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IMPLEMENTATION OF CLOUD BASED IOMT FRAMEWORK FOR HEALTH ASSESEMENT AND MANAGEMENT

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Abstract: This paper presents a secure IoT-based health monitoring system that shortens the distance between a patient and the relevant medical organization. Vital signals captured from sensors are processed and encrypted using AES (Advanced Encryption Standard) algorithm. A Node MCU microcontroller is utilized to carry out the processing and encryption functions, and for providing connectivity over WiFi. In addition, a medical specialist can visualize the private health data only after providing credentials. Moreover, the proposed system provides an alert by sending an email to some patient relatives or coordinating specialist if vital signs are outside the normal rates. The proposed system provides privacy, security, and real-time connectivity for private health data records.

Keywords Secure: Health Monitoring, Internet-of-Things (IoT), AES Encryption

I . INTRODUCTION

Technology has always been there to simplify and makes the human life much easier. It affected the various areas of life; the medical field is one of them. It benefits from the technology in different ways; now it is easier to diagnose internal diseases using some digital devices. The healthcare sector is going through a huge change, with digital capabilities changing the way doctors interact with their patients. Nowadays, patients have the tools to view their key vitals themselves and help doctors to have immediate access to patient data on-the- go. In a form of wearable devices e.g. Apple watches .m However, we note that these devices are quite expensive and it is difficult to find these devices used by poor people, who are facing the biggest part of diseases burden. Moreover, most of the existing medical devices are still need some investigations once it comes to the concept of the Internet of Things.

Heart rate, body temperature and blood pressure are the vital signs/body parameters which need to be monitored to get the information about the health/wellbeing of a person. Internet of Things (IoT) is nowadays finding great use in applications like smart homes, smart cities, smart retail, smart grid, wearable's, connected health etc. IoT is a platform where the sensors or devices or objects present in the network can communicate either with each other or with other objects in the network, and send the data over the internet without human interference .This not only reduces the system errors but also make the system more efficient and reliable. The use of IoT in remote health monitoring systems is seeking more attention. The people are conscious for their health and want to keep an eye on their health in order to live long and disease free life, but the lack of time prevent them to go for regular health checkups with their doctors. It becomes rather difficult for the elderly people to stand in long queues waiting for their turns at hospitals thus cost effective remote health monitoring is a need of society which will cut down the efforts and also save people's time.

II . PROPOSED METHODOLOGY

The implementation of the proposed system involves a three-layer system of different technologies collaborated together to accomplish the system goal. The layers of the proposed system are the patient layer which includes sensors and the patient, the IoT module, and the monitoring terminal. The system architecture of the proposed system with three layers is shown in Fig and described as follows.

Sensor module- This module involves capturing raw physiological data from a patient body and sending this data to a Micro Controller Unit (MCU) for processing. IoT biosensors are used to capture key biological parameters from a patient. Iot sensor used here are: pulse sensor, DHT -11, ECG sensor and Triple axis accelerometer. These sensors record the physical data by changing the voltage at their output pin in response to different physical condition. After acquiring data from the sensors this data is sent Iot module where further processing is done

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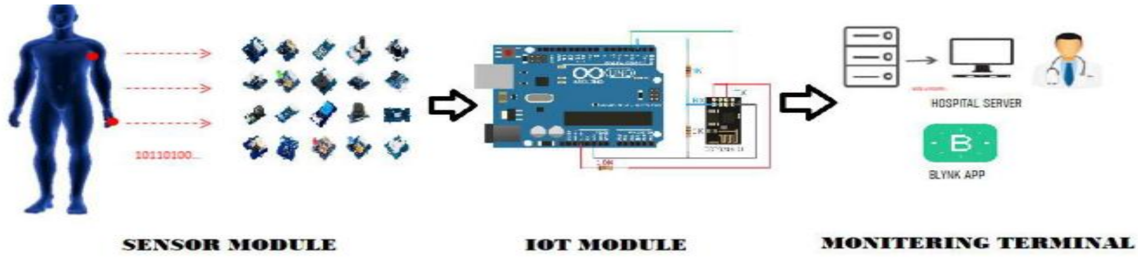

Fig.1. Architecture of the proposed system

IOT Module- IOT module is the coordinator of the whole sytem. It consists of arduino uno and wifi module (ESP8266). Process flow along this module includes the following steps:

1) Receiving raw physiological data from sensors through an appropriate interface (I2C or 1- Wire).
2) The data received from the sensor is processed and converted into numerical values.
3) Encrypting vital signs using the AES algorithm with a 128-bit key.
4)Sending ciphered data to monitoring terminal.

Monitoring Terminal-This entity is responsible for receiving the ciphered data from the IOT module, decrypting it with the appropriate decryption key,and then delivering it to the hospital local server and Blynk app. It also holds a database comprising a table for patient information, and another table for login credentials in order to control access to the system and provide authorization for users according to granted permissions. Only patient relatives or specialists at trusted healthcare centers can view the biological parameters of the patient as they are the only persons having the decryption credentials. Securing patient data ensures data privacyand secure distribution of patient data.The monitoring dashboard and blynk app is updated automatically with every update. Also, it provides email-based notifications sent to those related to the patient in emergency cases using Blynk app if some vital data is outside the normal range.

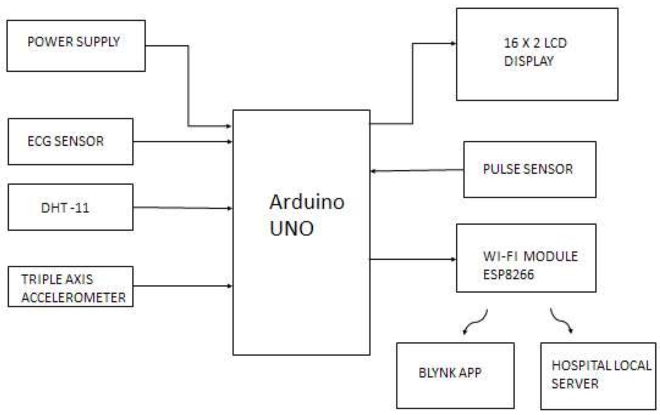

Fig.2 . Block diagram

III . HARDWARE AND SOFTWARE DESCRIPTION

1.Arduino UNO:

The Arduino uno is an open source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. The Uno board is the first in a series of USB- based Arduino boards and version 1.0 of the Arduino IDE were the reference versions

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of Arduino, which have now evolved to newer releases. The ATmega328 on the board comes pre programmed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.

Fig .3. Arduino uno microcontroller

2.NodeMCU WiFi module:

NodeMCU is an open source firmware for which open source prototyping board designs are svailable the “NODE MCU” the name NODE and MCU.(*micro controller unit*).The term "NodeMCU" strictly sp**e**aking refers to the firmware rather than the associated development kits. Both the firmware and prototyping board designs are open source. The firmware uses the Lua scripting language. The firmware is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson and SPIFFS. Due to resource constraints, users need to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also been implemented.

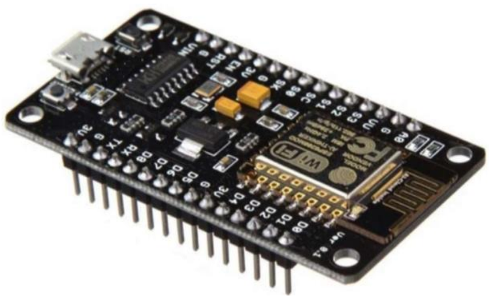

Fig .4. ESP8266 Wifi Module

3.ECG Sensor:

The AD8232 Single Lead Heart Rate Monitor is used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily. The AD8232 is an integrated signal conditioning block for ECG and other biopotential measurement applications.

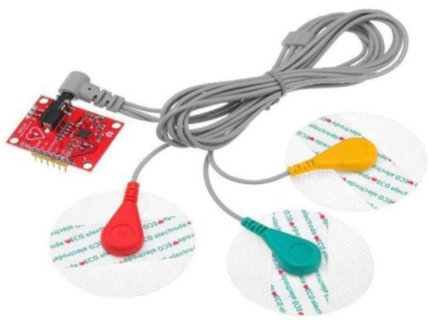

Fig .5. AD8232 ECG sensor

It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement.

4.Triple axis accelerometer:

Low power triple axis MEMS accelerometer from Analog Devices with extremely low noise – **ADXL335**. The sensor has a full sensing range of ±3 g. It can measure the static acceleration due to gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The sensor works on power between 1.8V to

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3.6VDC (3.3V optimal), and typically consumes just 350µA of current. However, an on-board 3.3V regulator makes it a perfect choice for interfacing with 5V microcontrollers such as the Arduino.. *This breadboard friendly board breaks out every pin of the ADXL335 to a 6-pin, 0.1" pitch header. This includes 3 analog outputs for X, Y and Z axis measurements, 2 supply pins and a self-test pin which allows you to check the functioning of the sensor in the final application. The analog outputs are* ***Ratiometric****, meaning 0g measurement output is nominally equal to half of the 3.3V supply voltage (1.65V), -3g is at 0v and 3g is at 3.3V with full scaling in between.*

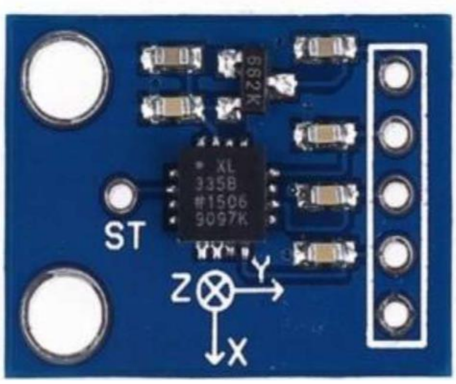

Fig 6 MEMS Accelerometer

5.DHT-11 sensor:

DHT11 is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc… to measure humidity and temperature instantaneously.
DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor. DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers. The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz .i.e. it gives one reading for every second. DHT11 is small in size with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5mA.

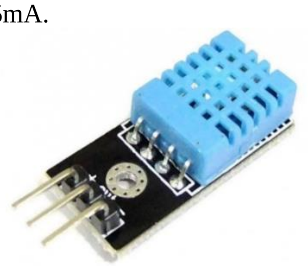

Fig .7 . DHT11 Sensor

6.LCD Display:

An LCD is an electronic display module that uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates o a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7 pixel matrix. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. When we send data to LCD it goes to the data register and is processed there. When RS=1, data register is selected.
CG-RAM is the main component in making custom characters. It stores the custom characters once declared in the code. CG-RAM size is 64 byte providing the option of creating eight characters at a time. Each character is eight byte in size.

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In LCD displays, each character is in a 5×8 matrix. Where 5 are the number of columns and 8 is the number of rows. A 16×2 LCD has two registers like data register and command register. The RS (register select) is mainly used to change from one register to another. When the register set is '0', then it is known as command register. Similarly, when the register set is '1', then it is known as data register. The main function of the command register is to store the instructions of command which are given to the display. So that predefined tasks can be performed such as clearing the display, initializing, set the cursor place, and display control. Here commands processing can occur within the register.

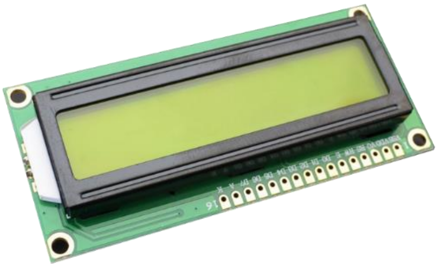

Fig.8. 16*2 LCD

7.Pulse sensor:

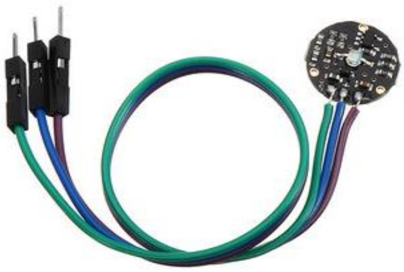

Fig .9.Pulse Sensor

Pulse sensors using the photoelectric pulse wave method are classified into 2 types depending on the measurement method: transmission and reflection. Transmission types measure pulse waves by emitting red or infrared light from the body surface and detecting the change in blood flow during heart beats as a change in the amount of light transmitted through the body. This method is limited to areas where light can easily penetrate, such as the fingertip or earlobe.
Reflection-type pulse sensors (Optical Sensors for Heart Rate Monitor) emit infrared, red, or green light (~550nm) towards the body and measure the amount of light reflected using a photodiode or phototransistor. Oxygenated haemoglobin present in the blood of the arteries has the characteristic of absorbing incident light, so by sensing the blood flow rate (change in blood vessel volume) that changes following heart contractions over time we are able to measure the pulse wave signal. Also, since reflected light is measured, the range of suitable areas is not limited as with transmission-type pulse sensors. When the heart beat detector is working, the beat LED flashes in unison with each heartbeat. This digital output can be connected to microcontroller directly to measure the Beats Per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal. The output signal is also indicated by a LED which blinks on each heart beat.

IV.SOFTWARE USED

1.Arduino IDE

Fig .10 . Arduino IDE

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The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards The source code for the IDE is released under the GNU General Public License, version 2.The Arduino IDE supports the languages C and C++ using special rules of code structuring.The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution.The Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware By default, avrdude is used as the uploading tool to flash the user code onto official Arduino boards.

2.Visual Studio

Fig.11. Visual Studio

Visual Studio is an **Integrated Development Environment (IDE)** developed by Microsoft to develop GUI(Graphical User Interface), console, Web applications, web apps, mobile apps, cloud, and web services, etc. With the help of this IDE, you can create managed code as well as native code. It uses the various platforms of Microsoft software development software like Windows store, Microsoft Silverlight, and Windows API, etc. It is not a language-specific IDE as you can use this to write code in C#, C++, VB (Visual Basic), Python, JavaScript, and many more languages. It provides support for 36 different programming languages .It can produce both native code and managed code.

Visual Studio Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop computer programs, as well as websites, web apps, web services and mobile apps. Visual Studio uses Microsoft software development platforms such as Windows API, Windows Forms, Windows Presentation Foundation, Windows Store and Microsoft Silverlight includes a code editor supporting IntelliSense (the code completion component) as well as code refactoring. The integrated debugger works both as a source-level debugger and a machine-level debugger. Other built-in tools include a code profiler, designer for building GUI applications, web designer, class designer, and database schema designer. It accepts plug-ins that expand the functionality at almost every level—including adding support for source control systems (like Subversion and Git) and adding new toolsets like editors and visual designers for domain-specific languages or toolsets for other aspects of the software development lifecycle (like the Azure DevOps client: Team Explorer).

3.Blynk app

Fig .12. Blynk app

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, vizualize it and do many other cool things.There are three major components in the platform: **Blynk App** - allows to you create amazing interfaces for your projects using various widgets we provide. **Blynk Server** - responsible for all the communications between the smartphone and hardware. You can use our Blynk Cloud or run your private Blynk server locally. It’s open-source,could easily handle thousands of devices and can even be launched on a Raspberry Pi..**Blynk Libraries** - for all the popular hardware platforms - enable communication with the server and process all the incoming and outcoming commands.

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V. RESULTS

The proposed system provides a way to keep an eye on key biological indicators of a patient in a secure and realtime basis. First, IoT biosensors are used to capture key biological parameters from a patient. Then, an IoT-based microcontroller processes, encrypts, and delivers it to the server and blynk app. Moreover, only patient relatives or specialists at trusted healthcare centers can view the biological parameters of the patient as they are the only persons having the decryption credentials. Securing patient data ensures data privacy and secure distribution of patient data in public networks. In addition, the proposed system provides an alert by sending an email to some patient relatives or coordinating doctor if vital signs are outside of normal rates.

1. HARDWARE OUTPUT

Fig .13. LCD displaying PIR Status and ECG Values

The LCD module makes an embedded system completely independent with which can take analog or digital input on its input pins and display the corresponding output in its own screen along with generating other kind of outputs. The LCD modules comes in different sizes varies from single line monochrome display to large graphical colour display all of them using almost same method for displaying data. In our project we are using a 16*2 LCD Module to display all the sensor values. All the sensors used in the project are connected to the patient body.

The output of each sensor is displayed on the LCD .Every second each sensor values pops up on the LCD screen. In the above figure 6.1 PIR status i.e ,a triple axis accelerometer connected to the human body detects the motion of the patient. MEMS accelerometer basically works on X Y Z coordinates. Tri axial accelerometers provide simultaneous measurements in three orthogonal directions, for analysis of all of the vibrations being experienced by a structure. Each unit incorporates three separate sensing elements that are oriented at right angles with respect to each other. If the patient is falling , it shows the threshold value on the LCD screen. The fig 6.1 also shows ECG value of the patient on the 16*2 LCD display.

2.LOCAL SERVER OUTPUT

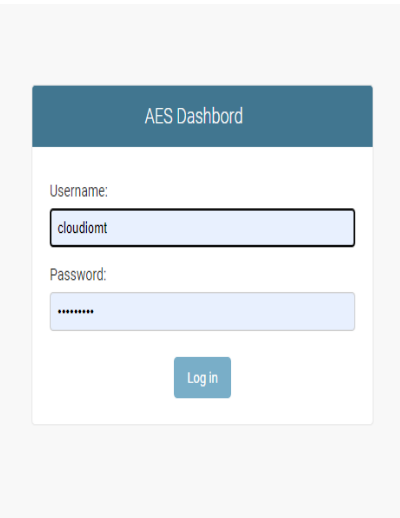

Fig .14.a) Dashboard login

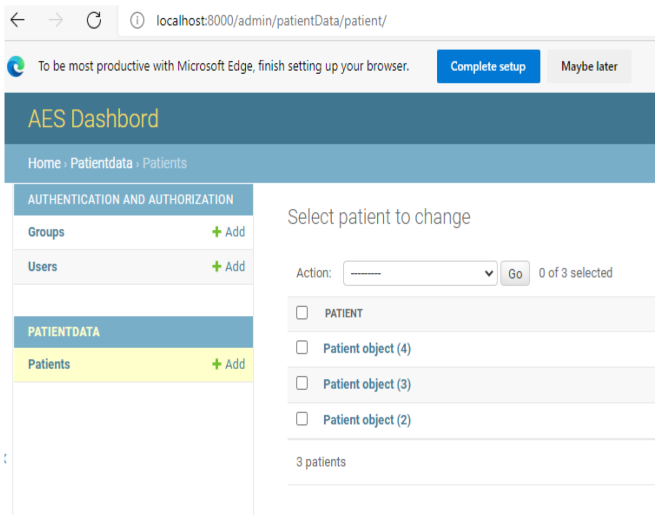

Fig .14. b) Patients data Portal

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The data collected from the sensors are sent to the IoT module .In the IoT module with the help of Esp8266 module, data is sent to the hospital local server. In this stage it has a dashboard comprising a table for patient information, and another table for login credentials in order to control access to the system and provide authorization for users according to granted permissions. The fig .14.a) is used to provide authentication where the user has to enter their username and password. This is the hospital server,so it is generally used by the doctors. Multiple users can login to this dashboard but the userID and password has to registered in prior by the users, in the users section shown in the figure 14. b).This figure also has patient object files .These files are created manually .Each time when the data is collected from the human body, Patient object file is created for each changed value.

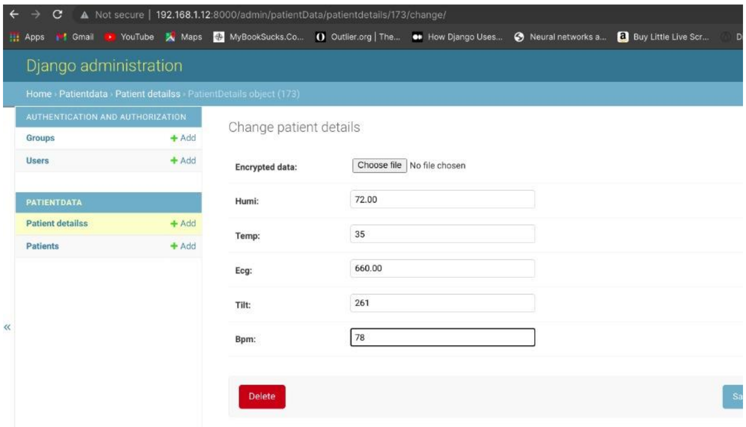

Fig .14.c) Patient details

Each patient object file has all the collected data from the sensors. Figure 6.2 c) shows the vitals of a patient. All these values are stored in real time which helps the doctor to easily visualize the data. Doctor can not only access the current vital data, but also previous history can be seen easily in this dashboard. The values sent from the sensors are encrypted using AES algorithm .Decryption is done in the backend. Along with decryption even authentication is performed which gives double layer security to the patient data. This dashboard is completely designed using the django framework.

3. BLYNK APP OUTPUT

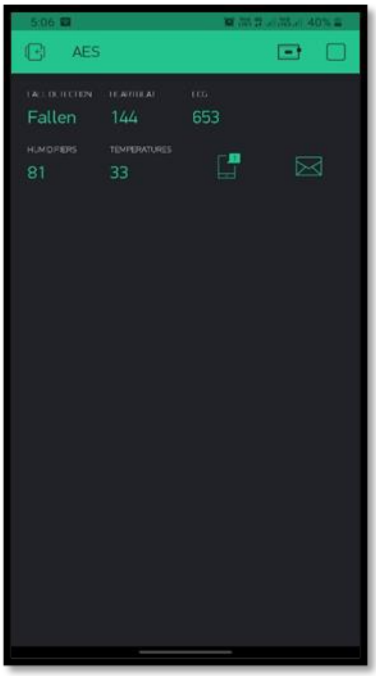

Fig.15 a) Vital values

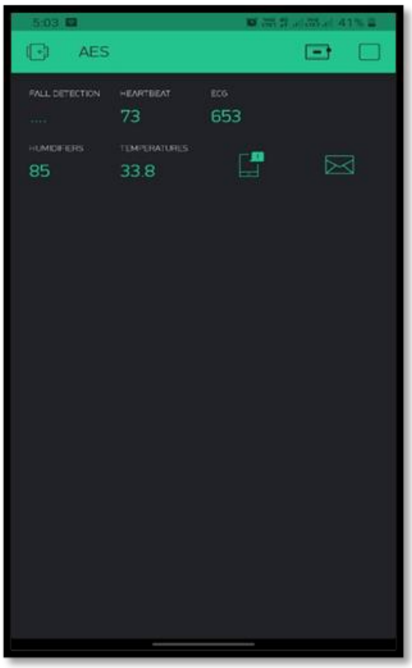

Fig.15 b) Vital values

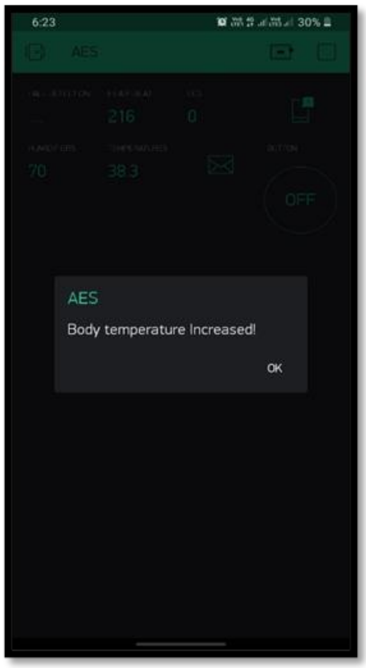

Fig 15.c) Alert Notification

Patient data from the sensors are sent to the hospital server, for the doctors to visualize the data and along with it data is also sent to the blynk server. Blynk application has a cloud .Cloud services of Blynk platform are used for storing the

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health related data. Blynk app can be downloaded in android phones or ios. Blynk can support a variety of hardware like Arduino UNO, Raspberry pi, Texas instruments, Spark fun red board, Beagle bone back etc.. Blynk provides a simple mechanism to create own Graphical Interface by dragging and dropping the history graph widgets , tables or any other suitable representation from the widgets column. Blynk also supports different Arduino connections types like Wi-Fi, Ethernet shield, Bluetooth, GSM technology. Since our Arduino is connected to internet through ESP8266 module, Blynk will get us online .This application can be installed in any smart phones easily. Auth token is a token provided by Blynk which acts as a connectifier between the mobile application and Arduino. To get this Auth token a new project has to be created in Blynk app by choosing the board which is Arduino in our case and connection which is Ethernet Shield in our system.

While creating a new project in Blynk app an email needs to be registered to get the Auth token. Next the Blynk library has to be installed manually. When the latest version of .zip file is
unzipped we find several folders and libraries. These folders and libraries are then connected to the sketchbook folder of IDE. Once the Blynk sketch code for the Arduino is ready, Auth token provided manually has to be included in sketch and results start getting displayed on the serial port of Arduino as well as Graphical User Interface based Blynk mobile application. Figures 6.3 a) b) depicts the output of each sensor connected to the human body. All the 5 sensors output variations can be easily observed in this blynk app. The values are updated continuously on our mobile application. We can keep a constant watch at our vitals by using the Blynk app. If any of the vitals are out of range a notification pop's up in the blynk app as shown in the above figure 6.3 c).The threshold temperature is set in the code. If the temperature value received from the sensors are above the threshold value alert notification is enabled.

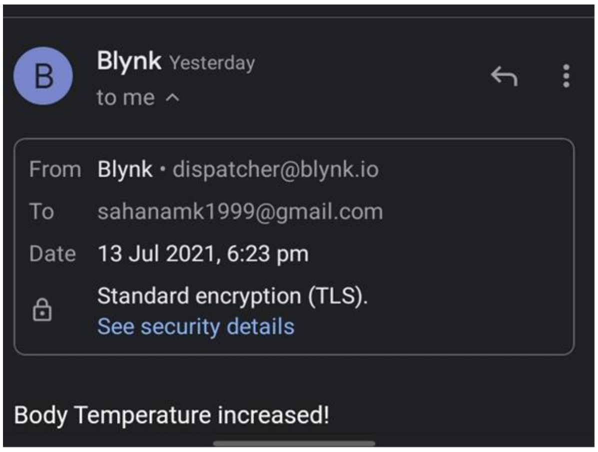

Fig.15.d) : Mail alert showing high temperature

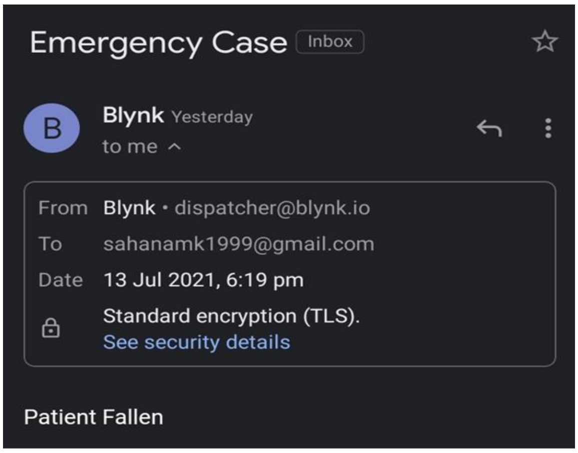

Fig.15. e) : Mail alert showing the patient fall

Apart from the notification even mail alert is also enabled. This helps the doctor as well as the patient relatives to constantly monitor the patient data remotely. An emergency is intimated immediately which can prevent any danger.

VI . FUTURE WORK

For future work, we can enhance the functionality of the system by adding more sensors and using it to collect data from a larger sample size of patients. A graphical LCD can be used to display a graph of the change of heart rate over time. Sound can be added to the device so that a sound is output each time a pulse is received. Serial output can be attached to the device so that the vitals s can be sent to a PC for further online or offline analysis. Warning or abnormalities (such as very high or very low heart rates) can be displayed on the LCD or indicated by an LED or a buzzer. The Whole health monitoring system, which we have proposed can be integrated into a small compact unit as small as a cell phone or a wrist watch. This will help the patients to easily carry this device with them wherever they go. The VLSI technologies will greatly come handy in this regard. We can also establish a Wi-Fi mesh type network to increase in the communication range.

VII . CONCLUSION

Health monitoring systems play a crucial role in the field of health care and early predicting issues regarding one's health. In addition, these systems are a means of cutting medical costs regarding periodical hospital checks and doctor visits. Thus, developing a system that delivers health data from patient place to a relative or a medical specialist became a necessity with increasing demand. This paper presented a secure, low cost, and trustable health monitoring system which provides a real-time monitoring dashboard for biological indicators within a secure environment using IoT technology and cloud computing. The proposed system involved the AES algorithm for encrypting vital signals captured from sensors

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before sending it to the cloud for storage. A NodeMCU microcontroller is utilized to carry out the processing and encryption functions, and connectivity to the cloud over WiFi. In addition, the proposed system provides an alert by sending an email to some patient relatives or the coordinating specialist if vital signs are outside the normal rates.

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