Health Monitoring System using IoT and Cloud Computing

Shraman kanthi
Electronic and Communication
KLE Technological University
Belgaum, India
02FE22BEC092@kletech.ac.in

Sanskruti Mirajkar
Electronic and Communication
KLE Technological University
Belgaum, India
02FE22BEC084@kletech.ac.in

Darshan Modekar
Electronic and Communication
KLE Technological University
Belgaum, India
02FE22BEC119@kletech.ac.in

Swati Patil
Electronic and Communication
KLE Technological University
Belgaum, India
02FE22BEC112@kletech.ac.in

***Abstract*—The paper presents the design and development of an IoT based Health monitoring system leveraging ESP32 microcontroller and cloud computing technologies. The system is an advanced embedded solution capable of continuously tracking vital signs such as heart rate, blood pressure and body temperature. The. ESP32 acts as the core processing unit integrating sensors for real time data collection, the collected data is transmitted to a cloud based platform for analysis, visualization and storage. The custom Android application provides user with real time access to their health data offering alerts in case of abnormalities. Additionally, a web-server is created to visualize the health of the patient and send alerts to the stakeholders in case if the sensor data exceeds the threshold value.**

***Index Terms*—Internet of things (IoT),Sensors,ESP32,Webserver,Alerts**

I. INTRODUCTION

The integration of Internet of things and cloud computing into healthcare has revolutionized the way health services are delivered, Monitored and managed. An IoT based health monitoring system leverages interconnected devices, sensors and cloud platform to collect, process and analyze health data in real time. These system empower both patient and healthcare providers by enabling continuous monitoring, early diagnosis and timely interventions significantly improving healthcare outcomes while reducing cost. The importance of such system lies in their ability to address the growing burden on health care infrastructure driven by aging population,rising chronic diseases, prevalence and the demand of personalized care.

The concept of IoT in health care has its root in the evolution of telemedicines and wearable technology. In the early 2000s, remote patient monitoring technologies emerge, but their potential was limited due to inadvocate data transmission capabilities. With advancements in IoT, affordable sensors and high-speed connectivity, healthcare entered a new era of digital transformation. IoT devices such as smart watches, fitness trackers and medical grade devices can now measure vital signs like heart rate, blood pressure, glucose level and oxygen saturation with remarkable accuracy. These devices transmit data to cloud servers, where it is proceeded and analyzed using sophisticated algorithms, enabling actionable insights and remote consultation.

The application of IoT in healthcare extends beyond individual monitoring to hospital management and community health. Hospitals uses IoT-enable system to track patient's conditions, manage medical equipment and streamline workflows, improving operational efficiency. For instance, IoT powered infusion pumps and ventilators can be remotely adjusted. reducing the workload on medical staff. On a broad scale IoT systems are developed for population health management, monitoring disease outbreaks and supporting public health initiatives. Morover, the integration of cloud computing enhances the scalability and accessibility of IoT Health monitoring system. Cloud platforms provide secure, centralized storage for massive volumes of data and enable real-time analytics, which is crucial for detecting anomalies and generating alerts. This combination ensures that patients, regardless of geographic location, can access quality healthcare

Fig. 1. Internet of Things

Identify applicable funding agency here. If none, delete this.

II. LITERATURE SURVEY

We have gone through various papers for our project. Totally we have surveyed for 6 papers. Paper [1] presents an IoT-based health monitoring system built on the ESP32 microcontroller, capable of tracking vital parameters such as oxygen levels and transmitting results to healthcare professionals online. Its compact and portable design ensures usability in critical scenarios. Paper [2] extends this idea by utilizing the MAX30102 sensor to measure blood oxygen concentration and air pressure. Despite facing implementation challenges, this system demonstrates the potential of IoT to provide real-time health updates to involved parties via the internet. Moving beyond healthcare, Paper [3] explores IoT applications in military operations, proposing a system to monitor soldiers' health and location during missions. This technology addresses safety concerns while enhancing operational efficiency, a critical need for national security. Paper [4] highlights a versatile embedded IoT device capable of measuring environmental parameters such as pressure, temperature, and humidity, in addition to heart rate. The integration of Bluetooth and Android app connectivity enhances real-time data accessibility for end-users. Similarly, Paper [5] emphasizes IoT's role in remote healthcare, introducing a biomedical sensor-based system for continuous patient monitoring, which bridges the gap between urban and rural healthcare facilities. Finally, Paper [6] focuses on health monitoring for disabled individuals, offering a mobile-linked device that predicts and addresses health risks, significantly improving their quality of life. Collectively, these studies illustrate the trans formative impact of IoT-enabled devices in healthcare and security. They highlight the potential of IoT to deliver timely, efficient, and accessible solutions across diverse applications. This growing body of work underscores the critical role of IoT in addressing modern healthcare challenges and ensuring the safety and well-being of individuals in various domains.

III. COMPONENTS OVERVIEW

After undergoing Literature Survey we have selected paper 3 as our base paper and selected different parameters of health i.e Heart Pulse, spO2, Body temperature and humidity and a ESP32, a micro-controller for our project

A. ESP32

The ESP32 is a low cost, high performance micro-controller system on chip widely used in IOT application due to its powerful features and versatility. Developed by Espressi Systems, it comes with a dual core processor, integrated Wi-fi, Bluetooth connectivitymaking it ideal for wireless communication projects. Its low power consumptions and deep sleep mode make it suitable for battery operated devices such as smart home system, wearable gadgets and health monitoring solution.

Fig. 2. ESP32

B. MAX30102 SENSOR

The MAX30102 is a high integrated pulse oxime-ter and heart rate sensor module designed for wearable and potable heart monitoring application. It utilizes optical technology with integrated red and infrared LED's along with a photo-detector to measure oxygen saturation and heart rate from blood flow changes in the capillaries.

Fig. 3. MAX30102 SENSOR

C. DS18B20 SENSOR

DS18B20 is a digital temperature sensor known for its accuracy, simplicity and wide range of applications in embedded systems of IoT project. It measures temperature from -55°C to +125°C with a precision of 0.5°C in the range of -10°C to +85°C.

Fig. 4. DS18B20 SENSOR

D. DHT11 SENSOR

DHT11 is a low cost digital sensor that measures temperature and humidity, widely used in IoT and environmental monitoring application. It features a capacitive humidity sensor and a thermistor to provide accurate readings of relative humidity and temperature.

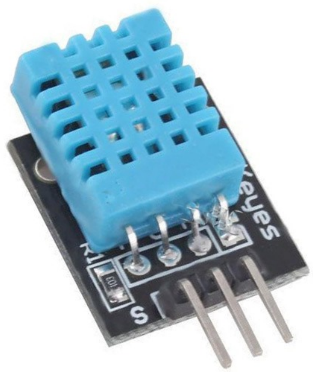

Fig. 5. DHT11 SENSOR

IV. DESIGN OF THE SYSTEM

A. FUNCTIONAL BLOCK

In the block diagram of a health monitoring system, the ESP32 micro-controller act as a central hub connecting various sensors to monitor a patient's vital signs. This system typically includes a heart rate sensor, spO2 sensor, a temperature sensor and a humidity sensor. Each of the sensor collects specific health data from the patient. The ESP32 processes the data received from these sensor converting the analog signal into digital format that can be easily analyzed and transmitted. Utilizing its build in WiFi capabilities, the ESP32 sends this health data to a cloud based web server. This server serves as an repository for all collected information, allowing for a real time data access and analysis. Healthcare providers, including doctor and nurse, can access the Web server to view the patient's health matrix through a user friendly interface. In case of variation in parameters, alerts are sent to the stakeholders.

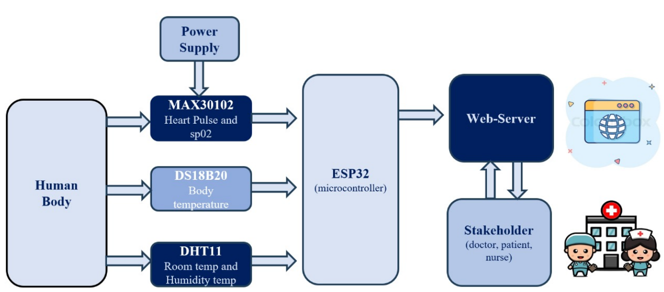

Fig. 6. BLOCK DIAGRAM

B. HARDWARE DESIGN

The hardware connection involves accurately interfacing the ESP32 to acquire and transmit data. The MAX30102 sensor responsible for measuring the hard pulse and spO2 levels is connected to the ESP32 via its I2C interface, requiring connections for data, clock, power, and ground. Similarly, the DS18B20 temperature sensor, which monitors the patient's body temperature, is connected to the ESP32 using a single wire communication protocol. A pull-up regulator is used on the data line to ensure stable communication.

The DHT11 sensor, used to measure ambient room temperature and humidity, is connected to one of the ESP32's GPI0 pins. It also requires a VCC and GND connection to operate. A common power supply is used to power the sensor and ESP32 ensuring stable voltage across all the components. The ESP32 acts as a central processing unit, collecting data from all the connected sensors and processing it for transmission.

The ESP32 utilizes its inbuilt Wi-Fi module to send the collected data to the Web server or thingspeak platform. The Web Server serves as a repository where the data is stored and accessed by the stakeholders, including doctors, patients and nurse. All connections are carefully established to maintain accuracy, ensure proper grounding, and prevent noise interface, enabling seamless functionality.

1) Stimulation: The Fig.7. shows the stimulation of our project, where all the sensors are connected to the ESP32 and futher data is stored through cloud computing. The stimulation is done using cricuito.io platform

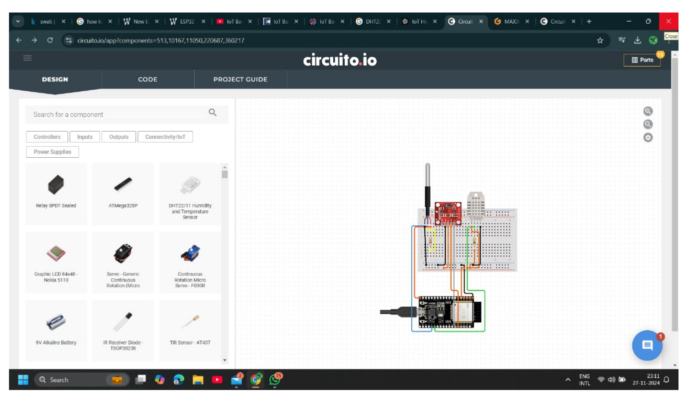

Fig. 7. STIMULATION

2) Hardware Implementation: Fig.8. shows the hardware connection as per the block diagram.

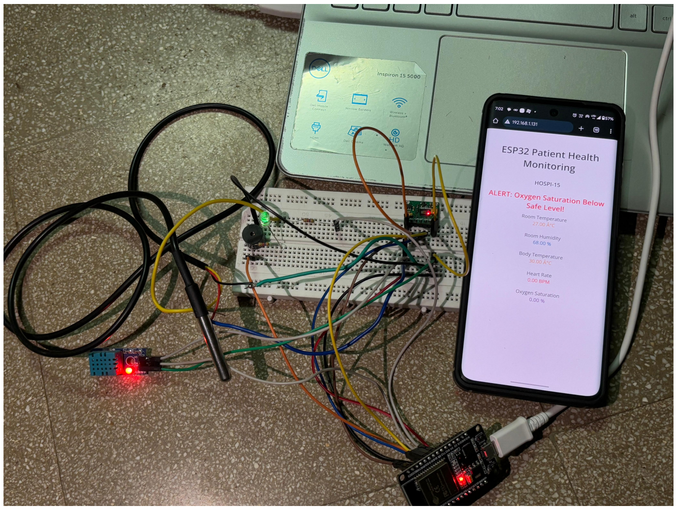

Fig. 8. HARDWARE

C. SOFTWARE DESIGN

The software connection focuses on the integration of sensor data equation, processing and transmission to a Web Server for remote monitoring. The ESP32 micro-controller plays a central role, running firmware written in a programming environment like Arduino IDE. The software is designed to initialize and configure the sensors, establish WiFi connectivity, and manage data communication with the Web server.

First, libraries specific to the sensors, such as MAX30102, DS18B20 and DHT11 are included in the firmware. These libraries provide pre-written functions to initialize the sensor, read data, and handle any necessary conversions. The software periodically reads the data from each sensor, ensuring that the system is operating in real time. The ESP32's is built in WiFi modules programmed to connect to a WiFi network. Using communication protocols, the ESP32 transmits the collected sensor data toward thingspeak app. The Web Server or the platform is pre-configured to receive, store and display the data in a user friendly format, such as graph or dashboard for a stakeholders like doctors, patient and nurse.

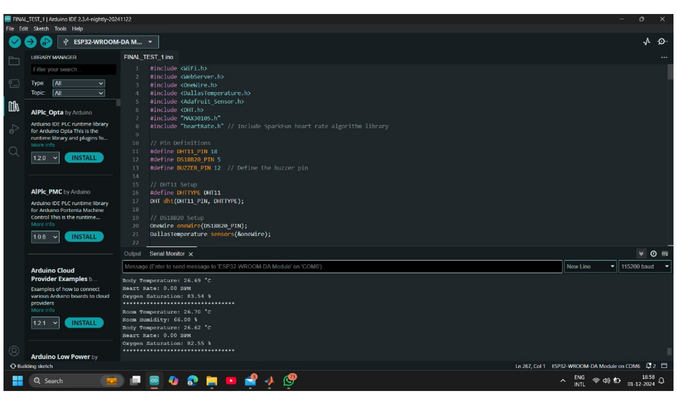

Fig. 9. ARDUINO IDE

V. RESULT

The results are displayed on the ThingSpeak dashboard, showcasing the real-time data collected from sensors. The dashboard consists of graphical representation and gauges of various health parameters, such as temperature, humidity, body temperature, heart rate, and oxygen saturation. Each parameter is monitored continuously and updated dynamically on dashboard, enabling stakeholders like doctors, nurses and patients to analyze the data conveniently.

When the sensor reading exceed a predefined threshold value, an alert mechanism is triggered. This is visually represented on the dashboard by a red indicator button. For example, if the heart rate or oxygen saturation level surpasses critical limits, the red lamp activates to signal immediately attention to immediate attention. This feature is crucial for timely intervention and enhances the system efficiently in critical health scenarios.

The graph provides trends over time for each parameters, allowing users to track variation and detect potential health issues early. The Gauges offer an initiative representation of current values, indicating whether the readings are within a safe ranges. The integration of Thingspeak ensures seamless data visualization and accessibility, making it easier to monitor health parameters remotely and act promptly in emergencies. We have created thingspeak app as well as web server to monitor the data efficient ly in real time. As the web-server does not store the previous data, we have more focused on the ThingSpeak. Based on the different parameters the reading of each parameters is showed below.

Table.1. shows the threshold levels of each parameter, based on these threshold levels the alerts are specified.

TABLE I
SENSOR THRESHOLD LEVELS

Sensor	Parameter	Threshold Level
MAX30102	Heart Rate	Above 100 bpm or below 60 bpm
MAX30102	SpO2 (Oxygen Saturation)	Below 95%
DS18B20	Body Temperature	Above 37.5°C
DHT11	Room Temperature	Above 30°C or below 15°C
DHT11	Humidity	Below 30% or above 70%

Fig.10 exhibit the Alert Indicator, and alerts in case of emergency according to the variation in the parameters depending on the threshold levels.

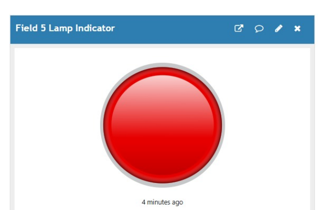

Fig. 10. Alert Indicator

The Fig.11 illustrates the room temperature data displayed using two visual formats. These visuals provide an intuitive approach for patients and healthcare providers to track temperature variations and identify any irregularities efficiently.

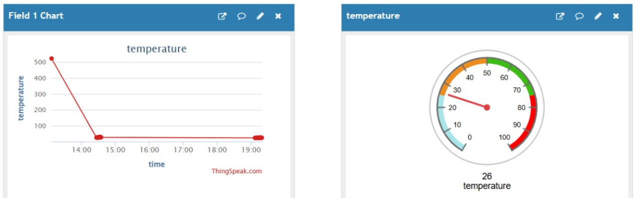

Fig. 11. Room Temperature

The Fig.12 illustrates humidity data presented in two visual formats. These visuals provide an accessible way for patients and healthcare providers to track humidity trends and quickly identify any anomalies. This approach enhances the understanding of humidity levels and their potential impact on health.

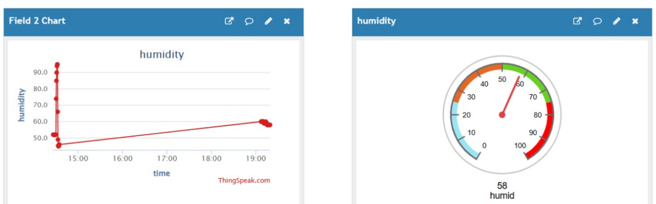

Fig. 12. Humidity Data

The Fig.13 depicts oxygen saturation data in two visual formats. These visuals offer an intuitive means for patients and healthcare providers to monitor oxygen saturation trends and promptly detect any irregularities. This method enhances the ability to understand oxygen levels and their significance for overall health.

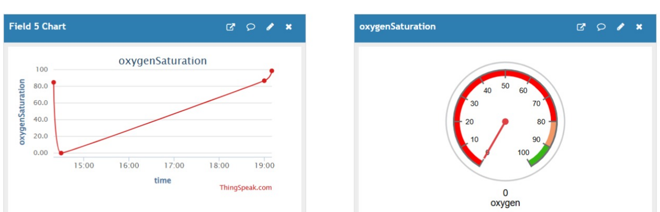

Fig. 13. Oxygen Saturation

The Fig.14 presents heart rate data in two visual formats. These visuals provide a clear and intuitive way for patients and healthcare providers to monitor heart rate trends and swiftly identify any irregularities. This approach enhances the understanding of heart rate variations and their implications for cardiovascular health.

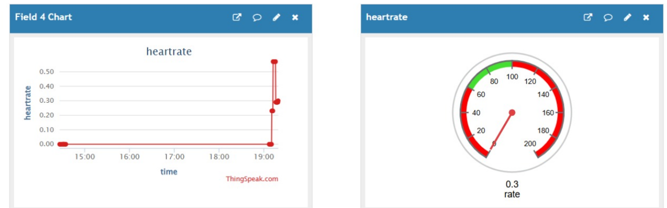

Fig. 14. Heart Rate

The Fig.15 shows the body temperature data using two visual formats. These visuals offer an intuitive way for patients and healthcare providers to monitor temperature trends and detect abnormalities quickly.

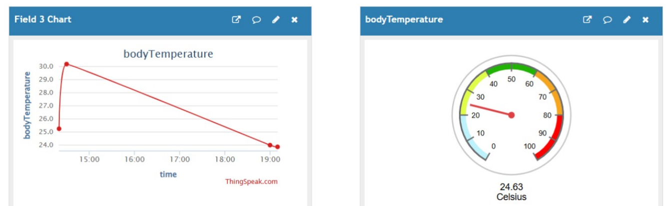

Fig. 15. Body Temperature

The Fig.16 is an overview of all the parameters in the ThinkSpeak

Fig. 16. Overview

VI. CONCLUSION

By leveraging these technologies, healthcare providers can efficiently monitor patient's vital signs, detect abnormalities, and facilitate timely intervention, ultimately improving patients outcomes. Additionally, the use of clouds computing allowe for scalable data storage and analysis, enabling healthcare professionals to access critical information from anywhere, fostering collaboration and informed decision-making. The key lessons learned include the importance of data accuracy, the necessity of user friendly interfaces of patients and providers, and the potential of IoT and cloud computing to enhance personalized healthcare. Overall, this approach has effectively address the challenges of traditional health care monitoring systems, providing a robust solution that promotes proactive health management and improves the overall quality of care.

VII. REFERENCE

- Siam, Ali I., et al. "Smart health monitoring system based on IoT and cloud computing." Menoufia journal of electronic engineering research 28.1 (2019): 37-42.
- Siam, Ali I., Atef Abou Elazm, Nirmeen A. El-Bahnasawy, Ghada El Banby, Fathi E. Abd El-Samie, and F. E. Abd El-Samie. "Smart health monitoring system based on IoT and cloud computing." Menoufia journal of electronic engineering research 28, no. 1 (2019): 37-42.
- Siam, A.I., Almaiah, M.A., Al-Zahrani, A., Elazm, A.A., El Banby, G.M., El-Shafai, W., El-Samie, F.E.A. and El-Bahnasawy, N.A., 2021. Secure health monitoring communication systems based on IoT and cloud computing for medical emergency applications. Computational Intelligence and Neuroscience, 2021(1), p.8016525.
- Hassanalieragh, M., Page, A., Soyata, T., Sharma, G., Aktas, M., Mateos, G., ... Andreescu, S. (2015, June). Health monitoring and management using Internet-of-Things (IoT) sensing with cloud-based processing: Opportunities and challenges. In 2015 IEEE international conference on services computing (pp. 285-292). IEEE.
- Cao, Shihua, et al. "Cloud Computing-Based Medical Health Monitoring IoT System Design." Mobile Information Systems 2021.1 (2021): 8278612.
- Cao, Shihua, Xin Lin, Keyong Hu, Lidong Wang, Wenjuan Li, Mengxin Wang, and Yuchao Le. "Cloud Computing-Based Medical Health Monitoring IoT System Design." Mobile Information Systems 2021, no. 1 (2021): 8278612.
- Cao S, Lin X, Hu K, Wang L, Li W, Wang M, Le Y. Cloud Computing-Based Medical Health Monitoring IoT System Design. Mobile Information Systems. 2021;2021(1):8278612.
- Chang, Hung-Fu, and Tzu-Kang Lin. "Real-time structural health monitoring system using internet of things and cloud computing." arXiv preprint arXiv:1901.00670 (2019).