Zigbee based Wireless Body Area Sensor Network for patient's physiological parameter monitoring

Mr. Akash Chouksey[1], Dr. Soni Changlani[2], Prof. Saiyed Tazen Ali[3]
#Department of Electronics and Communication Engineering
Lakshmi Narain Collage of Technology & Science Bhopal

Abstract: **This paper describes the design of a wireless body sensor network based on zigbee technology(IEEE 802.15.4)) for monitoring of patients physiological parameter monitoring like ECG, Body Temperature, Heart Beat, Blood Pressure It is mainly used for collecting and transferring the various monitoring information about the patients in hospitals to doctors or in their homes. This application consists of Zigbee based network,\ and four types of sensors ECG, Body Temperature, Heart Beat, and Blood Pressure sensors.**

Keywords: **Zigbee, Medical monitoring, Sensor Node, Heart Rate, Temperature, ECG (Electrocardiogram), Blood Pressures, Mat lab GUI**

I. INTRODUCTION

About the patients in hospitals or in their homes by using Body Area Sensor Network. This application consists of Zigbee based network, four sensors ECG (Electrocardiogram), Body Temperature, Heart Beat, and Blood Pressure. It is mainly used to monitor ECG, Body Temperature, Heart Beat, and Blood Pressure of patients. all sensors are connected to microcontroller and LCD. Data is digitized with microcontroller and send to a computer by using Zigbee transreceiver where Mat Lab based window represent it graphically shows the patients current status at receiver.

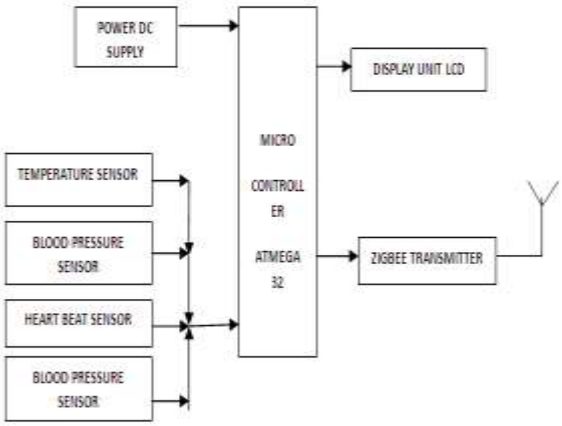
II. LITERATURE REVIEW

Currently, a number of studies have been proposed to patient's physiological parameter monitoring over wireless transmission. Patient monitoring systems [1] are gaining their importances the fast-growing Global elderly population increases demands for caretaking. These systems use wireless technologies to transmit vital signs for medical evaluation**.** According to Kinsella and He's [2] report from the US Census Bureau, the global elderly population is fast growing and will outnumber the population of children in near future. The aging society is bringing its impact on many developing countries and presents a stark contrast with the low fertility rate of these countries. The changes brought about by the aging society include an increasing demand for caretaking; thus, patient monitoring systems are gaining their importance in reducing the need for human resources. Caretaking homes and hospitals have been planning on the use of biological sensors to effectively minister to their patients. Vital signs, such as body temperature, blood pressure, and sugar level, can be regularly collected and remotely monitored by medical professionals, achieving a comprehensive caretaking system. ZigBee [3] is an open standard technology to address the demands of low-cost, low-power WMNs via short range radio. ZigBee [4] is targeted at RF applications that require a low data rate, long battery life, and secure networking. Its mesh networking also provides high reliability and more extensive range. The ZigBee devices can be combined with WWANs to achieve a seamless platform of wireless patient monitoring.
It is the basis for the ZigBee.Varshney [5] proposed a framework of patient monitoring systems, including patient monitoring devices, ad hoc wireless networks, and the receivers for healthcare professionals. This framework uses four routing schemes (multicast, reliable multicast, broadcast, and reliable broadcast) and several enhancing schemes to improve the transmission reliability over wireless ad hoc networks. Jovanov *et al.* [6] present wireless distributed data acquisition system. The system uses personal digital assistant as a mobile client to acquire data from individual monitors and synchronizes collected records with existing records on the telemedical server. Each client device uses local flash memory as a temporary storage until reliable connection with a mobile client is established.

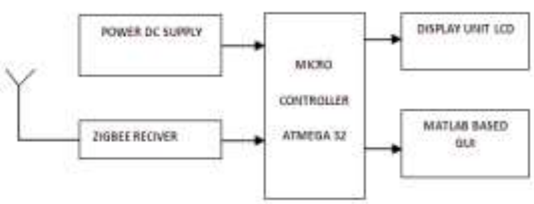
III. SYSTEM OVERVIEW

Patient monitoring systems become a important topic and research field today because of fast-growing global elderly population increases demands for caretaking This paper describes the wireless body sensor network based on ZigBee technology. It is mainly used for collecting and transferring the various monitoring information using ECG Sensor, Body Temperature Sensor, Heart Beat Sensor, Blood Pressure Sensor about the patients in hospitals or in their homes. It is mainly used to monitor patient's ECG (Electrocardiogram), Body Temperature, Heart

Beat, and blood pressures, Matlab based window represent it graphically shows the patients current status.



Transmitter Section



Receiver Section

Figure1. Block Diagram of Transmitter and Receiver for Wireless Patient Monitoring using zigbee

IV. HARDWARE

In above system hardware used is Zigbee, Microcontroller atmega32, Heart -Beat sensor, ECG Sensor, Temperature Sensor. Blood Pressure Sensor, and Temperature Sensor and LCD.

A. ZIGBEE

Range of Zigbee is from 30 meters-1km.The technology is intended to be simpler and less expensive than other WPANs such as Bluetooth and Wi-Fi. Its protocols are intended for use in embedded applications requiring low data rates and low power consumption. Its current focus is to define a general-purpose, inexpensive, self-organizing mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, etc. Specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones. This allows ZigBee networks to be formed ad-hoc, with no centralized control or high-power transmitter/receiver able to reach all of the devices. It is targeted at applications that require a low data rate, long battery life, and secure networking. It has a defined rate of 250kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. Consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. Transmission rates vary from 20 to 900 Data rates of 250 kb/s, 40 kb/s and 20 kb/s Home networking, automotive networks, industrial networks, interactive toys, remote metering, battery-operated products, building automation, personal healthcare, industrial control, residential or light commercial control, consumer electronics, PC and peripherals, etc.

IEEE 802.15.4

Its license free frequency bands are:

I. 2.4 GHz (16 channels with baud rate of 250 kbps)
II. 902 MHz – 928 MHz (10 channels with baud rate of 40 kbps)
III. 868 MHz- 870 MHz (1 channel with baud rate of 10 kbps)

North America, Australia, Europe and New Zealand use the 1 GHz bands whereas the rest of the world uses the 2.4 GHz bands.

Zigbee/IEEE 802.15.4 Architecture

Figure 2 shows the architecture of Zigbee which consists of Application, Zigbee alliance, IEEE 802.15.4 MAC and PHY. layers

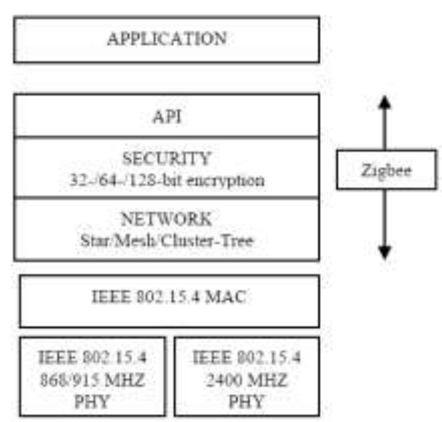


Figure2. Architecture of Zigbee/IEEE 802.14.5

Zigbee Alliance

The Zigbee alliance consist of API, security which includes 32-/64-/128- bit encryption and network which includes star, mesh and cluster tree. Above this layer is application layer.

B. ATMEL ATMEGA32 MICROCONTROLLER

The Atmel ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed. The ATmega32 provides the following features: 32Kbytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 1024bytes EEPROM, 2Kbyte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for Boundary scan, On chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented. Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential Input stage with programmable gain, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes.

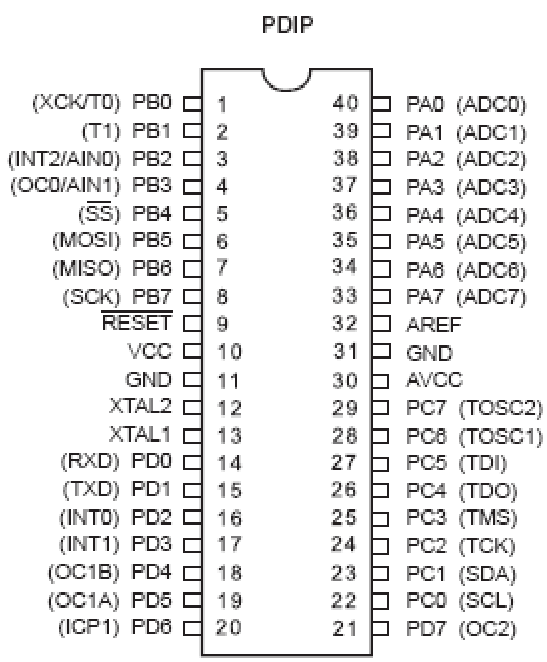


Figure-3 Pin Diagram of ATmega32

C. Heart rate measurement

Heart rate measurement is one of the very important parameters of the human cardiovascular system. The heart rate of a healthy adult at rest is around 72 beats per minute (bpm). Athletes normally have lower heart rates than less active people. Babies have a much higher heart rate at around 120 bpm, while older children have heart rates at around 90 bpm.

Table.1 Average Heartbeat Rate

AGE	RANGE	AVERAGE RATE
0-3 Month	100-180	142
4-12 Month	80-180	130
1-3 Years	80-160	120
4-5 Years	80-120	100
6-8 Years	70-115	92.5
9-11 Years	60-110	85
12-16 Years	60-110	85
>16 Years	60-100	80

Heartbeat is sensed by using a high intensity type LED and photo-diode it is shown in figure 4. The change in volume caused by the pressure pulse is detected by illuminating the fingertip's skin with the light from an LED using a photodiode sensor. With each heart beat, a surge of blood is forced through the vascular system, expanding the capillaries in the finger, and changing the amount of light returning to the photo detector. Very small changes in reflectivity or in transmittance caused by the varying blood content of human tissue are almost invisible. Valid pulse measurement therefore requires extensive preprocessing of the raw signal. A super bright LED is suggested in the circuit as it can also perform well as light sensor. Photodiode, whose resistance changes in response to amount of light shining on it.

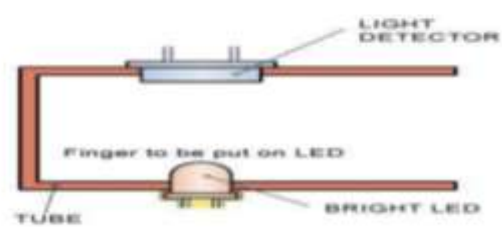


Figure-4 Heart rate measurement

D. ECG Signal

The electrocardiogram (ECG) is the record of variation of bioelectric potential with respect to time as the human heart beats ECG is accordingly widely used to infer about the pathological and biological mechanisms of the human heart and to diagnose for various heart disorders. ECG bandwidth between 0.05Hz and 100Hz is used for general diagnosis applications, and ECG bandwidth between 0.05Hz and 35Hz is used for patient monitoring or healthcare purposes. The individual ECG waveforms as shown in Figure A have to be analyzed to identify the cardiac abnormalities and to pinpoint the exact location of the problem. These ECG bandwidths can overlap with 60Hz power supply noise, baseline wandering due to respiration, high frequency noises originating from various electronic devices and equipments, motion artifact and electromcyogram signal of muscle tissue movements [10]

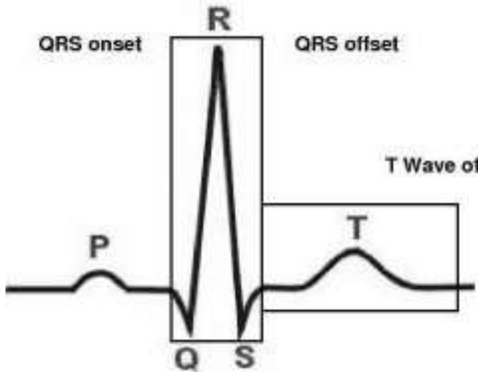


Figure 5: A Cardiac cycle

Table2 Durations of waves and intervals in a normal adult human heart

The Frequency Range :	0.05–100 Hz
No of Peaks	5
Amplitude	
P-wave	0.25 mV
R-wave	1.60 mV
Q-wave	25% R wave
T-wave	0.1 to 0.5 mV
Duration	
R-R interval	0.12 to 0.20 s
Q-T interval	0.35 to 0.44 s
S-T interval	0.05 to 0.15 s
P-wave interval	0.11 s
QRS interval	0.09 s

E. **Temperature Sensor**

LM35Temperature sensor is used to sense the temperature. The LM35 series are precision integrated-circuit Temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain\ convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to+150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor\ package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

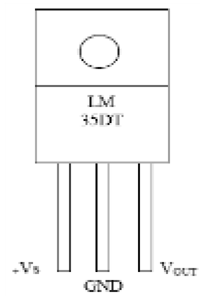


Figure 6: Temperature Sensor LM35

F. **Blood pressure measurement**: Usually when the doctor measures the patient's blood pressure, he will pump the air into the cuff and use the stethoscope to listen to the sounds of the blood in the artery of the patient's arm. At the start, the air is pumped to be above the systolic value. At this point, the doctor will hear nothing through the stethoscope. After the pressure is released gradually, at some point, the doctor will begin to hear the sound of the heart beats. At this point, the pressure in the cuff corresponds to the systolic pressure. After the pressure decreases further, the doctor will continue hearing the sound (with different characteristics). And at some point, the sounds will begin to disappear. At this point, the pressure in the cuff corresponds to the diastolic pressure. To perform a measurement of blood pressure method called oscillometric. The air will be pumped into the cuff to be around 20 mmHg above average systolic pressure (about 120 mmHg for an average). After that the air will be slowly released from the cuff causing the pressure in the cuff to decrease. As the cuff is slowly deflated, we will be measuring the tiny oscillation in the air pressure of the arm cuff. The systolic pressure will be the pressure at which the pulsation starts to occur. We will use the MCU to detect the point at which this oscillation happens and then record the pressure in the cuff. Then the pressure in the cuff will decrease further.

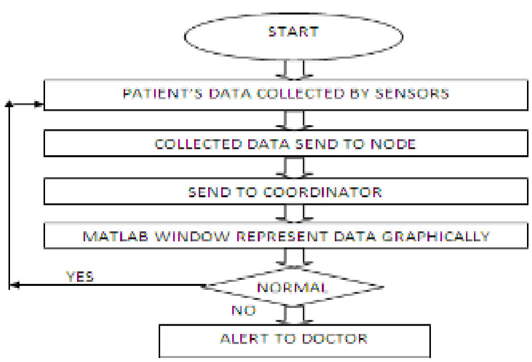
G. LCD

The LCD is used to visualize the output of the application. It is used to check the output of different modules interfaced with the microcontroller. Thus LCD plays a vital role to see the output and to debug the system module wise in case of system failure in order to rectify the problem.

V. SOFTWARE

MATLAB® is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, we can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java™. MATLAB for a range of applications, including signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology. More than a million engineers and scientists in industry and academia use MATLAB, the language of technical computing.

VI. FLOW CHART



VII RESULT

Thus the zigbee based wireless Heartbeat Body Temperature, ECG and Blood Pressure monitoring system is designed and implemented using microcontroller atmega 32**,** in which all signals (heart beat in BPM, Body Temperature in ^{O}C, ECG time interval, & blood pressure in mmhg) directly measured from the human body and all parameters values displayed on LCD.This data is transmitted to the receiver wirelessly through ZigBee module. The received signal sends to pc via RS-232 cable in which Matlab window display graph of patient's Physiological Parameters.

REFERENCES

[1]Shyr-Kuen Chen, Tsair kao, 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.

[2]K. Kinsella and W. He, ―An aging world: 2008,‖ 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.

[4] Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou Shen Hsinchu, 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.

[5] U.Varshney, ―Improving wireless health monitoring using incentive-based router cooperation,*Computer*, vol. 41, pp. 56–62, May 2008

[6] 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.

[7] R. S. H. Istepanian and A. A. Petrosian, Optimal zonal wavelet-based ecg data compression for a mobile telecardiology system,‖ *IEEE Trans. Inf. Technol. Biomed.*, vol. 4, no. 3, pp. 200–211, Sep. 2000.

[8] U. Varshney and S. Sneha, ―Patient monitoring using ad hoc wireless networks: Reliability and power management,‖ *IEEE Commun. Mag.*, vol. 44, no. 4, pp. 49–55, Apr. 2006.

[9] D. Cypher, N. Chevrollier, N. Montavont, and N. Golmie,Prevailing over wires in healthcare environments: benefits and challenges,‖ *IEEE Commun. Mag.*, vol. 44, no. 4, pp. 56– 63, Apr. 2006.

[10]Balambigai Subramanian Asokan RamasamyEfficient Zigbee Based Health Care System for Arrhythmia Detection in Electrocardiogram *EJSR1450-216X Vol.69 No.2 (2012), pp. 180-187*

[11] D.J.R.Kiran Kumar, Nalini Kotnana Design and Implementation of Portable Health Monitoring system using PSoC Mixed Signal Array chip *(IJRTE) 2277-3878, Volume-1, Issue-3, August 2012*

