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IoT-Based Health Monitoring System

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Abstract:- Wireless body area networks, known as body sensor networks, are wireless networks of wearable computing devices. In this case, the wireless network deployed is the Internet of Things or IoT. This special WBAN will allow nurses and doctors to have a real-time view of the patient's physiological data and thereby detect unusual activities in the patient's health. This is achieved by having a device that allows the patient to collect physiological data using sensors controlled by an Arduino microcontroller board. Doctors can then log into the website and monitor the patient's health status in real-time and over some time.

Keywords:- *Arduino; IoT; LCD; Pulse; Sensor; ThingSpeak; Wi-Fi.*

I. INTRODUCTION

According to the US Embassy in Nigeria, there are an estimated 100 million cases of malaria each year in Nigeria. More than 300,000 of these cases resulted in death, more people die from malaria than from AIDS. 11% of child mortality is due to malaria. Anemia is another serious disease that causes death among children in Nigeria, 68.3% of children under 5 years old are anemic. Many Nigerians also fall victim to cardiovascular diseases (CVD). In 2015, 17.7 million people died from these diseases, accounting for 31% of deaths worldwide [1].

Malaria, anemia and CDV, like all diseases, have symptoms. One of the main symptoms of malaria is fever (high body temperature), while tachycardia (high pulse) is a common symptom of anemia and CDV. Fever and rapid heart rate are symptoms of dozens of diseases that millions of Nigerians suffer from every day. Every year, millions of people die from diseases related to high body temperature and heart rate. Very often, these symptoms are not detected early. Patients suffering from or even recovering from these illnesses need to have their health monitored by a doctor or nurse to ensure their condition does not become life-threatening. Unfortunately, in Nigeria, the only way for a doctor or nurse to monitor a patient's health is to be present. This is a big problem because according to the World Health Organization, the doctor-to-patient ratio in Nigeria is 1:6,400. There are simply not enough doctors to continuously monitor the health of many patients with the disease.

Wireless body area networks, also known as body sensor networks, are wireless networks of wearable computing devices. In this case, the wireless network deployed is the Internet of Things or IoT. IoT is a giant network of connected ‘things’ – people to people, things to things, and people to things. This special WBAN will allow nurses and doctors to have a real-time view of the patient's physiological data and thereby detect unusual activities in the patient's health. This is achieved by having a device that allows the patient to collect physiological data using sensors controlled by an Arduino microcontroller board. This data will be transmitted using a Wi-Fi module stored on a cloud site. Doctors can then log into the website and monitor the patient's health status in real-time and over some time [2].

II. LITERATURE REVIEW

A project on a patient health monitoring system using IoT was developed in a technology-oriented healthcare environment [3]. People are facing the problem of sudden death due to heart attacks, due to not receiving timely medical care for patients. Therefore, the study developed a project to prevent sudden mortality using body health monitoring. In this system, the patient will carry a device with sensors and an Android phone application, the sensors will detect the patient's body temperature and heart rate and this data will be transmitted to the smartphone Android via Bluetooth or cloud-enabled Wi-Fi system. The database stores all the patient's health information and the doctor prescribes medication using this information stored in the cloud. The device even allows the patient to move freely and can be continuously monitored. The Android phone will contain an application that detects a heart attack based on the corresponding received data, and if any abnormal signs related to a heart attack are detected, a message will be sent to the doctor, who patient and the hospital. The SMS contains the patient's situation and location (via GPS) to provide emergency medical care.

The new architecture of the Internet of Things and Big Data ecosystem has been developed for a secure smart healthcare monitoring and warning system. Wearable medical devices with sensors continuously generate huge data, often referred to as big data combined with structured and unstructured data. Due to the complexity of data, it is difficult to process and analyze big data to find valuable information that is useful in decision-making. On the other hand, data security is a key requirement in Big Data healthcare systems. To overcome this problem, this paper proposes a new architecture for IoT implementation to store and process

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scalable sensor data (big data) for healthcare applications. The proposed architecture includes the MF-R architecture that uses Big Data technologies such as Apache Pig and Apache HBase to collect and store sensor data (big data) generated from other sensors each other and the proposed GC architecture is used to ensure fog integration, IT with cloud computing. This architecture also uses key management services and data classification functions (sensitive, critical, and normal) to provide security services. This framework also uses a Map Reduce-based prediction model to predict heart diseases. Performance evaluation parameters such as throughput, sensitivity, accuracy, and f-measure are calculated to demonstrate the proposed architecture's effectiveness and the prediction model [4].

In another project, a Big Health application system based on the Internet of Things and Big Data for healthcare was developed by [5]. The world is facing problems such as uneven distribution of health resources, increasing chronic diseases and increasing medical costs. Integrating the latest information technology into the healthcare system will significantly reduce problems. This article introduces a large medical application system based on the Internet of Health Things and Big Data.

A BSN CARE: Modern, secure healthcare system based on IoT using body sensor networks. Advances in information and communications technology have led to the emergence of the Internet of Things (IoT). In the modern healthcare environment, IoT technologies bring convenience to doctors and patients because they are applied to many different medical fields (such as practice). (time tracking, patient information management, and healthcare management). Body Sensor Network (BSN) technology is one of the core technologies of IoT developments in healthcare systems, where patients can be monitored using a set of sensor nodes, small and light wireless. However, developing this new technology in healthcare applications without considering security issues leaves patient privacy vulnerable. First, the study highlights the key security requirements of modern BSN-based healthcare systems. The research proposes a secure IoT-based healthcare system using BSN, called BSN-Care, that can effectively meet these requirements [6].

Reference [7] developed a project on an IOT-based patient health monitoring system, developing a microcontroller-based system for wireless heart rate and body temperature monitoring using a tissue-Wi-Fi module. Thanks to that, it can easily provide real-time information, available to many users and send them notifications during critical conditions on the Internet. In India, many patients die due to heart attacks and the reason behind this factor is that they do not get proper help during this time. To provide them with timely and appropriate help, the study first wants to ensure continuous monitoring of the patient's health. Fixed monitoring systems can only be used when the patient is in bed; these systems are very large and available only in critical care hospitals. The system was developed for home use by patients who are not in critical condition but need timely follow-up by their doctor or family. In any critical condition, an SMS will be sent to the doctor or any family member, so one can easily save many lives by providing timely service.

➢ *Problem Statement*

Going to the hospital, requiring a physicist's attention is inevitable in life. Considering the health situation in the country, hospitals are not well manned and equipped, and thus are filled up, an overwhelming number of patients turn up every day wanting to see doctors, which causes a lot of chaos. The transportation to be used in other to reach the hospitals is very poor, especially in populated states like Kano, the roads take lives just as much as the diseases. All the above-mentioned facts make it very difficult to go to hospitals, even when in need.

For the reasons mentioned above, I decided to design a Wireless Body Area Network for health monitoring. Therefore, this proposed system is needed in other to overcome the mentioned difficulties, easily link patients and doctors and save lives in the process.

III. METHODOLOGY

A. System Requirements

➢ *Functional Requirements*

- The system should be able to read the heart rate (pulse sensor) and the temperature (DHT11 sensor) of any placed finger.
- The sensors should communicate the captured data to the Arduino for processing.
- The controller should send the information to the software
- The system should allow the admin to add nodes to the system. Each node should be able to transmit physiological data from the patients.
- The system should receive physiological data from patients in real time.
- The system should display the physiological data from patients on a user interface (web page) for doctors and nurses to monitor the data in real time.
- The system should store the physiological data received.

➢ *Non- Functional Requirements*

- The system should be easy to maintain.
- The system should be compatible with different platforms.
- The system should be fast as customers always need speed.
- The system should produce reports in different forms such as tables and graphs for easy visualization by management.
- The system should be secure.
- The system should be accessible to online users.
- The system should provide easy, navigable and user-friendly interfaces.

B. System Specifications

The system is made up of the integrated components, the software that receives and displays the readings (ThingSpeak) and virtually the Wi-Fi connection that enables the wireless connection between the previous mentioned two.

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➢ *Hardware Requirements*

These are physical components used to develop the device, in other words, the connection or integration of these components is what makes up the device. These include:

- Arduino micro controller (Arduino Uno R3)
- Breadboard
- Liquid crystal display (LCD 16X2)
- Pulse sensor
- Temperature sensor
- Wi-Fi module (ESP8266)
- Light emitting diode (LED)
- Jumper wires

➢ *Software Requirements*

The following are the software applications, packages and web pages that were used to come up with the virtual part of the project:

- Working operating system
- Arduino IDE
- Sensor libraries
- LCD library
- ThingSpeak software
- Internet access

C. The Components

➢ *Arduino Uno R3*

This is the microcontroller, it has input and output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. It is programmed using the Arduino IDE software.

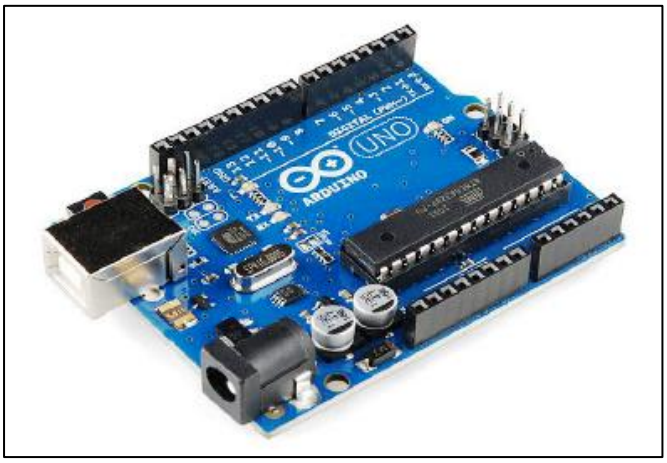

Fig. 1 Arduino Uno R3

➢ *Pulse Sensor*

This is a plug-and-play heart-rate sensor for Arduino. It is an integrated optical amplifying circuit and noise-eliminating circuit sensor. This sensor has three pins: VCC, GND & Analog Pin. Attach the Pulse Sensor to an earlobe or fingertip and through the Arduino, one can read his/her heart rate.

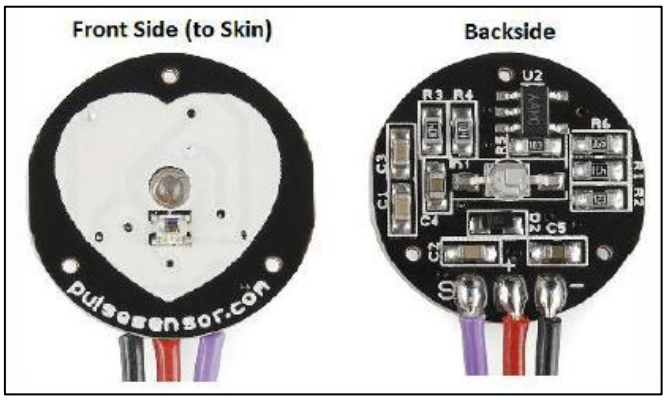

Fig 2 Pulse Sensor

➢ *LM35 Temperature Sensor*

These are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. It does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C, over a full −55°C to 150°C temperature range.

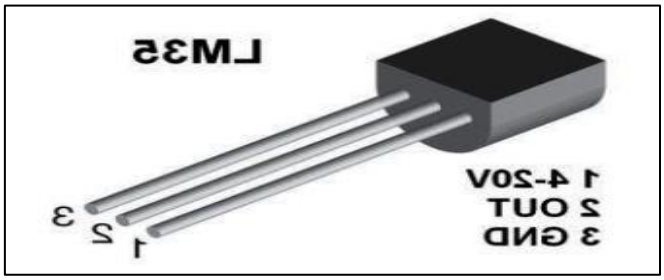

Fig. 3 LM 35 Temperature sensor

➢ *ESP8266 Wi-Fi Module*

This is a very user-friendly and low-cost device to provide internet connectivity. The module can work both as an Access point and as a station; hence it can easily fetch data and upload it to the Internet making the Internet of Things as easy as possible. It is programmed using the Arduino IDE.

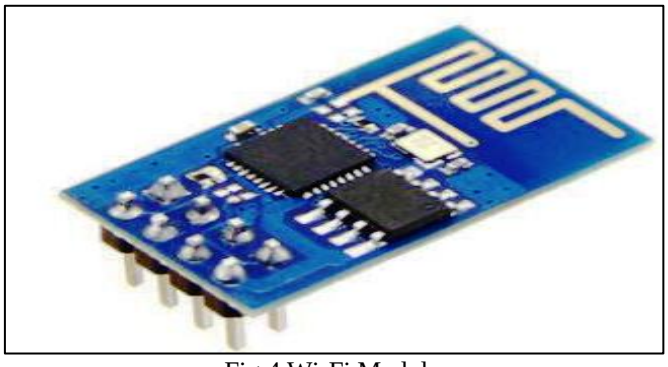

Fig 4 Wi-Fi Module

➢ *ThingSpeak Website*

This is an open-source Internet of Things (IoT) application and an API to retrieve and store data from things using the HTTP and MQTT protocol over the Internet. By using the ThingSpeak site, one can monitor data and control the system over the Internet, using the Channels and web pages provided by ThingSpeak.

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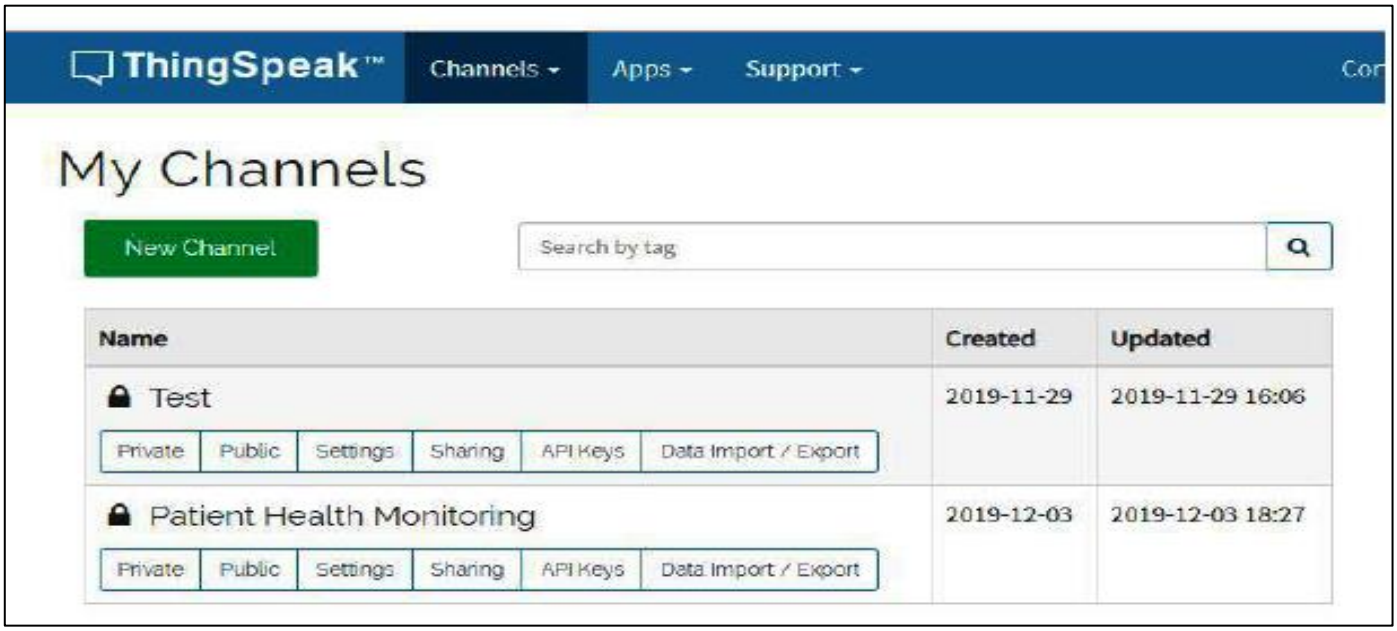

Fig 5 Thing Speak Web Page

➢ *Arduino IDE*

This is the development environment that is being used to code the micro controller; it is integrated with the necessary libraries of most of the sensors (components). It is user-friendly, it provides error messages where needed, it saves and uploads the codes to the board/microcontroller. It has a simple interface.

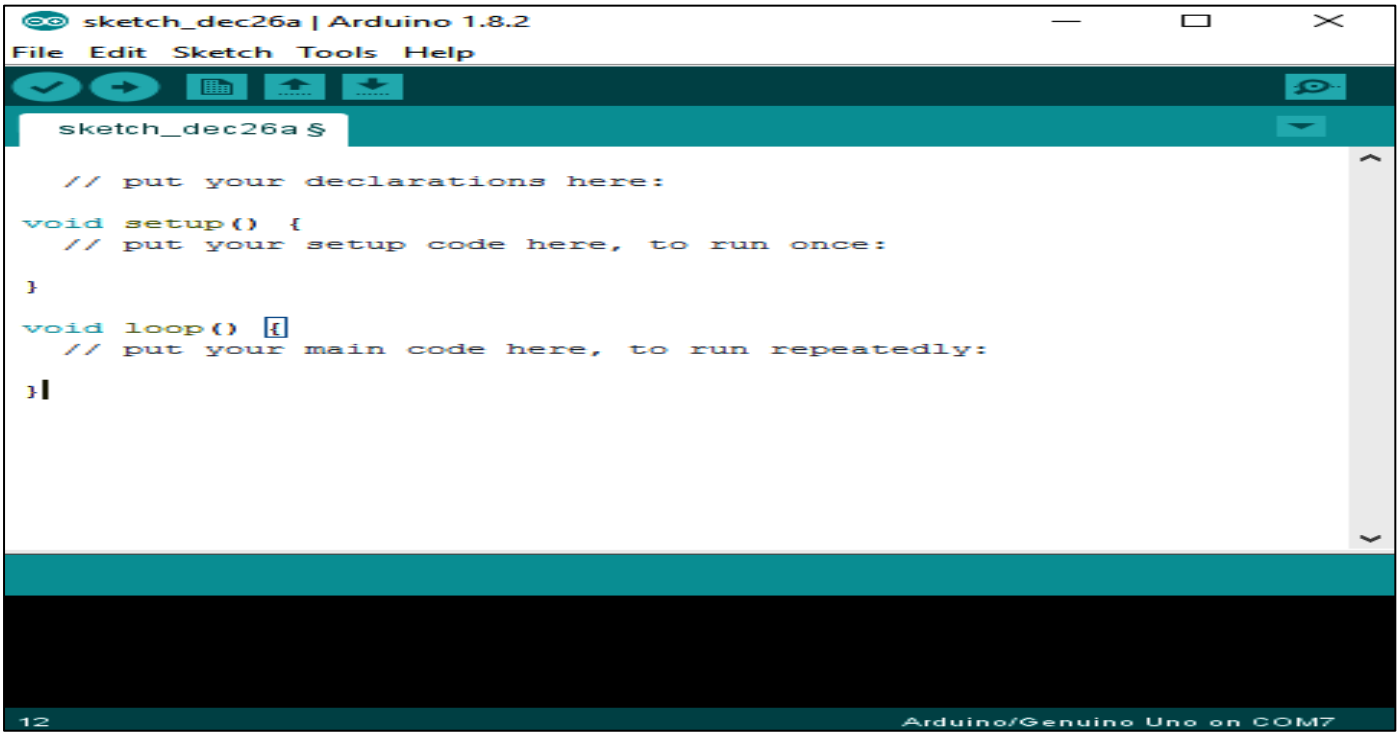

Fig 6 Arduino IDE Interface

IV. SYSTEM DESIGN

➢ *System Overview*

The Arduino Uno microcontroller board serves as the central processing unit of this system. Hence, the input components of the system are the temperature and pulse data of the patient through the temperature and pulse sensors respectively. The Arduino board processes this information and it is given out to two output devices. The first one is the LCD so the data can be displayed for the patient to see. The other output is the ESP8266 Wi-Fi module that transmits the data to the internet, specifically the private channel on ThingSpeak. Once the data is transmitted, a doctor who has access to the private channel can monitor the patient's health using any device that can connect to the internet.

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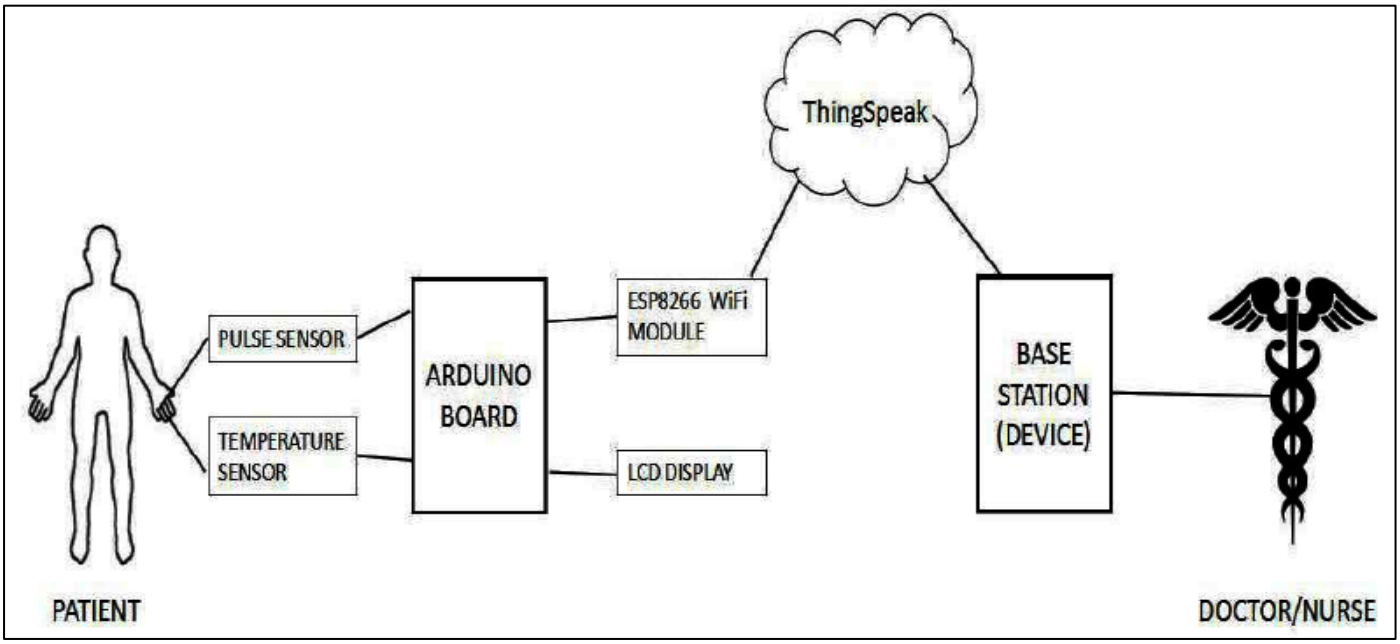

Fig. 7 System Architecture

➢ *Hardware Design*

The hardware design part shows how the hardware components of the system are connected. The components are: Arduino board, temperature and pulse sensors, LCD, and Wi-Fi Module. Using jumper cables, the LCD is connected to the digital pins of the Arduino Board. Both the pulse and temperature sensors are connected to the analog pins of the Arduino Board because the data being measured from these sensors are analog (continuous). The LCD and sensors are powered using the 5V pin from the Arduino board. The Rx (receive) and Tx (transmit) pins of the Wi-Fi module are connected to two of the digital pins on the Arduino. The Wi-Fi module only accepts 3.3V rather than 5V. For this reason, the module is connected to the 3.3V pin on the Arduino. The figure below clearly shows the circuit diagram.

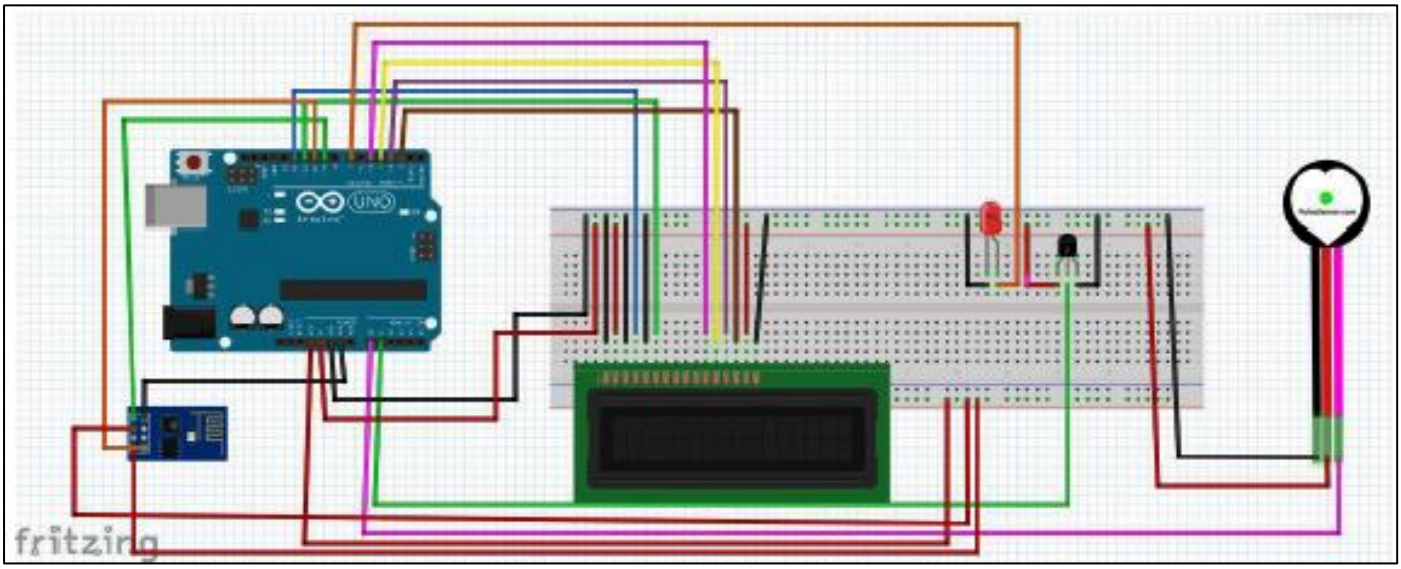

Fig 8 Circuit Diagram

➢ *Programming the Circuit*

After the hardware component is finished, the board must be programmed. This is done using the Arduino IDE software. The programming language for this environment is based on C programming language. When programming the board, it is vital one knows each and every component in the circuit and the coding. Also, one must make sure to include all the necessary libraries such as LiquidCrystal for the LCD and Serial Monitor to communicate with the Wi-Fi module. It is also very important to comment on the code as much as possible.

To monitor the data from the device, I use the ThingSpeak website. Once signed up, ThingSpeak will give you access to 4 private or public channels on their website. With a purchased license, more channels can be provided. One channel will be designated to one Wi-Fi module hence, one device. On this channel, one can add several fields of data. In

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this case, there will be two fields, one for body temperature, and the other for pulse. ThingSpeak also allows one to add features such as visualizations, widgets, graphs to provide an easier way to monitor the patient over some time. Finally, an API key will be provided for the private channel. This key will be used in programming the board.

- *Connections*

Basic engineering skills were used to check for the compatibility of the different components (sensors) and calculate the amount of current needed by each component. It also involves the drawing and implementation of the circuit diagram - that is, the physical arrangement of the components -. At this part, the connections were also specified and implemented between the components, to make it possible for each entity to communicate with any other required component, these connections were simply carried out using male and female jumper wires.

- *Coding*

This is the part that is the major aspect of the project, the required codes were typed into the system via the Arduino IDE. The code is to define the actual work of each and every component used in the system (sensors and the micro controller). Some of the components may require special codes that can be found in downloaded libraries. As mentioned earlier, C language is the basic of Arduino coding. The lines of code are provided in the appendix.

V. CONCLUSION

The new system will eliminate the hassle of going to the hospital, waiting in line and then seeing a doctor, saving time, energy, resources and traffic congestion in the hospital. The system will provide prompt and real-time doctor attention. This is a system that needs to be fully embraced and once implemented will help improve the health and lives of the society. As the world is constantly changing and technology is a key factor, healthcare also needs to be automated to keep up and there will definitely come a time when only the automated aspects of life will prevail.

Considering the Nigerian society, this project is deemed to face a number of limitations, due to the fact that it is purely automated and requires the internet; the funding and expertise needed for effective implementation, internet access, cost of internet services, computer literacy, and individual awareness.

Based on this project, it is hereby recommended that; the government should support this project for health sector development, endeavor to make available the components for the device, improve internet access and finally enlighten the masses.

Like all innovative designs, further work could be done to enhance the functionality of this system in the future. First, when implementing this design in an actual medical setting, instead of using a breadboard with the Arduino, the circuit diagram can be used to derive the schematic diagram and produce a PCB instead which will be more economical and convenient to use. Also, more medical sensors can be added to the device in other to enhance. Identification features such as fingerprint or optical sensors can be added to the device to ensure that the device is only used by the specific patient. Lastly, in the future a website can be developed and a server can be hosted for the system so hospitals and clinics can have a customized user interface to monitor their respective patients.

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