing the change of pulse wave velocity to the hydrostatic pressure change, the system can automatically calibrate its measurement. The equivalent analog output signal will be read by the microcontroller.

E. *Wireless Controller*

This is one of the most important modules in the health monitoring system. It consists of a microcontroller and a Bluetooth module for interfacing the sensors with the mobile phone. The Bluetooth module makes the system simple and wireless thereby making the system an easily portable one. The microcontroller is preprogrammed to collect the data coming from the sensors. The data which contains the vital parameters of the patients are then transferred to the Bluetooth module for its wireless transmission to the mobile phone. The system uses ARDUINO BLUETOOTH BOARD which is interfaced with ATmega328 microcontroller and Bluegiga WT11 Bluetooth module. ATmega328 is a 32 pin microcontroller out of which 23 are I/O pins. It has an operating voltage of 1.8V to 5.5V and high performance RISC architecture [7]. One of its important features is its low power consumption. The microcontroller is programmed wirelessly over the Bluetooth connection.

F. *Mobile Phone*

This module plays an important role in the health monitoring system. Any basic model mobile phones that have Bluetooth facility and that supports the HMA software can be used for the system. The mobile phone basically collects the data that send from the Bluetooth module in the wireless controller and process it using the patient HMA which is to develop and send it to expert doctors for better medical assistance. If the mobile phone has the facility of video calling or video conferencing, the system can make use of it by providing the far away doctors a better idea of patient's physical condition thus by providing medical assistance accordingly in a much better way. When considering the case with affordability and productivity the system is a reasonable one.

VI. DESIGN OF THE PROPOSED SYSTEM

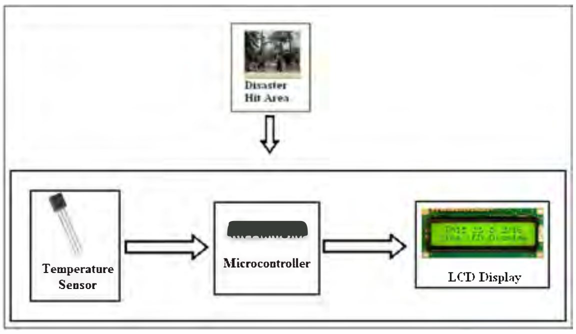

Figure2. Design of proposed system

A. *Temperature Sensor*

The human body has a remarkable capacity for regulating its temperature. The body temperature is a vital parameter in determining health status of a patient. So the temperature sensor must be able to sense even the minute temperature variations in human body. For the proposed system DS18B20 is used which is a one wire digital thermometer. The DS18B20 digital thermometer provides 9bit to 12 bit Celsius temperature measurement. The IC is available in 8-pin SO (150mils), 8-Pin SOP, and 3-Pin TO92 Packages. It has a power supply range of 3.0V to 5.5V [7]. It communicates over a 1-wire bus that by definition requires only one data line for communication with a central microprocessor. It has an operating temperature range of -550C to +1250C and is accurate to 0.5C. The temperature value of the patient is read using the microcontroller at regular interval of time [7]

B. *Microcontroller*

This is the core part of the entire system. The microcontroller is preprogrammed to collect the data coming from the temperature sensor and to display it on a LCD display board. The system used PIC16F877 microcontroller which has a high performance RISC CPU. PIC16F877 is a 40 pin microcontroller. It has an operating voltage of 2.0V to 5.5V [7]. One of its noted features is its Low power, high speed CMOS FLASH/EEPROM technology.

C. *LCD*

This is the part where the temperature is displayed which is been sensed by the DS18B20. The system used a 16x2 Display LCD board. It has features like 5 x 8 dots with cursor, + 5V power supply (Also available for + 3V), 1/16 duty cycle, B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED) [7].

VII. FLOW CHART OF THE PROPOSED SYSTEM

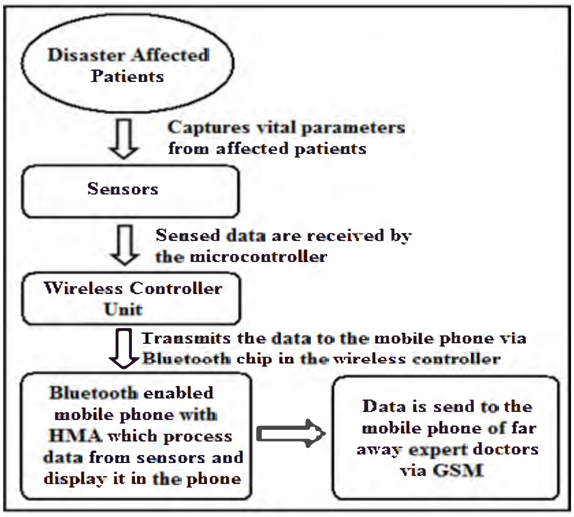

Figure3. Flow Chart

In a DHA there will be a large population of affected people. Using the sensors the vital parameters of the affected people is captured as shown in figure3. The vital parameters are received by the microcontroller which is preprogrammed and is transmitted to the Bluetooth chip inside the wireless controller unit. The Bluetooth module then transmits the data wirelessly to the mobile phone having Bluetooth facility and HMA which is capable of processing the received data and displays it in screen.

VIII. EXPERIMENTS AND RESULTS

Here Proteus 6 Professional simulator has been used for simulation purpose. The main components used are PIC16F877 microcontroller (which is the most important part that can control the rest of the components), DS18B20 temperature sensor, LM016L LCD display unit and resistors, capacitors and a LED according to the necessity. The data line of the temperature sensor is connected to RA0 pin of the controller, which is an input to the controller. And PORTC of the controller is taken as the output to PORTD of LCD display. Also a voltage of 5volts is provided according to the necessity.

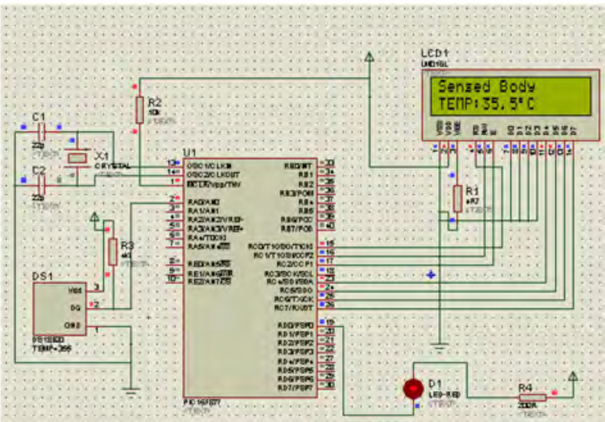

Figure 4. Simulation

IX. EXPERIMENTAL SETUP

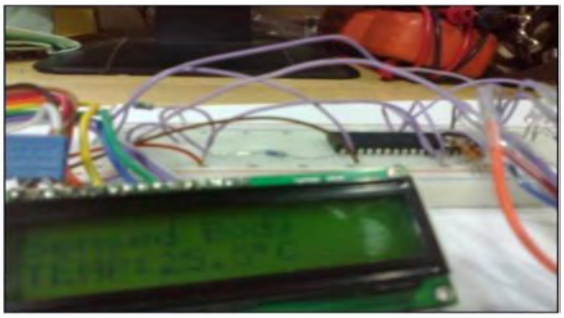

Figure5. Experimental Setup and Result

The previously mentioned simulation has been experimentally setup using the hardware components namely PIC16F877 microcontroller, DS18B20 temperature sensor, LM016L LCD (16x2) display unit, two 22pF capacitors, one 10K and two 4K resistors, one 4MHz crystal oscillator and a DC power supply. Data pin of temperature sensor is given as input to RA0 pin which is in PORTA of PIC16F877. And the output is taken from pins RC0 to RC7 which is PORTC of PIC16F877. This is given as input to pins D0 to D7 of 16x2 LCD display unit. And a DC supply of 5volts and ground are provided according to the necessities.

X. POWER MANAGEMENT OF THE SYSTEM

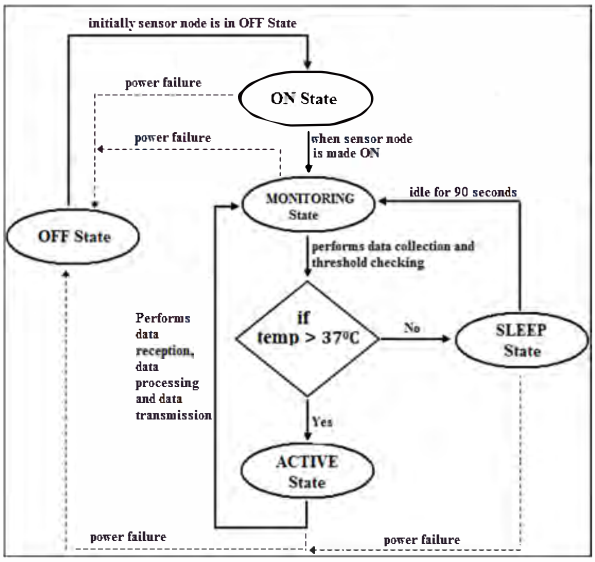

Figure5. Flow Chart

Initially the sensor node is in OFF state and when turn the sensor node ON the state of the sensor node is transitioned to the MONITORING state. In this state the sensor node is assumed to perform only data collection and threshold checking actions. If temperature>370C (threshold value) then transitioned to ACTIVE state. In ACTIVE state the sensor node is assumed to perform data reception, data processing and data transmission. After data transmission, state will be again transitioned to the MONITORING. If temperature <370C then transitioned to SLEEP State. In SLEEP state the sensor node is assumed to be idle and after 90 seconds state is again transitioned to MONITORING state. If power failure occurs then, from all other states namely SLEEP state, MONITORING state and ACTIVE state, the node is transitioned to OFF state.

A. State Transition Diagram for Power Management

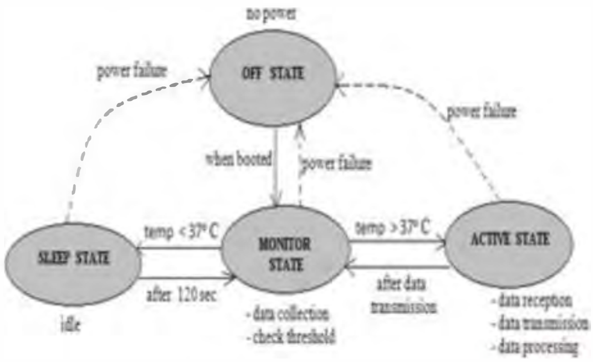

Figure 6. State Transition Diagram

In the proposed system in order to manage the power of the system, the following states are considered: OFF State, MONITORING State, ACTIVE State and SLEEP State. Initially the sensor node is in OFF state and when booted is transitioned to MONITORING state. In MONITORING state the sensor node is assumed to perform data collection and threshold checking actions. If the data collected in the MONITORING state is greater than the threshold value (37^0 C) then the state is transitioned to ACTIVE state. In ACTIVE state the sensor node is assumed to perform data reception, data processing and data transmission. After data transmission the sensor node is again transitioned back to MONOTORING state. Once if the data collected in the MONITORING state is less than the threshold value then the state is transitioned to SLEEP state. The sensor node is in the SLEEP state for 90 seconds and is again transitioned back to the MONITORING state. If in case with the power failure of the sensor node, from all the states namely SLEEP state, MONITORING state and ACTIVE state, the node is transitioned to OFF state [8].

B. Energy Optimization

Maximum energy consumption for any node is assumed as,

where is the total energy consumed by the node, is the energy consumed during data transmission, is the energy consumed during data processing and is the energy consumed during data reception.

Total energy consumed by the node in this system is,

where is the total energy consumed by the node, , , and are power consumed during MONITORING state, SLEEP state, ACTIVE state and OFF state respectively. Also , , are the fraction of time taken for each. As mentioned previously, the sensor node doesn't perform any action in the SLEEP state. So, energy consumed in SLEEP state,

Similarly, the actions performed in MONITORING state and ACTIVE state are data collection, data processing and data reception, data processing, data transmission respectively. So the energy consumed by MONITORING state is,

where and are the energy consumed during data collection and data processing respectively.

Voltage and Current consumed by the entire system is 5.5Volts and 0.3Ampere, so the total power consumed is,

$$Power = 1.65\ watts$$

$$Transmitting\ Power = 0.495\ watts$$

$$Processing = 0.0225\ watts$$

$$Sleeping\ Power = 1.8\text{x}10^{-6}\ watts$$

$$Receiving\ Power = 0.495\ watts$$

$$Total\ Power = 1.0125\ watts$$

Total time consumed by the system for monitoring the temperature of an individual is assumed as,

$$total\ time = 900 seconds$$

$$total\ energy\ consumed = 1485\ Joules.$$

Fraction of time spend in SLEEP state, MONITORING state and ACTIVE state are given below respectively,

, ,

When considering the state diagram, if the temperature is below threshold value then the energy consumed is,

So the conclusion is, without the state transition diagram the energy consumed is 1485 joules and with the consideration of state transition diagram and assuming that the temperature is below the threshold value, the energy consumed is 124.2 joules.

That indicates1360.8 joule of energy is saved with the help of state transition diagram.

C. *Energy Comparison*

Here $Energy_1$ represent the energy consumption of the system considering the state transition diagram and $Energy_2$ represents the energy consumption of the system without considering the state transition diagram.

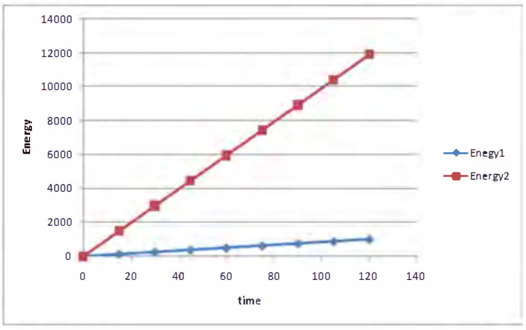

Figure 7. Energy Comparison Graph

XI. CONCLUSION AND FUTURE WORK

Accessing and providing connectivity to the DHA had already been a challenge task. Providing the people in the DHA with medical facility had been a major challenge due to the geographical constraints of the area. In such a case the proposed system is really effective. Also the portability of the system can be used to monitor a large number of populations within a short interval of time. The system also helps to provide communication with far away expert doctors for better medical assistance. HMA can be modified in such a way that it will be able to store the monitored details of each patient for any future reference. The system can be made to record the data and retrieve them whenever required by the doctors for further analysis. Also the application of the system can be used in remote areas where people don't have access to a good quality medical facilities and service of a good doctor. The application of the system can be also extended to homes also, where patients are old age people and cannot be taken to hospitals always.

ACKNOWLEDGMENT

We would like to express our immense gratitude to our beloved Chancellor Sri (Dr).Mata Amritanandamayi Devi for providing a very good inspiration and motivation for doing this research work

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