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Design and management of cloud assisted smart ICU for Covid-19 patients real-time health parameters measurement based on IoT's through wireless sensor network

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ABSTRACT

A smart healthcare monitoring and measurement system are designed to use in hospitals for monitoring various parameters such as oxygen level, ECG, temperature, humidity, blood pressure for Covid-19 patient, who needs an ICU. This framework can be carried out for numerous biological applications. Network of Covid-19 patient's nodes must be available in the ICU room for measurement. A base node collects all these signals and this is to be monitored in the monitoring room which is connected to the Cloud system for real-time monetization from any time anywhere. An ESP32 board is used in all nodes. For transferring ECG signals and other health parameters to the remote doctor, a smart ICU patient health monitor framework utilizing ESP-32 Web Server is deployed. Thus, the remote specialist doctor could be checking his patients' condition through the web. In this project, AD8232 ECG Sensor is interfaced with ESP32 Module and observe the ECG signal on Ubidots platform. The other sensors that connected with the module show the current state of the ICU Covid patient. Through this doctors and other medical staff can easily remotely monitor the patient in real-time.

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INTRODUCTION

Covid-19 second wave reaches to its pick as many COVID patients are in necessitate for care and monitor continuously. Doctors, nurses, and staffs confronts with more challenges every day. It is fundamental to accomplish exact and quick analysis framework for patients who experience the ill effect of Covid-19 disease. Consequently, it is important to monitor oxygen level, temperature, heart rate, blood pressure, humidity & ECG signal incessantly. All these heath parameters are monitored through an IoT device which is connected on wireless sensor network. All data received from patient's node are stored in a private Cloud system for real-time monitoring. Telemedicine is an extraordinary piece of exploration for more than thirty years. Some of its apparatuses were carried out through wired communications. The improvement of wireless communication allows telemedicine to work remotely. As a result, escalating its advantages, administrations, and applications. WSN consolidates a huge scope of advantages to extend to facilitate with hardware, systems software, networking, and programming method (Ahmed & Ali, 2016). With lots of latest healthcare technology innovations, IoT is rapidly reforming the medical services industry (Vedaei et al., 2020a) .

In the early months of the pandemic situation no assigned cure to fix or immunization, the barely approach to break the contamination chain is self-detachment and keeping up social distance (Vedaei et al., 2020b). Keeping track of the health status for the medical staffs Covid patients continuously a difficult task. Old age patients' needs periodic monitoring. This paper is a creative framework that recommends automated task conveniently. In this article it is presented, an expected utilization of the Internet of Things (IoT) in medical services for continuous monitoring of Covid patients with maintaining physical distances. The IoT device tracks wellbeing boundaries, including blood oxygen level, heart rate, ECG etc. and at that point refreshes the data to show the monitoring ailments through cloud networking. This proposed system sees the patient to keep 24/7 monitoring from an actual distance of more than two meter or six feet, which is a crucial factor in controlling (Vedaei et al., 2020a) infection among the medical staffs.

Wireless sensor network contains several quantities of self-determining sensors that sense and dragonizes patient condition persistently. Individual node gathers data from several sensors mounted on the Arduino board, locally processes, and transmit the data through WSN with the goal that other it could save it for the cloud for monitoring. Then this collected data will be imparted to next neighbouring nodes by means of a wireless connection. There are three significant issues that ought to be respected for WSN plan with equipment stage to pick appropriate hardware, patient information security and the correspondence technique. Improvement sections of remote sensor node are contemplating the specialized technical difficulties and the introduced design philosophy. ESP-32 Web Server is utilized in this framework that contains data visualization in the web from anyplace from the world. Here MAX30100 Pulse Oximeter sensor is utilized to quantify heart rate/pulse and the blood oxygen level. Similarly, DS18B20 Temperature Sensor is used for quantifying the body temperature. Essentially covid patient room temperature and humidity level should be, set such a wat that patient does not feel annoying. For doing that, the room temperature and humidity need to be monitored. So, a DHT11 Humidity & Temperature Sensor is used for this purpose. To monitor the ECG signal only when the medical staffs are present the IoT device relates to Internet and make ECG & Heart monitoring possible remotely. The AD8232 is used for ECG applications. Along these AD8232 ECG Sensor is interfaced with ESP32 Module to monitor ECG signal on Ubidots platform so that we can monitor all the patient info remotely because all the data are stored in cloud by using WSN. In the following paper in area (II) the system model, in segment (III) the outcome will be discussed. At the end of the paper, we will conclude, and discussion will also be done for future improvement of this project.

The key theme in this paper is to design an IoT based wireless remote covid-19 patient health monitoring framework easily from anywhere any time. It sends patient various health parameter records to the monitoring room which is connected through a private cloud network. In this module, patient screens their ailment from home also, if the case is not serious. It's a useful method to give necessary health data regarding sicknesses. This IoT device will be successful for heart illnesses patients also as ECG module is included. Numerous cardiovascular related diseases occur for the cutting-edge way of life, junk food, smoking tobacco, and for not doing physical exercise. For those

patients who need to monitor ECG consistently after certain period of their treatment. In these diseases, patient surges are insufficiently influenced by Coronavirus. A distance health care monitoring framework is viable further required to transform from one person to another. The gadget will screen patient wellbeing information quickly if any breathing issue or other issue happens it will send a report to the monitoring unit and consequently find out patients needed oxygen or other treatment. Sensors included in the IoT device will measure the patient's temperature, SPO2, blood pressure, pulse, blood pressure and ECG. Sensors give data about the patient's wellbeing information and the patient's present condition continuously. This ICU system management framework is organized of three sub-frameworks. First one is ICU/emergency patient node which contains the IoT device, second part is the cloud integration, and the last part is the monitoring unit for observation from remotely.

During the previous years while, diverse IoT applications have been proposed to improve ICU management and health care frameworks (Vedaei et al., 2020a). The IoT can be utilized for distant patient observing, e.g., interfacing seniors who have covid can consult to specialists. In a savvy medical care setting, the IoT can assist with giving remote diagnosis for more proficient treatment. Geo location of individuals gives significant data about an expected flare-up during this pandemic. It very well may be acted in numerous points of view, each having its upsides and downsides even though giving precise assessments. Already this sort of work has shown the possibility of utilizing the WLAN or WSN. Now a days, Apple and Google announced that they would use Bluetooth for contact tracing of iOS and Android customers (Vedaei et al., 2020a). Customers can turn it on or off, and the data would simply be given to confide to health authorities that follow practice security methodologies. Audio signal processing is another region that can be helpful for conclusion of various respiratory infections (Vedaei et al., 2020a).

This segment evaluates the related work on patient's health monitoring based on WSN, and it includes introduction to conventional sensor networks, deliberates the advantages and key issues in health monitoring and in addition to this part analyze the patient observing dependent on various detecting boundaries. The body-sensing sensor module estimates the body's physiological signs; the body wireless network gathers data which furthermore forwards this data to mobile nodes. Then node will show the data when the patient's sensor value is less than the threshold value like heartbeat, pulse, and blood pressure. Hua et al., 2014 analyzed the fall-discovery component with the assistance of oxygen level sensor, pulse Sensor, Temperature & Humidity Sensor, and GPS Sensor. When the normal value worth surpasses a worth of fifteen percent, which is very alarming. These dangerous values will be detected by using micro controller and from the controller the information will be sent to the display unit at the same time it will be updated in the cloud server. Maria et al., 2014 (Ahmed & Ali, 2016) examined wireless sensing monitoring framework for pulse-oximetry sensors. Many pulse oximetry sensors were put on a few hearts patients' body without utilizing a wired or infrastructure network. These detected signs will be sent to the web through WLAN and GPRS. Data exchange between the patients and specialist doctors will be more proficient, fast and secure by utilizing Wi-Fi and GPRS. By using a wireless handheld device, the doctors can access patient's history, medicine and lab reports etc. examined wearable sensor technology. Electrocardiography sensor, blood pressure sensor, breathing sensor, electromyogram sensor and electropalatogram sensors were used to monitor biological functions of the patients.

These wireless sensor nodes will form medical super sensor. This server will collect the information from WBAN and give priority to the sensed parameters. Lai et al., 2010 (Shahzad et al., 2018) examined versatile body posture investigation for elderly falling recognition. Collaborative accelerometer sensors, body posture investigation, versatile changes in model and fall detection. In collaborative detection, persons standing, sitting, and lying down positions angle values are kept as a threshold value and if the detected acceleration value does not coincide with the threshold the fall has occurred. Lai et al., 2011 (*What Is Cloud Monitoring? Benefits and Best Practices*, n.d.). Investigated the body acceleration depends according to the gravity towards the earth surface. While sitting, standing, and lying the gravitational direction will vary and the acceleration will differ. This system uses several sensor modules to improve accuracy fast Fourier transform is used and it is a combination of fall sensing methods and cognitive adjustment technology. Constantinescu et al., 2012 (Vedaei et al., 2020a) studied dynamic integration of multimedia medical data. This system is constructed by self-managing and automated

network for medical data, and it can be accessed by any handheld devices. Service oriented architecture is used to add web service software application to the existing tool. This will create a complex medical application and mount them on the cloud network. Basu et al., 2012 (Wang et al., 2018) studied fusion architecture for cloud network. Combination design comprises of infrastructure service and health care services applications. The framework layer contains data about stored information of patients, correspondence between the healthcare providers. Data management block is used for data encryption, data retention and data analyses and it will also provide data authentication. Thomas et al., 2010 (*MAX30100 Pulse Oximeter with ESP8266 on Blynk IoT App*, n.d.) analyzed fall detection using wristwatch. Fault detection algorithm was built in wristwatch. It will be easy to handle. The wristwatch will alert the relatives or call center through wireless link. Chen et al., 2012 (Vedaei et al., 2020b) examined fall detection mechanism. This system uses tri-axial accelerometers, barometer, and ZigBee protocol. This method has higher accuracy by using patient's daily activity details. The system has sensitivity and specificity of 95.71% and 97.78%. Covid-19 new variants spreads rapidly that affect the doctors, nurses, and other medical, thus, this device is essential.

METHODS

System Model

In this task, the researcher made IoT based ICU patient Health Monitoring System Project. Several sensors was utilized for diagnosis the Covid-19 ICU patients continuously and monitor remotely using cloud arrangement. The block diagram of proposed system using ESP-32 is shown below.

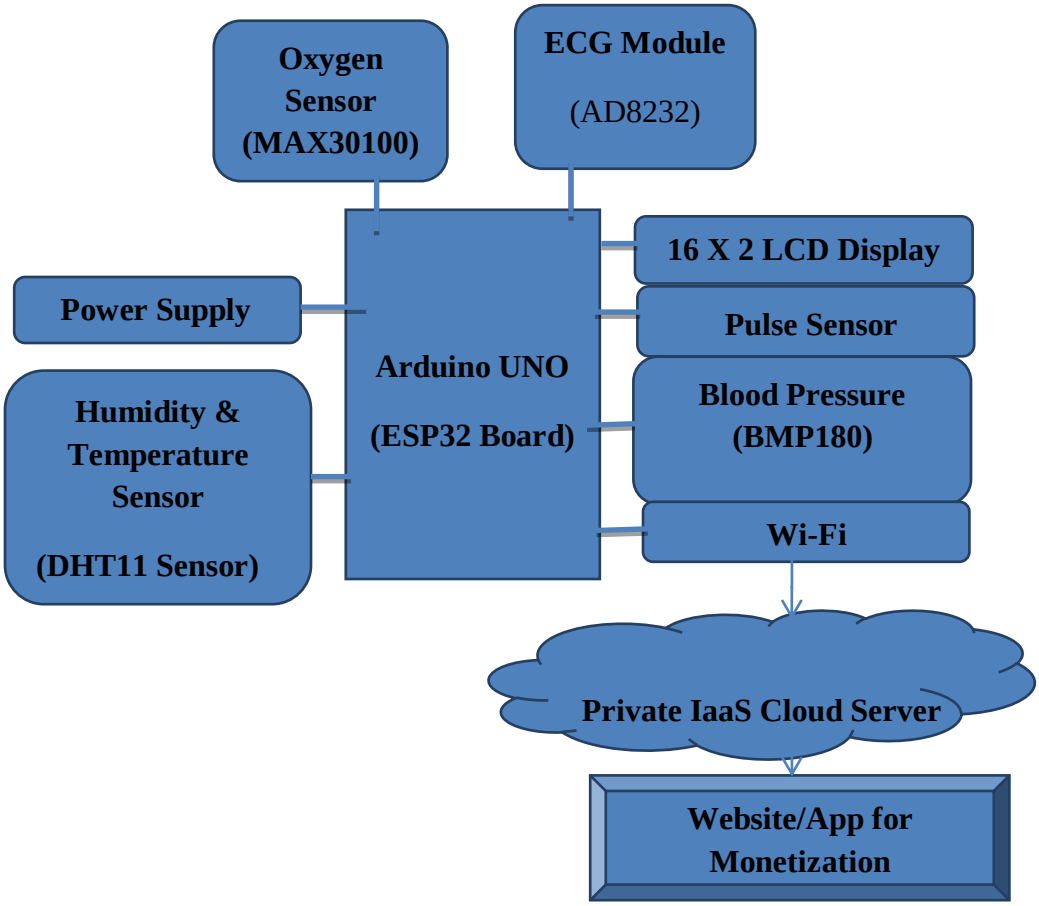

Figure 1. *Proposed Remote ICU patients health monitoring framework system block diagram*

System Component Description

In this proposed system several body sensors are used including ECG Module (AD8232), DS18B20 Sensor, MAX30100, BMP-180, DHT11 etc. In this a brief description will be given regarding various components used in this project.

ESP-32

It is probably the best solution for IoT applications. It has Tensilica Xtensa LX6 microchip with integrated antenna switches, RF balun, power amplifier, filters, and power modules (Wang et al., 2018). In a low-power IoT sensor node application circumstance, ESP32 is woken up discontinuously and exactly when a predetermined condition is perceived; low duty cycle is used to restrict the utilization of energy that the chip burns-through and to achieve an ideal trade-off between correspondence range, data rate and system power utilization of output amplifier.

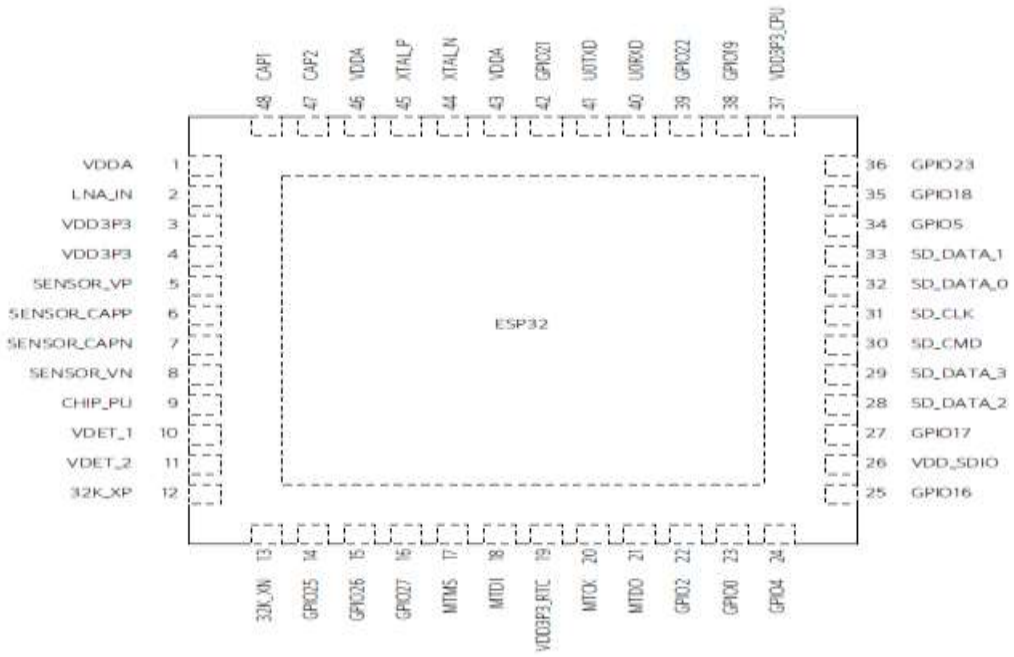

Figure 2. *Pinout of ESP-32*

Features

Performance to price ratio is high. Small in size and easily embedded with other products. It supports LWIP protocol, Freertos & Lua program. It has three modes. They are AP, STA, and AP+STA. Built in Wi-Fi and Bluetooth facilities. Its peripherals includes capacitive touch, ADCs, DACs, UART, SPI, I2C and so forth (*Getting Started with the ESP32 Development Board | Random Nerd Tutorials*, n.d.). ESP32 has both single and dual core processor options which runs 32-bit program. Processor clock frequency varies up to 240MHz and having 512 kB RAM (*Getting Started with the ESP32 Development Board | Random Nerd Tutorials*, n.d.).

Figure 3. *ESP-32 Arduino UNO*

ESP32 peripherals includes eighteen ADC and two DAC channels. It has sixteen Pulse Width Modulation for output channels. Beside these ESP-32 has three SPI, two I2C, two I2S, three UART interfaces and 10 Capacitive sensing GPIOs. The ADC and DAC highlights are allotted to explicit static pins. This is conceivable because of ESP32 chip has multiplexing feature (*Getting Started with the ESP32 Development Board | Random Nerd Tutorials*, n.d.). Although it characterized pins properties on the software. Pins are assigned as demonstrated in the accompanying figure 2. The accompanying table shows what pins are ideal to use as input, output and which ones need to be careful. Pins that featured in green are OK to utilize. Yellow highlighted pins are OK to utilize with paying consideration since they may have unexpected conduct basically at boot. The pins included in red are not recommended to utilize as input or output.

MAX30100 Pulse Oximeter Sensor

This sensor is a complete heartbeat oximetry and pulse monitor sensor arrangement which combines two LED's, a photodetector, optics, and low-commotion analog signal processing to perceive heartbeat and pulse signals (*MAX30100 Pulse Oximeter with ESP8266 on Blynk IoT App*, n.d.). Its functioning voltage range is 1.8V and 3.3V from power supplies and with the assistance of programming with very small current it is permits power supply to remain connected consistently (*IoT Based Patient Health Monitoring on ESP32 Web Server*, n.d.; *IoT Based Patient Health Monitoring Using ESP8266 & Arduino*, n.d.; Wang et al., 2018).

Figure 4. *MAX30100 Pulse Oximeter Sensor*

The sensor has two LED's, one emanating red light, another transmitting infrared light. For beat rate, simply the infrared light is required. Both the red light and infrared light is used to measure oxygen levels in the blood. Exactly when the heart siphons blood, there is an augmentation in oxygenated blood because of having more

blood. As the heart relaxes, the volume of oxygenated blood similarly reduces. By knowing the time between the expansion and decline of oxygenated blood, the beat rate is settled. It ends up, oxygenated blood holds more infrared light and passes more red light while de-oxygenated blood ingests red light and passes more infrared light. This is the principal function of MAX30100. It read the retention levels for both light sources and put away them in a support that can be perused I2C.

DS18B20 Temperature Sensor

This Sensor can quantify the temperature between - 55 to 125°. As it is digital, there is no signal corruption in long distances. This temperature sensor works precisely over ±0.5°C territory which offers 12 bits of precision from onboard DAC and works with any micro controller utilizing single digital pin (*Interface BMP180 Pressure & Temperature Sensor with Arduino*, n.d.).

Figure 5. *DS18B20 Temperature Sensor*

DHT11 Humidity & Temperature Sensor

DHT11 is a fundamental, cheap digital temperature along with humidity sensor which utilizes a thermistor and capacitive humidity sensor to quantify district air furthermore lets out a digital signal on data pin and it does not need any analog input pins (*Interface BMP180 Pressure & Temperature Sensor with Arduino*, n.d.).

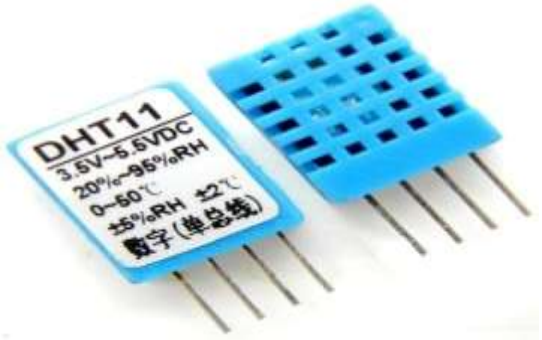

Figure 6. *DHT11 Humidity & Temperature Sensor*

AD8232 ECG Sensor

AD8232 is an incorporated block for ECG estimation which is constructed to extract, amplify, and filter small bio potential signals in harsh conditions**.** Moreover, ECG signal is a mile volt signal, so it needs amplification

and filtration to remove noise. This design takes into consideration an ultra-low-power ADC or a micro-controller to get the output signal without any problem. The AD8232 can carry out 2 pole high pass filter for getting out motion artifacts and electrode half-cell potential. Filter is combined with the amplifier to permit both large gain and high pass filtering in a single stage, consequently saving space and cost. To eliminate extra noise, an uncertain operational amplifier is enabled to make 3 pole low-pass filter. Users can select frequency cut-off of all filters to suit different kinds of usages. To improve common mode dismissal of the line frequencies in the system and other undesired impedance, the AD8232 combines an amplifier for driven lead applications. (*IoT Based Low-Cost ECG & Heart Monitoring System with ESP32 and Ubidots Platform - Electronics Innovation*, n.d.).

Figure 7. *ECG Electrode Connector -3.5 mm*

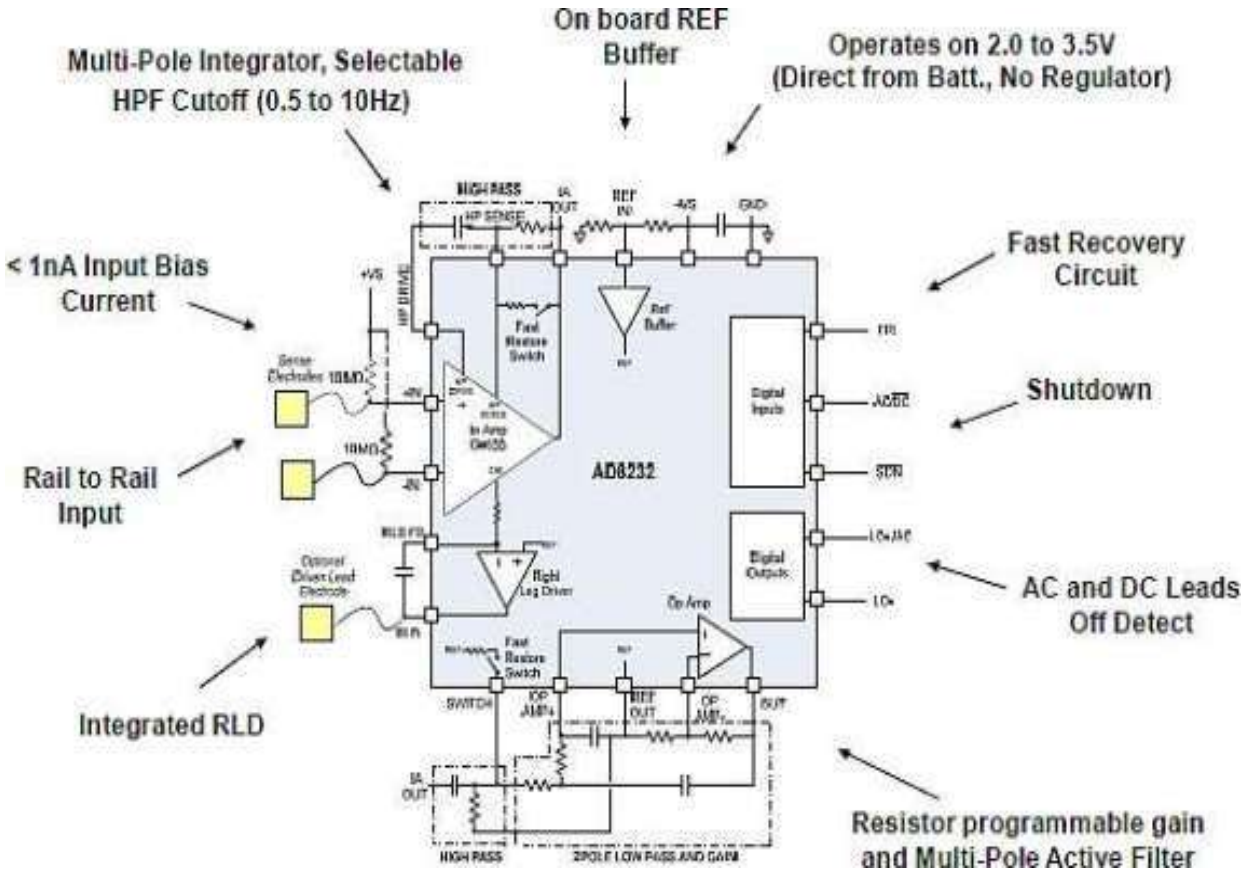

Figure 8. *Pinout diagram of AD8232*

Execution temperature is from 0°C to 70°C and is operational from - 40°C to +85°C (*IoT Based Low-Cost ECG & Heart Monitoring System with ESP32 and Ubidots Platform - Electronics Innovation*, n.d.).

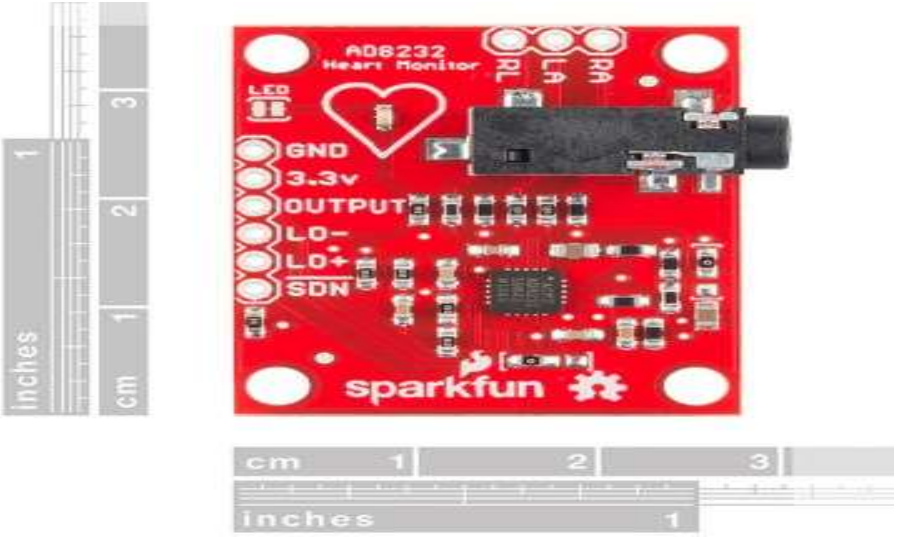

Figure 9. *ECG Module AD8232*

BMP180 Barometric Sensor

This sensor is for estimating barometric pressure and temperature. It is a super low-power advanced temperature and pressure sensor with high precision and stability. Since pressure changes with elevation, it can be utilized as an altimeter. It estimates the absolute pressure of the air around it. It has an estimating range from 300 to 1100hPa with a precision down to 0.02 hPa. It can quantify altitude and temperature (*Interface BMP180 Pressure & Temperature Sensor with Arduino*, n.d.).

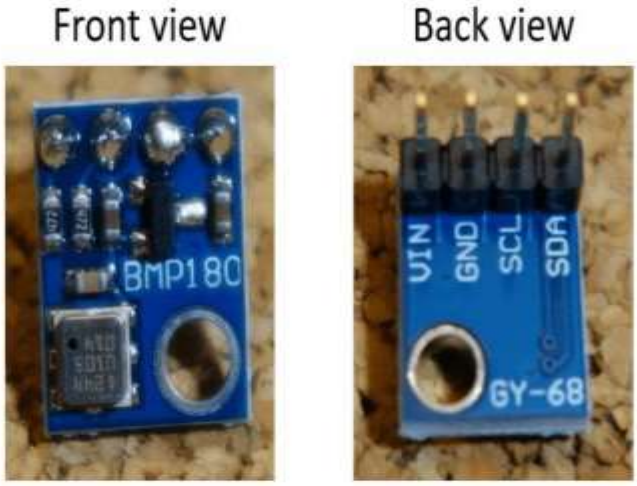

Figure 10. *BMP180 Barometric Sensor*

It involves a piezo-resistive sensor, an ADC, and a control unit with EEPROM and a consecutive I2C interface. BMP180 passes on the uncompensated value of pressure and temperature. This micro controller sends a beginning sequence to begin a pressure or temperature assessment. After changing after some time, the outcome value can be perused through the I2C interface. For computing temperature in °C and pressing factor in hPa, the calibration information should be used. This constant perhaps perused out from the BMP180 E2PROM by means of the I2C interface at software initialization. The sampling rate can be expanded up to 128 samples each second for dynamic estimation. For this situation, it is adequate to measure the temperature only once each second and to utilize this value for all pressure estimations during similar period (*Interface BMP180 Pressure & Temperature Sensor with Arduino*, n.d.). BMP180 Features & Specifications are given below:

Proposed IoT System Model

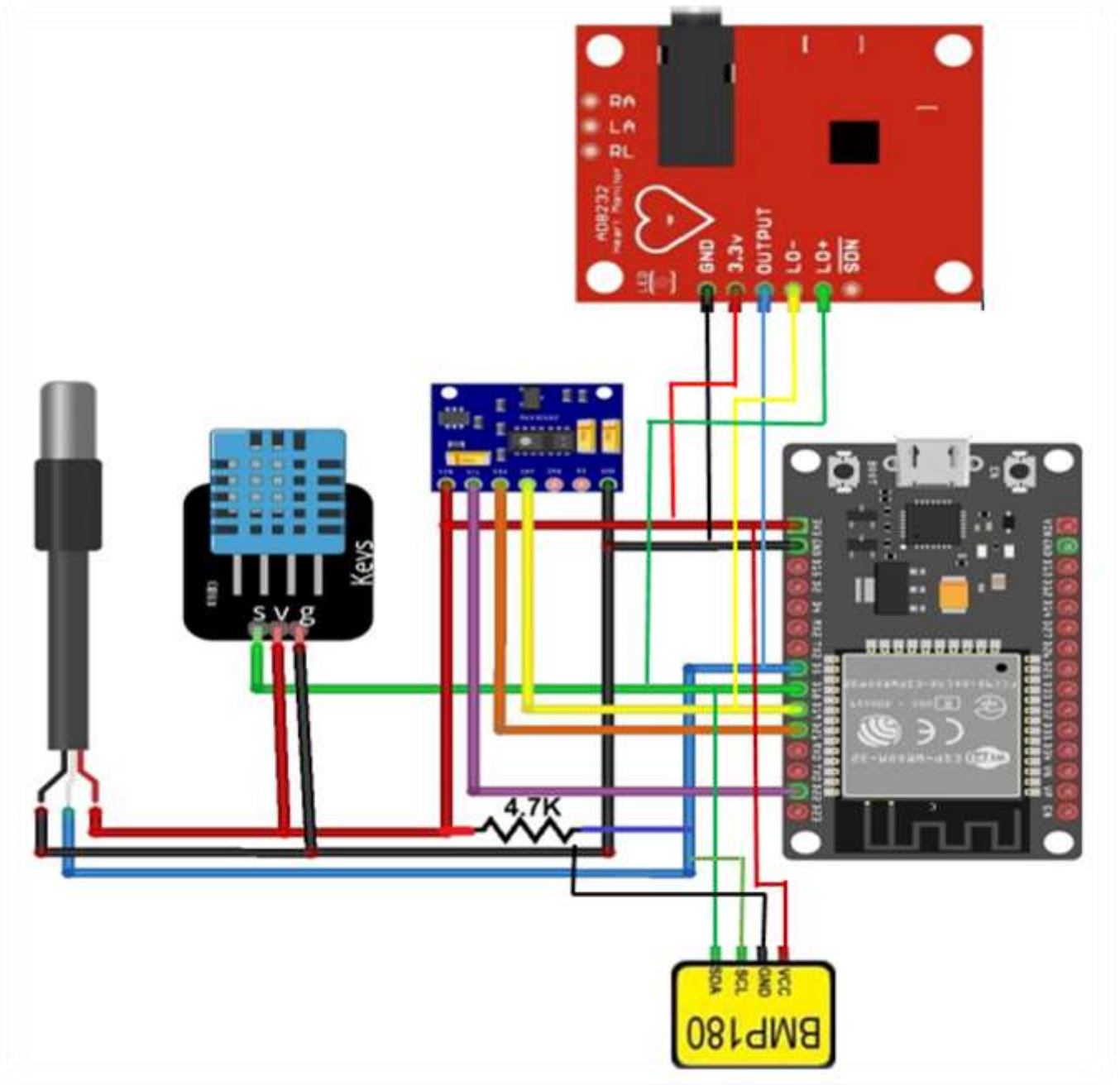

Figure 11. *Circuit diagram for Proposed IoT healthcare monitoring model*

Patient Side Interface

In the patient node the proposed IoT device is connected. Through Wi-Fi the IoT device transmit the ICU patient data to the private cloud server connected to it. Through the private cloud server, the doctors and other medical staffs can easily observe the covid-19 ICU patient heath conditions remotely from any time anywhere.

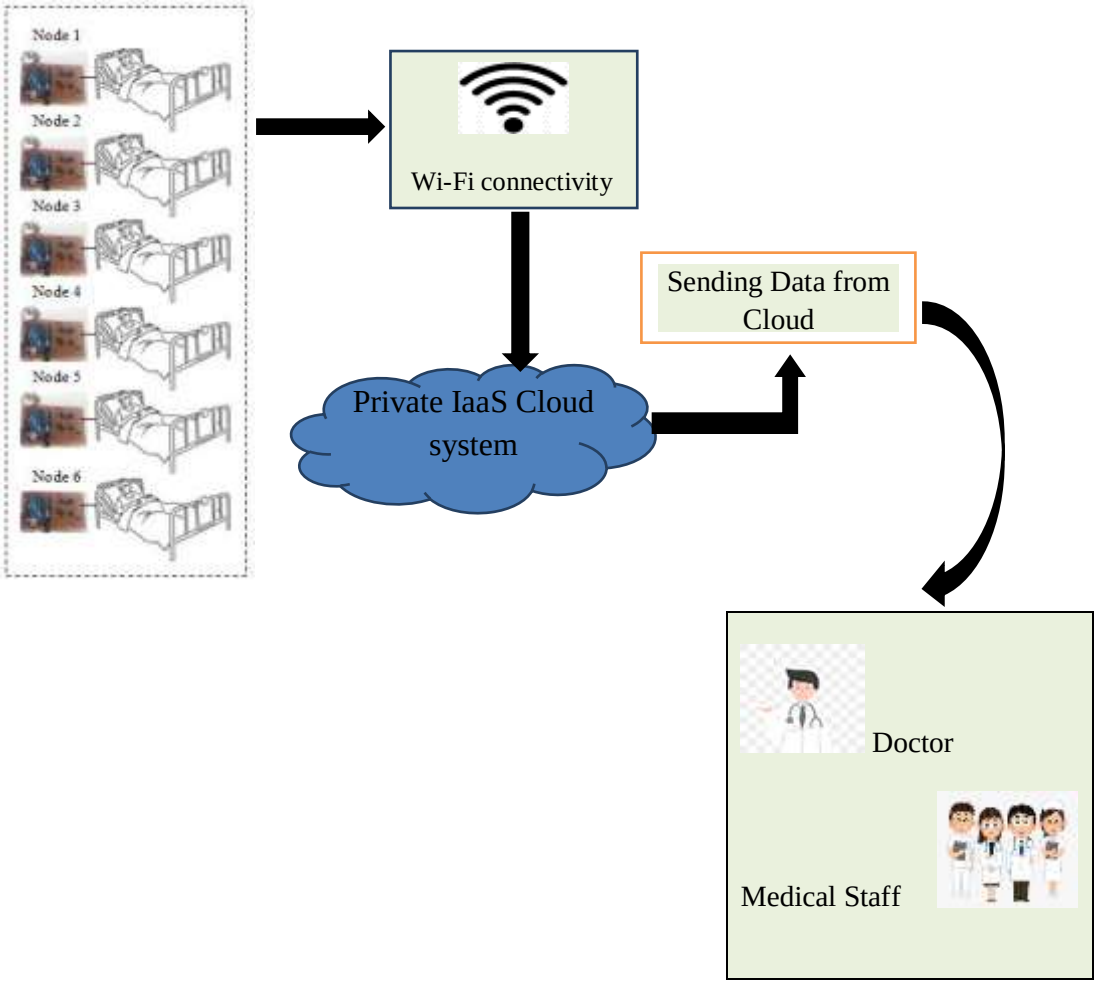

Figure 12. *Symmetric block diagram for proposed cloud assisted IoT based ICU patient management system.*

Cloud Configuration for Smart IoT based ICU Monitoring and Management System

For getting to and observing the ICU Management data at Covid emergency hospital compound, a private cloud computing platform is developed by the hospitals networking team (Shahzad et al., 2018). This framework predominantly envelops that the private cloud computing system framework advancement with the predefined responsibilities furthermore designated to platform entities. (1) A controlled entity is assigned to build the cloud furthermore performing renovating processes for applications that was conveyed by software specialists. (2) Developer entity is assigned to build the virtual atmosphere through a virtual machine furthermore approved to give an affirming interaction of virtual machine. (3) Cloud utilizing applications are planned as well as sent next to Information Technology specialists. (4) During an application running in private cloud, the framework community is assigned, and issue or problem is detected as well as solve the issue.

Private Cloud Virtual Machine Manager

For private cloud computing, virtual machine administrator is a design block and the essential administration tool for managing the legitimate data centre. It offers essential services that are used in building and

overseeing of cloud and makes (Shahzad et al., 2018) the virtualization environment through virtual machines and thoughts, in which the virtual cloud host are configured and managed through VMM as a segment of private cloud computing plan and its administrations. This framework offers administrations, for example management services, library services, database or storage services, command shell service, and security and scalability service to convey the virtual machine manager for proficient private cloud computing. For our situation, the virtual machines are made to remotely access the database of the ICUs for ICU patients for continuous heath data checking.

Private Cloud Application Controller

It gives overseeing of the offices for private cloud system, to manage the conveyed applications, for monitoring, separately. An incorporated self-service web-based interface is additionally given, whichever permits clients to make invocation that coordinated towards the designed private cloud, to convey, configure and deal with the designed cloud administrations.

Private Cloud Service Manager

This is an incorporated, self-service portal and an automated management. For instance, another interaction is characterized that needs to control private cloud environment (Shahzad et al., 2018), furthermore prior to preparing, consent standards must be satisfied and ought to be conceivable with the help of service manager (Shahzad et al., 2018).

Databases

For this situation, the data base is most significant modules which keeps record of data that is retrieved from ICU Management software through Wi-Fi connectivity. MySQL is utilized to convey furthermore keep records of every patient's medical data through an identifier that makes a differentiation between each patient's captured data (Shahzad et al., 2018). Every time real time data is sent, and it is stored as table records. It will additionally retrieve data depends on queries that will be requested by medical staffs. (Shahzad et al., 2018).

ICU Management Software: For this situation, an ICU Management software is the most significant and a model should create to retrieve the real-time data (Shahzad et al., 2018). Thusly, for this reason, software is modelled, which will be installed in approved PC. After enrolment of registration of a username and security password in the cloud, that makes the process more secured.

Chat Engine and Authorized Access

Chat engine facility is additionally a significant part of suggested framework representation which gives group chat service including both call and text correspondence among the consultants and data inputters appointed on the Control room/Monitoring room. (Shahzad et al., 2018). As it is a private system so some data cannot be shared in public cloud as they are sophisticated.

Because of technological demands, medical system has been updated with the new trend setting innovations; nonetheless, there are still few difficulties. Maybe expense is additionally a major issue, while updating from current frameworks with new cloud developments. Thusly, a cloud platform is perhaps one of the best answers for battle against the covid issue. For this situation customized and special requirements for communication prerequisites for correspondence information security necessities is designed and demonstrated for private cloud computing environment as well as ICU patient in the premises of hospital is monitored progressively. For a sensible in advance venture of time and cash, monitoring applications can convey an abundance of continuous information (*What Is Cloud Monitoring? Benefits and Best Practices*, n.d.). It merits seeing application observing to provide details regarding how cloud assets are being utilized (*What Is Cloud Monitoring? Benefits and Best Practices*, n.d.). As COVID-19 second wave booms very rapidly and it reaches at its pick, this covid situation may last for 2-3 years or more. For this project the IaaS Private Cloud system is suitable and the best option for the

project. Due to its low cost, reliable and secured service of Amazon web service, Flexible Customization Platform and software system and pay as you go service and most importantly future increase or decrease system capacity make IaaS Private Cloud system most compatible for the project. As there is a possibility of scalability so according to ICU needs the infrastructure demand can be scalable up or down or easily depends on number of patients increases or decreases during this pandemic period.

OUTCOMES

When the code is uploaded the serial monitor can be opened. The ESP32 will attempt to connect with the network. When it is associated, it will show the IP Address (*IoT Based Patient Health Monitoring on ESP32 Web Server*, n.d.; *IoT Based Patient Health Monitoring Using ESP8266 & Arduino*, n.d.)

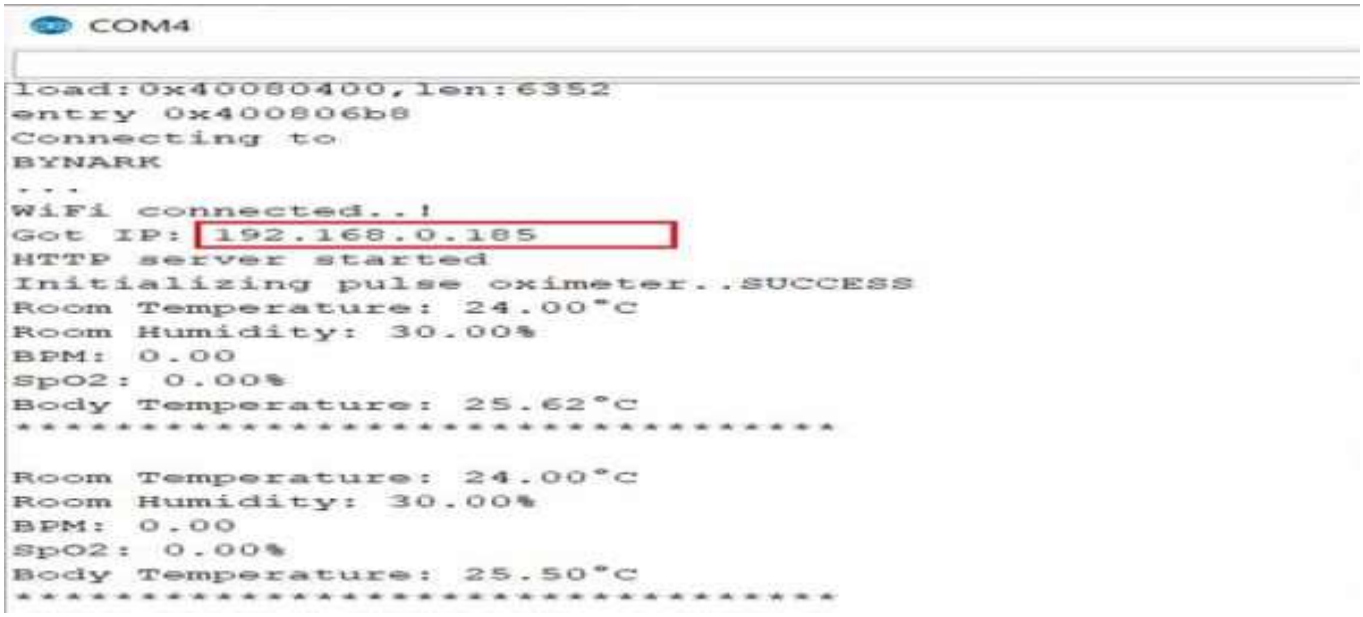

Figure 13. *ESP-32 web server integration*

The IP Address is copied and pasted it on any Web Browser and hit entered and seen patient room temperature and humidity, pulse, patient body temperature, oxygen level in the blood and so on.

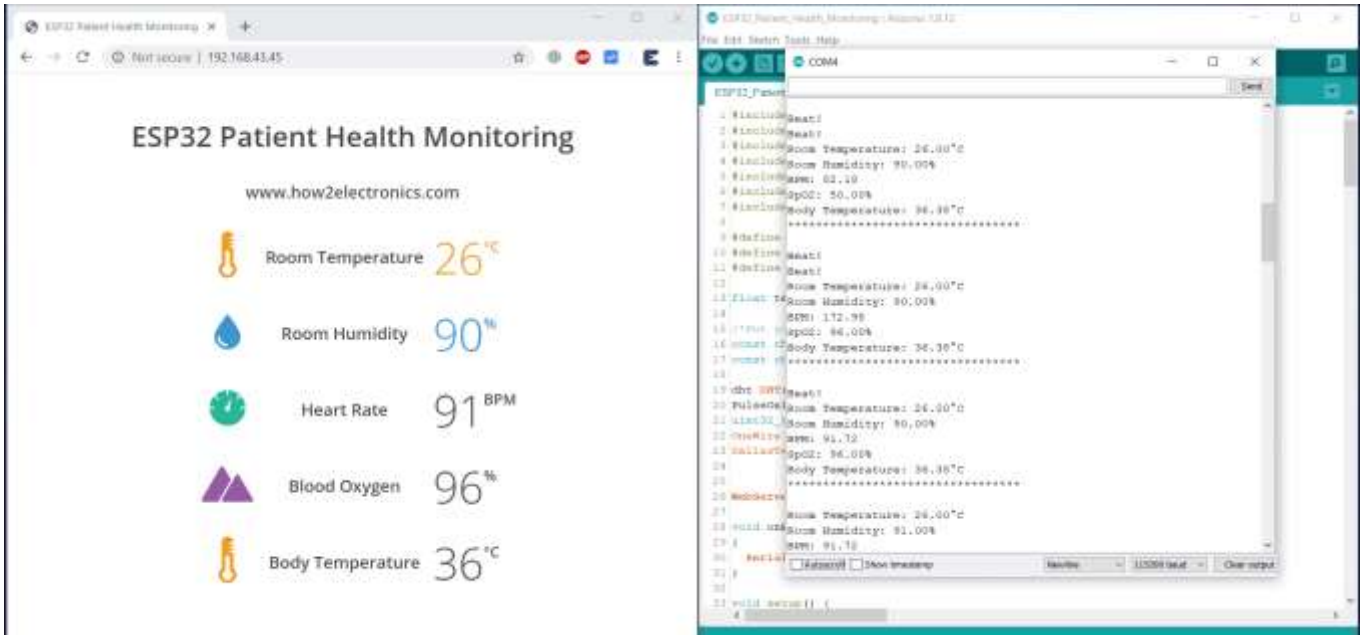

Figure 14. *ESP-32 web server view*

Additionally, we can see the patient different health parameter status on mobile Phone. By copying and pasting IP Address on web browser of cell phone**.** Setting up Ubidots: For ECG monitoring we need to login this web portal. First, we visited to ubidots.com. Ubidots is one of the best IoT Platform to connect things and visualize data. As it is seen here, Ubidots have wide no of data visualizing options, and it has an eye-catching user-friendly interface. For project purpose we signed up by providing all the required details (*IoT Based Low-Cost ECG & Heart Monitoring System with ESP32 and Ubidots Platform - Electronics Innovation*, n.d.).

Figure 15. *Home page view of Ubidots*

After logged in to account, clicked on devices, created a new device, selected blank device, entered the name for the device then clicked on this green tick mark to create the device. That is, it the device is successfully

created. Then clicked on the freshly created device. After that clicked on add variable, then chosen the raw option. Then renamed this variable with some name. That is, it, variable also successfully created (*IoT Based Low-Cost ECG & Heart Monitoring System with ESP32 and Ubidots Platform - Electronics Innovation*, n.d.). To create a dashboard, went to Data & then Dashboard. Then clicked on the "dashboard" icon in the top-left of the user interface, keep all fields default and then create it. Then chose on add new widget, then we prompted with a bunch of data visualization options. One among them was chosen and the line chart to plot graph is used using the uploaded payload data from esp32 Module. Top on add variables, then selected the device, and select the variable, Added a name for the graph. Kept the rest of the options default. Since our device did not communicate with Ubidots, it will show No Data Found. Once our device started posting data, we could see the data here itself (*IoT Based Low-Cost ECG & Heart Monitoring System with ESP32 and Ubidots Platform - Electronics Innovation*, n.d.).

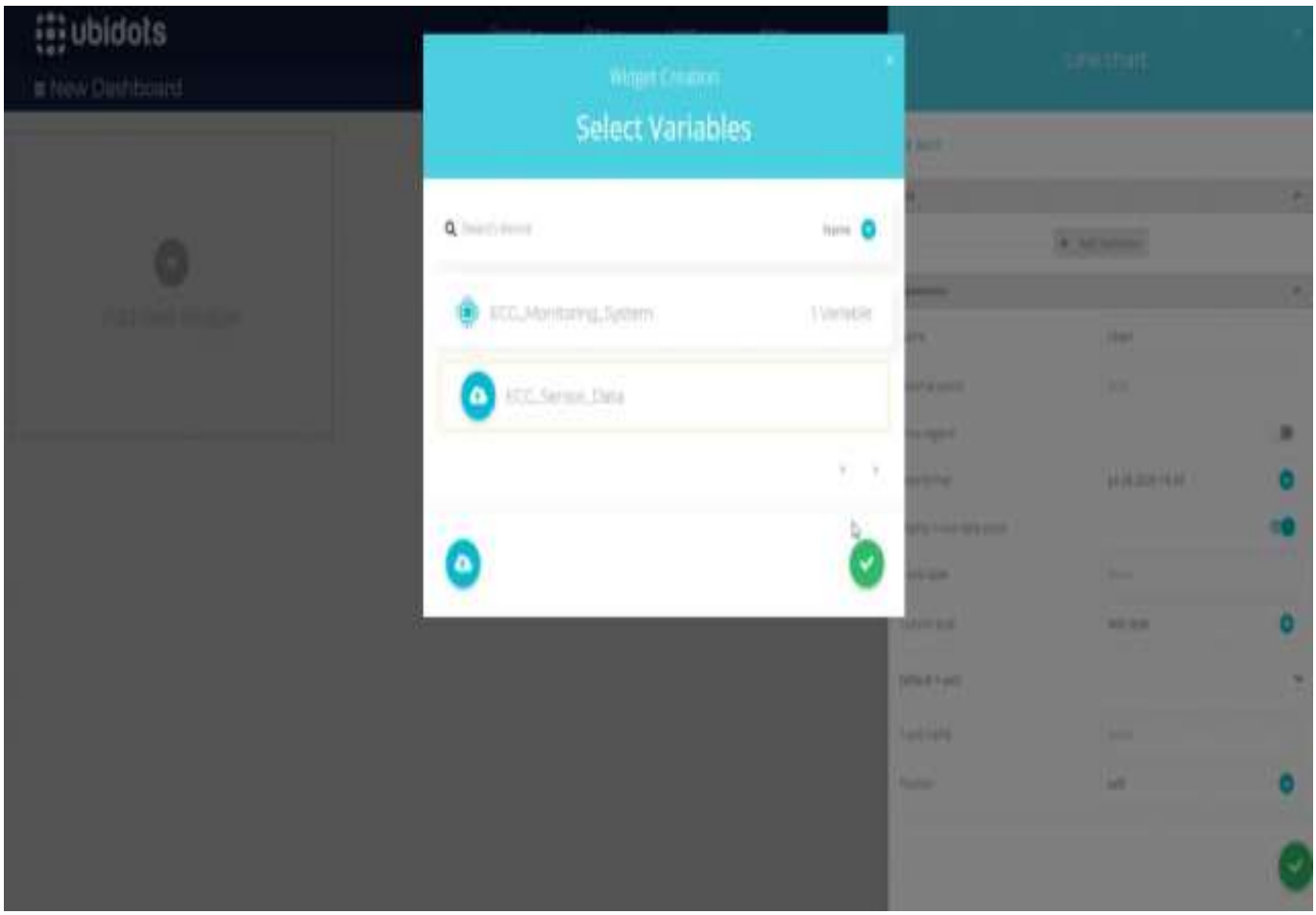

Figure 16. *Installing ESP32 add-on required libraries and programming part*

After programmed the ESP32 using Arduino IDE. It was installed in our Arduino IDE. After the Arduino was coded then the Wi-Fi SSID and password for internet connection was provided.

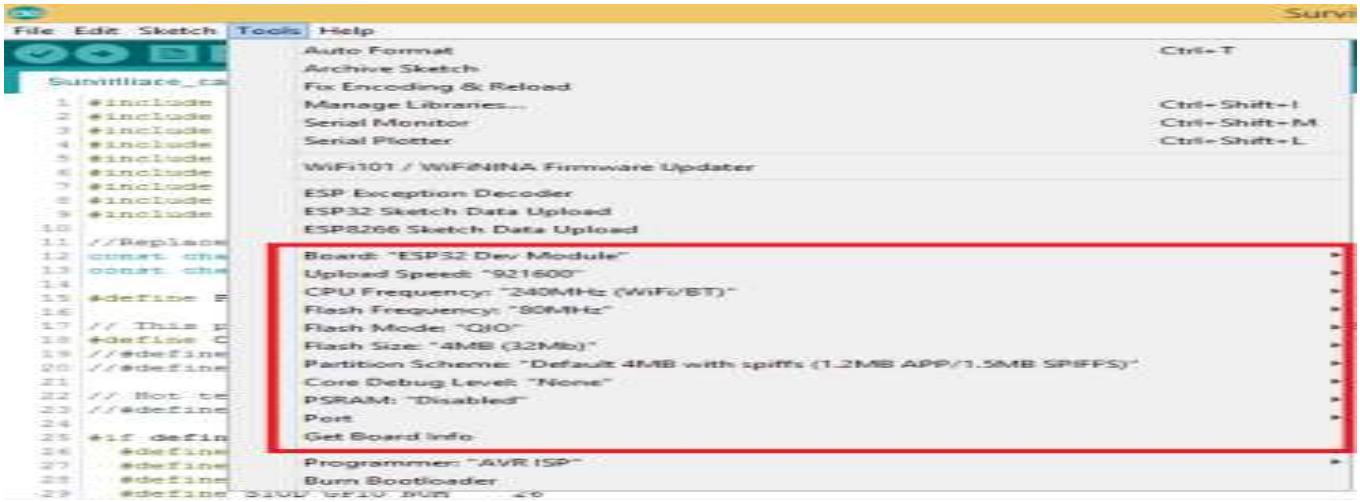

Figure 17. *Code uploading on ESP 32 module*

After successfully uploaded open serial monitor, on the serial monitor, it was seen our ESP32 successfully connected to the programmed Wi-Fi and allocated with IP address. Then initiated MQTT connection with Ubidots cloud and connected to it. Then it started publishing ECG data along with a timestamp. Each data packet contains Variable Label and 4 data points with the exact timestamp. Since we are sending data with Timestamp, there will be no delay because of server latency on the graph. This helps Ubidots to plot an accurate Electrocardiogram (*IoT Based Low-Cost ECG & Heart Monitoring System with ESP32 and Ubidots Platform - Electronics Innovation*, n.d.).

Figure 18. *ECG acquisition from Ubidots*

CONCLUSION AND FUTURE WORK

It is high-level that IoT cloud-based remote ICU patient monitoring framework that lessens the information precision of human mistakes and save lives of Covid affected people. The doctor and other medical stuffs can make essential steps by utilizing patient. The cloud-based hospital framework is presently presented broadly during this pandemic**.** This proposed model has remote ECG, temperature, oxygen level, humidity, room temperature, pulse/hear rate monitor based on wireless network and IOT device for data conveyance and prompts accomplishment of correct outcomes from patients' nodes to the monitoring/control room which is a base node and give a real time data streaming. Patient information security is a significant issue in this framework. As a result of the wellbeing data of an individual is very sensitive, it ought to be held confidential. For further progression about it, the data security system for the patient information should be redesigned as it gets more secured. The checking and acquiring of Coronavirus patients' health parameter data are truly vital for further treatment**.** WSN based IoT system medical services frameworks convey a lot of information gathered from several biomedical sensors**.**

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