



# A Working Prototype Using DS18B20 Temperature Sensor and Arduino for Health Monitoring

Ramesh Saha<sup>1</sup> · Suparna Biswas<sup>2</sup> · Satyajit Sarmah<sup>1</sup> · Sushanta Karmakar<sup>3</sup> · Pranesh Das<sup>1</sup>

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## Abstract

Due to the successful emergence of internet of things, sensor-based real-time health monitoring is getting popularized. A usable health-monitoring system is required for prolonged monitoring of the patient with reduced cost. This paper describes a working prototype system for real-time health-monitoring system using DS18B20 temperature sensor, Arduino Nano with micro-controller ATmega328 where Zigbee module is used for wireless communication. In this prototype sensor data gets acquired and analyzed to give proper feedback to the patient with or without mobility support at indoor. The sensor vitals are collected and sent to the computing device using shielded cable and ZigBee, i.e., through wired and wireless communication, respectively. Analysis of patient vitals based on medical definitions gives patient's real-time health condition so that if condition is not normal, then timely preventive measures can be taken to avoid further complication. Per user data can be saved in the system database for further reference.

**Keywords** Health monitoring · Temperature sensor · Arduino · Zigbee · Prototype · Mobility

## Introduction

Internet of things (IoT) [1–5] has changed our daily living with its different applications. The concept of the IoT reflects a connection in a set of any time, anything, anyplace, any network, and any services. IoT moves to the up and coming age of advancements that can affect an entire

human life. IoT provides a wide range of applications such as smart city, waste management, traffic congestion, emergency services and structure of health, industrial control, surveillance and healthcare. Smart and remote healthcare is the most on demand application of IoT. It has many potential applications to give rise to healthcare applications like remote health monitoring, a fitness program for home-based health-monitoring, chronic disease detection, and older people care, etc. IoT based healthcare service utilizes wireless body area network (WBAN) [6–8] which is a subset of wireless sensor network (WSN) [9, 10]. Usage of WBAN in healthcare increases the QoS and reduces the costs with enhanced usability. Initially, IoT based WBANs [6, 7, 11] are one of the most desirable technology for building smart health monitoring for the patient. The application of health-care monitoring using WBAN consists of a specified number of heterogeneous sensor nodes. This sensor node is capable of sensing one or more physiological parameters of the human body, e.g.,—blood pressure, the heart rate, electrocardiograms (ECG) electromyograms (EMG) [12], muscular activity and body temperature, etc. Then acquired signals are transmitted to the sink or coordinator of the WBAN for further processing [12, 13]. The sink or coordinator is equipped with sufficient resources of this activity. It has

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✉ Suparna Biswas  
mailto:suparna@gmail.com

Ramesh Saha  
ramesh1saha@gmail.com

Satyajit Sarmah  
ss@gauhati.ac.in

Sushanta Karmakar  
sushantak@gmail.com

Pranesh Das  
pranesh.das@gmail.com

<sup>1</sup> Department of Information Technology, Gauhati University, Guwahati, Assam, India

<sup>2</sup> Department of Computer Science and Engineering, Maulana Abul Kalam Azad University of Technology, West Bengal, Kolkata, West Bengal, India

<sup>3</sup> Department of Computer Science, IIT Guwahati, Guwahati, Assam, India



software enable system which collected data from WBAN sensors and sent to the medical server for a physician can monitor the patient more efficiently.

Marius Roşu and Sever Paşca [4] has been proposed a real-time remote healthcare solution for patients. It can surveillance the patient anytime from anywhere. Here the author used a programmable ECG sensor with wire able wireless body/personal area network (WWBAN) and sent data to the medical server to check the condition of the patient. In this paper, using ZigBee technology and low power wireless sensor with local processing capabilities to achieve high mobility and flexibility of the patient. Author added here if the emergency condition of the patient happens then the programmable ECG sensor automatically sends an alert to the caregiver.

Muhammad Udin Harun Al Rasyid et al. [5] proposed an e-health sensor system that can be used to read vital health signals and store in the database server—here used body temperature sensor and a blood oxygen sensor. In these systems, vital signals collected from sensors and sensors data reading to a desktop application as well as store data in the database and display the data via a website in the form of report that can be accessed remotely.

Benjamin Kommey et al. [6] proposed a patient medical emergency alert system (PMEAS). It uses two sensors: temperature sensor and heart rate sensor as a hardware unit and android application. In that system, collected patient vital signal gets displayed on an LCD screen and sends to the android device via bluetooth and managed by the apps. If any abnormal condition seems to the system, an alert is sent to the caregiver through email or SMS in a confidential manner. This system also forms a graph to help determine the state of health of the user.

Ying Zhang and Hannan Xiao [7] proposed a Bluetooth based sensor network system which remotely monitors patient physiological signal. Authors focus on implementation issues and describe these system architecture using heart activity sensors. The proposed network system is developed using intelligent physiological sensor nodes, intelligent Bluetooth technology, hardware and software. Authors gave a solution for onboard signal processing.

Young-Dong Lee and Wan-Young Chung [8] developed a smart shirt to monitor patient's health continuously based on WBAN technology. The smart shirt is attached to the ECG and acceleration sensor. The shirt mainly collected health data from patients' bodies as electrodes and transmitted to base station from the ad-hoc network using 802.15.4 communication standard.

Adrian Burns et al. [9] have been applying new sensing technology to the emerging global healthcare system. Authors developed new approaches for continuous health monitoring using SHIMMER™.

Chih-Ming Chen [10] developed a model to provide long medical treatment which is web-based. The proposed system can be used to study and analyze a patient's condition remotely.

Navya and Murthy [14] proposed a health network model using ZigBee. Here patient health physiological data of the patients are monitored and the output of the sensors data is sent to the personal computer. It is a remote health network system that can be a data store for future use. In that system, sensors are used to measure temperature, heart rate, and fall monitoring of the patient using ZigBee. Authors also proposed a solution for patient monitoring when patient data crosses the threshold value, and the personal computer sends a message to the mobile phone of the caregiver.

Prajakta A. Pawar [14] presented a system which is used to monitor physical parameter of the human body like a heartbeat. This system can be used in a rural area or remote area; by using GSM, module patients can be transmitted data to the doctor mobile. This system is an appropriate home-based effective health-monitoring system that can be monitored elder people.

Amna Abdullah et al. [12] proposed a field-tested real-time health monitoring using a PDA device. The main objective of the proposed model is to study the patient's health condition regularly. Authors proposed system can measure or monitoring patient-important physiological data and is collected by the sensors and transmitted it to the mobile android based apps, besides this system also able to generate an alarm message or confidential email if patient health in critical condition and send it to the healthcare professional for necessary medical advice.

Johan Wannenburg and Reza Malekian [13] designed and implemented a mobile health-monitoring system. The system capable of measuring vital physiological signals of the patient, interpret the collected signal, and monitoring. In some cases, abnormal conditions occurred, then it detected and sent to a medical team for analysis. The system is an analysis and investigation of various biological extraction methods. All the required parameters were measured accurately by following medical standards. The system should be providing accurate feedback to the user and successfully identify the medical problem and send a notification to a doctor for prescribing the next step.

Kumar and Pallikonda Rajasekaran [15] proposed a model for monitoring patients' condition by Raspberry Pi. The author implemented a simple healthcare application using a temperature sensor for body temperature, ECG for heart bit, and proximity for movement. These sensors send the vital signal to the Raspberry Pi, and sensor data can be monitored in the monitored screen of the computer by using Raspberry Pi, which acts as a Linux PC as well as anywhere in the world using the Internet.

Table 1 Summary of related works

Author details	Year of publication	Prototype or framework description	Used sensor hardware component	Used software component	Communication module	User of the prototype/framework work
Valerie Gay and Peter Leijdekkers [1]	2007	A health monitoring prototype for personnel health monitoring using smart phone	A&D blood pressure monitor and alive ECG/Accelerometer monitor	Visual studio 2005	Wi-Fi, GPS	Using ECG health monitoring for patient
Chris A. Otto, Emil Jovanov, and Aleksandar Milenkovic [2]	2006	A health-monitoring prototype. WBAN sensor collect vital data and send to the home health server and which store data in predefined database, if needed further observation then information send to the medical server	Hart sensor Acidometer sensor	Microsoft .NET 2.0 framework and Visual C#	Internet	Health monitoring for cardiac rehabilitation patients or elder people
Ahmed Baraka, Ahmed Shokry, Ihab Omar, Saged Kamel, Tarek Fouad, Mohamad Abou El-Nastr, Heba Shaban [3]	2012	Investigation a framework which is software enabled and it can be WBAN sense data send to the medical server for physician, who monitor the patient efficiently	SHIMMER's 9DoF kinematic sensor and ECG sensor	SHIMMER connect software package and MATLAB	Not specify	Physical can more efficiently monitor patient
Marius Roşu, Sever Paşca [4]	2013	A WBAN-ECG based healthcare solution for monitoring patient from anywhere and anytime	ECG sensor	Not specify	ZigBee wireless technology	ECG-based health monitoring
Muhammad Udin Harun Al Rasyid, Bih-Hwang Lee, Amang Sudarsono and Taufiqurrahman [5]	2015	A system, collected vital signal from the patient and store data in the database as well as show via web application and print it as a report	Body temperature sensor and blood oxygen sensor	We based application	Wire connection	A health-monitoring sensor and web bested system, which can perform user vital data reading and storage in the database
Benjamin Kommey, Seth Djanie Kotey and Daniel Opoku [6]	2018	A patient medical emergency alert system (PMEAS), Which collected user vital data using hardware sensors and send it android app via Bluetooth as well as android management the data and any abnormal condition observed the a SMS or email send to the caregiver as confidential manner	Heart rate sensor, body temperature and LCD	Android application	Bluetooth	A system user can able to display vital data in a graph form and determine state of art of health condition

Table 1 (continued)

Author details	Year of publication	Prototype or framework description	Used sensor hardware component	Used software component	Communication module	User of the prototype/framework work
Young-Dong Lee, Wan-Young Chung [8]	2009	A smart shirt-based WBAN health-monitoring system, which collected ECG and acceleration sensor data as electrode and it transfer to the base station and base station to server PC for real-time continuous monitor health and activity of the user	ECG and acceleration sensor	Embedded TinyOS is used	Wireless communication (802.15.4)	ECG and acceleration sensor-based WBAN smart shirt system, development for ubiquitous health and activity monitoring
Adrian Burns, Barry R. Greene, Michael J. McGrath, Terrance J. O’Shea, Benjamin Kuris, Steven M. Ayer, Florin Stroiescu, and Victor Cionca [9]	2010	Using SHIMMER firmware collected different sensor data like ECG, EMG GSR and kinematic sensor data for health monitoring	SHIMMER sensor kit	SHIMMER software package and library management	IEEE 802.15.4	SHIMMER kit-based health-monitoring system
Chih-Ming Chen [10]	2011	A web-based remote health analysis system which can continuous monitor human pulse data and if urgent situation then inform to the caregiver for sudden diseases	MLT1010 pulse transducer piezoelectric sensor	PHP language, Apache web server, and MySQL database	Wire connection, Wireless and Internet	Web based remote health monitoring and analyze system using human pulse sensor
K. Navya, Dr. M. B. R. Murthy [11]	2013	A ZigBee based monitoring device by which patient physiological data send to the personal computer, When data crossed the some standard r measured value then personal computer generate a message and send it to the caretaker mobile phone	Temperature sensor, hart rate sensor, MEMS Sensor and saline level sensor	Graphical User Interface (GUI) and database	ZigBee	Patient monitoring system using ZigBee communication
Prajakta A. Pawar [14]	2014	Rural or remote based health-monitoring system, it collected heart rate data from the patient and send it to the Doctor mobile by using GSM module	Heart rate sensor and Arduino	Arduino IDE and C/C++	GSM module	Patient as well as elder people health-monitoring system

Table 1 (continued)

Author details	Year of publication	Prototype or framework description	Used sensor hardware component	Used software component	Communication module	User of the prototype/framework work
Anna Abdullah, Asma Ismael, Aisha Rashid, Ali Abou-El Nour, and Mohammed Tarique [12]	2015	Mobile Android application based real-time health-monitoring system. It collected physiological data from the patient by the sensors, if critical condition occurred then an alarm or email send to the medical professional for necessary advices	ECG electrodes, temperature sensor (LM35) blood pressure sensor, blood and glucose sensor	LabVIEW Software and Android apps	ZigBee	Mobile application-based health-monitoring system
Johan Wannenburg and Reza Malekian [13]	2015	Mobile health-monitoring system, different sensor nodes attached to the body for collecting relevant physiological data of the patient and measured as per medical slandered, if emergency condition, then a notification to the medical team. The system, monitoring the patient's health condition and provided feedback to the user as well as sending information to the doctor for a consult	Temperature sensor, heart rate sensor, SPO2, blood pressure	Android application	Bluetooth, Wi-Fi, Internet (3G)	Mobile-based health-monitoring system Which measures and analyze the patient's physiological signal
R. Kumar and M. Pallikonda Rajasekaran [15]	2016	An IoT based healthcare system using Raspberry Pi. Here data collected from the sensors and monitored in the monitor of the computer screen as well as anywhere of the World by using the Internet	Temperature sensor, heart sensor, and Raspberry Pi	Web-based application	Internet	Health monitoring system here used Raspberry Pi
Md. Shaad Mahmud, Hong-gang Wang, A.M. Esfar-E-Alam, Hua Fang [16]	2017	Wireless health-monitoring system using a smartphone. Here designed a smart case that includes a microcontroller with Bluetooth device. It is not like the chip-based health-monitoring system	Mobile, ECG sensor, RFDuino	Android application	Bluetooth	Health monitoring using a smartphone and a smart case

**Table 1** (continued)

Author details	Year of publication	Prototype or framework description	Used sensor hardware component	Used software component	Communication module	User of the prototype/framework work
T.S. Sollu, Alamsyah, M Bachtiar and A G Sooi [17]	2018	Using wireless sensor networks, a real-time health-monitoring system using hart rate sensors	Heart rate, arduino	Arduino IDE	ZigBee	Health monitoring system for user especially elder people
Nabeel Salih Ali, Zaid Abdi Alkaream Alyasseri, Abdulhussein Abdulmohson [18]	2018	A real-time Heart Rate Monitoring System using Mobile application and Wireless sensor network Here pulse data collected from the sensor and sent it to the computer or mobile via microcontroller and display it in the web application through internet. This architecture user can show the HP data anywhere and it is user friendly	Pulse sensor, Arduino, Mobile	Arduino IDE, Web application	Ethernet shield and internet	Real-time Heart Pulse monitoring using mobile apps for continuous health-monitoring user or patient
Afef Benjemmaa, Hela Ltfi and Mounir Ben Ayed [19]	2019	A remote heart monitoring system (RHMS) for remote cardiac patients. In this architecture sensor data collected and send it to the server and used the Multi-modeling techniques for improving quality of remote data and management their out-of-hospital data	Heart rate, blood pressure, temperature, oxygen saturation,	Mobile apps and Web-based application	Bluetooth and Wi-Fi	Health monitoring system for cardiac patient, who is out door of the hospital
Proposed		Working prototype of smart healthcare monitoring with or without user mobility support at indoor	Temperature sensor, Arduino Nano with Atmega 328 having ZigBee module and shielded cable	VB based application	Zigbee, shielded wired cable	Patient at indoor, may be at home or at hospital

Shaad Mahmud et al. [16] proposed a prototype of healthcare to study patient vital data. Authors focused on real-time Electrocardiogram and heart rate monitoring using a smartphone case. The proposed system is an embedded system. A 3D printed PDA device is also developed by the author to validate the proposed embedded system. The system can be a comparable medical-grade device.

T. S. Sollu et al. [17] has been proposed a system using a wireless sensor. It can be monitoring the patient heartbeat. The system uses an electrocardiogram (ECG) mounted on the patient's body, and ECD data sent to the server through the ZigBee. Author concerned with heart rate monitoring is essential for health, especially for the elder people.

Nabeel Salih Ali et al. [18] proposed a system in real-time to monitor health based wireless sensor technology. In the proposed system, they have concentrated on the heart pulse (HP) of the patient. The proposed system provides a user-friendly solution and it is not only for the specialist.

Afef Benjemmaal et al. [19] implemented and design a remote heart monitoring system for cardiac patient. The proposed system sent and analyzed the collected real-time data to take an important decision-making in the case of remote cardiac patients. Here used two important technology is used. One is a machine learning approach, and another is visual analytic for gaining instant for collected real-time data from a sensor. In the RHMS system used multi-agent modeling for improved quality, which helped remote patients to improve the management of their out-of-hospital data.

Related works that focus on real-time different sensor-based health-monitoring system and provided solutions are summarized in Tables 1. A detailed study on papers published during 2004 to 2019 is done to find the trends of IoT based healthcare systems.

Figure 2 shows the graphical presentation based on a published paper on remote healthcare solutions using hardware sensor devices to build working prototype compared to total publication on healthcare. In 2016 and 2017 more device based works have been published in compared to 2015, 2018 and 2019.

## Motivation and Contribution

Real-time health-monitoring system design is a challenging task to implement using the WBAN sensor nodes [26, 27]. Many people suffering from ailments may not receive treatment in proper time due to unavailability of local healthcare facility as moving to further distance causes time and money which may not be affordable always. Here comes the role of proposed IoT and sensor-based model for acquisition and analysis of patient vitals remotely to provide primary care to any abnormality identified [28]. Patient vitals sensed through sensors are analyzed at local server to find

the health condition. If any abnormality found that can be intimated to the doctor for necessary advice and support without physical movement of the patient thus eliminating the above mentioned problems. Here lies the motivation of design and development of proposed model.

## Contribution

This simple health vital monitoring with user mobility support using Zigbee module for wireless data transferis contributed as follows:

- (i) Usable and low cost working prototype for human body temperature collection using temperature sensor
- (ii) The server analyses the data continuously in real time and patient's health condition in terms of sensed vital is displayed on monitor of developed system for notice of concerned person
- (iii) Why only temperature sensor used here? The reason behind is that the normal body temperature of an individual changes based upon sex, ongoing movement, nourishing, and liquid utilization, time of day, and for females during different phases of biological changes, thus can primarily indicate any abnormality.

## Methodology and Implementation

The proposed system includes: (a) system design, (b) system installation and (c) coding. Figure 3 shows the different important stages of the integrated prototype.

### Used Hardware Components

The different hardware components used are described below: among various physiological primary parameters to observe from the patient is body temperature. So a body temperature sensor is required for collecting temperature as a vital signal which is measured using an embedded system that is connected with the sensor and processing of the vital signal. Here the DS18B20 [26, 28] temperature sensor is used and shown in Fig. 4 [26, 28, 29]. Advanced features of used temperature sensor are 1-wire interface, 64-bit serial stored in an On-Board ROM, not required external component. It operates using power supply 3.0v-5.5v.

After collecting the sensor data by using temperature sensor, required to connect with interface and power supply of the system, here used Arduino with micro-controller ATmega328. Our proposed system used Arduino Nano, shown in Fig. 5 [30]. The main purpose of using Arduino Nano is that it is embedded with ATmega328. It has many advantages over Arduino Uno. ATmega328 is an 8-bit AVR Microcontroller manufactured by Microchip, follows RISC



PATIENT HEALTH MONITORING BASED RESEARCH PUBLICATION

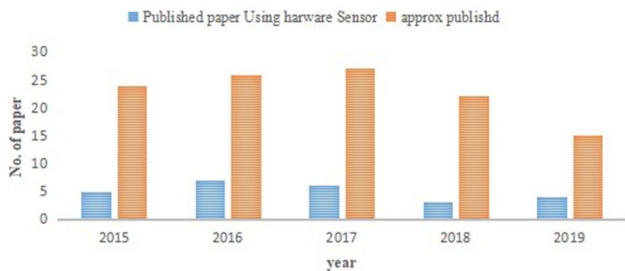


Fig. 2 Comparison of publication of hardware sensor and IoT based remote healthcare and total healthcare solutions

Fig. 3 Different stage of the proposed prototype

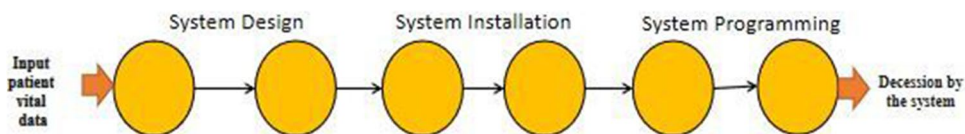


Fig. 4 DS18B20 temperature Sensor

architecture, and it has a flash type program memory of 32 KB. ATmega328 has 28 pins. ATmega328 has 1 KB Electrically Erasable Programmable Read-Only Memory (EEPROM) and 2 KB SRAM memory.

The embedded sensor and microcontroller are used to collect data from the patient’s body and need to connect to the CCU or computer. Generally, in the market, there are different types of communication modules available like Bluetooth, Wi-Fi, ZigBee, and USB shielded cable, and so on. In particular, an application like in our proposed system

Fig. 5 Arduino Nano with pin configuration

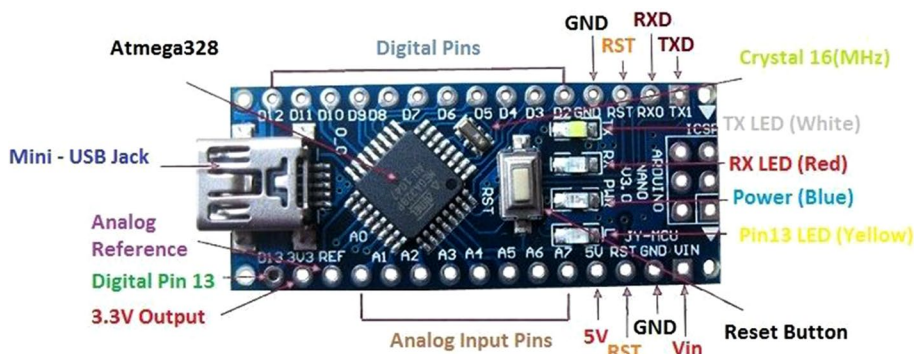


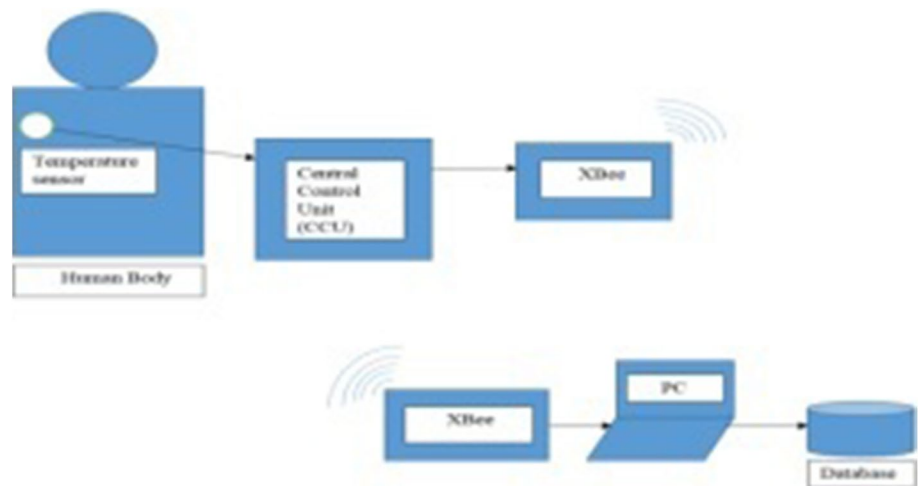
Fig. 6 ZigBee communication module

can be decided by examining several characteristics like power consumption, data rate and range. Based on the above characteristics, ZigBee is used for wireless communication shown in Fig. 6 [25] and for wired connection USB shielded cable for when patients in the range of CCU or computer. In healthcare applications, ZigBee is more suitable over other wireless communication. ZigBee has the following features like power consumption is very low, the range of ZigBee is very large (300 ft–40 miles), the data rate in ZigBee (250 Kbit/s) is low as well as the cost is low.

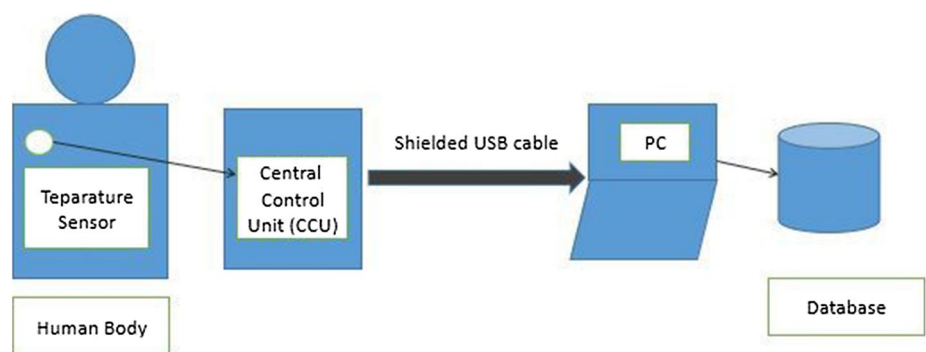
**Used Software Components**

In the proposed system different hardware is described above, now needs to interface hardware to the software system and establish a reliable communication system for healthcare. Different software and APIs are used in the proposed system.

**Fig. 7** Using ZigBee communication



**Fig. 8** Using Shielded USB cable



## Arduino IDE

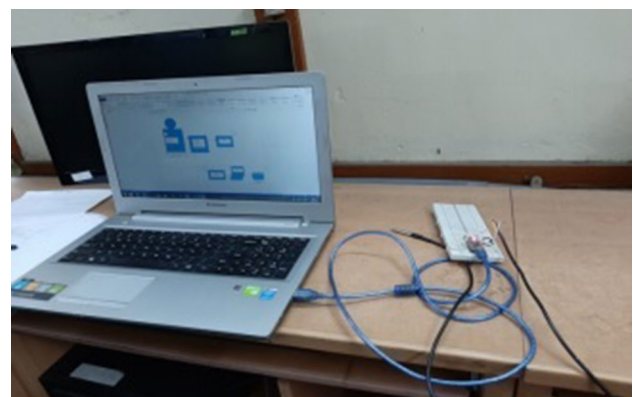
Arduino IDE [24, 32], i.e., Arduino Integrated Development Environment. It connects to Arduino and hardware for uploading programs and communicating with them. Programs are written in Arduino IDE editor. It is an open source and easy programming environment for Arduino modules.

## Microsoft Visual Basic 6

Programs created with Visual Basic run on Windows, on the Web, within Office applications, or on mobile devices. Using Visual Studio programs are created compatible in all these platforms thus preferred by all educationists and budding researchers. Visual Studio.NET provides development tools to create programs based on the .NET framework, such as ASP.NET applications, which are often deployed on the Web.

## WAMP Server

WAMP Server [33, 34] allows us to develop dynamic applications based on web with MySQL, PHP and Apache 2 [35].



**Fig. 9** Wired connection of the implemented system

WAMP Server automatically installs everything you need to intuitively develop Web applications. There are many useful feature line MySQL services for Database management, switch online/ offline to give access to everyone, or only localhost and manage servers.



Fig. 10 Wireless connection of the implemented system

**XCTU**

XBee Configuration and Test Utility (XCTU) [20] is a program using which users can interact with devices enabled with digital radio frequency (RF) through a graphical interface. Built-in tools of this application make it easy to set up, configure, and test digital RF devices.

**Implementation of Working Prototype**

Now all the softwares required for the proposed system are installed and the hardware system is arranged properly. In

this proposed system, two types of communication are used: one is wired communication for the patient who is in a static position using Shielded USB, and another is wireless communication for the patient who is mobile using ZigBee communication. Here body temperature sensor is used to read body vital to analyze and find the health fever condition according to predefined medical science information. Block diagram of both the systems is shown in Figs. 7 and 8.

In wired connection, body temperature sensor is connected to the Central Control Unit, here micro-controller Arduino with breadboard proper connections. Then Arduino connected to the PC and real-time data transfer to PC. In case of wireless connection, CCU or Arduino connected to the transmitter of the ZigBee in the bard board with proper connection and receiver of the ZigBee in connected to the PC. Both connections are shown in Figs. 9 and 10.

Now, all the software’s need to be installed to create a real-time data collection system. Per user a unique-id is created along with several attributes e.g. age, gender, address, contact, email etc. All these details are stored in the database which include attribute of the PC which is required for the proposed system, create a real-time data connection system where user can create own-id which include attribute and back end database shown in Fig. 11 which stores data for future purpose.

Now, the proposed system is ready for monitoring patient using body temperature. The normal body temperature of an individual change relying upon sex, ongoing movement, nourishment, and liquid utilization, time of day, and for females during the phase of the menstrual cycle. Typical

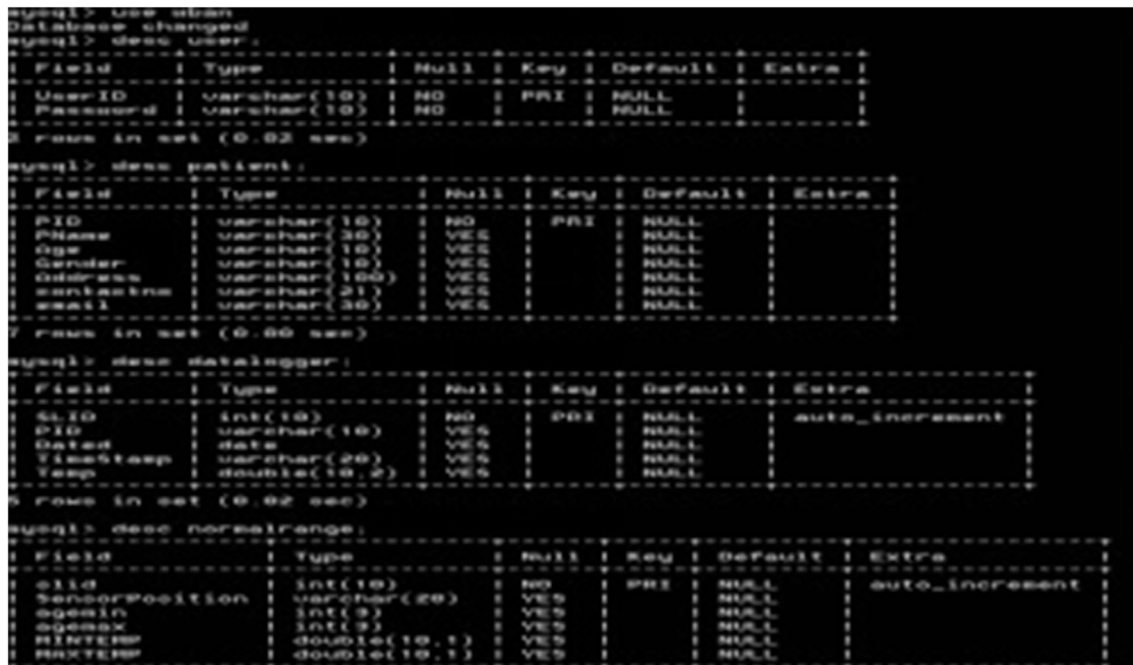


Fig. 11 Back-end database of the system





Fig. 14 Login page



Fig. 15 login credentials not matched with existing database

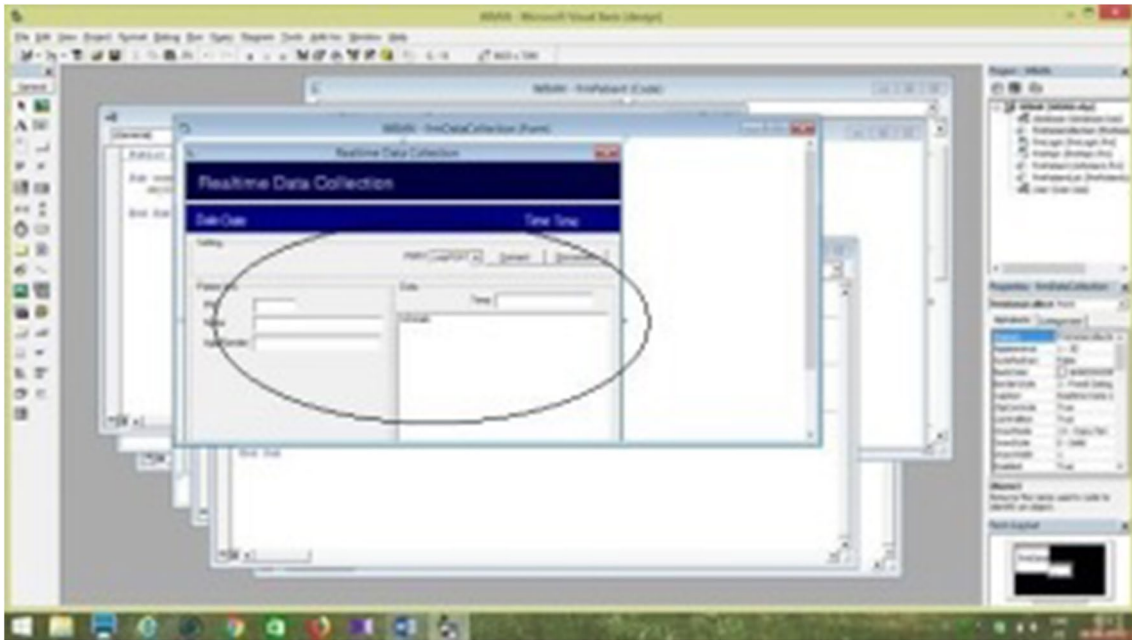


Fig. 16 Accessibility by the user to collect real-time data



Fig. 17 Administrator adds new patient



Fig. 18 Administrator updates patient information



Fig. 19 Administrator can check previous data

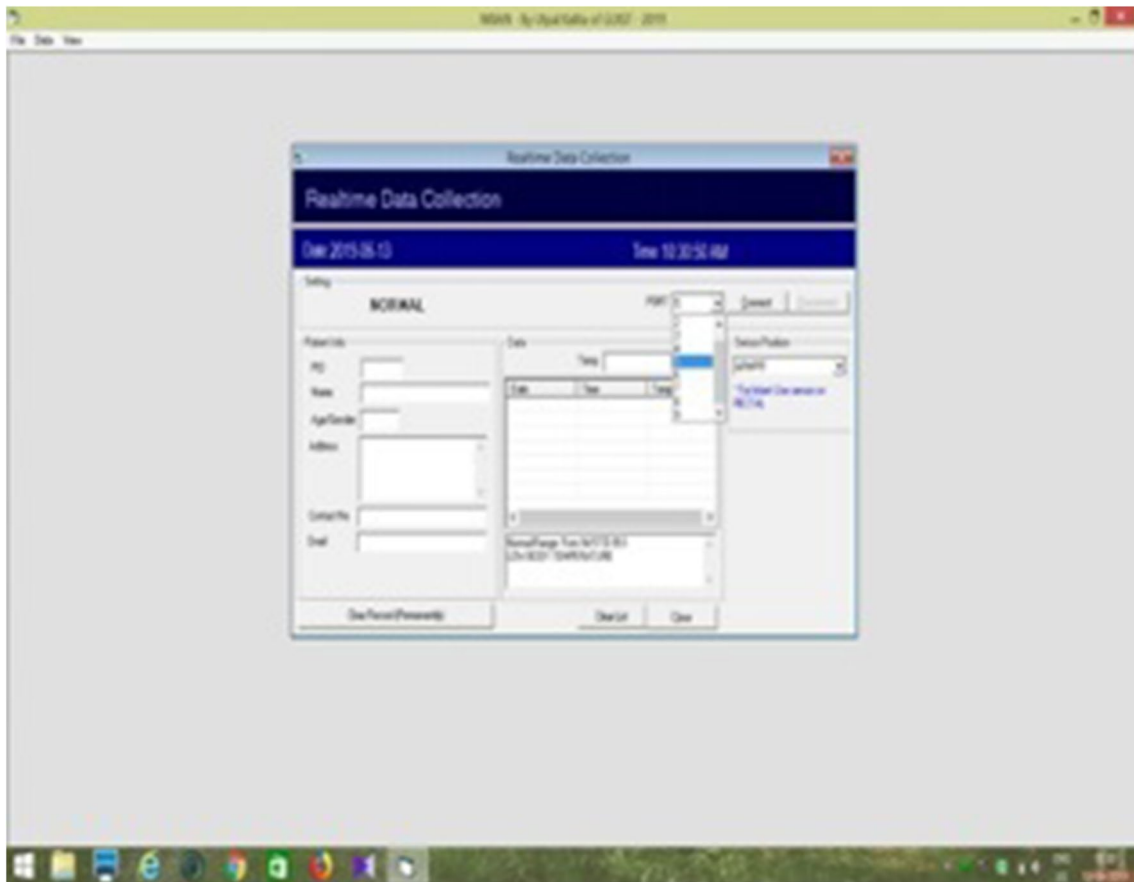


Fig. 20 Create id and password of sensor hardware port of CCU

Table 2 Body temperature of normal range for adult and child according to the medical science [20–25]

Type of reading	0–2 years	3–10 years	11–65 years	Over 65 years
Oral	95.9–99.5 °F (35.5–37.5 °C)	95.9–99.5 °F (35.5–37.5 °C)	97.6–99.6 °F (36.4–37.6 °C)	96.4–98.5 °F (35.8–36.9 °C)
Rectal	97.9–100.4 °F (36.6–38 °C)	97.9–100.4 °F (36.6–38 °C)	98.6–100.6 °F (37.0–38.1 °C)	97.1–99.2 °F (36.2–37.3 °C)
Armpit	94.5–99.1 °F (34.7–37.3 °C)	96.6–98.0 °F (35.9–36.7 °C)	95.3–98.4 °F (35.2–36.9 °C)	96.0–97.4 °F (35.6–36.3 °C)
Ear	97.5–100.4 °F (36.4–38 °C)	97.0–100.0 °F (36.1–37.8 °C)	96.6–99.7 °F (35.9–37.6 °C)	96.4–99.5 °F (35.8–37.5 °C)

considered as fever, and hypothermia is defined as a drop in body temperature below 95 °F.

In the above system used a DS18B20 temperature sensor for collecting patient body temperature instead of thermometer and set a LAB environment in our IoT lab. Although, this sensor is used for collecting body temperature from the above body position. Temperature is collected as analog signal and send it to the laptop which acts as local server using micro-controller Arduino. In PC VB is used as an interfacing software which displays and stores data in specific format. Collected data that are stored in the database. Here using VB programming, acquired data is analyzed w.r.t. medical definition as given in Table 2, Fig. 12. Patient’s health

temperature accordingly and corresponding health condition is displayed.

### Experimental Results

The result of this system can be visualized with the help of the graphical user interface of software and hardware modules. The detail of the output is illustrated step by step as follows. The system setup is shown in Fig. 13.

At first a login interface appears just like as given in run the program, once if program is executed, then a login interface is appeared just like as given Fig. 14. To start using the



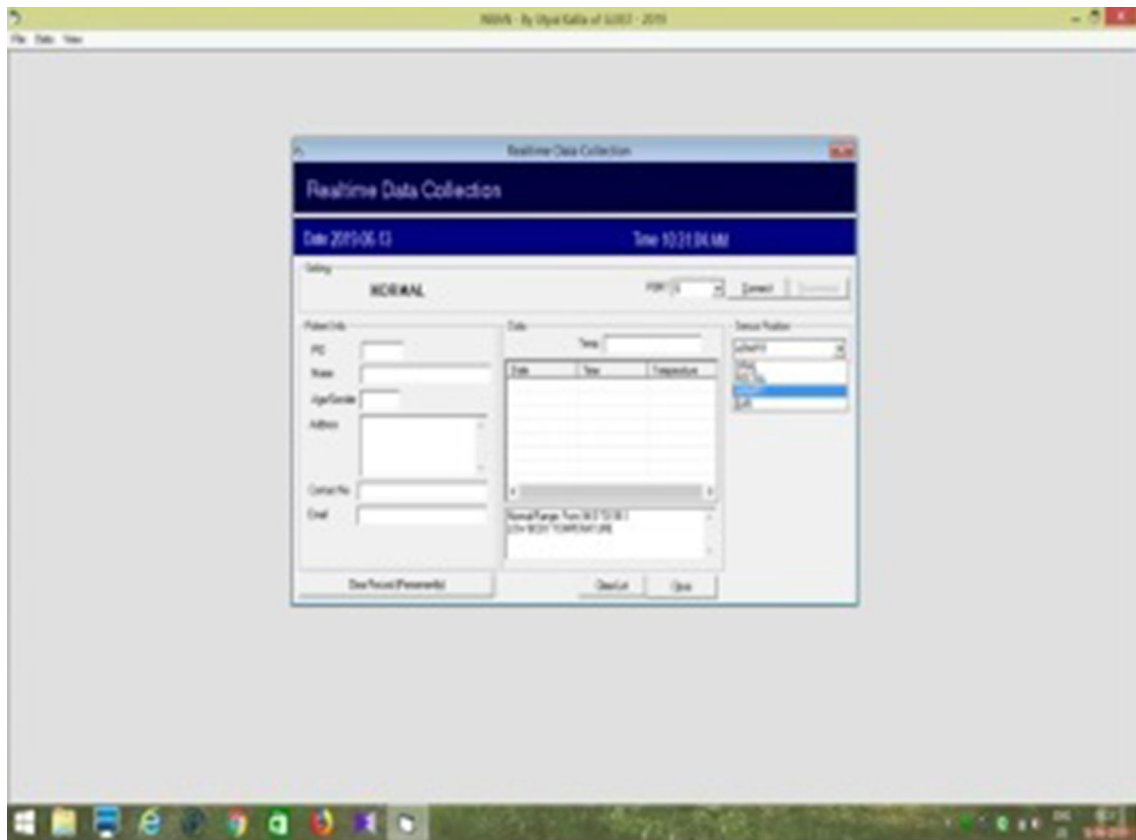


Fig. 21 Sensor data collection from different body parts



Fig. 22 System collects real-time data

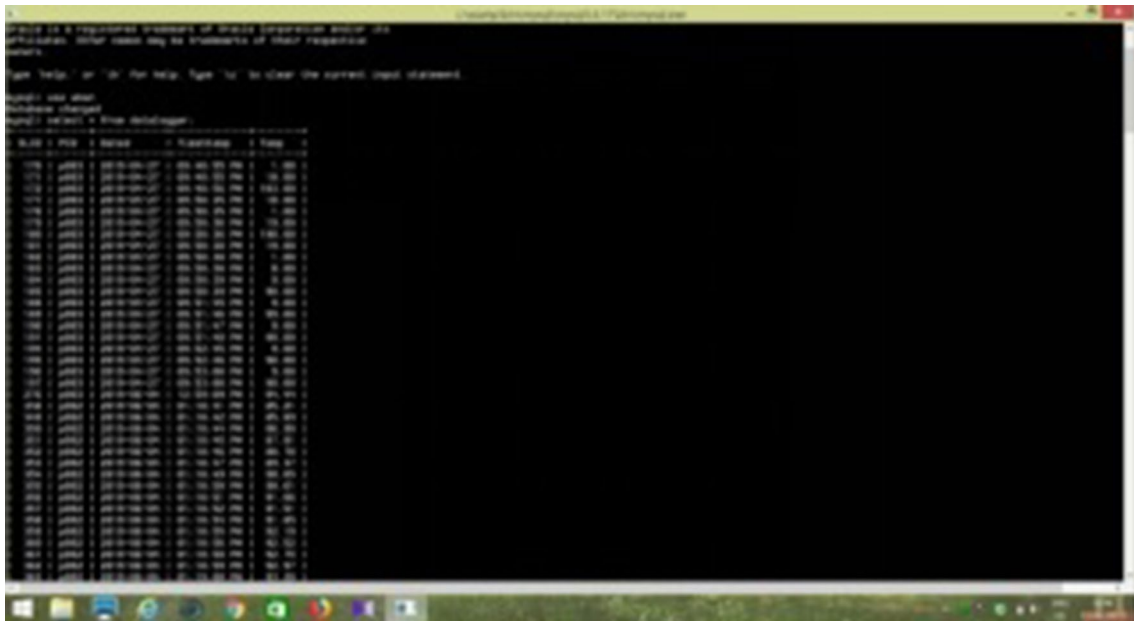


Fig. 23 Display of real-time data in the database

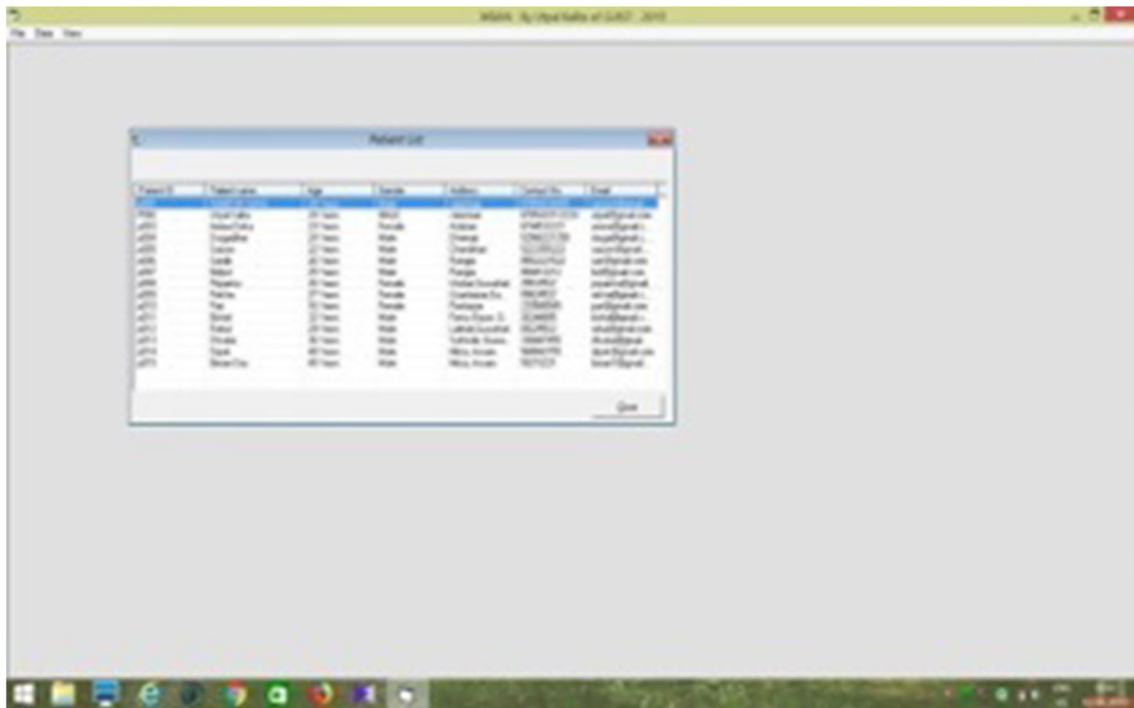


Fig. 24 Display patient list in the database



Fig. 25 Display condition of the patient



Fig. 26 Display normal condition of the patient

system, authentication in terms of login credentials is done for both administrator and patient.

If authentication fails, no one can access the system as shown in Fig. 15.

If the username and password given by the admin matches with the database, then the admin will get the accessibility of the home page where the admin can access all the details of Patient, Patient list and also can monitor the real-time data of the Patient shown in Fig. 16.

Administrator can add new patients as shown in Fig. 17 as well as update patient table as shown in Fig. 18.

If administrator wants to check previous data it is possible in this system shown in Fig. 19.

Now new patient first create the patient login Id and password and select the hardware port in the system which is shown in Fig. 20 and position of temperature sensor of the human body like oral, rectal, armpit, ear as given in Fig. 21. This position is armpit here for collecting body temperature of the patient.

Now the administrator enter the patient id, system starts collecting real-time patient data and display. Figure 22 illustrated that currently body vital of patient id 4 is being collected and his body temperature is normal.

If any data to be retrieved, patient id has to be given and corresponding temperature with data and time will be displayed as given in Fig. 23, as well as shows the patient list of the database shown in Fig. 24.

Now, give an example of our system that how take the real-time patient data and monitoring in LAB environment. First take Ramesh Saha as a patient or user of the system. Create database and added different attribute of the patient like PID, Name, Age or Gender, address Contact Details and email-id is p001, Ramesh Saha, 28, Jalukbari, 8,765,334,455 and ramesh@gmail.com respectively. Now select the PORT here it is 6 and sensor position of the user here is EAR as being shown in Fig. 25. After sensor node is connected with the selected position i.e. EAR of the user or patient, then in data box, upper portion shows the data in the format of (date, time and temperature) which gets stored in the database automatically. Below part shows the condition of the patient as per medical science. Here in Fig. 26 is LOW BODY TEMPERATURE because collected temperature is below normal temperature i.e. 93.87 degree Fahrenheit.

Now, if body temperature is in normal range, it shows NORMAL, if more than normal range that condition of patient is also displayed. Accordingly these findings can be sent to doctor to get proper advice in time.

## Conclusion

In our experimental work we are focusing on building a working prototype of a WBAN in which using a temperature sensor DS18B20, connected with the computing device, collects and transmits signals using wired and wireless communication. Here shielded USB cable and ZigBee module are used for data transfer. The outcome of the system is satisfactory after comparing the temperature obtained from a conventional medical thermometer. It is working properly the way we have designed for collecting body temperature, transmitting over wireless communication and analyzed data after receiving. Body temperature indicates symptoms of other physical abnormalities hence needs to be monitored, specifically for elderly and diseased people with freedom of movement due to daily cores at indoor. The working prototype can be extended including other sensors e.g. pulse rate sensor, heart rate sensor, Spo2, Nasal airflow sensor etc. to build a prototype for COVID 19 patient monitoring at home.

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## Compliance with Ethical Standards

**Conflict of interest** None.

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