Multi-parametric Telemetry Patient Monitoring System

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Abstract- This proposed system explains the wireless body sensor network based on ZigBee technology and GSM Platform. It is mainly used for collection and transmitting the various monitoring information or physiological parameters using Temperature Sensor, Heart Beat Sensor, Blood Presser, and ECG about the patients in hospitals or in their homes to an assigned medical doctor or practitioner. Here the physiological parameters or conditions of the subjects or the patients are monitored by sensors and the output of these sensors is transmitted via Zigbee-GSM communication medium and the same has to be sent to the remote wireless monitor for acquiring the observed patient's physiological signal. The measured signal is sent to a PC, or mobile phone through the wireless transmission. The first procedure of the system is that the wireless sensors are used to measure Heart rate, temperature, blood pressure, and ECG waveform monitoring from human body using Zigbee. The measured signal is sent to the PC or mobile phone via the RS-232 serial port communication interface.

Index Terms- ECG; GSM-ZigBee Platform, Mobile phone; Telemedicine

I. INTRODUCTION

Technology has brought a lot of transformation to the medical field. Thus Wireless sensors and sensor networks have become a powerful tool to research, scientific and technological world. Though sensor networks have been with us or in existing for more than a few decades now, the wireless domain has opened up a whole new application space of sensors [1]. Wireless sensing units combines or integrate wireless communications and mobile computing with transducers to deliver a sensor platform which is cost effective to install in many applications. Indeed, integrating computational power and radio frequency (RF) communication within the sensor unit itself is a distinct feature of wireless sensing. In this contemporary world, the progress in science and technology provides portable, miniaturization, speed, intelligence, sophistication, and new materials at lower cost, giving development of various high-performance smart sensing system. Many new research is going on that are geared towards improving accessibility and quality of human life in terms of health by designing, developing and fabricating sensors which are either in direct contact with the human body (invasive) or indirectly(non-invasive) [2]. This leads in a requirement for medical care,[3] which is expensive for long-term monitoring and long waiting lists for consultations with health professionals. The cost of hospital care is ever going up, so is the cost of rehabilitation after a major illness or operation. Hospitals are considering sending patients back home as soon as they recover. During this recovery period or time, many physiological parameters need to be continuously monitored and measured. Hence, telemedicine and remote monitoring of patients is becoming added importance and urgency [4]-[6]. Patients are being monitored using a network of wireless sensors [7]. Many old age people anticipate with great apprehension of the idea of being forced to live with their adult children, or in a rest home or in other sheltered living environment. They want to live independently and keep managing their own lives. Yet at the same time they know there is a high tendency of injury or even death because of a fall, strange disease or stroke. Such people need to be monitored continuously and provided with immediate medical care and attention when the need arises. A system to monitor the overall health of resident's patients who need constant health- care, have been designed. [5], this system has been designed with wireless sensors, wireless repeaters and a host computer [8]. The system consists of sensors, Zigbee–GSM platform, a microcontroller, and a low power transceiver. It records respiration activity and indicators of other parameters as being configured. These data are transmitted to the wireless repeater by the transceiver. The wireless repeaters, which are installed throughout the welfare facility, send data, including the repeater's ID, to the host computer. The ID is used to detect the resident's patient in that home [4].The host computer stores the data, which can be used to analyze the resident's patient overall health condition [12]. When the patient is in an emergency situation, such as falling or in an inactive state for more than the allotted time, the host computer automatically alerts the situation to the care physician by an alarm sound and also by mobile phone [13] and action is now taken to save the patient due to the responses of patient monitoring system [16]. Moreover, almost all the existing systems are relatively expensive and the cost depends on the number of sensors used and this has led to the development of home based monitoring system with, optimum number of sensors [15].These facts show an increasing demand for long-term health monitoring and measurement which is affordable, continuous, and effective which will have strong impact on healthcare management system. [10], [14]. Wearable systems for continuous health monitoring are a key technology in helping the transition to more practical, effective, high quality and affordable healthcare. [11] This does not only allows the user or the patient, subject to closely monitor changes in his or her physiological parameters but also gives feedback to help monitor and maintain an optimal health-care status. This is the novel design goal of the work presented in this system.

II. SYSTEM'S OVERVIEW

A. Zigbee Technology

The diagram of a Transmitter/Receiver of a ZigBee module is shown in Figure 1. This is redolent of the invisible webs of connections existing in a fully wireless environment [33]. ZigBee is the name of a specification for a suite of high level communication protocol using small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs), such as cell phones via short-range radio[33]. The technology is intended to be simpler and cheaper than other WPANs, such as Bluetooth. ZigBee is targeted at radio- frequency (RF) applications which require a low data rate, long battery life, and secure networking. In the present work point to point communication between 40 to 120 meters. The power of ZigBee module is about 2mW when running operation and lower than 1 micro-watt when is in sleep operation modes [34].

FIGURE 1 Zigbee Technology

B. Body Temperature Measurement

Thermistor (bead type) is used for the measurement of body temperature and respiratory temperature. Thermistor is a passive transducer, resistance of which varies inversely with temperature. In the present work thermistors are mounted on the surface of the body (on hand) and near the nose as compliment to LM35and are connected in a potential divider circuits with an excitation voltage. Resistance of the thermistors varies with body temperature which leads change in the output voltage. The output voltage is conditioned, processed, transmitted, displayed and recorded over a distant PC. If the body temperature exceeds the normal temperature and if it is found to be of risk for the wellbeing of a patient, an alarm will be triggered by the system to give a caution to doctors. Measurement of airway temperature may help in the respiratory gas concentration monitoring. The change in the composition of respiratory gas stream may give rise to significant alteration in the thermal conductivity of the stream, and lead to rise or fall in temperature of the element in the path. The thermistor placed at the nostrils will detect the changes in temperature, which enable the system to monitor the changes the composition of the respiratory gases, in particularly the changes in the concentration of CO2.

C. Software Implementation

The designed and developed multi-parametric patient monitoring system requires appropriate software to provide useful diagnostic information and display of important parameters. After initialization of PIC microcontroller and COM port, the data about ECG, pulse rate, temperature and blood pressure are acquired through signal conditioning unit and their outputs are displayed. An extra feature is also incorporated for patient's advantage such as information about the availability of skilled person / nurse with name and other details.

D. Design Software

National Instrument Multisim

Multisim is the schematic capture and simulation application of National Instruments Circuit Design Suite, a suite of EDA (Electronic Design Automation) tools that assists you in carrying out the major steps in the circuit design flow. Multisim is designed for schematic entry, simulation, and feeding to downstage steps, such as PCB layout.

E. Simulator Software Used

MPLAB

MPLAB simulator is debugging software designed to stimulate the operation of the PIC microcontroller families. This microcontroller is the main heart of the system. It's a reprogrammable flash memory device, which has been programmed for such application. The patient body temperature, blood pressure, ECG, heart beat results are display in LCD display using wireless Zigbee communication. Should there be any problem, this activated the alarm circuit to make audible sound.

The system has already been stored on normal body level condition to microcontroller, there are four sensors that will aid in obtaining the signal from the patient body and send the signal to PIC via amplifier and signal conditioned unit. Then microcontroller sends the signals to PIC microcontroller via Zigbee wireless one transmitter and one receiver. Then this controller sends the signals to LCD and alarm circuit. Driver circuit is used to activate the alarm circuit .

F. System Hardware Design.

Circuit Operation

The circuit is made of four sensors, namely Temperature sensor, Heart beat sensor, Blood pressure sensor, ECG sensor. All sensors are attached to Zigbee via 8051 microcontroller. These sensed data go to microcontroller for further processing before transmitting through Wireless Zigbee network. After the initialization of all the sensors, each of the sensors will continuously check for the data. Each node after obtaining the real time data will send the data to Zigbee via microcontroller. Zigbee is used here in RF module configuration [30]. In receiver part, the sensed real time data will be received by another Zigbee for analysis purpose. The Data received is sent to microcontroller for control action. Here limits are defined for each of the sensor node according to the requirements and can be change with the progress in patient. After checking for the limits, status of the patient under supervision will be known. If the data is more than the limits defined, status is Abnormal and if less than or equal to the limits defined, status is Normal depending on the configuration limit input.

After this comparison of the values, Alert system comes into action. Alert system includes LCD display, and PC display. The data from microcontroller will be sent to LCD HDD44780 which is a 14 pin display, PC display through serial communication modem. For serial communication through RS232 standard, MAX232 IC is used. This IC is used to make RS232 voltage levels compatible with microcontroller levels. To receive the data serially and for capturing the real time data on PC, HyperTerminal is used. Either the abnormal or Normal data will be sent to PC and LCD unit. The receiver section is placed at the staff level so that they can check for the status of the patient and can take appropriate action. Buzzer alarm is used to alert the staff.

E. Hardware Design

The system hardware design is classified into two categories: the Transmitter and Receiver sections. The Transmitter will be placed near the patient. The receiver section is placed at the staff level so that they can check for the status of the patient and can take appropriate action.

In the transmitter section, the following sensors are used;

1. Body Temperature sensor.
2. Heart Beat sensor.
3. Blood pressure sensor.
4. ECG Reading.

These sensors and wireless technology with the help of Microcontroller are used continuously to monitor the vital signs until an abnormal condition is detected. After the initialization of all the sensors, each node after obtaining the real time data will send the data to Zigbee via microcontroller.

III. TRANSMITTER SECTION DESIGN

All the Transmitter section sensors are attached to Zigbee via 8051 microcontroller as the brain of the system. Temperature sensors used is LM35 which is a precise integrated-circuit sensor which output voltage is linearly proportional to Celsius temperature.

The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. The blood pressure sensor uses the MPX2010 pressure transducer. This element has a membrane that flexes as pressure changes. It is arranged to measure differential pressure. Essentially, the action potentials from different nodes in the heart are what make up electrocardiograph (ECG) signals. ECG signals are comprised of the superposition of the different action potentials from the heart beating. Lastly, to measure Heart beat in Beats per Minute (BPM) rate, Heart beat sensor by Sunrom Technologies is incorporated here [29]. It is a digital heart rate monitor and is compact in size. All these sensors are the basic requirements of general ward patients so as to provide healthy environment and care to them in hospitals. Then, the sensed data will go to microcontroller for further processing before it is transmitted through Wireless Zigbee network. The combination of the following (A/D converter, microcontroller and Zigbee) being considered as Transmitter parts and will be placed near the patient.

IV. RECEIVER SECTION DESIGN

After the initialization of all the sensors, each of the sensors will continuously check for the data. Each node after obtaining the real time data will send the data to Zigbee via microcontroller. Zigbee is used here in RF module configuration [30]. In receiver part, the sensed real time data will be received by another Zigbee for analysis purpose. The Data received is sent to microcontroller for control action. Here limits are defined for each of the sensor node according to the requirements and can be changed with the progress in patient. After checking for the limits, status of the patient under supervision will be known. If the data is more than the limits defined, status is Abnormal and if less than or equal to the limits defined, status is Normal.

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A. Signal Conditioner Unit

The signal conditioning unit accepts input signal from the analog sensors and gives conditioned output of 0-5V DC corresponding to the entire range of each parameter.

B. Circuit Alarm

An alarm gives audible with visual LED blinks about a problem or condition. An amplifier can also be considered the driver for buzzer, or a constant voltage circuit that keeps an attached component operating within a broad range of input voltages. The circuit is designed for possible control of the buzzer. The buzzer ON and OFF is controlled by the transistor. When high pulse signal is given to the base of the transistor, the transistor is conducting and closes the collector and emitter terminal via buzzer, hence the buzzer is ON. When high pulse signal is given to base of the transistor, the transistor is conducting. There will be no current flowing through the transistor so the buzzer will be OFF.

C. LCD Display

Liquid Crystal Display (LCDs) displays information about the patient's status. This helps to actually understand the condition of the patients when the alarm sounds. The interpretation of the alarm is given meaning by the LCD. LCD display is shown in figure 2.

Figure 2. LCD Display

V. RESULTS AND DISCUSSION

Firstly, blood pressure of the subject was taken. When the blood pressure go variance with the threshold (120mmhg/80mmhg) then the condition is identified as abnormal and an alarm will sound indicating the critical condition of the patient. Also, sensed signals were observed through Personal Computer (PC) and Liquid Crystal Display (LCD) for thorough understanding of the alarm.

Secondly, heart rate of the subject was taken. When the heart rate goes out of the 72 beats per second threshold, the condition was identified as abnormal. Also sensed signals were observed through Personal Computer (PC) and Liquid Crystal Display (LCD), to correspond with the sounding of the alarm through simulation.

Thirdly, temperature measurements of the subject were taken, should the temperature goes below or above the normal condition, and this indicates that the patient is in abnormal condition. The following simulation waveform figures show the blood pressure, heart beat rate, the ECG and temperature respectively. Hence, research is considered successful.

Simulation Waveforms

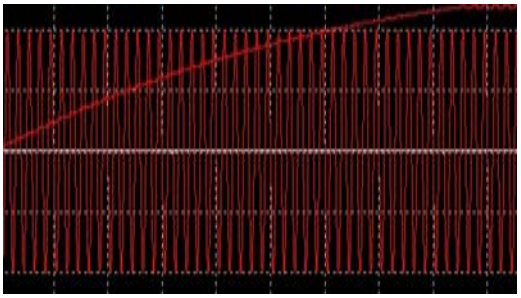

Figure 3. Blood Pressure Waveform

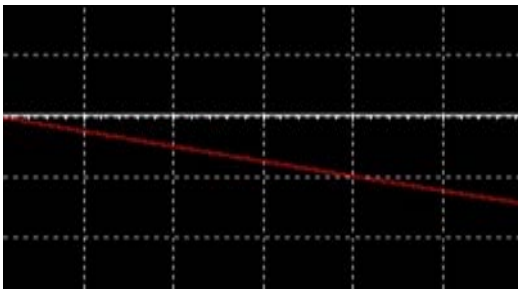

Figure 4. Heart Rate Waveform

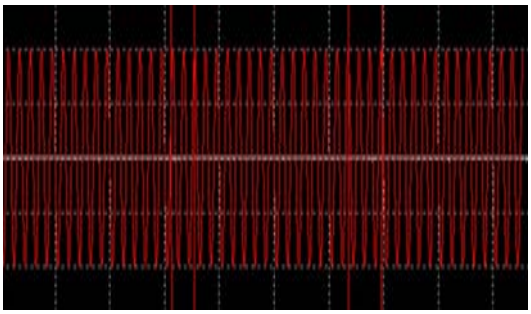

Figure 5. ECG Waveform

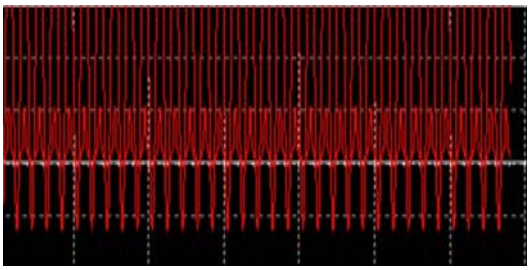

Figure 6.Temperature Waveform

VI. CONCLUSION

The work presented reveals that, a wireless health monitoring system is achievable to transmit and receive data for an immediate action to be taken according to the simulation results been obtained. This system provides effective solution to upgrade the existing health system by using different kind of sensors mounted on a single system. Besides, this system is based upon wireless technology, Zigbee IEEE 801.15.4 providing low cost effective solution. The system consisting of 8051 microcontroller support and one can set values according to the requirement of the patient under consideration. The parameters can be modified as the patient's condition improves with time of recovery and meaningful monitoring of patients health can be assured in a remote distance. As the parameters can be modified, this system will be unique for multiple applications, thus the system is convenient and efficient in nature and will improve interaction between patient and doctor and ultimately to avoid unexpected tragedy. The unique combination of sensors, wireless standard and microcontroller will eliminates

the barriers in patient health monitoring to enhance practical health delivery

REFERENCES

[1] J. L. Weber and F. Porotte, "Medical remote monitoring with clothes," in PHealth, Luzerne, Jan. 2006, vol. 31, pp. 246-252.
[2] J. M. Wilkinson, "Medical market for Microsystems," Int. Newsletter Microsyst. MEMS, no. 4/02, p. 37, Sep. 2002.
[3] Y. Hao and J. Foster, "Wireless sensor networks for health monitoring applications," Physiological Meas., vol. 29, no. 11, pp.R27-R56,2008.
[4] A. Pantelopoulos and N. Bourbakis, "Design of the new prognosis wearable system-prototype for health monitoring of people at risk," in Advances in Biomedical Sensing, Measurements, Instrumentation and Systems, S. C. Mukhopadhyay and A. Lay-Ekuakille, Eds. : Springer-Verlag, 2010, vol. 55, Lecture Notes in Electrical Engineering, pp. 29-42.
[5] S. Ohta, H. Nakamoto, Y. Shinagawa, and T. Tanikawa, "A Health monitoring system for elderly people living alone," J. Telemedicine and Telecare, vol. 8, no. 3, pp. 151-156, Jun. 2002.
[6] A. Dittmar, F. Axisa, G. Delhomme, and C. Gehin, "New concepts and technologies in home care and ambulatory monitoring,"Studies in Health Technol. Inform., pp. 9-35, 2004.
[7] F. Rahman, A. Kumar, G. Nagendra, and G. Sen Gupta, "Network approach for physiological parameter measurement," IEEE Trans. In-strum. Meas., vol. 54, pp. 337-346, Feb. 2005.
[8] E. Jovanov, D. Raskovic, J. Price, J. Chapman, A. Moore, and A. Krish-namurthy, "Patient monitoring using personal area networks of wireless intelligent sensors," Biomed. Sci. Instrum., pp. 373-378, 2001.
[9] M. Scholtz, "Addressing the global demands for improved healthcare," in Proc. Telemedicine 21st Century, Opportunities Citizens, Society, Industry, 1999, pp. 11 -18.
[10] Eastern Michigan University, "Lock-in amplification overview."[Online].Available: http://www.physics.emich.edu/molab/lockin/index. html
[11] H. Maki, Y. Yonczawa, H. Ogawa, H. Sato, A. W. Hahn, and W. M. Caldwell, "A welfare facility resident care support system,"Biomed.Sci. Instrum., pp. 480^183, 2004.
[12] K. Malhi, "Wireless sensors network based physiological parameters monitoring system," M.S. THESIS, MASSEY UNIVERSITY,Palmerton, New Zealand, 2010.
[13] Fall Detection Sensor System, Swiss Centre for Electronics and Mi-crotechnology (CSEM). [Online]. Available: www.csem.ch
[14] A. Lymberis, "Smart wearable systems for personalized health management: Current R&D and future challenges," in Proc. IEEE25th Ann. Int. Conf.: EMBS, Sep. 2003, vol. 4, pp. 3716-3719.
[15] A. Gaddam, S. C. Mukhopadhyay, and G. Sengupta, "Smart home for elderly using optimized number of wireless sensors," in Advances in Wireless Sensors and Sensors Network. : Springer-Verlag, 2010, vol. 64, Lecture Notes in Electrical Engineering, pp.307-328.
[16] N. Hamza, F. Touati, and L. Khriji, "Wireless biomedical system design based on ZigBee technology for autonomous healthcare," in Proc. Int. Conf. Commun., Comput., Power (ICCCP'09), Muscat, Feb. 15-18, 2009, pp. 183-188.
[17] Shyr-Kuen Chen, Tsairkao, Chai- Tai Chan, Chih-Ning Huang, Chih-Yen Chiang, Chin-Yu Lai, A Reliable Transmission Protocol for ZigBee Based Wireless Patient Monitoring‖ IEEE Trans Inf. Technol. Biomed.,vol.16,No.1 JANUARY 2012.
[18] K. Kinsella and W. He, ―An aging world: 2008,‖
[19] International Population Reports, U.S. Census Bureau, Washington, DC, Tech. Rep. P95/09-01, 2009. 3. J. S. Choi and M. Zhou, ―Performance analysis of Zigbeebased body sensor networks,‖ in Proc. IEEE Conf. Syst., Man Cybern.,2010, pp. 2427–2433.
[20] Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou ShenHsinchu, Taiwan ―A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi,‖ The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON) Nov. 5-8, 2007, Taipei, Taiwan.
[21] ZigBee Alliance Chairman Bob Heile's October 2008 ZigBee Alliance Member Meeting Presentationlow-
[22] E. Jovanov, A. O'Donnel, A. Morgan, B. Priddy, and R. Hormigo, ―Prolonged telemetric monitoring of heart rate variability using wireless intelligent sensors and a mobile gateway,‖ in Proc. Eng.Med. Biol., 24th Annu. Conf. Annu. Fall Meet. Biomed.Eng. Soc. EMBS/BMES Conf., 2002. Proc. 2nd Joint, oct. 2002, vol. 3, pp. 1875–1876.
[23] Balambigai Subramanian AsokanRamasamyEfficient Zigbee Based Health Care System for Arrhythmia Detection in
[24] Electrocardiogram EJSR1450-216X Vol.69 No.2 (2012), pp. 180-187
[25] D.J.R.Kiran Kumar, NaliniKotnana Design and Implementation of Portable Health Monitoring system using PSoC Mixed Signal Array chip (IJRTE) 2277-3
[26] . http://www.sunrom.com
[27] CDC - http://www.cdc.gov/nccdphp/overview.htm
[28] A precision low-level DAS/ECG Cardiotachometer Demo Board, a Texas Instruments technical presentation created by John Brown.
[29] ECE 445 Biopotential amplifiers prepared by Professor Andrew Mason
[30] .Lighting Design Lab. (n.d). Lighting Design Lab Articles-Occupancy sensor method of operation. Retrieved February 26, 2012, from Lighting Design Lab: htto://www. Lightingdesignlab.com/articles/occ_sensor/method_open.htm
[31] Heart Beat Sensor. http://www.sunrom.com/files/1157-datasheet.pdf
[32] XBee/XBee-PRO OEM RF Modules. http://www.nexrobotics.com/images/downloads/Manual_xb_oem-rf-modules_802.15.4.pdf.
[33] J.B.Peatman, "Design with PIC Microcontrollers'', PHI 1998.
[34] Barrnett C and Cull, "Embedded C programming and the microchip PIC', Thomson Publications 2004.
[35] N. Watthanawisuth, T. Lomas, A. Wisitsoraat, A.Tuantranont, "Wireless Wearable Pulse Oximeter for Health Monitoring using Zigbee Wireless Sensor Network'', Nanoelectronics and MEMS Laboratory, National Electronics and Computer Technology Conference on Computer, Mechanical, Control and Electronic Engineering (CMCE)., pp.172-175,2010.Center (NECTEC)., Pathumthani, Thaiiand 12120
[36] Wang Feng Qin, Li.Yang "Zigbee Technology for Designing and Implementing aEemote Medical Monitoring System'', International Conference on Computer, Mechanical, Control and Electronic Engineering (CMCE). pp.172-175,2010.
[37] M. Arumugam, "Biomedical Instrumentation", N. Dhanalakshmi Publication, 2006.
[38] Nagashima T, "Expiratrory ventilation and carbon dioxide production measured with a thermistor flow-through system", Nihon kyobuShikkanGakkaiZasshi (Japanese), vol. 34, n0.3, pp.281-289, 1996. PMID: 8778467.
[39] R.S. Khandpur, "handbook of Biomedical Instrumentation", Tata McGraw Hill, 2004.

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