EFFICIENT DATA TRANSMISSION IN WSN USING WEARABLE SENSORS FOR HEALTHCARE MONITORING

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ABSTRACT

Real time health monitoring using WSN of imbed and wearable sensors is visualized as a continual monitoring solution of bedridden outpatient with motility. This paper aims to implement a instantaneous patient monitoring framework, which is proficient in collecting, transmitting and monitoring patient's perceptual conditions. In present Health monitoring frameworks, the patients are supervised by medical professionals using various equipment's which are hardwired to nearby bedside monitors or PCs, and essentially these equipment's are substantial and consequently it keeps patients confine to bed. The drawbacks of these frameworks may affect the patient's mobility during monitoring the vital signs. Our proposed real time health monitoring framework can detect patient's health conditions like pulse rate, body temperature and electrocardiograph using different bio sensors, the collected data will be processed using ARM7LPC2148 and the processed data is efficiently transferred wirelessly to LabVIEW software via ZigBee. In case of abnormalities, the SMS will be sent to doctors/care givers using GSM. In addition, the proposed framework uses ZigBee technology since it is low cost and achieves low power usage to maximize the network lifetime, accelerate and expand transmission protocols and also battery life is significantly improved. This framework will help patients to recover easily and also provides enhanced medical care to patients at a low cost. Furthermore, the framework provides profitable benefits for virtually monitoring individuals living away from the remote areas, old individuals, heart patients and can be used for COVID19 patients in home and hospitals thereby improving medical administrations.

Keyword: *ZigBee, Realtime Monitoring, Wireless Network, Wearable sensors, Healthcare, Pulse rate, temperature, ECG.*

1. Introduction

As the population ages and the risk of Arrhythmia, Heart Infections, Myocardial infraction, Preeclampsia, Hypertension, Atherosclerosis, corona virus disease, lower respiratory infections, renal failure, Chronic obstructive pulmonary disease increases, simultaneously the cost of healthcare will rise and the quality of services does not

meet the needs of modern society. Remote health monitoring provides one potential solution to overcoming these challenges of Constantly monitoring the patient's wellbeing via wearable devices.

Wireless sensor networks (WSN) play a key role in such a monitoring framework application, owing to the fact that WSN can give several advantages over other types of wireless frameworks in particular their scalability, improved productivity, power management, cost efficiency and design versatility. Wearable devices are contributing in a significant manner to disease prevention, diagnosis, and precautionary steps. As Wireless technology and healthcare advance, they will become more sophisticated with enhanced patient safety.

Although number of radical achievements have been noticed in the medical service sector over the last few years. Adhering to an excellent standard of measure cause-of-death data remains crucial for improving health and decrease preventable deaths in every country. This paper presents ultimately to build a Remote health monitoring framework, that has potential to detect the abnormalities in the patient's heart rate and measure the body temperature. Furthermore, it ensures to notify the warning messages namely short message service (SMS) to the healthcare personnel in case of emergency.

The remaining paper is as follows. Section II explains the related work and shortcomings of those frameworks. Section III describes proposed framework in detail. Conclusion is depicted in section IV.

2. Related Work

Few of the recent works on mobile based healthcare monitoring framework was proposed in [1]. The presented framework provides real-time medical conditions of a patients which is capable of sending alerting notes through SMS when the health status of the patient is critical. Data from sensors is collected by Arduino, ZigBee is used to transmit the collected data to smartphone which has LabVIEW software running in it, LabVIEW is used to gather and transmits physiological information, Finally results are published on internet with the intention of the caretaker can access the data from any place at one's convenience.

Smart health care monitoring framework for remotely monitoring the elderly people was proposed in [2]. The framework comprises of four main components viz., (i) Wearable sensors (pulse sensor): the wearable sensors are connected to the patient's body to collect the biological data. (ii) Gateway: the recorded data from the wearable devices will be sent to data centers via gateway. (iii) Cloud: the recorded data will be stored in cloud data center and it also performs machine learning activities to detect abnormalities in patient's data (iv) Monitoring platforms: If any abnormalities are found then the data will be reported to authorized health personnel for immediate treatment.

A healthcare monitoring framework with a 3-tier architecture has been developed in [3] composed of a wearable sensor that can continually track the patient health. This system involves multiple sensors that capture data in terms of biomedical signals which are interpreted into digital form using microcontrollers that acquires data and then transmits it to clinical server for storing and handling through wireless networking. These details are made accessible to medical staff on internet across the world using IOT software.

Wearable Wireless Body Area Networks are proposed in [4] as a key mechanism that enables subtle, continuous, ambulatory health monitoring has been empowered. This new innovation can offer a wide range of advantages for primary identification of unhealthy situations, managed retrieval and eventual detection of awareness by Data analysis among all collected data. Major implementation issues, and a WWBAN prototype focused on WSN and customized ECG and gesture sensors has been identified. Patient health monitoring framework with LabVIEW and WSN to monitor the patient's vital signs was presented [5].

The framework is able to take biological parameters from patients and transmitting them wirelessly via XBee. The authors have paid much attention to the development of this subject in order to enhance access to care and improve patient health.

A BSN architecture intended for continuous healthcare tracking using biosensors has been developed in [6]. A number of wireless biosensors were devised with the BSN architecture, including ECG and Blood oxygen saturation, Context Sensors such as accelerometers, humidity sensors, temperature and are also combined with the

BSN cluster to assist the amalgamation of gathered data. In addition, a lightweight flash BSN card is designed for PDA, where the PDA will collect,analyse,display sensor signals can also act as router connecting the BSN clusters and host computer, rather than serving as processor it can collect sensor data and transmits for extended storage and pattern discovery through Wi-Fi/GRPS network.

The author has presented some noteworthy healthcare applications and challenges for WSN[7]. The level of authenticity required and necessity that guarantee the confidentiality and safety of patient database. The resource depletion inherent in wireless sensor network platforms exacerbates these challenges. The author has also outlined prototype frameworks from neurobiological and action tracking to comprehensive biological and metabolic experiments covering different domains and highlight current scientific experiments.

A Study on WBAN for medical care has been discussed[8]. WBANs consist of advanced miniaturized devices has a capacity to detect, interpret and transmission. They are intended to be worn, track and relay sensory data to healthcare professionals. The author has also discussed about sensing and tracking in WBAN, analysis of energy efficient guidelines, explore the WBAN frameworks, methods to WBAN routing, various security techniques including protocols.

A real-time, portable wireless remote monitoring framework was developed[9]. The framework tracks and control Heart rate and oxygen saturation in the blood of patients using ZigBee wireless technology, the pulse oximetry data are transmitted to database computer server in the area of WPAN. The sensor modules were developed with a framework for low energy which can configure energy consumption according to power source and current power operation scenarios.

In [10] the author presents the state of the art of different forms of the network of WBASN, their Networking mechanisms, applications of WBASN program design frameworks, privacy problems and protocols for power efficient networking. By means of some analysis about existing radio technology for such kind of network, the author has covered the latest developments. The author has also outlined numerous factors and problems of WBASN, possible visualizations and obstacles in this field are addressed.

The solution in [11] supports the mobility of nodes with no limitations in communication. The author has presented a reliable solution to enable nodes mobility in controlled situation such as in hospital environment. The solution suggests a new approach to an intra-handover process that minimizes the exchange of messages between nodes and points connected to their network (Aps). Even if the patient's travel across various coverage areas of WSN Aps, it guarantees connectivity to the mobile nodes.

The author in [12] illustrates the use of WSNs as a main infrastructure that allows for unobtrusive, continuous, primary care health monitoring. Through continuous monitoring the framework can detect the unusual behaviours, structured recovery and has the possible knowledge consciousness by data analysis of all information collected and it offers a wide variety of advantages for patients, health professionals and community. The author has illustrated a overall WWBAN framework, Major deployment problems and WWBAN framework focused on standard wireless sensor system and customized prototypes of ECG and gesture sensor designs.

Advanced study on biological parameters and performance tracking framework is presented in [13]. The framework can provide tracking and data processing, as well as predictive algorithms, which can potentially offer a higher level of trust in the prognosis of such illness, contributing to early detection and treatment. An overview on textile based sensors which can be possibly utilized in embedded frameworks is additionally discussed. Consequently, the consistency of numerous consultation innovations and perhaps even forthcoming bits including development issues for Realtime healthcare systems are analyzed.

Realtime health tracking framework for cardiac patients found in distant ranges has been proposed in [14]. Portable sensors, web applications and android hand-held gadgets are included in proposed framework. The framework is versatile yet has capacity to obtain specific parameters for example pulse rate, temperature also blood weight of different patient's at same time. The collected information is transferred to android gadgets utilizing Bluetooth and also transmitted to web application for advance handling. In the event of variations from the norm, the framework sends alarm messages to the specialist.

The author in [15] depicts clinically significant biological measurements that can be restrained from sustainable gadgets nowadays and emphasizes its points such as wellbeing, steadiness and recuperation of COVID-19 people and lead specialists. The objective spreading from the paper is to start a call over activity among lead specialists and technicians toward creating advanced wellbeing stages for checking and overseeing this widespread.

Several architypes for medical care monitoring framework is identified in articles. In the recent times, multiple and consistently growing technological innovation activities have been acknowledged. Subsequently our project is connected with ZigBee architecture, we concentrate mostly on the Realtime healthcare frameworks that have already been developed.

ZigBee is better than Wi-Fi or Bluetooth, since it requires low power so that it improves battery life and it is cost effective. Table 1 depicts the comparison of wireless technologies as shown below.

Description	ZigBee	Wi-Fi	Bluetooth
Maximum range	10 – 100 m	50 – 100 m	10 – 100 m
Power consumption	Very low	High	Medium
Network Topologies	Ad-hoc, star and mesh	Point to hub	Point to point or point to multipoint
Data transfer rate	250 Kbps	450 Mbps	2.1 Mbps
Channel capacity	5 MHz	160 MHz	902 MHz
Cost	Low	High	Medium

Table-1: Comparison of wireless technologies

3. Proposed Framework

The proposed framework comprises of two major sections Hardware and Software.

3.1 Overview of System architecture

The entire System architecture is shown in figure 1.
It is comprised of
(i) Wearable biosensors that can be embedded in a patient's body to fetch the biological data.
a. Pulse rate sensor: When the heart pumps blood, pulse waves cause changes in the volume of blood vessels, which are measured by an optical pulse rate sensor.
b. Temperature sensor: used to measure temperature anywhere between -55^{o}C to 150^{o}C
c. Electrocardiograph sensor: It is used to process the recording of electrical impulses of the heart using electrodes which are placed on human body.
(ii) ARM7LPC2148: It process the input data obtained from the biosensors.

(iii) ZigBee modules: Used to transfer the input data collected from sensors at a rate of about 250 kbps.

(iv) LabVIEW tool: It is used for data analysis, signal processing and present results to the user.

(v) GSM modem: It is used to alert the patients critical parameters to the physicians through SMS.

3.2. ARCHITECTURE

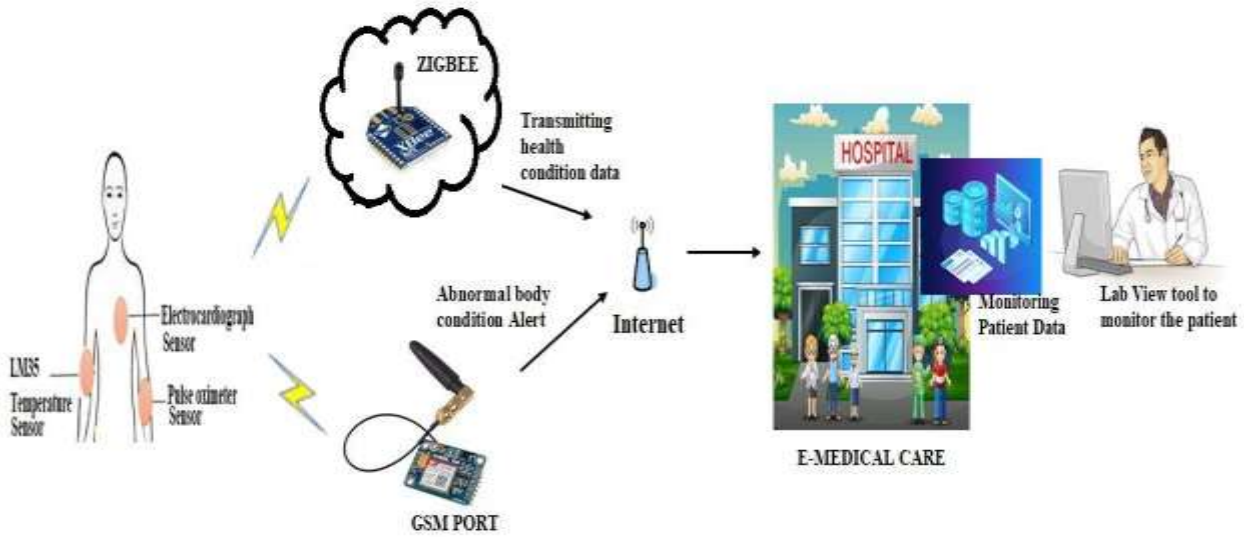

Fig-1: Structure of Healthcare Monitoring using Wireless Sensor Networks

Figure 1 depicts the overview of proposed framework. The framework consists of three sensors heartbeat, temperature and ECG sensors which are wearable by the patient's and the data collected from these sensors are processed by ARM7 LPC2148. The acquired data is sent through ZigBee to the PC which has LabVIEW software operating on it to extract the bio signals from patient's body. The input signals are managed and presented on LabVIEW by using Data Control panel application and information are also saved instantaneously and offered in a report form. Furthermore, a number of patient's personal data are collected. In emergency circumstances, an alerting note is delivered to healthcare personnel via GSM. The data is then posted on internet with the aim of providing access to obtain patient's records from anywhere at any time by the approved healthcare professionals.

3.3 Requirements

3.3.1 Major Hardware Requirements

1. ZigBee Module

Fig-2: ZigBee Module

XBee with Wire Antenna offers point to multipoint gadget network with ease, providing cost-effective wireless solutions for electronic gadgets. This module permit a consistent and naive communication amongst controllers, computer frameworks with an interface. Communication intervening two end nodes are favorable. This module has been used to both transmitter and receiver section.

2. ARM7LPC2148

Fig-3: ARM7LPC2148 Board

The LPC2148 has 32kB on the SRAM chip and 512kB on the FLASH memory chip. Up to 2kB of endpoint USB RAM is supported by this chip. For almost all applications, this memory is more than enough. 32kB of static RAM that can be used for storing code and data is supported by LPC2148. It is accessible in 8-bit, 16-bit, and 32-bit formats. For many more apps such as sensors, electrical control, mobile application, and much more, LPC2148 is suitable. The LPC is much faster than the Arduino (60 MHz) and power consumption is less compared to Arduino.

3. GSM modem

Fig-4: GSM module

The SIM800LV2.0 GSM/GPRS Module has a built-in regulatory circuit with QUAD-BAND GSM/GPRS module. The module functions by adding both GSM (voice call or SMS) and GPRS features. The advantages of these modules are the 5V voltage serial levels of VCC and TTL, and it can communicate with controllers or another minimum framework with a voltage level of 5V. In case of emergencies, this module is used to alert the care givers if the patient's temperature or pulse rate is abnormal.

4. Wireless biosensors in WSN

- Wireless biosensors persuade the necessities such as easy to wear and achieves clear and unobtrusive continuous monitoring of health, the biosensors are miniaturized, energy efficient and identify biomedical signals such as pulse rate, Hypertension, Respiration rate, ECG and temperature, so that it improves the user's level of comfort.
- For instance, rather than sending raw ECG data from biosensors, feature abstraction can be performed on biosensors and required data will be transferred about an outcome. Additionally wireless networks support the use of bio medical sensors which are characterized by its (i) very low transmit power to coincide with other medical tools. (ii) High data rate to allow implementation with high QoS (Quality of service). (iii) Low cost, low complexity to allow feasibility.

a] Pulse oximeter

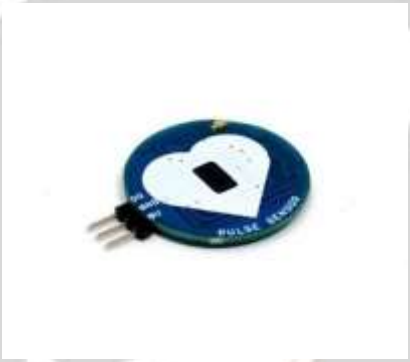

Fig-5: Pulse Sensor

The pulse rate is one among the foremost vital signs, primarily for cardiac patients should be promptly monitored. Generally, the pulse rate of a normal person limits from 60 to 100 BPM. However, counting on individual's activity and biological condition, heart rates may vary. This constraint is often utilized with the aim of diagnosing tons of cardiac diseases. A regular pulse rate sensor has a set of LEDs facing with a photo sensing module spots infrared and red light exposed by finger and also it senses the difference in the volume of blood with reference to pulsation and Eventually creates a pulse in the output of photo sensing module. It combines an easy optical pulse sensor with magnification and noise reduction circuit generating quick and straightforward to obtain consistent pulse rate.

b] LM35 Temperature Sensor

Fig-6: LM35 temperature Sensor

Temperature sensors are diversely used in medical devices for health monitoring. LM35 is a combined analog temperature sensors used to estimate human body temperature. In general, Normal person body temperature ranges from 36.1°C or above. This sensor has capacity to measure body temperature in the intervals of - 55°C and 150°C. It omits exterior normalization or clipping to supply predictable accuracies. It also procures minimal self heating and ceases temperature rise more than 0.1^{o}C in atmosphere. LM35 sensor is small and cheap Integrated Circuit yield voltage differs by 10mV in reaction to every ^{o}C rise or fall in surrounding environment.

c] Electrocardiograph Module

Fig-7: Electrocardiograph probes

The ECG module is cost-effective and it is used to detects the electrical activity generated every time pulsation occurs. During an electrocardiogram, ECG electrodes are placed on the skin of a patient's body, typically the arms, chest, and legs. The number and location of electrodes on body parts may differ, but the functionality stays same. These electrical activities are often outlined as an ECG. The ECG records are applied to recognize a comprehensive span of cardiac conditions.

Signal	**Characteristics**
Pulse rate	45– 150 bpm
Blood Pressure	dc – 60 Hz
Temperature	-55^{o}C - 150 ^{o}C
Electrocardiograph (ECG)	0.05 – 100 Hz 10 mV (Foetal), 5mV (Adult)

Table-2 : Wearable Sensors Characteristics

3.2.2 Software requirements

1. LabView Software

LabVIEW is a framework design integrating platform and development environment for obtaining, handling, and transmitting the biological information. It is user friendly software that represents a graphic user interface design that can obtain physiological data. The principle of dataflow oversees program execution in a simple way. LabVIEW programs can effortlessly executed specifically to machine language with the aim of a mainframe can process it. Additionally, the outturn information created by the LabView and it can effectively procured. The attainment of data will be carried out utilizing the National Instrument's Data Acquisition System (DAQ).A huge set of data produced from a range of estimations arising from sensors and data acquisition systems can be modelled and analyzed. It offers very strong tools for data acquisition, data analysis, and data visualization. The use of DAQ reduces the complexities such as hardware issues and to fit for more options it can be quickly remodeled and adjusted.
For instance,

- Embedded option embeds the virtual instrument's (VI) front panel so that users can remotely view and control the front panel using a browser.
- The Snapshot option displays a static image of the browser's front panel and it does not permit the browser to interact with the virtual instrument's (VI) controls.
- The Monitor option shows an animated snapshot that is continuously updated and it does not allow the browser to interact with the virtual instrument's (VI) controls. LabVIEW can instantly store patient's biological information in report format, which is a major advantage. LabVIEW provides certain unique features based on the stored information, such as transmitting a message to notify specialists and posting the details on internet as then concerned healthcare professionals can retrieve from any place around the World at one's convenience.

2. XCTU Software

XCTU is compatible with Windows, Mac-OS and Linux and it is open-source, cross-platform application developed to programmers, through a easy user friendly interface, to interrelate with XBee modules. It comprises a tools required by programmer to operate with ZigBee modules. Also these modules can be easily built, programmed and evaluated. It is a convenient programming language to quickly build XBee API modules is XBee API Frame Constructor. The XCTU software is used to manage and configure the multiple XBee modules to communicate wirelessly with each other. It includes comprehensive and complete documentation that can be accessed at any time.

4.Conclusion

Wearable technology plays an essential role in the healthcare sector as well as in our daily life by providing real-time remote monitoring. In the literature articles, there are other survey studies designed to track several parameters such as heart rate, Blood pressure, Temperature and data obtained from the sensors is accessed via integrated circuits, and this data is transferred through Bluetooth or Wi-Fi module to the smartphone/PC. Many of the existing frameworks have used wi-fi, which absorbs high power and is often costly, and a few other frameworks have used Bluetooth modules with almost the same properties. However, the candidate wireless technologies are contrasted from these studies, however, where Zigbee demands low power and properties such as high reliability, low complexity, low cost, and greatly improves battery life.

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