International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 6, June - 2013

Design and Implementation of Wireless Body Area Sensor Network Based Health Monitoring System

S. M. Mahalle[1], P. V. Ingole[2]
Department of Electronics & Telecommunication
G.H. Raisoni College of Engineering and Management, Amravati

Abstract: -In this paper, Design and Implementation of Wireless Body Area Sensor Network (WBASN) Based Health Monitoring System (HMS) is presented.In the era of miniature and wearable gadgets monitoring of health parameters for patient with medical warning is essential. To address the need of such patients this system is designed. The proposed WBASN usesminiaturesensors to detect the health parameters. These health parameters are then communicated to physician's server. The physician set various threshold values for the health parameters to caution the patient. The caution messages are generated by the physician's server to send back the physicians advice to the patient on his current health condition. It is found that the measurement of physical parameters are found be faithful. The communication of patient health parameters to physician server and physician advice to the patient are successfully implemented using long range wireless technology GSM.

Keywords: Wireless Body Area Sensor Network(WBASN); HMS (Health Monitoring System);GSM (Global System for Mobile Communication); Health Parameters; Miniature Sensors; Physician' server.

I. Introduction

In the area of healthcare,according to the World Health Organization's statistics, millions of people suffer from obesity or chronic diseases every day, while the agingpopulation is becoming a significant problem. With the growing needs of healthcare services and the recent advances in integrated circuits, wireless communication technology, miniaturization of sensors and internet technology, there has been considerable interest in development of wearable and wireless health monitoring systems.Wearable health monitoring systems coupled with wireless communications are the substratum of an emerging class of sensor networks: Wireless Body Area Sensor Networks (WBASNs).WBASN is one of the most promising approaches in building wearable health monitoring systems. WBASN plays an important role in enabling ubiquitous communication between the patient and the physician which targets at ambulatory health status monitoring. A typical WBASN is comprised of inexpensive,small, lightweight and miniature sensors and microcontroller unit, which wirelessly provides the physiological signals. Eachphysiological sensor is capable of measuring one or more significant physiological parameters, e.g. body temperature, heart rate, blood pressure, SpO_2 etc.These sensors could be placed strategically on thehuman body or

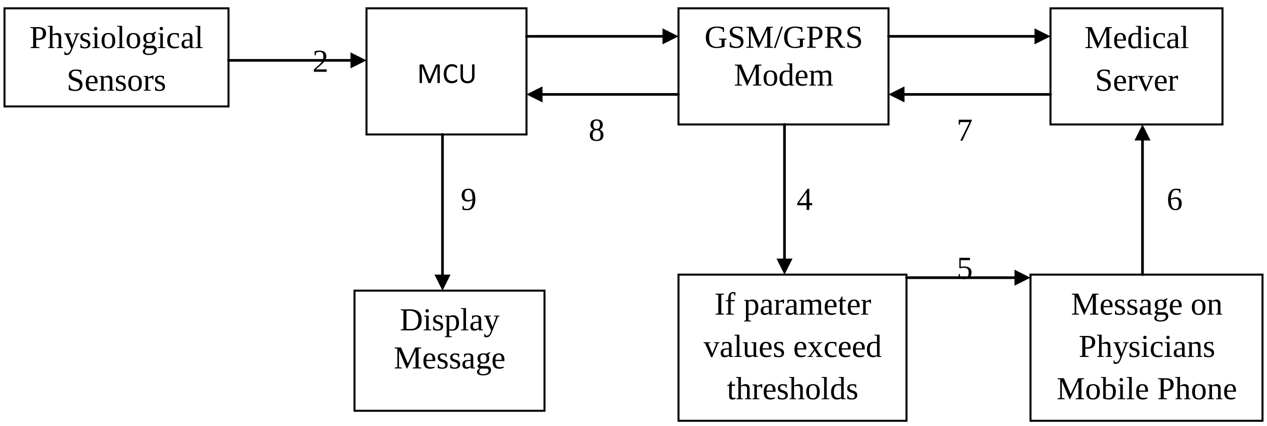

Figure 1: Data flow in WBASN based HMS

integrated into users clothing as a tiny patches allowing ubiquitous health monitoring in their native environment forextended periods of time.This offers the freedom of mobility and enhances the patient'squality of life

This wearable and WBASN health monitoring system provides an ambulatory monitoring of status of the health parameters without disturbing the daily activitiesof the patient. That means it allows health monitoring at any timeand at any location.The ambulatory health monitoring and providing the health services to the patient by physician is made possible with the help of long range wireless communication technology: GSM. In case, if the patient is not in the network coverage area, the data regarding the health parameters would be continuously collected by microcontroller unit (MCU) and then it is transmitted to the medical server as soon as patient reaches into coverage area. By examining the values of the patients' health parameters on the medical server from any location, physician can initiate healthcare action accordingly. An additional facility is also designed such that, when the values of the health parameters would cross the threshold values; message will be sent to the doctor's mobile phone as well as on the predetermined relative's mobile phone. So that doctor can access the internet immediately and provide the healthcare action accordingly. The values of the health parameters are collected by the microcontroller unit. These values of the health parameters are end to the medical server andalso are displayed on the patient side which allows an individual to observe the changes in his/her vital signals.

This paper presents design and implementation aspects of WBASN based Health Monitoring System. The remaining paper is organized as follows. System architecture is discussed in section II. This section depicts the hardware architecture and the software architecture. Section III discusses the wireless connectivity.Section IV gives the scheme of working. Experimental results are presentedin Section V. Finally section VI gives the conclusion.

II. System Architecture

In design and implementation of a WBASN based HMS to monitor the patients' health parameter status pervasively, WBASN is implemented at the patient side and the patient database is created at medical server side by maintaining a unique patient ID on both sides.It is possible to monitor hundreds' or thousands of patients at the same time by physician having this WBASN based HMS by registering and generating a unique patient ID for each patient.This

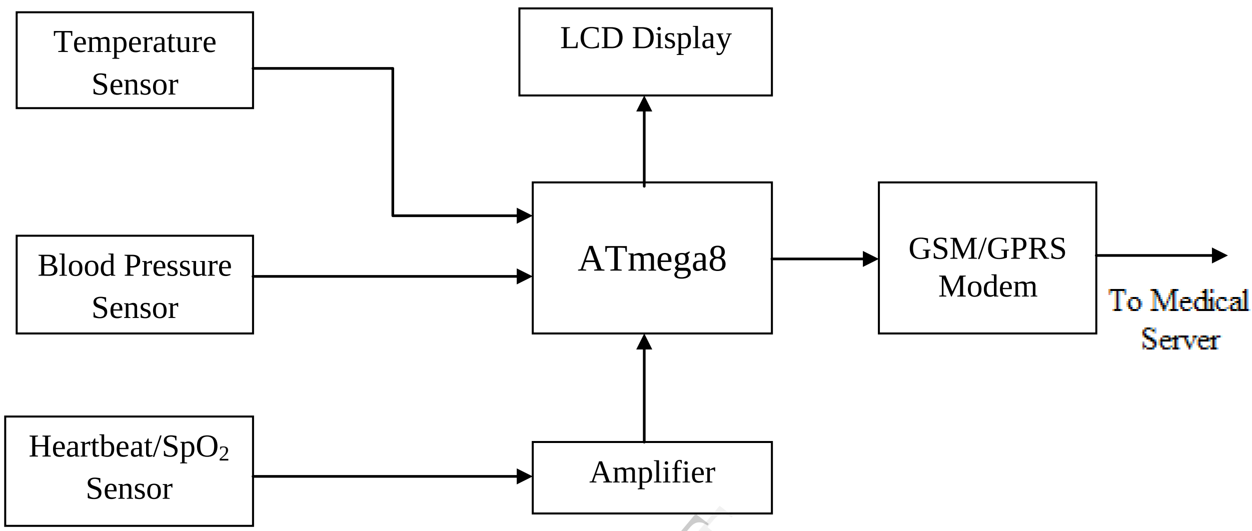

Figure 2: Block diagram of Hardware Architecture at patient's terminal

wireless health monitoring device not only receivesphysiological signals, but also transfers the physiological data through the wireless network to the back-end health management server, so that complete and continuous personal physiological records can be kept [3]. The communication between the patient server and medical server is accomplished by GSM/GPRS wireless communication technology.The typical example of data flow from patient side to the physician and from physician to patient side is shown in figure 1.

1] Hardware Architecture

Hardware architecture is implemented at the patient side. The components of the wearable and wireless health monitoring system includes miniature sensors, microcontroller, and LCD display and wireless transmission device as depicted in figure 2. The different kinds of vital sign sensors are placed strategically on human body to collect vital health signals from human body. The different vital sign sensors are pressure sensor or pressure transducer based on piezo-electrical materials for measurement of systolic and diastolic blood pressure, infrared sensors for body temperature estimation and optoelectronic sensors for SpO_2measurement and heart rate measurement.Thesephysiological sensor nodes are connected to Atmega8 microcontroller unit to continuously collect the data regarding the number of health parameters viz;body temperature, systolic blood pressure, diastolic blood pressure, heart rate and SpO_2.The communication between the vital sign sensors and microcontroller is a wired transmission. Microcontroller display the measurement results of health parameter on LCD screen and transmits the data regarding of physiological parameters to the medical server via internet using GSM/GPRS modem.When the sensor wearing patient isout of the range of transmissions of healthparameters data, the measurements of health parameters are recorded in an on-board storage medium, and can beuploaded to the server when the wearer is again back within the transmission range.In addition, Atmega8 always perform the comparison between the measured values of the patients' health parameters and the threshold values of the health parameters set by the physician, and if in case any value of measured health parameters would crosses the threshold value, then the facility is provided to send message on to physicians mobile phone and also to relative's mobilephone in case of threatening conditions. The components of wearable and wireless health monitoring system are explained as follows.

A. Temperature Sensor

The body temperature is measured by LM35, a precision integrated-circuit TemperatureSensors,whose output voltage is linearly proportional to the Celsius temperature.It is an electronic device which provides a voltage analogue of thetemperature of the surface on which it ismounted [9]. The LM35 is a 3 pin IC, pin configuration of which is shown in figure 3.
The data sensed by the temperature sensor is send to ADC at PC5 ofAtmega8 MCU through a wired transmission to convert the measured analog output voltage at pin number 3 into digital form.

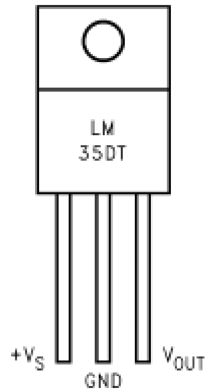

Figure: 3 Temperature Sensor

The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.Normally the body temperature for a normal human being is about 35 degree Celsius.

B. Heartbeat Sensor

The Heartbeat rate sensor provides a simple way to measure the heart rate and also provide the SpO_2value. Heart rate is measured in pulses per minute. As the heart forcesblood through the blood vessels in the finger, the amount of blood in the finger changes with time.This sensor comprise of transmitter and receiver which monitors the flow of blood and generates a pulse by placing it on a fingertip. These pulses are amplified by an amplifier which is designed using IC LM358 and whose output is connected to PD2.Timer T1 is set to count the pulses in 15 seconds and after 15 seconds interrupt INT0ofPD2 is generated on rising edge to call interrupt service subroutine, where pulses counted in 15 seconds are multiplied by 4 to calculate the heart rate per minute. When the heart beat detector is working, the beat LED flashes in unison with each heartbeat. Normal resting heart rates range from 60-100 beats per minute.At rest, an adult man has an average pulse of 72 per minute. Athletes normally have a lower pulse rate than less active

people. Children have a higher heart rate (approx. 90 beats per minute) and it exhibits large variations as well. Often it is more convenient to use a program that simply displays the pulse rate in beats per minute.
SpO_2value is calculated by simple equation: SpO_2 = Heart Rate/ 1.1.

C. Blood Pressure Sensor

Blood pressure (BP), is also referred to as arterial blood pressure, is the pressure exerted by circulating blood upon the walls of blood vessels, and is one of the principal vital signs. During each heartbeat, blood pressure varies between a maximum (systolic) and a minimum (diastolic) pressure. Pressure transducer or the sensor based on piezo-electrical material is used to measure the systolic BP and diastolic BP. The output voltage of pressure transducer is connected to ADC of PC4. The normal systolic BP range from 105-135 and normal diastolic BP range from 70-85.

D. Microcontroller

The microcontroller used is Atmega8.The program on the microcontroller, reads the value of body temperature, systolic BP, diastolic BP, heart rate and SpO_2. Then the processed output in digital form is sent to the medical server through GSM/GPRS transmission and also display on LCD screen. The microcontroller programming is done using Embedded C, a middle level language for controller units. The Atmega8 microcontroller has an Operating Speed Max 16 MHz; Voltage-(4.5 V -5.5 V). Memory consists of Flash Program memory, RAM, EEPROM and Data Memory. It has 3 ports for internal and external usage. It has three on chip Timers and in built Analog to Digital Converter. It has serial as well as Parallel Communication facilities.

E. GSM/GPRS

GSM/GPRS modem used is SIM300, a global digital mobile communication system, whosecoverage is the widest and reliability is very high. SMS (Short Message Service) is a kind ofmessage service, by which the limited data or text message can be transmitted and GPRS provides Internet service by which faster data transmissioncan be done all over the globe. A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves. GSM is the most popular standard for mobile phones in the world.Microcontroller transmits and receives the data through GSM/GPRS by connecting TxD pin of ATmega8 to RxD pin of GSM/GPRS modem and RxD pin of ATmega8 to TxD pin of GSM/GPRS modem. Like a GSM/GPRS mobile phone, a GSM/GPRS modem requires a SIM card from a wireless carrier in order to operate.

Additionally a LCD Display is provided for displaying the Physiological parameters of the patient locally for observation purpose.

2] Software Architecture

At the medical server the database is created using MySQL and PHP (Personal Home Pages). Database of patient is stored by giving unique ID to the patient having wearable WBASN based HMS. To monitor the health parameters of the patient a webpage is designed, so that the physician can access the webpage via internet at any time, any location and examine the patients' health status. To monitor the health parameters and to initiate a healthcare servicephysician should know username and password as there is a login facility for security purpose. The webpage access is limited to physicians having username and password. After performing login to the webpage, the physician can monitor the health parameters of the patient by observing the graph of each health parameter. On the same page there is a facility to send the message of healthcare and to set the threshold values to the patient by entering a patient ID. When the values of the health parameters would cross the threshold values, physician receives message (SMS) and he will access the internet to initiate a healthcare action accordingly.

III. Wireless Connectivity

The WBASN based HMS system targets at ambulatory monitoring. So it is required to use wireless communication between the patient and the physician by which it does affect the daily routine of an individual. To perform the communication or data flow from the patient to medical server or physicians mobile and the feedback flow from physician to patient wirelessly SIM300 GSM/GPRSmodem is used. Like GSM mobile phone it is necessary to insert a SIM card into this GSM/GPRS modem by activating internet facility without which data cannot be uploaded on the webpage and patient also will not be able to receive healthcare advice from physician. The kind of SMS service of GSM modem is used to send the message to physician and to patients' relative in case of threatening condition.

IV. Scheme of Working

In this section the overall working of health monitoring system is described with the help of algorithm and flowchart at patients' terminal and at medical server.

A)Algorithmatpatients' terminal:

1. Place the physiological sensors on human body and switch on the WBASN based HMS.
2. Systems display the title "Health Monitoring System Using ATmega8".
3. Display the values of health parameters such as body temperature, BP systolic, BP diastolic, heartbeat rate and SpO_2.
4. Connect to GPRS to upload the current values of the health parameters.
5. Read response from medical server.
6. Extract the message of doctor and threshold values
7. Compare current health parameters with threshold values,
   i) If current values cross the threshold values then send message to physician's number and relatives' number. And go to step 5.
   ii) If health parameters are in expected health metrics then go to step 5.

B) Algorithmat Medical Server

1. Open the webpage of Health Monitoring System.
2. Login to homepage by entering username and password in respective fields.
3. Click on each health parameter to load the recorded of points.

4. Click on "Plot Graph" tab to observe graph of respective health parameter to check the health status.
5. If values of health parameters are not in expected range of health metrics initiate healthcare action.
6. Enter patient ID in the field of "Patient Number".
7. Type message in "Message" field.
8. Set threshold values in "Threshold Values" field.
9. Click on "Send Message to Patient" to send healthcare message.

V. Experimental Results

In this setup the health parameters under observations are body temperature, blood pressure systolic (BPS), blood pressurediastolic (BPD), heartbeat rate and SpO_2. In the first experiment the faithful measurement at patient terminal and at medical server were observed and found to

Table1: Health Parameter Measurement using Physicians Equipment and WBASN based HMS

Sr.No.	**Patient Age**	**Health Parameters Measured by Physicians Equipment**					**Health Parameters Measured by WBASN based HMS**				
		Temp.	BPS	BPD	Heart Rate	SpO_2	Temp.	BPS	BPD	Heart Rate	SpO_2
1.	26	37	130	90	65	95	35	132	82	64	99
2.	15	37.5	110	60	141	93	38	128	69	156	99
3.	17	35	110	80	72	98	34	122	80	92	99
4.	40	34	130	80	73	98	37	122	81	92	99
5.	40	37	120	70	77	99	36	121	81	68	74
6.	54	37	150	100	102	98	36	118	81	108	99
7.	47	38	120	80	76	98	39	118	81	72	79
8.	80	36	130	90	84	98	35	122	81	88	96

be absolutely safe. So it can be deduced that the faithful transmission of data from patient terminal to medical server is successfully implemented.

Secondly, the patient terminal outputs are verified against the measurement of these same parameters using standard medical equipment's was found to be fairly faithful as shown in table 1. The noted variations are attributed to the conditions under which the parameters are recorded.

Thirdly, patient after wearing the WBASN gadgets was allowed to perform simple exercises so that the health parameters will vary to cross the predetermined thresholds. Our system successfully generated the relevant data and the SMS from the medical server to alert the concern physician.

VI. Conclusion

WBASN based HMS monitor vital signs and provide ubiquitous and affordable health monitoring.The proliferation of wireless and wearable devices and recent developments in miniature sensorsprove the technicalviability ofambulatory heath monitoring system.In this paper we have presented design and implementation at patients' terminal and at medical server and also the scheme of working for overall system. An unobtrusive and continual communication between patients' terminal and medical server is achieved using GSM/GPRS wireless communicationtechnology. Health parameters are continuously uploaded on medical server using GPRS service.Any abnormalities in health conditions are informed via SMS to the indicated mobilenumber through GSM.

WBASN based health monitoring system prove that Internet has changed the way people communicate to each other and allowan individual to manage their health in a better manner. We believed that wearable and wireless health monitoring system has potential to provide a better quality of life with self-management of chronic diseases.

References:-

[1] Qiang Fang, Shuenn-Yuh Lee, Hans Permana, Ghorbani, and Irena Cosic "Developing A Wireless Implantable Body Sensor Network In MICS Band," IEEE Transactions on Information Technology in Biomedicine, Vol. 15, No. 4,pp 567-576 , July 2011

[2] AlexandrosPantelopoulos and Nikolaos G. Bourbakis, "A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis," IEEE Transactions on Systems, Man, and Cybernetics—Part C: Applications And Reviews, Vol. 40, No. 1, pp 1-12 January 2010

[3] Chung-Chih Lin, Ren-GueyLeeb, Chun-ChiehHsiaoc, "A pervasive health monitoring service system based on ubiquitous network technology," International Journal of Medical Informatics 77, pp 461-469, (2008)

[4] Chris Otto, AleksandarMilenković, Corey Sanders, Emil Jovanov "System Architecture Of A Wireless Body Area Sensor Network For Ubiquitous Health Monitoring," Journal of Mobile Multimedia, Vol. 1, No.4, pp 307-326, (2006)

[5] Emil Jovanov, "Wireless Technology and System Integration in Body Area Networks for M-Health Applications,"Engineering in Medicine and Biology Society, 2005. IEEE-EMBS 2005, Conference Publications,pp7158– 7160, 17-18 Jan. 2006

[6] Royal College of Physicians,"National Early Warning Score (NEWS): Standardising the assessment of acute illness severity in the NHS," Report of a working party. London: RCP, pp 1-29, 2012.

[7] R.S.H. Istepanian, E. Jovanov, Y.T. Zhang, "Guest Editorial Introduction to the Special Section M-Health: Beyond Seamless Mobility and Global Wireless Health-Care Connectivity," IEEE Transactions on information technology in biomedicine, vol. 8, no. 4,pp 405-414 December 2004

[8] AleksandarMilenkovic, Chris Otto, Emil Jovanov, "Wireless sensor networks for personal health monitoring: Issues andan implementation," Computer Comm. 29, pp2521–2533**,** (2006)

[9]S.JosephineSelvarani , "Online Health MonitoringSystem Using Zigbee," International Journal on Computer Science and Engineering (IJCSE),Vol. 3 No. 4, pp 1578-1583, Apr 2011

Shweta M. Mahalle received B.E. degree in Electronics and Tele comm. engineering from S.G.B. Amravati University, Maharashtra, India, in 2010.She is currently working toward the M.E. degree in Electronics and Telecommunication at G.H. Raisoni College of Engineering and Management, Amravati, S.G.B. Amravati University India. In June 2011 she joined the faculty in Electronics & Telecommunication DepartmentatS.G.B. Amravati University, India. Her research interests include wireless body area sensor networks, wireless communication, and wearable and wireless health monitoring system. She is a Life Member of IETE.

Dr. Prashant V. Ingolereceived his B.E. degree in 1989 in Electronics Engineering and M.E. degree inAutomatic Control and Robotics from College of Engineering Badnera, Amravati University, Amravati and Faculty of Engineering and Technology M.S. University Baroda respectively. He received his PhD degree in 2010 from Visvesvaraya National Institute of Technology, Nagpur in the area of Medical Image Processing and Image Retrieval. He worked as Lecturer, Assistant Professor and Professor at P.R.M.I.T. & R., Badnera (Formerly College of Engineering, Badnera). Currently, he is working as Principal of G.H. Raisoni College of Engineering and Management, Amravati. He has more than 30 research papers in his credit in National and International Conferences and Journals. His research interests include Digital Signal Processing, Soft Computing, Image Processing, and Embedded System. He is a fellow of IETE and IEI and a Life Member of ISTE.