# SMART HEALTH CARE SYSTEM USING SENSORS, IOT DEVICE AND WEB PORTAL

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## Abstract

*Smart health care devices are slowly gaining popularity because of their many advantages over conventional health care system. In the conventional approach, a patient approaches a doctor either in the clinic or hospital. Much of time is spent in patients travel and wait period before he gets approval to meet the doctor. This is much worse for a patient who lives far away and has to spend lots of time in travelling. In general, when a patient first meets the doctor for treatment, he needs to register and then get diagnosed followed by some prescription. After that the patient routinely meets the doctor again leading to travel and wait periods. This will build up lots of stress in the patient especially if he has become weak and if the patient is quite old. The doctor maintains a record of diagnosis and prescription for each patient and this record gets updated on every visit by patient. It may also happen that the doctor may not be available for consultation on certain days due to some emergency or other reasons. This paper suggests a method of handling these issues faced by patient by developing a device and a web portal. The device consists of microcontroller connected to some bio-medical sensors like Temperature, Pulse-Oximeter, ECG, etc. This device can be used to read the patient's health data on a regular basis and then send it to the Web Server via Wi-Fi module.A Web Portal is also being developed for viewing patient's data regularly.*

**Keywords :** IoT, ECG, RFID, WSN, BAN, 6LOWPAN, Wi-Fi

## I.  Introduction

The advent of Internet Of Things (IoT) has drastically improved the efficiency of many routine processes like health care, safe driving, logistic tracking, irrigation, industrial control, etc. The IoT incorporates many technologies which have evolved over a period of few decades and is fast maturing in the next few years. The IoT is becoming a vast network around the globe which will connect billions of

people, object and devices to sensors and actuators. Hence enabling and making it easy and faster to perform many activities with much less effort and expenses. This is becoming possible because of the dropping prices of sensors, actuators, electronic devices and network connectivity. A great paradigm shift is being witnessed from the decades old internet connecting end user devices to the new internet connecting everything. The IoT will enable wide range of interaction within this highly interconnected and networked world and will lead to a highly smart world. Every object and devices that connects to IoT requires a unique address or identification which can be accomplished with the help of IPv6 internet protocol.

The IoT can enable object linking to the Internet using unique marker which are attached or integrated with the object [IV].Some of these unique markers are RFID tags, Bluetooth Beacons, Barcodes[IX],[XIII],[XXI],[XXII].These object tags or markers can be read by the corresponding wireless modules and the information about the object can be displayed [III].

A variety of sensors which are attached to the body of a patient can be used to get health data securely, and the collected data can be analysed and sent to the server using different transmission media which is connected to the Internet [XXIV]. All the medical professionals can access and view the data, take decision accordingly to provide services remotely.

We can construct systems which can continuously monitor the patients, perform remote consultationand health care management. These platforms use different techniques and equipment which can sense, capture, measure and transmit the information of body[VII].

With sensors and microcontroller we can get accurate measurement and then monitor and analyse the health condition of a patient. This combined with IoT will significantly increase the contribution of IoT in healthcare. The sensors can include temperature, heart rate, blood pressure, oxygen saturation in blood, levels of glucose and motion of body [VIII].

The IoT based healthcare system involves integration of different systems like hospital information system, services provider system, context management framework, knowledge-based systems and environment integration platform [I].

Research has been carried on the e-Health Records (Electronic Health Record, EHR) standards and how to access and display the data shared by organizations. This also involves designing the interface between the platform and medical establishment's w.r.t. network construction [XXIII].

Remote Monitoring & Management Platform of Healthcare Information was carried out by using body sensors, a sensor network, wireless communication modules, home gateway or mobile phone/tablet and information storage [XXV]. The authors analyse their platform with existing telemedicine services.

A new service to integrate the e-Health and IoT in order to provideuniversal communication platform for delivering the complex medical services is available.

The e-Health services are delivered through three phasesusing different standards and protocols [XVI].

A health care application to collect the data in smart spaces consisting of three subsystems was developed [XV]: (a) Physical devices (Smart phones, Tablets and PC) from which requests are generated with the help of GUI, (b) Wireless Sensor Network (WSN) and (c) Body Area Network (BAN).

A 2G-RFID based e-Healthcare system was developed with emergency response service [II]. This system consisted of RFID tags, Wireless BAN, Cell phone and Communication Gateway, Healthcare Database, Pilot Services (Automated Services, Emergency Medical Response Service).

An intelligent home-based platform for IoT called iHome Health-IoT was developed [VI]. This system consisted of three things: (i)Intelligent Medical Box (iMedBox) which is based on open platform; (ii) iMedPack Intelligent pharmaceutical packaging; and (iii) Bio-Patch biomedical sensor devices. iHome Health-IoT has a three-layer structure: (i) sensor data collecting layer, (ii) medical resource management layer, (iii) and smart medical service layer. The system provides different services like Remote Prescriptions, Medication Reminder, Medication Non-compliance Control and Intelligent Analysis and First Aid Alarm.

Anarchitecture of Smart Community and IoT was developed, which consisted of the Neighbourhood Watch Application and Pervasive Healthcare Application [XII]. This smart community architecture has three domains: (i) Home Domain, (ii) Community Domain and (iii) Service Domain. It also explains the model of Pervasive Healthcare in normal situation, emergency situation, and critical situation.

A 6LoWPAN-based IoT architecturewas developed for connecting the real-timeglucose sensor with their IoT (called m-IoT)in diabeticpatients [XVIII]. They implemented and tested the system performanceusing Java and with the help of 6LoWPAN and TelsoB sensors.

A 6LowPAN-based ubiquitoushealthcare system called U-healthcare was developedwhich performs thehealth monitoring in both indoor and outdoor conditions [XIX]. Thesystem uses a live streaming platform for reading of remotemonitoring sensors of ECG and temperature.The designed system can store the sensed data at remote serverand use free Cloud service like UbuntuOne.

*Remote Monitoring Information System* based on IoT was developed which can collectand process the information intelligently with the help ofhuman monitoring sensors and WSN technology [XI]. It can monitor the user physical information like temperature, heart rate,oxygen, blood pressure etc. The system also monitors motioninformation like physical exertion, speed, respiration rate etc.

Different applications of IoT in e-Healthcare, in particular sleep studies and elderly care w.r.t remote monitoring applications have been implemented [XIV]. Here the authors explain the concept of Remote Sleep Monitoring and Elderly Monitoring in the context of IoT. They also discuss the privacy and security issues related to electronic medical data.

Introduction and comparison of different IoT paradigms and applications of IoT in medical like identification and authentication, tracking of patient flow or moment, data collection of patients, and sensing for diagnosing patient conditions are discussed by the authors in reference [X].

In reference[V], the authors present the implementation and testing of an application called CardioNet, which is a distributed medical system linking different medical entities and systems like hospitals, emergency units, general practitioner cabinets, laboratories, personnel and patients. The implemented system is web based using ontology and can provide different services such as remote monitoring, online consultations, and hospital activity administration.

IoT supports different and latest technologies like RFID, WSN, 3G, 4G networks etc. Using these technologies, one can obtain data related to patient's health and send it to a remote server for further processing and storage [XXI].

An IoT based Smart Health Care Kit was developed by Punit Gupta et al [XVII], which provides support for emergency medical services like intensive care unit (ICU).

This paper presents a Smart Healthcare Device which can be used regularly at home or any place. Any individual can read all his health data like body temperature, pulse rate, oximeter, ECG graph, etc using this device and the associated sensors. The data can then be sent to the server/cloud using Wi-Fi and Internet connection. A Web Application (www.eiotlab.com) has been developed, from which the data can be downloaded from the server and examined. This server can receive the data coming from many devices/individuals. The doctor can log into the Web Application and constantly monitor his patient's health status. The doctor can use this application to register new patients. Once registered, the patient can regularly send his health data to the server. There is no limit on the number of doctors who can use this application and also on the number of individuals registered under each doctor. The application also has the provision of sending medical prescriptions to each patient.

## II.    Block Diagram

The DOIT ESP32 microcontroller is used to capture the health data from the various sensors like LM35 Temperature Sensor, MAX 30102 Pulse Oximeter, Mikroe ECG Click Module-Cable-Electrodes. An LCD is used for interacting with the user and also for displaying the various data and the connection and internet transfer status. The ESP32 has a Wi-Fi module which can be used to make connection to any local Wi-Fi hotspot and then to Internet.
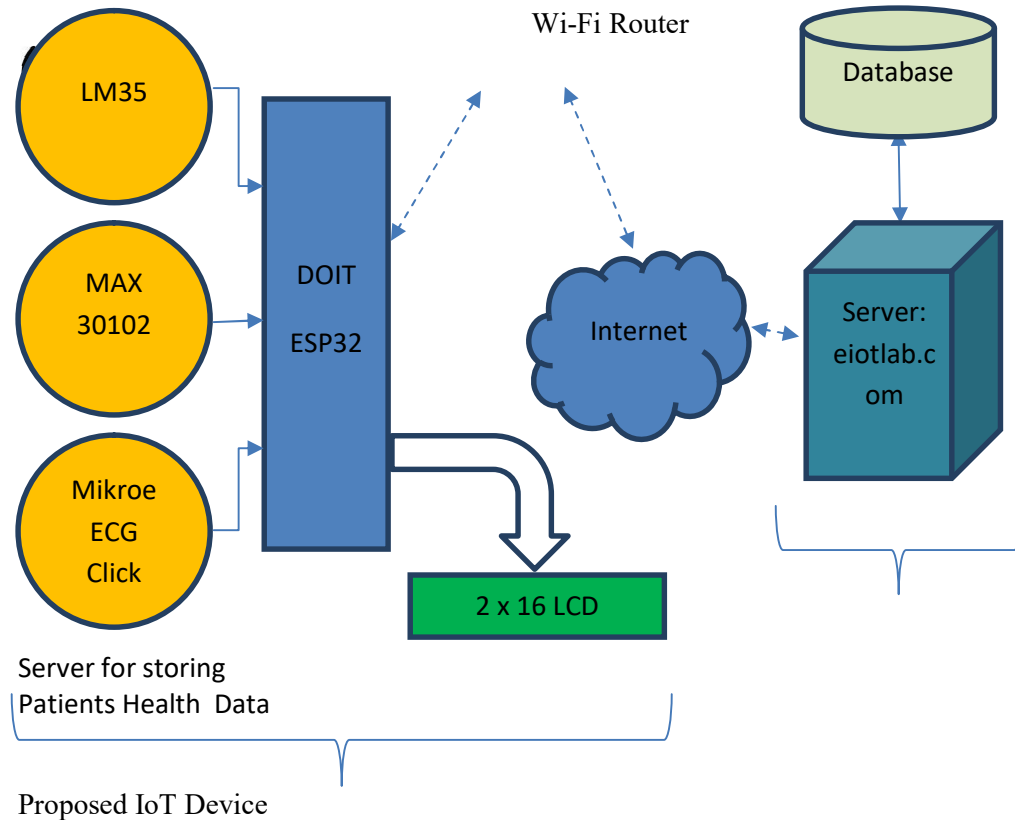
Fig 1. Block Diagram of the proposed Health Care System

Pin VP of ESP32 connected to LM35 Analog output pin.
Pin VN of ESP32 connected to ECG Module Analog output pin.
Pin D21 of ESP32 connected to SDA pin of MAX 30102.
Pin D22 of ESP32 connected to SCL pin of MAX 30102.
ESP32 GPIO pins 3,23,17,5,18,19 are connected to the LCD pins RS,EN, D4, D5, D6, D7

## III. Methodology

There are mainly two subsystems in the smart healthcare system:

(1) ESP32 Microcontroller subsystem along with the associated sensors and Wi-Fi module. This subsystem reads all the sensor data and transmits it to the server using the in-built Wi-Fi module. This is called IoT device which can be used by the patient regularly to send his health data to the server. The server holds data for each doctor registered on the web app. Each doctor's data base has a list of patient data in the form of table. Each patients IoT device has a unique registration ID and password to send data to his doctor's database in the server.

(2) Web Application based on the linux apache server system with the domain name www.eiotlab.com. The main start page is a HTML file used for logging into the healthcare page. The healthcare login page is implemented using PHP. Each doctor can login using a unique User Name and Password. After login the doctor can view the table consisting of the list of his patients and their health data. The Server uses the MySQL Database for storing the health data.

**ESP32 Microcontroller Software**

The development of ESP32 software is carried out using the ARDUINO IDE. The following are the various steps performed by the software code.

Include Files:<Wire.h>,<WiFi.h>,<HTTPClient.h>,<LiquidCrystal.h>, "MAX30105.h","hearRrate.h", "spo2_algorithm.h"

Globals
```
    // String for storing ECG values
    String ecgstr = "";
    // String for storing the jason packet
    String packet_jason = " ";
    // String for storing the variable names
    String field[7] = { "id" , "udat" , "temp" , "bpm" , "po2" , "keey" , "ecg" };
    // String for storing the variables
    String value[7] = { "" , "" , "" , "" , "" , "" , ""};
    // Global object for MAX30102 sensor
    MAX30102 particleSensor;
    // LCD object
LiquidCrystal lcd(3,23,17,5,18,19); // ESP32 GPIO PINS 3,23,17,...
```

In the setup function:
```
    Set the serial baud rate at 115200
```

In the loop function:
```
void loop()
{ // Start of loop function
```
**(1) Read the Temperature. Place the finger on the Temperature Sensor**
```
    adcin = analogRead(36);
    adcmV = (3300.0/2048.0)*adcin;
    tempC = 0.1 * adcmV; // Temperature in degrees centigrade
    tempF = (tempC * 1.8) + 32; // Temperature in Farenhiet
    Display on the LCD
```
**(2) Read the Pulse Rate and Oximeter. Place the finger on the pulse oximeter sensor.**
```
    // Begin, Initialize the MAX30102 sensor
    particleSensor.begin(Wire, I2C_SPEED_FAST)
    //Configure sensor with these settings
```

```
particleSensor.setup(ledBrightness, sampleAverage, ledMode, sampleRate,
pulseWidth, adcRange);
// Read Red LED Sensor Data (for i = 0  to 100)
redBuffer[i] = particleSensor.getRed();
// Read IR LED Sensor data (for i = 0 to 100)
irBuffer[i] = particleSensor.getIR();
//Calculate heart rate and Oxygen levels after 100 samples
maxim_heart_rate_and_oxygen_saturation(irBuffer, bufferLength, redBuffer,
&spo2, &validSPO2, &heartRate, &validHeartRate);
```

Note: The code for the Pulse Oximeter is available on GitHub. The C++ files used are MAX30102.cpp, heartrate.cpp, SPO2_ALGORITHM.cpp

Display the Pulse Rate and % Oxygen Level on the LCD

**(3) Read the ECG value for 10 seconds into a buffer. Connect ECG cable and electrodes.**

```
ecgval[i] = analogRead(39); delay(20); // for i = 0 to 500
```

**(4) Formation of Jason String for storing the sensor data**

```
value[0] = String((int)id),DEC);
value[1] = String("Date"); // Enter the Date as DD-MM-YYYY
value[2] = String((int)tempC,DEC);
value[3] = String(heartRate,DEC);
value[4] = String(spo2,DEC);
value[5] = String("PASSWORD"); // Enter the password
ecgstr.concat(String(ecgval[i],DEC)); // i = 0 to 500. ECG string
value[6] = ecgstr;
```

**(5) Connect to Wi-Fi Network**

```
WiFi.begin(ssid, password); // Wi-Fi Router ID and password
while (WiFi.status() != WL_CONNECTED) // Check for the connection
{
     delay(1000); // Check connection for every one second
}
delay(1000);
Serial.println("Connected to the WiFi network");
delay(1000);
```

**(6) Create http client and connect to the web server and send health data**

```
if (WiFi.status()== WL_CONNECTED)
{
//Check WiFi connection status
    HTTPClient http;   // HTTP Client
    delay(3000);
    http.begin(dest_addr);  // Specify destination for HTTP request
                        // www.eiotlab.com
    http.addHeader("Content-Type", cont_type);  // Specify content-type header
                                        // cont_type = "application/json"
    payload_jason(); // Form the Jason Payload
    int httpResponseCode = http.POST(packet_jason); // Post the data
    if (httpResponseCode > 0)
    {
```

```
         String response = http.getString(); // Get the response to the request
         delay(3000);
      }
      else
      {
        Serial.print(" HTTP POST Error on Sending Jason Packet\n");
        Serial.print(" HTTP Response Code: ");
        Serial.println(httpResponseCode);
        delay(3000);
      }
      http.end();  //Free resources
   }
    else
    {
       Serial.println(" Error in WiFi connection");
       delay(3000);
    }
    delay(60000);  // Delay of 1minute
} // End of loop function

// Function for forming Jason Payload
void payload_jason()
{
  packet_jason = "{"; // JSON dictionary to send
  for(uint8_t i = 0; i < 7; i++)   {
    packet_jason.concat( "\"" + field[i] + "\":\"" + value[i] + "\"");
    if (i < 6) packet_jason.concat(",");
  }
  packet_jason.concat("}");

} // End of payload function
```

**After sending the data to the server, the data can be viewed using any browser for the web app[www.eiotlab.com](www.eiotlab.com)**

**Web Application**

The application is available by entering the website [www.eiotlab.com](www.eiotlab.com) in any browser.On the main page the application name HCARE needs to be entered for logging in. After this the "Health Care Login Form" appears. This page can be used by the doctors for login. After entering the USERNAME and PASSWORD and login, the "Health Care Main Page" appears. Now by pressing the Healthcare Menu, a Page which shows the table consisting of the list of patients and their health data will be displayed. **Any new data sent by the patient's iot device will update this table in the server.**Table 1 below is just an illustration.

**Table-1:** Sample Web Page showing List of Patient registered under a doctor

| No | ID | Name | Reg Date | Last Updated Date | Deg Cent | BPM Beats per Min | O2 % O2 | ECG graph | Prescription |
|---|---|---|---|---|---|---|---|---|---|
| 1 | X01 | Anusha Rao | 29-01-2019 | 15-08-2019 | 30 | 80 | 87 | Show | Edit |
| 2 | X02 | Bharath Penna | 15-02-2019 | 16-08-2019 | 31 | 70 | 95 | Show | Edit |
| 3 | X03 | Bijuna Kapoor | 02-03-2019 | 14-08-2019 | 33 | 90 | 91 | Show | Edit |
| 4 | X04 | Anjuna Sharma | 18-03-2019 | 20-08-2019 | 29 | 68 | 99 | Show | Edit |
| 5 | X05 | Ravi Pachori | 14-04-2019 | 22-08-2019 | 35 | 75 | 98 | Show | Edit |
| 6 | X06 | Mallika Chopra | 07-05-2019 | 23-08-2019 | 34 | 85 | 89 | Show | Edit |
| 7 | X07 | Krishna Patil | 16-07-2019 | 25-08-2019 | 32 | 82 | 92 | Show | Edit |

> **SUBMIT NEW PATIENT**

There are three additional features listed below:

(1) Adding new patient. By clicking the "SUBMIT NEW PATIENT" button, a form appears for entering/registering a new patient. Once registered, the patient can use his IoTdevice for sending his health data to the server.

(2) The doctor can view the patient's ECG graph/plot by clicking the "**Show**" link under the ECG column.

(3) The doctor can send prescription to patients email address by clicking the "**Edit**" link under the Prescription column. Provision can also be made to send Prescription through SMS.

## IV.  Conclusion and Future Scope

The proposed IoT device can be used for regular health check-up by the patients. The device will be inexpensive if it can be mass produced. It will be very useful for patients who need to perform regular check-up with doctors.The doctors also can monitor their patient on a continuous basis as he gets the patients data regularly. The device can be further enhanced by adding additional sensors for measuring patient's blood pressure, sugar levels, etc. The device can also be enhanced to send the exact location of patients and any other additional information.

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