“VIRTUAL DOCTOR USING IOT”

The Major project Report Submitted to

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment of the requirements for the award of degree of

Bachelor of Technology in

ELECTRONICS AND COMMUNICATION ENGINEERING

by

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DECLARATION

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CERTIFICATE

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This is to certify that the dissertation entitled **"VIRTUAL DOCTOR USING IOT"**, being submitted by **A. Anwesh Goud, D. Vinay Kumar, G. Ajay Reddy, B. Poorna Chandra**, bearing **Roll Nos: 19X31A0408, 19X31A0437, 19X31A0440, 20X35A0405,** to **Jawaharlal Nehru Technological University Hyderabad** in partial fulfillment of the requirements for the award of the degree of ***Bachelor of Technology*** in ***Electronics and Communication Engineering***, is a record of bonafide work carried out by them. The results of investigations enclosed in this report have been verified and found satisfactory. The results embodied in this dissertation have not been submitted to any other University or Institute for the award of any other degree or diploma.

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ABSTRACT

With an improvement in technology and miniaturization of sensors, there have been attempts to utilize the new technology in various areas to improve the quality of human life. One main area of research that has seen an adoption of the technology is the healthcare sector. The people in need of healthcare services find it very expensive this is particularly true in developing countries.

As a result, this project is an attempt to solve a healthcare problem currently society is facing. The main objective of the project was to design a remote healthcare system. It's comprised of three main parts. The first part being, detection of patient's vitals using sensors, second for sending data to cloud storage and the last part was providing the detected data for remote viewing. Remote viewing of the data enables a doctor or guardian to monitor a patient's health progress away from hospital premises.

The Internet of Things (IoT) concepts have been widely used to interconnect the available medical resources and offer smart, reliable, and effective healthcare service to the patients. Health monitoring for active and assisted living is one of the paradigms that can use the IoT advantages to improve the patient's lifestyle. In this project, I have presented an IoT architecture customized for healthcare applications. The aim of the project was to come up with a Remote Health Monitoring System that can be made with locally available sensors with a view to making it affordable if it were to be mass produced.

Hence the proposed architecture collects the sensor data through Arduino microcontroller and relays it to the cloud where it is processed and analyzed for remote viewing. Feedback actions based on the analyzed data can be sent back to the doctor or guardian through Email and/or SMS alerts in case of any emergencies.

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Chapter-1

1 INTRODUCTION

1.1 Background of the study

What is a Remote Health Monitoring System?

A Remote health monitoring system is an extension of a hospital medical system where a patient's vital body state can be monitored remotely. Traditionally the detection systems were only found in hospitals and were characterized by huge and complex circuitry which required high power consumption. Continuous advances in the semiconductor technology industry have led to sensors and microcontrollers that are smaller in size, faster in operation, low in power consumption and affordable in cost.

This has further seen development in the remote monitoring of vital life signs of patients especially the elderly. The remote health monitoring system can be applied in the following scenarios:

1. A patient is known to have a medical condition with unstable regulatory body system.This is in cases where a new drug is being introduced to a patient.
2. A patient is prone to heart attacks or may have suffered one before. The vitals may bemonitored to predict and alert in advance any indication of the body status.
3. Critical body organ situation
4. The situation leading to the development of a risky life-threatening condition. This isfor people at an advanced age and maybe having failing health conditions.
5. Athletes during training. To know which training regimes will produce better results.

In recent times, several systems have come up to address the issue of remote health monitoring.

There is also the issue of internet connectivity where some systems to operate, good quality internet for a real-time remote connection is required. Internet penetration is still aproblem in developing countries.

Many of the systems were introduced in the developed countries where the infrastructure is working perfectly. In most cases, the systems are adapted to work in developing countries. To reduce some of these problems there is need to approach the remote detection from a ground-up approach to suit the basic minimal conditions presently available in developing countries.

A simple patient monitoring system design can be approached by the number of parameters it can detect. In some instances, by detecting one parameter several readings can be calculated. For simplicity considerations parameter detection are: i) Single parameter monitoring system:

This has multiple parameters being monitored at the same time. An example of such a system can be found in High Dependency Units (HDU), Intensive Care Units (ICU), during the surgery at a hospital theatre or Post surgery recovery units in Hospitals.Several parameters that are monitored include the ECG, blood pressure, respiration rate. The Multiparameter monitoring system basically proof that a patient is alive or recovering. In developing countries, just after retiring from their daily career routine majority of the elderly age group, move to the rural areas.

1.2 Statement of the problem

REMOTE HEALTH MONITORING

Remote health monitoring can provide useful physiological information in the home. This monitoring is useful for elderly or chronically ill patients who would like to avoid a long hospital stay. Wireless sensors are used to collect and transmit signals of interest and a processor is programmed to receive and automatically analyze the sensor signals. In this project, you are to choose appropriate sensors according to what you would like to detect and design algorithms to realize your detection. Examples are the detection of a fall, monitoring cardiac signals.

Using a single parameter monitoring system an approach to a remote health monitoring system was designed that extends healthcare from the traditional clinic or hospital setting to the patient's home. The system was to collect a heartbeat detection system data, fall detection system data, temperature data and few other parameters. The data from the single parameter monitoring systems was then availed for remote detection.

During design the following characteristics of the future medical applications adhered:

a) Integration with current trends in medical practices and technology,

b) Real-time, long-term, remote monitoring, miniature, wearable sensors and long battery life of a designed device.

c) Assistance to the elderly and chronic patients. The device should be easy to use with minimal buttons.

1.3 Purpose of the study

Design a Remote Patient Health Monitoring System (RPHMS) which has heartbeat detection system, a fall detection system, temperature detection system, a humidity detection system, a toxic gas and air quality detection system and SPO2 detection system. A doctor or health specialist can use the system to monitor remotely of all vital health parameters of the patient or person of interest.

An attempt at designing a remote healthcare system made with locally availablecomponents.

i. The fall detector, temperature, humidity, pressure, toxic gas, air quality control, SPO2 modules comprise of an accelerometer, wireless transmitter and microcontroller. The data collected was transmitted wirelessly to a receiver module.

ii. ECG consists of a non-invasive infrared finger detector, Liquid Crystal Display (LCD), a designed circuit for cardiac signal detection and microcontroller. The detected analog signal was then digitized to give a digital value that was read on the LCD.

iii. A simple cloud server where hosted with a database for all the vital data to be accessed remotely whenever required.

1.4 Objective of the study

Here the main objective is to design a Remote Patient Health Monitoring System to diagnose the health condition of the patients. Giving care and health assistance to the bedridden patients at critical stages with advanced medical facilities have become one of the major problems in the modern hectic world. In hospitals where many patients whose physical conditions must be monitored frequently as a part of a diagnostic procedure, the need for a cost-effective and fast responding alert mechanism is inevitable.

The use of sensors detects the conditions of the patient and the data is collected and transferred using a microcontroller. Doctors and nurses need to visit the patient frequently to examine his/her current condition. In addition to this, use of multiple microcontrollers based intelligent system provides high-level applicability in hospitals where many patients must be frequently monitored. For this, here we use the idea of network technology with wireless applicability, providing each patient a unique ID by which the doctor can easily identify the patient and his/her status of health parameters. Using the proposed system, data can be sent wirelessly to the Patient Monitoring System, allowing continuous monitoring of the patient.

Contributing accuracy in measurements and providing security in proper alert mechanism give this system a higher level of customer satisfaction and low-cost implementation in hospitals. Thus, the patient can engage in his daily activities in a comfortable atmosphere where distractions of hardwired sensors are not present. Physiological monitoring hardware can be easily implemented using simple interfaces of the sensors with a Microcontroller and can effectively be used for healthcare monitoring.

This will allow development of such low-cost devices based on natural human-computer interfaces. The system we proposed here is efficient in monitoring the different physical parameters of many numbers bedridden patients and then in alerting the concerned medical authorities if these parameters bounce above its predefined critical values. Thus, remote monitoring and control refer to a field of industrial automation that is entering a new era with the development of wireless sensing devices.

The Internet of Things (IoT) platform offers a promising technology to achieve the healthcare services, and can further improve the medical service systems. IoT wearable platforms can be used to collect the needed information of the user and its ambient environment and communicate such information wirelessly, where it is processed or stored for tracking the history of the user. Such a connectivity with external devices and services will allow for taking preventive measure (e.g., upon foreseeing an upcoming heart stroke) or provide immediate care (e.g., when a user falls and needs help).

1.5 Limitation of the study

The scope of the project was limited to ECG, fall, temperature, humidity, pressure, toxic gas, air quality and SPO2 detection and remote viewing of the collected data for a single patient. Here, the most important specification considered was that they should be safe to use and accurate. This is because the physiological information being detected determines the severity of a critical life-threatening situation.

CHAPTER – 2

2 LITERATURE STUDY

2.1 Development and Clinical Evaluation of a Home Healthcare System

Measuring in Toilet, Bathtub and Bed without Attachment of AnyBiological Sensors

Daily monitoring of health condition at home is important for an effective scheme for early diagnosis, treatment, and prevention of lifestyle-related diseases such as adiposis, diabetes and cardiovascular diseases. While many commercially available devices for home health care monitoring are widely used, those are cumbersome in terms of self-attachment of biological sensors and self-operation of them. From this viewpoint, we have been developing a non-conscious physiological monitoring system without attachment of any sensors to the human body as well as any operations for the measurement.

We developed some devices installed in a toilet, a bath, and a bed and showed their high measurement precision by comparison with simultaneous recordings of ordinary biological sensors directly attached to the body. To investigate that applicability to the health condition monitoring, we developed a monitoring system in combination with all the monitoring devices at hospital rooms and previously carried out the measurements of patients' health condition. Further, in this study, the health conditions were measured in 10 patients with cardiovascular disease or sleep disorder.

2.2 Intelligent wireless mobile patient monitoring system

Nowadays, Heart-related diseases are on the rise. Cardiac arrest is quoted as the major contributor to the sudden and unexpected death rate in the modern stress filled lifestyle around the globe. A system that warns the person about the onset of the disease earlier automatically will be a boon to the society. This is achievable by deploying advances in wireless technology to the existing patient monitoring system. This paper proposes the development of a module that provides mobility to the doctor and the patient, by adopting a simple and popular technique, detecting the abnormalities in the bio signal of the patient in advance and sending an SMS alert to the doctor through Global System for Mobile (GSM) thereby taking suitable precautionary measures thus reducing the critical level of the patient. Worldwide surveys conducted by World Health Organization (WHO) have confirmed thatthe heart-related diseases are on the rise.

Many of the cardiac-related problems are attributed to the modern lifestyles, food habits, obesity, smoking, tobacco chewing and lack of physical exercises etc. The post-operative patients can develop complications once they are discharged from the hospital. In some patients, the cardiac problems may reoccur, when they start doing their routine work. Hence the ECG of such patients needs to be monitored for some time after their treatment. This helps in diagnosing the improper functioning of the heart and take precautions. Some of these lives can often be saved if acute care and cardiac surgery is provided within the so-called golden hour. So, the need for advice on first-hand medical attention and promotion of good health by patient monitoring and follow-up becomes inevitable.

This paper proposes the development of a module that provides mobility to the doctor and the patient, by adopting a simple and popular technique, detecting the abnormalities in the bio signal of the patient in advance and sending an SMS alert to the doctor through Global System for Mobile(GSM) thereby taking suitable precautionary measures thus reducing the critical level of the patient. Worldwide surveys conducted by World Health Organization (WHO) have confirmed that the heart-related diseases are on the rise.

2.3 The real-time monitoring system for in-patient based on ZigBee

The system is made up of two sub-systems: patient physical states data acquisition and communication system based on ZigBee technology, and hospital monitoring and control center. The patient physical states data acquisition and communication system monitors the main physical parameters and movement status continuously. The information from data acquisition system is sent to hospital monitoring center by ZigBee wireless communication module. The monitoring center receives the information from each patient and save them to the database, and then judges the states of the patient by fuzzy reasoning. The data from the patient can be displayed as a graph or numeric on the monitor if it is necessary, and then the doctor can diagnose the patient according to the recorded continuous data.

Wireless sensor network is made up of a lot of wireless sensors based on ZigBee technology. The ZigBee technology provides a resolution for transmitting sensors' data by wireless communication. ZigBee technology can transmit data with a rate of 250kbps, and then it is enough for the physical parameters of the patient.

ZigBee technology owns many virtues, such as low power consumption, low cost, small size, free frequency, etc. To know the physical states of in-patient, the physical parameters need to be monitored real-time. The traditional medical test instrument is a large size and connected by wire often, and the patient is required to be quiet during the test. In most of the hospital, the medical instruments need to be read by doctor or nurse, and the physical parameters are tested and recorded one or two times each day, the real-time monitoring is expensive for most of the patients, and can be only acquirable for ICU by a nurse.

CHAPTER – 3
3 EXISTING SYSTEM

3.1 Existing System

In the existing system, we use active network technology to network various sensors to a single PMS. Patients' various critical parameters are continuously monitored via single PMS and reported to the Doctors or Nurses in attendance for timely response in case of critical situations. The sensors are attached to the body of the patients without causing any discomfort to them. In this PMS we monitor the important physical parameters like body temperature, ECG, heart beat rate and blood pressure using the sensors which are readily available. Thus, the analog values that are sensed by the different sensors are then given to a microcontroller attached to it. The microcontroller processes these analog signal values of health parameters separately and converts it to digital values using ADC converter.

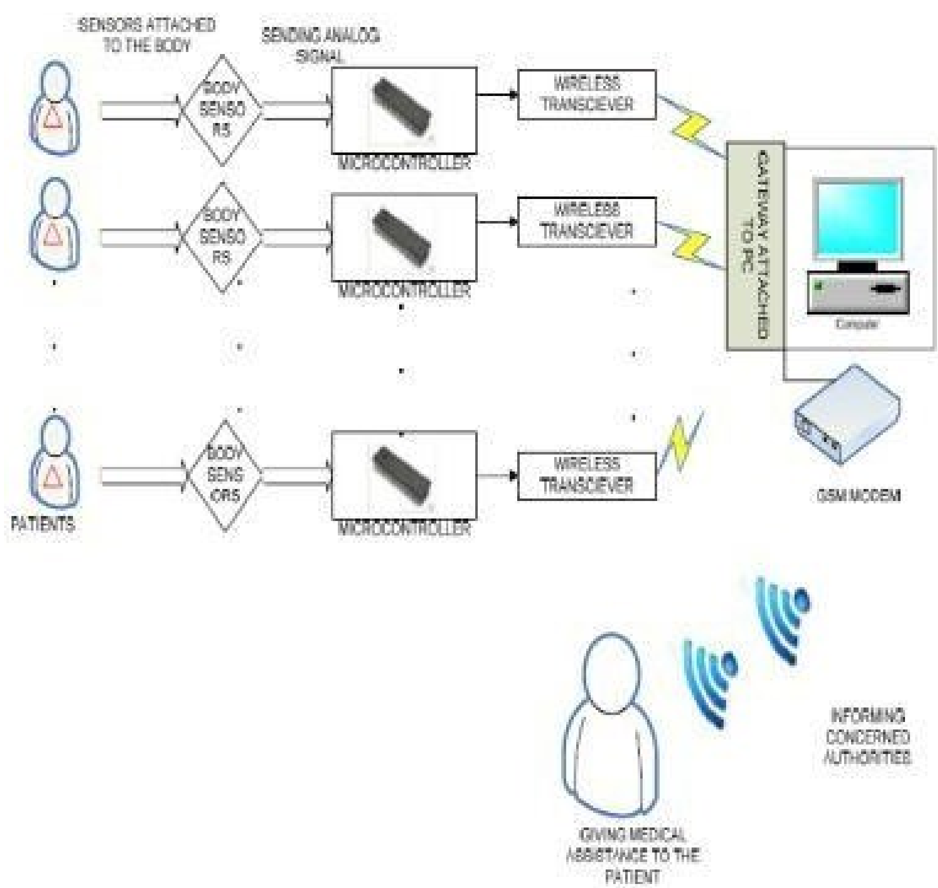

Figure 3.1:*Existing System*

Now, the digitalized values from more than one microcontroller are sent to the Central PMS. Each of the sensors attached microcontroller with a transceiver will act as a module which has its own unique ID. Each module transmits the data wirelessly to the gateway attached to the PC of the Central PMS. The gateway is attached to the PC i.e. Central PMS which is situated in the medical center, is capable for selecting different patient IDs and allowing the gateway to receive different physical parameter values the patient specified by the ID.

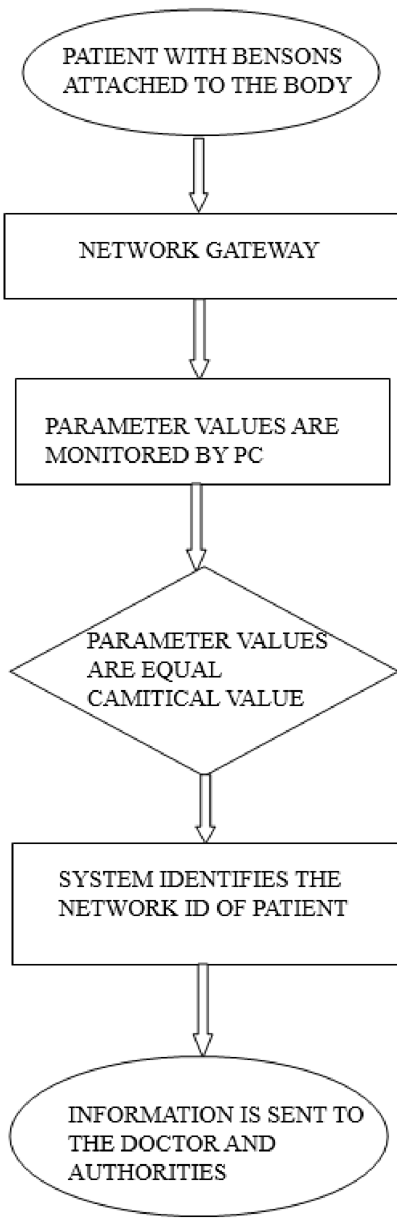

Figure 3.2: *Flowchart of Existing System*

In this PMS we monitor the important physical parameters like body temperature, ECG, heart beat rate and blood pressure using the sensors which are readily available. Thus, the analog values that are sensed by the different sensors are then given to a microcontroller attached to it. The microcontroller processes these analog signal values of health parameters separately and converts it to digital values using ADC converter.

In case of a critical situation which requires the immediate attention of the doctors or nurses for any of the patients, the custom software will instruct the Central PMS to enable the GSM modem to send an SMS with the patient ID.

CHAPTER – 4

4 PROPOSED MODEL

The main objective is to design a Patient Monitoring System with two-way communication i.e., not only the patient's data will be sent to the doctor through SMS andemail on emergencies, but also the doctor can send required suggestions to the patient or guardians through SMS or Call or Emails. And Patient or guardian can able to track patient's location at any point in time through Google Maps which would enable to send medical services in case of an emergency for non-bed ridden patients.

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Heart rate monitors are very popular features in wearable devices like smartwatches and fitness trackers. Many of these devices also connect wirelessly to smartphones and computers. That allows users easy access to review their heart rate data.

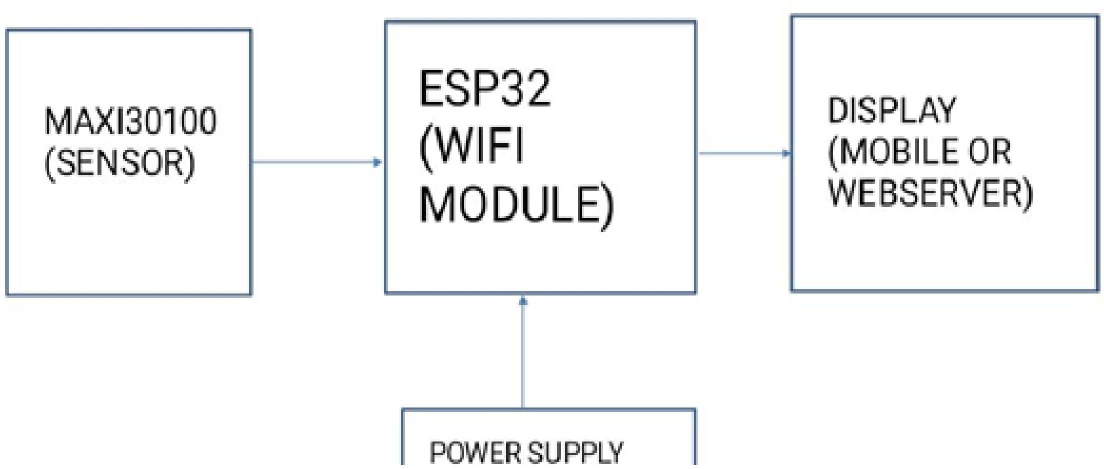

Figure 4.1: *Block Diagram of Proposed model*

Heart rate monitors are devices that detect and measure your heart or pulse rate. Thanks to advances in technology, these devices are small, wearable and many use sensors that are very accurate. However, while these devices are excellent for personal use, they are no substitute for medical devices that are much more accurate.

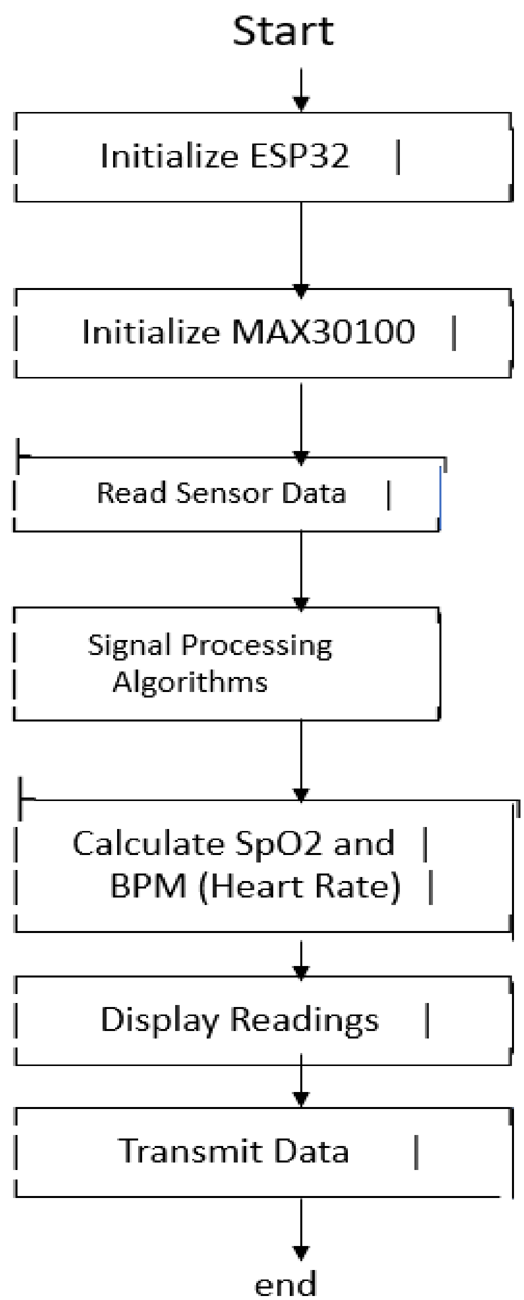

Figure 4.2 *: flow Chart of Proposed Model*

CHAPTER 5

5 SENSORS AND MODULES

Proposed system consists of following sensors and modules

1) ESP32
2) MAXI30100 Sensor
3) Heart beat Sensor

5.1 ESP32 Micro controller

The ESP32 is a powerful and versatile microcontroller and system-on-chip (SoC) that is widely used in IoT (Internet of Things) applications. It is developed by Systems and is a successor to the ESP8266. Here is a brief overview of the ESP32:

5.1.1 Architecture and Features:

Dual-Core Processor: The ESP32 features two Tens LX6 microprocessor cores, which can be individually controlled and clocked up to 240 MHz

Wi-Fi and Bluetooth Connectivity: The ESP32 has built-in Wi-Fi (802.11 b/g/n) and Bluetooth (Classic and BLE) capabilities, enabling easy integration with wireless networks and communication with other devices.

Memory: It has up to 520KB SRAM for data storage and 4MB Flash memory for program storage.

Peripherals: The ESP32 offers a rich set of peripherals, including GPIO pins, SPI, I2C, I2S, UART, ADC, DAC, and PWM. It also supports touch sensors, capacitive touch pads, and external sensors through various interfaces.

Security: The ESP32 provides hardware-accelerated encryption (AES, RSA, SHA, etc.) and supports secure boot, secure storage, and secure communications.

5.1.2 Development Environment:

Arduino IDE: The ESP32 can be programmed using the Arduino IDE, which provides a user-friendly environment and a vast library ecosystem.

ESP-IDF: provides the ESP-IDF (IoT Development Framework), a comprehensive software development kit (SDK) specifically designed for ESP32, offering more advanced features and low-level control.

5.1.3 Applications:

The ESP32's versatility and features make it suitable for a wide range of applications, including:

IoT Devices: It is commonly used for developing IoT devices such as smart home automation systems, environmental monitoring devices, and industrial automation.

ESP32 is the name of the chip that was developed by Espressif Systems. This provides Wi-Fi (and in some models) dual-mode Bluetooth connectivity to embedded devices. While ESP32 is technically just the chip, modules and development boards that contain this chip are often also referred to as “ESP32” by the manufacturer. The differences between these are explained further on in the article.

The ESP32 chip has a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, with a clock rate of over 240 MHz. There are now several different chip models available, including:

- ESP32-D0WDQ6 (and ESP32D0WD)
- ESP32-D2WD
- ESP32-S0WD
- And the system in package (SiP) – ESP32-PICO-D4

Models are available with combined Wi-Fi and Bluetooth connectivity, or just Wi-Fi connectivity.

The ESP32 is most engineered for mobile devices, wearable tech, and IoT applications – such as NATO. Moreover, with Mongoose OS introducing an ESP32 IoT Starter Kit, the ESP32 has gained a reputation as the ultimate chip or module for hobbyists and IoT developers.

While this reputation is not unmerited, the low-cost device can also be used in several different production systems, and its capabilities and resources have grown impressively over the past four years.

Processors – As previously mentioned, the ESP32 uses a Tensilica Xtensa 32-bit LX6 microprocessor. This uses 1 or 2 cores (*all chips in the series are dual-core, except the ESP32-S0WD). The clock frequency reaches up to 240MHz and it performs up to 600 DMIPS (Dhrystone Million Instructions Per Second). Moreover, its low power consumption allows for ADC conversions, computation, and level thresholds, all while in deep sleep mode.

Wireless connectivity – The ESP32 enables connectivity to integrated Wi-Fi through the 802.11 b/g/n/e/i/. Moreover, dual-mode Bluetooth is made possible with the v4.2 BR/EDR and features Bluetooth Low Energy (BLE).

Memory – Internal memory for the ESP32 is as follows – ROM: 448 KiB (for booting/core functions), SRAM: 520 KiB (for data/instructions), RTCfast SRAM: 8 KiB (for data storage/main CPU during boot from sleep mode), RTC slow SRAM: 8 KiB (for co-processor access during sleep mode), and eFuse: 1 KiBit (256 bits used for the system (MAC address andchip configuration) and 768 bits reserved for customer applications).
Moreover, two of the ESP32 chips – ESP32-D2WD and ESP32-PICO-D4 – have internally connected flash. The others are as follows: 0 MiB (ESP32-D0WDQ6, ESP32-D0WD, and ESP32-S0WD chips), 2 MiB (ESP32-D2WD chip), and 4 MiB (ESP32-PICO-D4 SiP module).

External Flash and SRAM – ESP32 supports up to four 16 MiB external QSPI flashes and SRAMs with hardware encryption based on AES to protect developers' programs and data. It accesses the external QSPI flash and SRAM through high-speed caches.

Security – IEEE 802.11 standard security features are all supported, including WFA, WPA/WPA2 and WAPI. Moreover, ESP32 has a secure boot and flash encryption.
ESP32 Functions:

ESP32 has many applications when it comes to the Internet of Things (IoT). Here are just some of the IoT functions the chip is used for:

- **Networking:** The module's Wi-Fi Antenna and dual-core enables embedded devices to connect to routers and transmit data.
- **Data Processing:** Includes processing basic inputs from analog and digitalsensors to far more complex calculations with an RTOS or non-OS SDK.
- **P2P Connectivity:** Creates direct communication between different ESPs and other devices using IoT P2P connectivity.
- **Web Server:** Access pages written in HTML or development languages. ESP32 Applications

The ESP32 modules are commonly found in the following IoT devices:

- Smart industrial devices, including Programmable Logic Controllers (PLCs)
- Smart medical devices, including wearable health monitors
- Smart security devices, including surveillance cameras and smart locks

Figure 5.1 : *Microcontroller*

5.2 MAX30100

5.2.1 Internal Function

The MAX30100 features a wearable-friendly minimalistic design to offer pulse oximetry and heart rate sensor systems in a single package without sacrificing optical or electrical performance. The sensor achieves the desired functions through red and IR LEDs, a photodetector, optimized optics, and a low-noise analog signal processing unit. It operates between 1.8V to 3.3V and can achieve ultra-low-power operation with a negligible standby current of 0.7µA through software.

The typical functional diagram of the MAX30100 sensor is shown below.

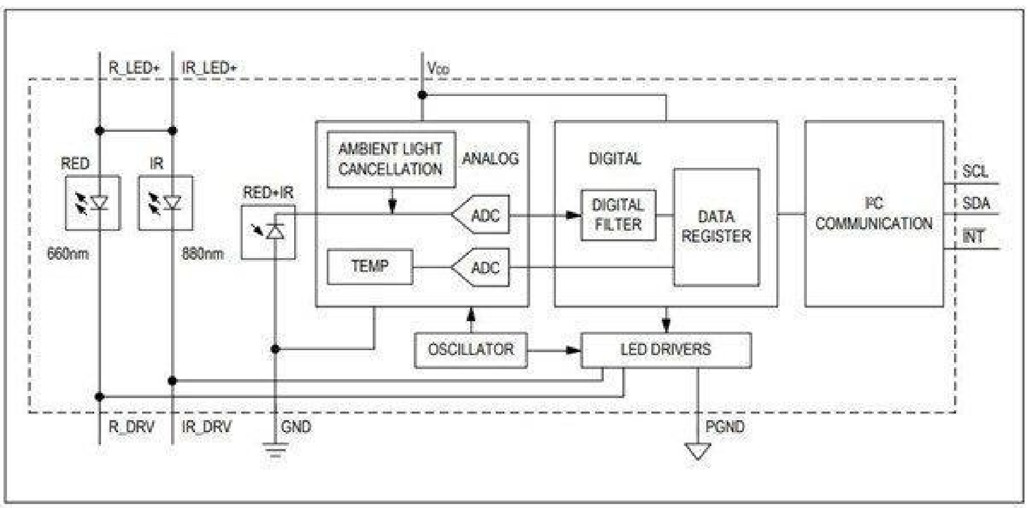

Figure 5.2 : *MAX30100*

The SpO2 subsystem features ambient light cancelation (ALC) application to overcomeexternal light interference with signals coming from LEDs. Also, it successfully cancelsout low-frequency noise with a proprietary discrete-time filter. With an on-chip temperature sensor, it further takes care of any reading error due to ambient temperature fluctuations.

The sensor combines signals from red and IR LED drivers to drive pulse for pulse oximeter and heart rate measurements. The LED current and pulse width can be programmed from 0mA to 50mA and 200µs to 1.6ms, respectively, to optimize measurement accuracy and power consumption.

5.2.2 Salient Features

- Complete pulse oximeter and a heart-rate sensor
- Ultra-low power operation
- Improved measurement performance
- Fast data output
- I2C interface

5.2.3 Specifications

Some of the main specifications found in MAX30100 sensor datasheet include:

- Input power: 1.7 to 2.0 V
- Temperature range: -40 to +85 °C
- LED Current: 0mA to 50mA (typ)
- LED pulse width: 200µs to 1.6ms
- Supply current in shutdown: 0.7-10µA
- Package: 5.6mm x 2.8mm x 1.2mm 14-Pin SiP

The sensor comes in the SiP package offering significant space and cost-saving advantages in reduced board area and board layers.

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Two diagrams below show the pin configuration and pins description of MAX30100.

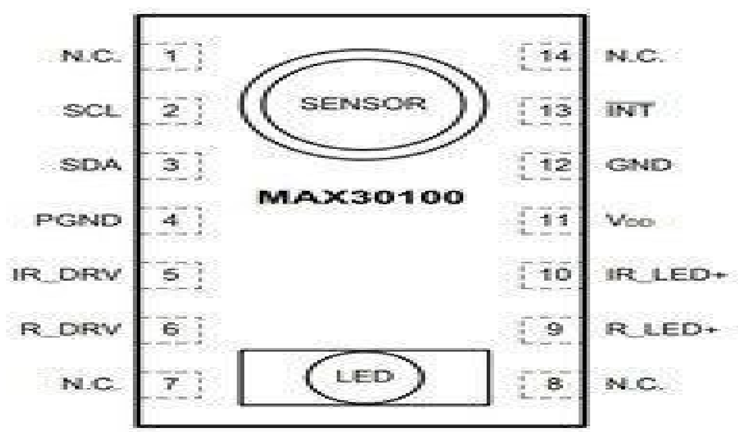

Figure 5.3 : *MAX30100 pin description*

5.2.4 Power Requirement

The MAX30100 chip requires two different supply voltages: 1.8V for the IC and 3.3V forthe RED and IR LEDs. So the module comes with 3.3V and 1.8V regulators.

This allows you to connect the module to any microcontroller with 5V, 3.3V, even 1.8V level I/O.

Figure 5.4:*Max30100*

One of the most important features of the MAX30100 is its low power consumption: the MAX30100 consumes less than 600µA during measurement. Also it is possible to put the MAX30100 in standby mode, where it consumes only 0.7µA. This low power consumption allows implementation in battery powered devices such as handsets, wearables or smart watches.

5.3 Heartbeat Sensor

Heartbeat sensor provides a simple way to study the function of the heart which can be measured based on the principle of psycho-physiological signal used as a stimulus for the virtual-reality system. The amount of the blood in the finger changes with respect to time. The sensor shines a light lobe (a small very bright LED) through the ear and measures the light that gets transmitted to the Light Dependent Resistor. The amplified signal gets inverted and filtered, in the Circuit.

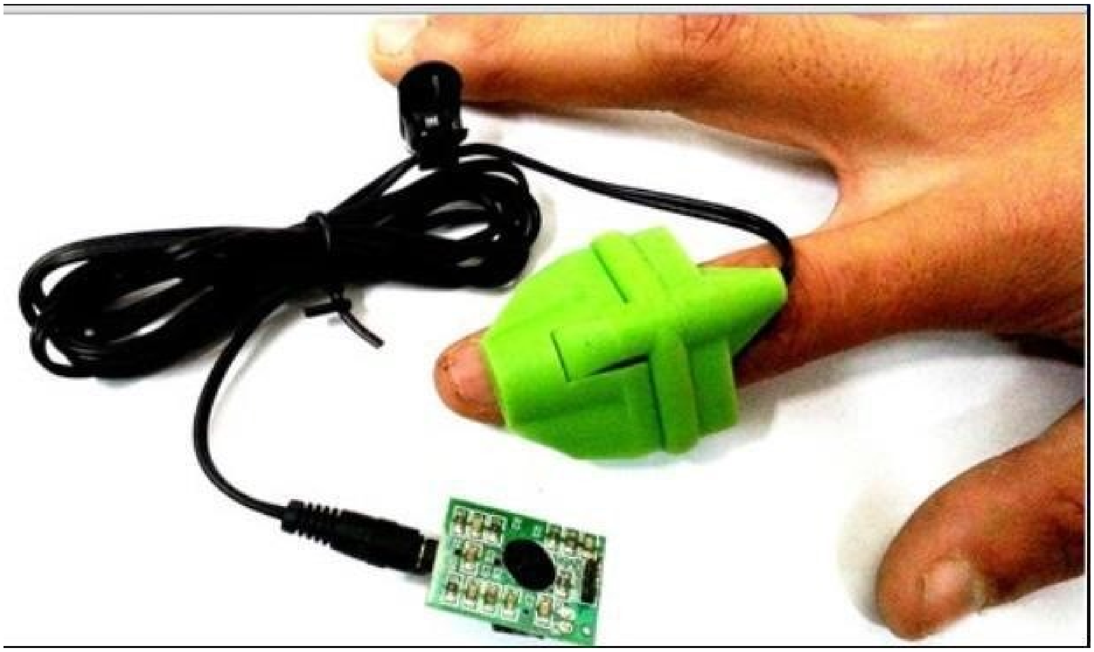

Figure 5.5:*Heartbeat Sensor*

CHAPTER-6

6 REQUIREMENT ANALYSIS

Requirement Analysis is the first and important phase of the software developing activity in developing any kind of project effectively. I started to list out all the functionalities that my application should provide. There have been some minor changes with respect to the functionalities over the course of development. After a meeting with my Professor Dr. Daniel Andresen, following are the requirements that have been implemented in this project.

6.1 Functional Requirements

- Application must have a module for login using unique credentials of a patient forthe doctor to monitor patient's vital data.
- Application must have a module for login using unique credentials of a patient for Guardian/Caretaker to monitor patient's vital data.
- Location Tracking: Application must have track location option with which doctor or guardian can track location of the patient.
- Location sender: Hardware must have a GPRS module to fetch location coordinates which can be used to track location of patient.
- Messaging Service: Hardware must have GSM module which send's SMS alert messages to doctor and guardians upon any emergencies. And application must send email alerts upon any emergencies.

6.2 Non-Functional Requirements

Non-functional requirements are not directly related to the functional behavior of thesystem.

- Web application must be user friendly, simple and interactive.
- The user interface is designed in such way that novice users with little knowledge.

6.3 Software Specifications

- Operating System: Windows 7 or higher
- Platform: IoT Cloud
- IDE: Arduino 1.8.4

6.4 Hardware Specifications

Microcontroller: Arduino Uno Board.

Sensors: Temperature (LM35), Toxic gas (MQ9), GSM Module, GPRS Module, ECG , Humidity, Air Quality, Pressure.

Processor: Pentium or Higher.

Processor speed: 1.6GHz.

RAM: 512MB.

CHAPTER – 7

7 SYSTEM DESIGN

Systems design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Overall product architecture, the subsystems that compose the product, and the way subsystems are allocated to processors are depicted using the System Design. UML is used to model system designs. Unified Modelling Language is a standard object-oriented analysis and design language. Use Case diagram and Sequence diagram, which are types of UML diagrams, of the application are shown below application.

Actors: The Actors of the system are Patient, Guardian, and Doctor.

Use cases: I have identified a set of use cases based on the functionalities and goals of theapplication.

- **Login-** This use case denotes a set of actions required for Subject to login into theapplication.
- **Call Service-** This use case denotes a set of actions required by doctor to call aguardian or patient in case medical emergencies
- **Messaging Service-** This use case denotes a set of actions required by doctor tosend a message to subject's guardian in case of emergencies.

7.1 Sequence Diagram

Sequence diagrams model the flow of logic within your system in a visual manner, enabling you both to document and validate your logic, and are commonly used for both analysis and design purposes.

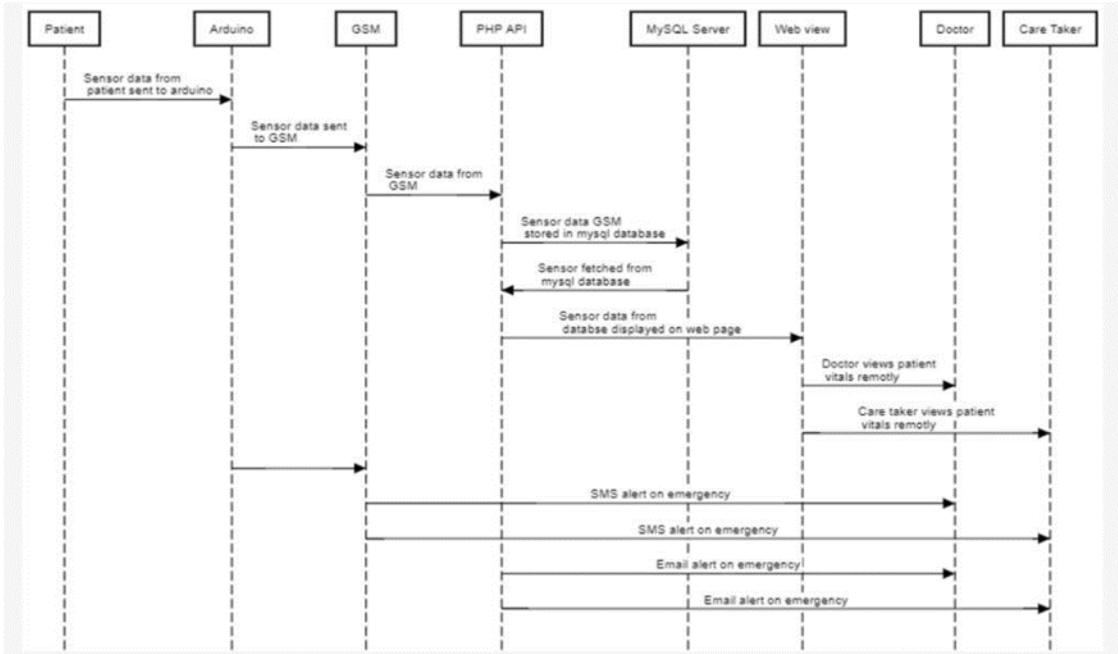

Figure 7.1 *: Sequence Diagram*

CHAPTER 8

8 SOFTWARE DESIGN

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>
#define REPORTING_PERIOD_MS 1000
char auth[] = "w2yoZ3qIQpfq1DmTMYUcEB1Nd3s_HnwO";
// You shouldget Auth Token in the Blynk App.
char ssid[] = "Alexahome";                    // Your WiFi credentials.
char pass[] = "12345678";
// Connections : SCL PIN - D1 , SDA PIN - D2 , INT PIN - D0
PulseOximeter pox;
float BPM, SpO2;
uint32_t tsLastReport = 0;
void onBeatDetected()
{
Serial.println("Beat Detected!");
}
void setup()
{
Serial.begin(115200);
pinMode(19, OUTPUT);
Blynk.begin(auth, ssid, pass);
Serial.print("Initializing Pulse Oximeter..");
if (!pox.begin())
```

```
{
Serial.println("FAILED");
for (;;);
}
else
{
Serial.println("SUCCESS");
pox.setOnBeatDetectedCallback(onBeatDetected);
}
   // The default current for the IR LED is 50mA and it could be changed by
uncommenting the following line.
pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
}
void loop ()
{
pox.update();
Blynk.run();
BPM = pox.getHeartRate();
SpO2 = pox.getSpO2();
if (millis() – tsLastReport > REPORTING_PERIOD_MS)
{
Serial.print("Heart rate:");
Serial.print(BPM);
Serial.print(" bpm / SpO2:");
Serial.print(SpO2);
Serial.println(" %");
Blynk.virtualWrite(V3, BPM);
Blynk.virtualWrite(V4, SpO2);
tsLastReport = millis();}
```

CHAPTER - 9

9 IMPLEMENTATION

This project has been developed with Esp32 microcontroller connected with sensors which are attached to the patient. All the sensors and location data sent from microcontroller to MySQL database into the cloud. A doctor or guardian can log in to web portal to monitor patient's data at any point in time. In case of emergencies, like temperature spike or heartbeatspike or detection of toxic gas etc. an SMS and email alert sent to doctor and guardian's mobile and email.

And at any point of time either a doctor or guardian can log into web portal with patient unique credentials and can track patient's location which would help medical services to send appropriate help in case of emergencies.

A doctor or guardian can log in to web portal to monitor patient's data at any point in time. In case of emergencies, like temperature spike or heartbeat spike or detection of toxic gas etc. an SMS and email alert sent to doctor and guardian's mobile and email.

9.1 Esp32 Micro controller Init

Gsm_init(): With this event, Arduino board checks out network connectivity before fetching sensor data and relay it to cloud. Below Algorithm in Arduino board executes

series of AT commands which would check network connectivity and enables internet.

```
void gsm_init()
{
lcd.clear();
lcd.print("GSM TESTING..");
boolean at_flag=1;
while(at_flag)
{Serial.println("AT");while(Serial.available()>0){if(Serial.find("OK"))at_flag=0;}delay(1000);}
lcd.clear();lcd.print("GSM CONNECTED");delay(1000);lcd.clear();
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.print("Disabling ECHO");
boolean echo_flag=1;
while(echo_flag)
{Serial.println("ATE0"); while(Serial.available()>0){if(Serial.find("OK"))echo_flag=0;}delay(1000);}
lcd.clear();  lcd.print("Echo OFF");delay(1000);lcd.clear();
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.print("Finding Network..");
boolean net_flag=1;while(net_flag){Serial.println("AT+CPIN?");
while(Serial.available()>0){if(Serial.find("+CPIN: READY"))net_flag=0;}delay(1000);}
lcd.clear();lcd.print("Network Found..");
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.setCursor(0,1);lcd.print("GSM NETWORK");delay(1000);lcd.clear();
///////////////////////////////////////////////////////////////////////////////
lcd.clear();lcd.print("TEST MESS");
boolean test_flag=1;while(test_flag){Serial.println("AT+CMGF=1");
while(Serial.available()>0){if(Serial.find("OK"))test_flag=0;}delay(1000);}
lcd.clear();lcd.print("TEST MESSAGE");delay(1000);
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.clear();lcd.print("CGATT");
boolean test1_flag=1;while(test1_flag){Serial.println("AT+CGATT=1");
while(Serial.available()>0){if(Serial.find("OK"))test1_flag=0;}delay(1000);}
lcd.clear();lcd.print("AT+CGATT=1");delay(1000);
/////////////////////////////////////////////////////////////////////////////////////////////

lcd.clear();lcd.print("GPRS1");
boolean test2_flag=1;while(test2_flag){Serial.print("AT+SAPBR=3,1,\"CONTYPE\",\"GPRS\"\r\n");
while(Serial.available()>0){if(Serial.find("OK"))test2_flag=0;}delay(1000);}
lcd.clear();lcd.print("GPRS START1");delay(1000);
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.clear();lcd.print("GPRS2");
boolean test3_flag=1;while(test3_flag){Serial.print("AT+SAPBR=3,1,\"APN\",\"internet\"\r\n");
while(Serial.available()>0){if(Serial.find("OK"))test3_flag=0;}delay(1000);}
lcd.clear();lcd.print("GPRS START2");delay(1000);
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.clear();lcd.print("GPRS MAIN");
boolean test4_flag=1;while(test4_flag){Serial.print("AT+SAPBR=1,1\r\n");
while(Serial.available()>0){if(Serial.find("OK"))test4_flag=0;}delay(1000);}
lcd.clear();lcd.print("GPRS CAME");delay(1000);
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.clear();lcd.print("HTTP1");
boolean test5_flag=1;while(test5_flag){Serial.print("AT+HTTPINIT\r\n");
while(Serial.available()>0){if(Serial.find("OK"))test5_flag=0;}delay(1000);}
lcd.clear();lcd.print("HTTP1");delay(1000);
/////////////////////////////////////////////////////////////////////////////////////////////
lcd.clear();lcd.print("HTTP2");
boolean test6_flag=1;while(test6_flag){Serial.print("AT+HTTPPARA=\"CID\",1\r\n");
while(Serial.available()>0){if(Serial.find("OK"))test6_flag=0;}delay(1000);}
lcd.clear();lcd.print("HTTP2");delay(1000);
```

```
#include <Wire.h>
#include"MAX30100_PulseOxmeter.h"#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>
#define REPORTING_PERIOD_MS 1000

char auth[] ="w2yoZ3qIQpfq1DmTMYUcEB1Nd3s_HnwO";

// You shouldget Auth Token in the Blynk App.

char ssid[] ="Alexahome";                    // Your WiFi credentials.
char pass[] ="12345678";
// Connections : SCL PIN - D1 , SDA PIN - D2 , INT PIN - D0
PulseOximeter pox;
float BPM, SpO2;
uint32_t tsLastReport =0;
void onBeatDetected()
{
Serial.println("Beat Detected!");
}
void setup()
{
Serial.begin(115200);
pinMode(19, OUTPUT); Blynk.begin(auth, ssid, pass);
Serial.print("Initializing Pulse Oximeter..");
if (!pox.begin())
{
Serial.println("FAILED");
```

```
for(;;);
}
else
{
Serial.println("SUCCESS"); pox.setOnBeatDetectedCallback(onBeatDetected);
}
   // The default current for the IR LED is 50mA and it could be changed by
uncommenting the following line.
pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
}
void loop()
{
        pox.update();
        Blynk.run();
        BPM =pox.getHeartRate();SpO2 =pox.getSpO2();
        if (millis() -tsLastReport > REPORTING_PERIOD_MS)
{
        Serial.print("Heart rate:");
        Serial.print(BPM);
        Serial.print(" bpm / SpO2:");
        Serial.print(SpO2);
        Serial.println(" %");
        Blynk.virtualWrite(V3, BPM);
        Blynk.virtualWrite(V4, SpO2);
        tsLastReport =millis();
  }
}
```

CHAPTER - 10

10 GRAPHICAL USER INTERFACE

This Project is designed to make sure that user interface pages are easily understandable and the navigation between pages is obvious

10.1 Web Page Login

Here doctor or care taker enter patient's unique credentials. Once the credentials are verified, login page will be navigated to patient vital monitoring page where doctor or caretaker can view current vital readings of the patient. Here patient's unique credentials must be kept confidential by the doctor and caretaker to protect privacy of the patient data.

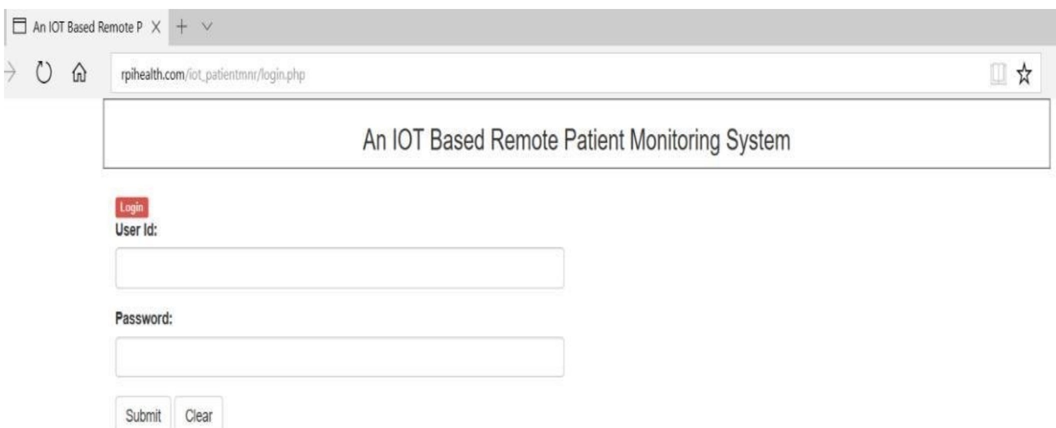

Figure 10.1:*Webpage login*

10.2 Patient's Vital Monitoring Page

After doctor or care taker login successfully, either can able to view live patient's vital information which includes temperature, humidity, heartbeat, ECG etc.

In below images, it is shown in detail about that the current readings of the patient are displayed on patient vital monitoring page without any error. In case device is not connected or any of the sensor is not attached to patient, then all the readings or respective reading would be shown as zero in case of digital values.

Figure 10.2 *: BPM & SpO2*

10.3 Show History of Patient data

Here doctor can see history of patient vitals that has been recorded and stored in server in tabular form. This data can specifically be used by doctor to perform analysis on patient health condition to predict any irregularities in health conditions, to recommend change in medication or treatments etc. and can be used to recommend patient regular visits.

Figure 10.3*:Patient Data*

10.4 System Setup

In the above image, it is shown complete device setup which includes Arduino micro controller board with power supply attached to it. Micro controller is connected with all the sensors which includes from right bottom Fall detection sensor (Body Movement sensor), Air quality sensor, Toxic gas sensor, Humidity sensor, ECG sensor, Pressure sensor, Temperature sensor, Heartbeat sensor. Micro controller also connected with alarm which will be used in

Logout

Monitor Patient Vitals

Track Patient Location

An IOT Based Remote Patient Monitoring System

TEMP	HEART BEAT	ECG	HUMIDITY	AIR PRESSURE	TOXIS GAS	AIR QUALITY	BODY FALL	Date/TIME
23	0	349	0	49	10	20	NO_	2017-11-08 01:29:55
23	0	348	0	49	10	21	NO_	2017-11-08 01:29:23
20	0	348	0	49	10	22	NO_	2017-11-08 01:28:52
22	0	349	0	49	10	24	NO_	2017-11-08 01:28:28
23	0	245	0	49	11	27	NO_	2017-11-08 01:27:57
21	0	0	0	49	18	45	NO_	2017-11-08 01:27:17
21	0	0	0	49	18	45	YES	2017-11-08 01:27:07
21	0	349	0	49	17	206	YES	2017-11-08 01:27:00
21	0	0	0	49	30	228	NO_	2017-11-08 01:26:20
21	0	0	0	49	30	228	YES	2017-11-08 01:26:11
19	0	0	0	48	30	258	YES	2017-11-08 01:25:53

Figure 10.4: *System Setup*

case any of sensor data conditions are not met like temperature spikes, toxic gases etc. And GSM and GPRS modules are connected which are used to send sensor data into server and fetch location coordinates of the patient respectively.

of information as soon as device is turned on which includes location coordinates and HTTP protocols which shows the network connect procedure. In case device unable to connect to network, we could see the command at which device currently halted and can be used to diagnose the issue. And finally, once device is connected to network, it displays all the patient information on it along with any irregularities of patient vitals.

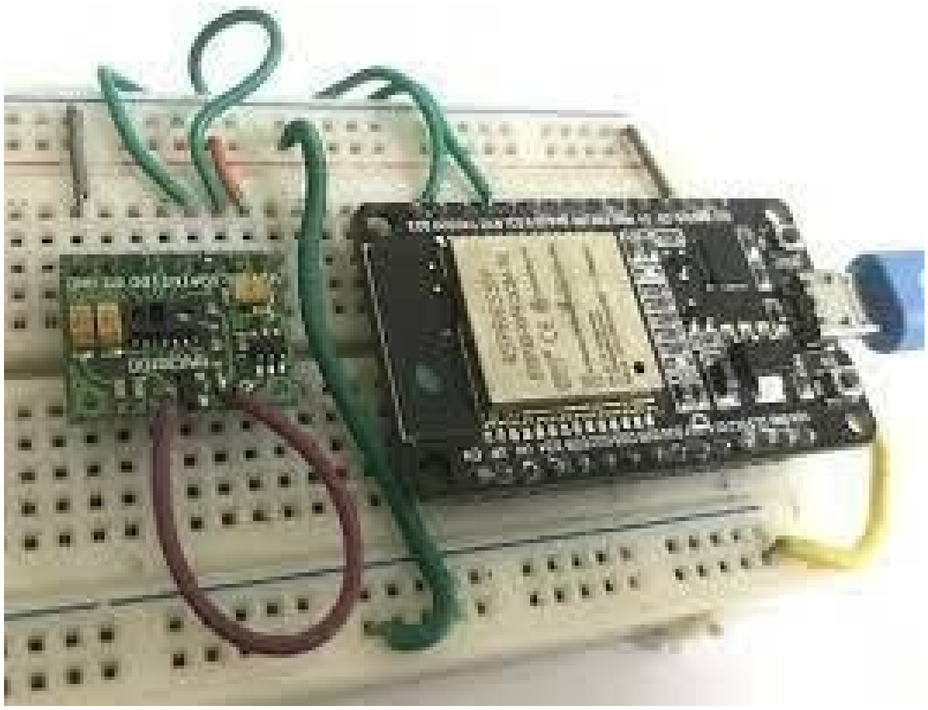

Figure 10.5 *: Experiment Kit*

10.5 Results

Alert: Here email alert has been sent to registered email with the information about patient vitals and link to patient monitoring page.

Figure 10.6*:Result*

CHAPTER – 11

11 TESTING

Software Testing is a process of executing the application with an intent to find any software bugs. It is used to check whether the application met its expectations and all the functionalities of the application is working. The final goal of testing is to check whether the application is behaving in the way it is supposed to under specified conditions. All aspects of the code are examined to check the quality of application. The primary purpose of testing is to detect software failures so that defects may be uncovered and corrected. The test cases are designed in such way that scope of finding the bugs is maximum.

11.1 Testing Levels

There are various testing levels based on the specificity of test.

- ***Unit testing***: Unit testing refers to tests conducted on a section of code in order to verify the functionality of that piece of code. This is done at the function level.
- ***Integration Testing***: Integration testing is any type of software testing that seeks to verify the interfaces between components against a software design. Its primary purpose is to expose the defects associated with the interfacing of modules.
- ***System Testing***: System testing tests a completely integrated system to verify that the system meets its requirements.
- ***Acceptance testing***: Acceptance testing tests the readiness .

11.2 System Test Cases

A test case is a set of test data, preconditions, expected results and post conditions, developed for a test scenario to verify compliance against a specific requirement. I have designed and executed a few test cases to check if the project meets the functional requirements.

Test Objectives: Navigation from Login page to Monitoring page

TEST CONDITION	**INPUT SPECIFICATION**	**OUTPUT SPECIFICATION**	**PASS/FAIL**
The user is currently on the login page	User enters credentials and clicks on login button	Directs to monitoring page	PASS

Table 11-1*:Test case for navigation from login page*

Test Objectives: Navigation from Monitoring page to Google Maps page

TEST CONDITION	**INPUT SPECIFICATION**	**OUTPUT SPECIFICATION**	**PASS/FAIL**
The user is currently on the Monitoring page	User clicks on Track location link on monitoring page.	Directs to google maps page	PASS

Table 11-2:*Test case for navigation from Monitoring page to Google maps page*

CHAPTER – 12

12 PERFORMANCE TESTING

Performance of the system can be determined based on the system/application responsiveness under all kinds of load. Performance testing in IoT framework is little different than traditional performance testing. IoT devices generates a lot of data which is saved in server and analyzed for immediate decisions. Hence IoT system must be built for high performance and scalability. And to measure these two key attributes, it is important to understand the business value for which it is build i.e. in our case patient health data. Hence it is necessary to simulate real world models, network conditions etc.

12.1 Performance Testing Challenges in IoT

- IoT does not have a standard protocol set to establish a connection between IoT application and devices. IoT protocols used range from HTTP, MQTT, AMQP and more. These protocols are still in early phases of development and different IoT vendors come up specific protocol standards. Since these are new protocols, current performance testing tools may or may not support them.
- IoT devices or sensors spread across different places and use different network to connect to servers to send and receive data. As a part of PT, we can simulate devices from different locations using different networks such as 2G, 3G, 4G, Bluetooth, WIFI etc.
- Sometimes IoT implementations require the data from device that needs to be processed at runtime and based on data received, corresponding decision to be made. These decisions are generally notifications or alerts. As a part of PT, these notifications are to be monitored i.e., time taken to generate the notification.

Performance testing approach on IoT Framework	
Section	**IoT PT**
Simulation	On devices or sensors
Scale	Few devices to thousands of devices
Protocols	IoT uses non-standard and new protocols to communicate
Requests/Respon se	IoT devices create the requests and receive response as well as request and provide response
Amount of data	Sends and receives minimal data per request but data is shared continuously with time interval

Table 0-1: *Performance test on IoT framework*

12.2 Performance Test Cases

Following are the scenarios where performance testing can be performed on IoTframework.

1) Device to device communication
2) Device to server communication
3) Server to server communication
4) Network bandwidth, latency and packet loss

Based on above scenarios and focusing the scope of this project, below are the performance test cases that are tested on this project.

Test Objectives: Time taken to send data to cloud

TEST CONDITION	OUTPUT SPECIFICATION	OPTIMAL
Time taken to send sensor data to MySQL database in cloud.	Micro controller sends data every 15 seconds to cloud. Here network plays important role and time taken to send each record is <200ms including response time. But if there is issue with network bandwidth then performance will be deteriorated as system takes additional to check network connectivity and send data to cloud.	TRUE

Table 0-2:*Test case checking time taken to send data to cloud*

Test Objectives: Time taken to initialize GSM Module

TEST CONDITION	OUTPUT SPECIFICATION	OPTIMAL
Time taken to initialize GSM module to identify network and enable internet	Micro controller executes set of commands on GSM module which takes 2min to 5min once the system powered on. And once network is found and connected, system would be able to send data in a real time.	TRUE

Table 0-3: *Test case for checking time taken to initialize GSM*

Test Objectives: Time taken to initialize GPRS Module

TEST CONDITION	OUTPUT SPECIFICATION	OPTIMAL
Time taken to initialize GPRS module to identify location coordinates	Micro controller GPRS module takes 5min to 15min to identify coordinates once system powered on. Once GPRS module fetch coordinates, data is sent in real time.	TRUE

Table 0-4: *Test case for checking time taken to initialize GPRS*

Test Objectives: Time taken to relay patient data on web page

TEST CONDITION	OUTPUT SPECIFICATION	OPTIMAL
Time taken to fetch data from cloud and view it on web	Time taken to run query and relay information on web page is <500ms	TRUE

Table 0-5: *Test case for checking time taken to fetch data from cloud and relay on web*

Test Objectives: Time taken to relay patient data to Micro controller

TEST CONDITION	OUTPUT SPECIFICATION	OPTIMAL
Time taken tofetch data from sensors to Micro controller	Time taken to fetch data from sensor andrelay information to Micro controller is <50ms	TRUE

Table 0-6: *Test case for checking time taken to fetch data from sensor to Micro controller*

Test Objectives: Time taken to send Email alert by GSM Module

TEST CONDITION	OUTPUT SPECIFICATION	OPTIMAL
Time taken to send Email alert.	PHP API sends email alert to doctor and caretaker in real time.	TRUE

Table 0-7: *Test case for checking time taken to send email alert*

Test Objectives: Time taken to display patient history data on web page

TEST CONDITION	OUTPUT SPECIFICATION	OPTIMAL
Time taken to display patient vitals history data.	PHP API displays history of patient's data in real time. This scenario has been tested with mock data dump of >100000 records and system is able to relay data on web page in one second.	TRUE

Table 0-8: *Test case for checking time taken to display patient history*

12.3 Fault Tolerance

There is chance that any of the above test cases fails in this architecture. Sometimes sensors may get damaged, run out of power, communication between GSM module and server may be interrupted due to unavailability of network, GPRS module may not fetch location coordinates or relaying information from board to server may delayed due to network unavailability.

CHAPTER – 13

13 SUMMARY OF THE STUDY, CONCLUSION & RECOMMENDATIONS

Summary of the StudyThe remote patient monitoring system was researched, designed and presented theconcept of the Internet of things. Personal physiological data from the patient is collected that simulates fall detection, heartbeat, temperature, humidity, toxic gas, air quality control, pressure. The readings are collected in a simple cloud database and can be viewed remotely by a doctor or Healthcare giver. The data can also be used in research onmedical issues affecting the elderly or chronically ill. On the security of the data, the database system is protected with Advanced Encryption Standard (AES). This generates the secret key which can be used to decrypt the patients’ records ensuring that only authorized personnel access the data. This safeguards the patients’ records from unauthorized users and hackers who may want to intercept.

On the security of the data, the database system is protected with Advanced Encryption Standard (AES). This generates the secret key which can be used to decrypt the patients’ records ensuring that only authorized personnel access the data. This safeguards the patients’ records from unauthorized users and hackers who may want to intercept.

CHAPTER-14

14 FUTURE SCOPE AND POTENTIAL IMPROVEMENTS

14.1 Portable Design

Future versions of the virtual doctor could include a more portable design like a wearable that feels less obtrusive and is more comfortable to wear throughout the day.

14.2 More Health Metrics

As technology advances, additional health metrics can be added to the virtual doctor, providing a more comprehensive health check-up, including temperature, blood pressure, and respiratory rate

14.3 AI integration

Artificial intelligence can be integrated into the virtual doctor to identify patterns in lifestyle and health that could lead to serious conditions like heart disease, leading to timely interventions.

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