2017 2nd IEEE International Conference On Recent Trends in Electronics Information & Communication Technology (RTEICT), May 19-20, 2017, India

Implementation of Health Monitoring in Sensor Platform for Wireless Body Area Network

Jijesh J.J
Dept. of Electronics and Communication Engineering,
Sri Venkateshwara College of Engineering, Bangalore.
jijesh_jj@yahoo.co.in

Shivashankar
Dept. of Electronics and Communication Engineering,
Sri Venkateshwara College of Engineering, Bangalore.
chenduss123@gmail.com

Abstract — Nowadays, with the development of sensor technologies more accurate health sensors are accessible in the bazaar, which permits both people and doctors to observe their health and lifestyle on continuous basis to make use of better diagnoses. In recent days there exists a drastic increase in health related issues in terms of breathing and cardiac conditions, as these are closely related with the environmental changes as well as the change of average life span of humans, which has fallen in to the range of 40-65 in recent days. One of the major reasons for the diagnosis of the cardio and respiratory diseases is due to the incorrect and incomplete data samples of the medical conditions, our model captures the clients data on basis of cardio and respiratory conditions, it stores these data in a non volatile memory for overcoming the issue of diagnosis of the medical condition. It also intimates the closest medical center during emergency conditions. Constant measurement with the help of different wearable sensors implies that statistical data from the vital sensors can be captured, stored and processed in order to assist the medical diagnosis of the patient.

***Keywords* — health, patient monitoring, sensors, WBAN.**

I. INTRODUCTION

The evolution of applications over the years in the medical sciences have simplified the medical issue diagnosis. Everyone would look for an e-Health medical application which is more robust as well as flexible and provides efficient service in an economical manner. The robustness of the application can be increased using Wireless Body Sensor Networks; however this alone is not adequate as the system involves patient monitoring on a regular basis. The physiological features of the patients like positional information, body temperature, hear beat, airflow details, pH monitor, brain liquid pressure monitor are some of the parameters used for monitoring the patients' health [1]. These parameters which are regularly sensed should be continuously monitored to evaluate the possible variations in the patients' health condition and stored in a database where it can be readily accessed by the doctor. The proposed system takes into consideration the vital combination of heartbeat and temperature as the primary sensing metrics based on which the health status is monitored. The system is made user centric by providing a telemedical framework which acts as the platform for referring and handling sensed data by patient and physician.

Breathing also known as pulmonary ventilation, is essential part of physiological respiration essential to sustain life. The rate of breathing is controlled by the nucleus in brain stem which send impulses even during sleep. The improper circulation of air that affects breathing when the person is in sleep is known as Apnoea. The sleep apnea is mainly classified into three types, obstructive sleep apnea (OSA), central sleep apnea (CSA) and mixed sleep apnea. Sleep disorders that include struggle breathing during sleep are classified as sleeping disorder breathing (SDB). The SDB is found in 24% of middle a

ged men and 9% of women which eventually results in hypertension, obesity, diabetes and stroke. The test performed to diagnose sleep disorders is known as Polysomnography (PSG).PSG test involves nasal pressure transducer which is used to measure the parameters breathing rate and airflow. To calculate the breathing rate, the sensor is installed on the patients face to capture breathing [2].

To calculate the heart rate from an Electrocardiogram (ECG), the number of RR intervals in the physiological rhythm strip and multiply it with a factor to get bpm. This method is more efficient when the received signal is irregular and has ability to identify the cardiovascular diseases. The Heart rate variability (HRV) is a process of change in the time interval between heartbeats and found by the variation in the beat-to-beat interval.

II. MOTIVATION AND ASSOCIATED WORK

A. *Motivation*

In the real life scenario it has become necessary in healthcare with Wireless Body Area Network (WBAN) to have a control over the data through the electronic devices. The information need to be accessed by doctor on duty as well as other doctors along with all others associated with the patient when the patient is hospitalized. If the intensity of the disease is rigorous then it becomes so complex that there should not be any mistake and all the information from the patient need to be observed minute to minute. So in the WBAN design with the sensors several technical challenges had been faced [3]. So it becomes necessary to tackle these problems by providing the best technical support and instant data transfer to the medical fraternity immediately[8,9].

B. *Associated work*

This section explains the summery of the research work which is closely associated with this work.

In the paper *Junnila et al.* [4] had performed a patient monitoring system in-home with Zigbee networks, thus which can be used for the applications related to e-health.

The author *D. Halperin et al*. [5] had carried out the privacy and security analysis of Implantable Cardiac Defibrillators (ICDs) which are available commercially. They found that the radio based attacks will affect the patient's privacy and safety.

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In the paper [6] *Clifton et al*. had addresses the machine learning method for the monitoring of the patients thereby providing immediate information of physiological parameters to the concerned.

Each Wireless Sensor Network (WSN) is composed of the autonomous sensing nodes which are embedded with several other supporting components to form the WSN and carry out the functionalities of the underlying application. The WBAN can be defined as a collection of invasive or non - invasive sensor nodes used to monitor the health conditions of a person.

III. METHODOLOGY

The patient observing framework is a promising approach to help the medical experts for enhancing their checking capacities. The medical experts are constrained and they are overburdened. The status of patient is assessed by observing different physiological information, for example, heartbeat, airflow and temperature. Particular sensors are placed on the patient's body for the physiological information. The situation where the patient condition is not intense or have minor wellbeing issue, then the patient can wander around the hospital still the patient will be under observation. Fig. 1 demonstrates the framework architecture of versatile patient observing framework. In this framework, sensors are set closer to the patient body, that gathers physiological information like temperature, heartbeat rate and so on. These remote sensors transmit detected information to router and it advances to coordinator which allows family, and Doctor to constantly screen the patient condition.

The proposed WBAN for mobile wellbeing checking is contained inside of a telemedicine framework which compasses a system contained individual wellbeing checking frameworks that interface through the Internet to a restorative server. The framework is not just an appropriated information data logger, which in itself would give awesome point of preference over current frameworks, however gives disseminated information handling and investigation capacities. The system is intelligent and gives some type of examination; now and again it might be workable for on-the-spot continuous analysis of conditions.

The WBAN sensors must to be in scope of gateway, to give nonstop monitoring. The principle target of such a system is to assemble detected information and transmit it to doctor's facility focus in the better way. This framework permits the ongoing transmission of gathering information over general society remote system to the wellbeing focus, and patient will have the capacity to get therapeutic exhortation from a distance. The server is upgraded to service hundreds or a large number of individual clients who are interconnected to medical staffs and healthcare experts. Every client wears various sensor hubs that are deliberately put on the body. The hubs are intended to test essential signs and exchange the information to an individual server through a remote personal area network implemented utilizing ZigBee (802.15.4) or Bluetooth (802.15.1). Flowchart and admin control for patient monitoring is as shown in Fig. 2, and Fig. 3. The individual server, executed on a home PC or advanced mobile phone controls the WBAN and preparatory examination of physiological information. It gives interface to the client, and exchanges captured wellbeing data to the medical server through the Internet.

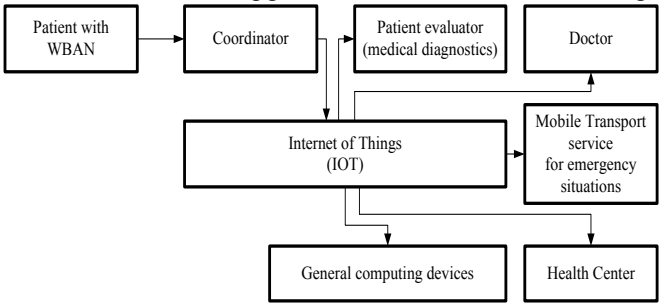

Figure.1. System model for patient observing framework

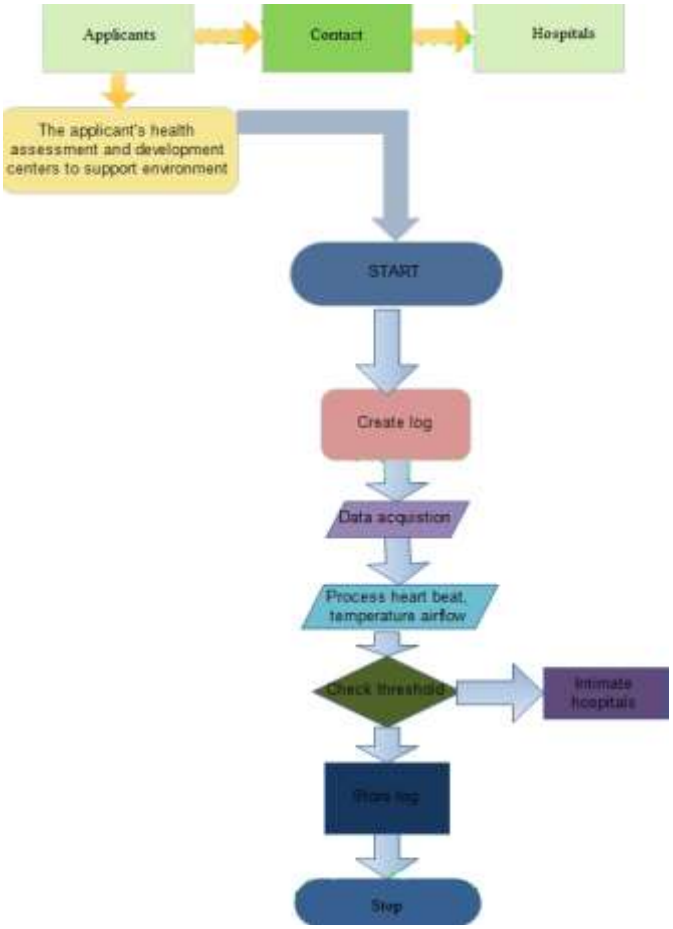

Figure.2. Flowchart for patient observation

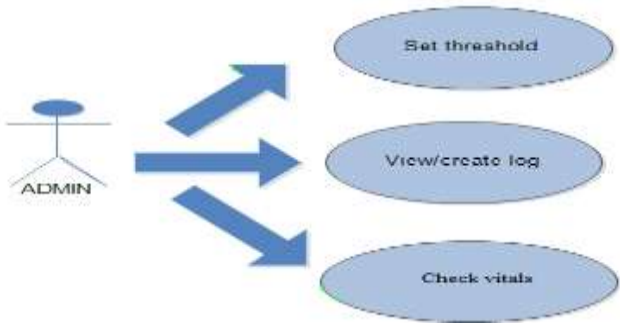

Figure.3. Admin control for monitoring

IV. APPLICATIONS AND CHALLENGES IN WBANs

A. Applications of WBAN

The recent developments in wireless technology, power efficient ICs and micro sensors endorsed the implementation of WBAN. The WBAN technology offers applications in the areas such as consumer electronics, interactive gaming and real time health monitoring. For patients, the implantable sensor allows physical mobility thereby increasing the efficiency of health monitoring system. The major applications where WBAN is used are listed below:

- *Medical:* The medical applications gives the interfaces for remote monitoring and diagnostics of patient information by doctor.
- *Lifestyle:* The WBAN enable functions and services for wireless networks including navigation support in the car or while walking, wearable entertainment system, infant monitoring, heart rate and performance monitoring in sports etc.
- *Military:* The military applications include monitoring temperature, health and hydration levels of soldiers.

B. Challenges of WBAN

WBAN is one of the growing technologies, although there are open issues which need attention and yet to be addressed correctly. Major challenges faced by WBAN are listed below:

- *Scalability:* The size of body sensors range from millimeters to centimeters. The design requirements for a body sensor are to be small, power efficient, compatible to wireless communication and durable.
- *Node Size and Density:* There is always a need for miniaturization for pervasive monitoring. Lower the number of nodes, lesser the size and complexity.
- *Data Protection:* High Level wireless data transfer security system is needed to protect patient's data.
- *Bio-Compatibility:* For implantable body sensors, the bio compatibility is very important which results in increased cost.
- *Wireless Technology:* Low power wireless technology with effective signal detection is more challenging as well as to meet the need of accuracy and real time delivery of data which requires additional measures to ensure QoS (Quality of Service).
- *Power Supply:* WBAN devices are powered by batteries, which is inaccessible and difficult to replace when the devices are implanted in the human body.

V. DEVELOPMENT OF A NODE

The framework has been intended to incorporate the pulse and temperature signal determination capacity, the continuous pulse and human body temperature was collected from body sensor networks and these signs are being confirmed however assist factual studies for more evaluation. WSN was actualized utilizing a tree topology where sensors gather information and send it to the base station in the network. Two sensor hubs have been intended to gather, process, and transmit the pulse rate and temperature signals progressively. The framework works inside of a scope of 100m from the base station and is suitable for observing the patient's wellbeing.

Every transmitting hub comprises of Arduino Uno micro-controller, ZigBee wireless module, heartbeat sensors, temperature sensor, and a GPS module. The ZigBee operates at a frequency of 2.4GHz with an information transmission rate of 250kbps and output power of 1mW using 802.15.4 protocol. Every transmitting hub is powered by a 9V battery and the information gathered is sent to the base station for storage and handling. The Arduino controller is programmed in the transmitter hub, by using Arduino open source environment. The transmitter hub Collect nonstop and continuous sensor information such as body temperature, airflow and pulse rate from the patient furthermore Transmit the processed data to the base station occasionally for further investigation and display. Wireless correspondence between the transmitter hub and the base station is set up.

Base station as system coordinator deals with the activities of individual hubs by asking for information periodically. Along with data integration and examination, the base station likewise transfers handled information to gadgets and individual computerized aides. The base stations comprised of an Arduino Uno micro-controller and a ZigBee receiver utilized as the wireless module that can gather information from the different transmitting nodes in real time and the received data is stored, processed and visualized. The captured information can be continuously observed and displayed progressively for immediate and proper response to the patent from the medical assistance.

VI. DATA ACQUISITION

Data Acquisition (DAQ) is the method of measuring and converting an electrical, analog, digital or physical phenomenon using sensors to the information recognized for IoT module to communicate with the base station and sensory logs. DAQ system consists of hardware, actuators and sensors, signal conditioning and a host computer with DAQ software. A transducer sensor converts a physical signal into an electrical signal.

A. Airflow sensor

The nasal airflow sensor is a sensing device commonly used to monitor the breathing airflow rate of a patient who needs respiratory support. This equipment is used to sense, measure and record breathing signals under the patients breathing abnormalities [7]. In this project, the airflow sensor is connected to the hardware peripheral, which is used for converting the sensor data into a pulse data with maximum peak of 5 volts. The pulse data is then transferred to the serial

Figure 4. Airflow sensor connected to patient

receptor which is connected to the system with the baud rate of 9600 bps. The airflow sensor is as shown in Fig. 4.

B. Temperature sensor

Nominal human body temperature, also known as normothermia, is the typical temperature range found in humans. The normal body temperature range is typically

specified as 97.7–99.5 °F (36.5–37.5 °C). In adults, body temperature fluctuation about 0.9°F (0.5°C) depending on the body's needs and activities. In this project, the sensor measures the key features for body temperature monitoring. The temperature sensor is shown in Fig. 5 and pseudo code in Fig. 6. It is important to measure body temperature to detect number of diseases that are accompanied by typical changes in body temperature and thereby improves the efficiency of treatment by the physician. The body temperature measurement values are shown in table 1.

Figure 5. Temperature sensor

1. **Start**
2. Read analog input
3. Convert analog to digital
   Volt = Analog value * Given voltage input
   Value = Volt / 1024
4. Display Temperature
5. Go to 3
6. **End**

Figure 6. Pseudo Code of Temperature algorithm

TABLE I. TEMPERATURE EVALUATION

SL. No.	Body Temperature Measurement Values		
	Parameter	*Range in °C*	*Range in °F*
1.	Hypothermia	< 35.0	< 95.0
2.	Normal	36.5–37.5	97.7–99.5
3.	Fever or Hyperthermia	> 37.5–38.3	> 99.5–100.9
4.	Hyperpyrexia	> 40.0–41.5	> 104–106.7

C. *Pulse and Oxygen in Blood (SpO_2) Sensor*

The heartbeat sensor is a digital pulse module which is further connected through the interrupt module of the hardware so it can be calculated with beats per second, hence targeting the final value of total beats per minute. The pseudo code and SpO_2 sensor is shown in Fig. 7 and Fig. 8.

1. **Start**
2. Set heartbeat byte in respective bits
3. Digital read heartbeat sensor
4. **If** (Heartbeat is present), **Then**
   Find Heartbeat until n < k
   Time 1 = Millis ()
5. Time 2 = Millis ()
6. Rate = Time 2 – Time 1
7. Rate = Rate/k
8. Rate = 60000/Rate
9. Set rate to Heartbeat
10. Display Heartbeat
11. Reset data
12. Go to 3
13. **End**

Figure 7. Pseudo Code of Heartbeat algorithm

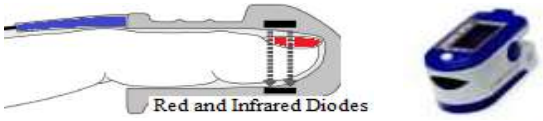

Figure 8. SpO_2 Sensor

The measurement values of various parametes are shown in the table 2. The expirimental hardware setup is as shown in Fig. 9 where all the sensors are interfaced with board.

TABLE II. MEASUREMENT

SL. No.	Measurement Values		
	Parameter	*Range*	*Unit*
1.	Body Temperature	0-50	Degree Celsius (°C)
2.	Respiratory rate	0-60	PPM (Peaks per minute)
3.	Breathing intensity	0-3, 3	Volts
4.	Pulse	25~250	PPM (Peaks per minute)
5.	SpO_2	35-100	Percentage

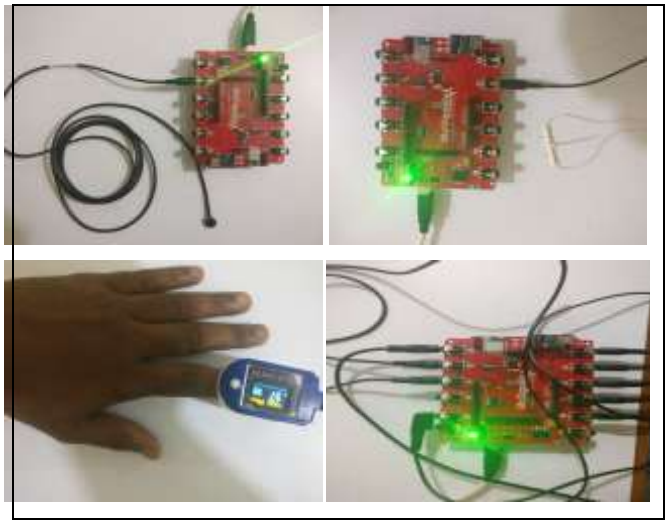

Figure 9. Expirimental hardware Setup

VII. RESULTS

An experimental test bed setup for WBAN has been done using the sensors and the experimental results are analyzed as given below.

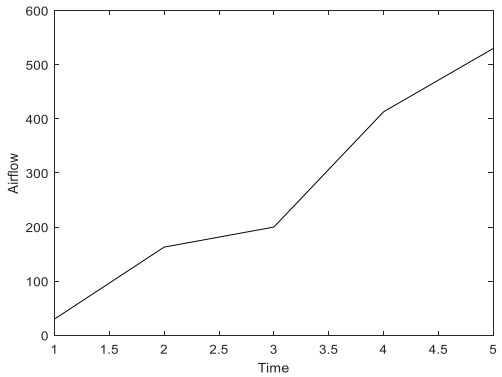

Figure 10. Airflow curve with time

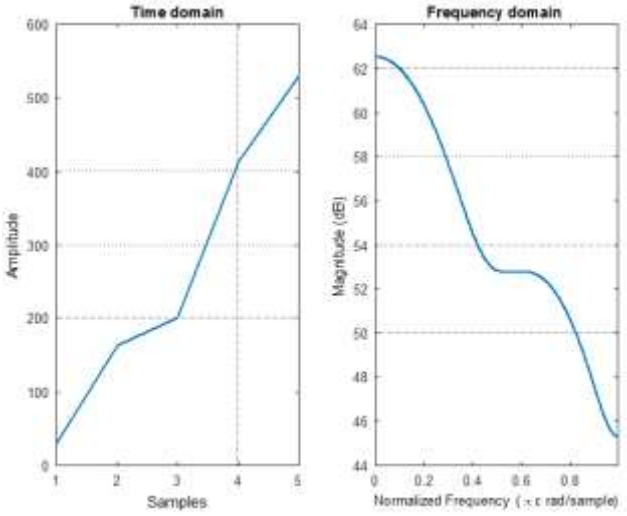

Figure 11. Airflow in time and frequency domine

The nasal airflow is monitored and the breathing airflow rate is recorded with respect to time as shown in Fig. 10 and Fig. 11. Similarly the measurement of patients temperature minute to minute needs to be observed and recorded as in Fig. 12 and Fig. 13 for necessary action.

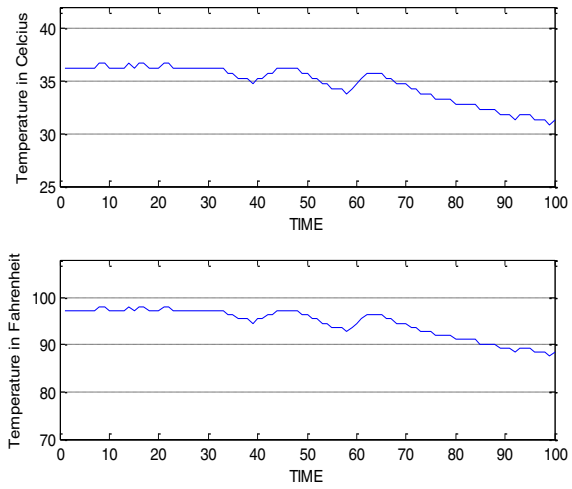

Figure 12. Generation of temperature sensor information

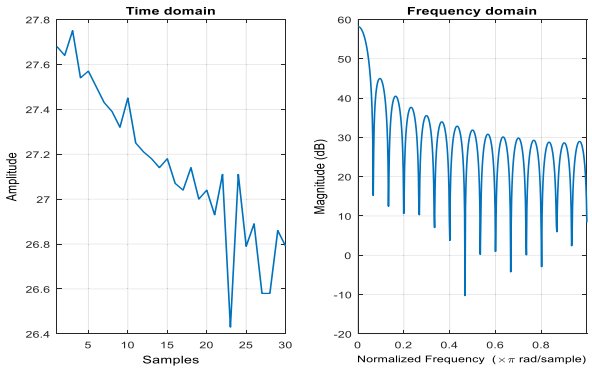

Figure 13. Temperature in time and frequency domine

Heartbeat sensor is connected through hardware and the values are obtained in beats per second as shown in Fig. 14.

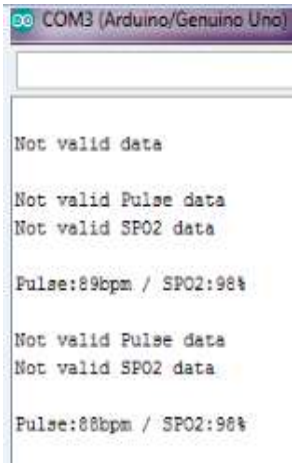

Figure 14. Pulse data from SpO_2

CONCLUSION

The increasing population of senior citizens has necessitated the need for a health monitoring system as they are often susceptible to major health issues due to their age factor. The module works in combination of analog and digital values along with serial communications, however the drawback of the module is the high cost which exists on establishing the transmission sector as well as in the communication of packets via the network. The network module can be enhanced by introducing the routing protocols, as well by introducing machine learning protocol in the field of routing. WBSN is a technology that can solve next generation healthcare issues and reduce healthcare costs. By investigating the sensor nodes, a detailed study is carried out and the best is selected which can overcome the issues and challenges for a reliable data transfer. The research done in this paper helps to serve the foundation of the research to be carried out and the extension of the work.

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