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IOT Based Health Monitoring System using Thing- Speak with Emergency Alert Mechanism

Sumit Kumar[1], Shivam Kumar Pandey[2], Aniket Raj[3], Ms. Neha[4]
[1,2,3] *Student, Department of Electronics and Communication Engineering, NIET Greater Noida*
[4] *Guide, Assistant professor Dept. of Electronics and Communication Engineering, NIET Greater Noida*

Abstract— **This paper presents the design and implementation of a practical Internet of Things (IoT)-based multi-parameter health monitoring system integrated with an emergency alert mechanism for real-time patient care. The proposed system continuously monitors key physiological parameters, including heart rate, blood oxygen saturation (SpO_2), and body temperature, using biomedical sensors such as MAX30100 and LM35. These sensors are interfaced with an ESP32 microcontroller, which processes the acquired data and transmits it to the ThingSpeak cloud platform for real-time visualization, storage, and remote access to enhance patient safety, an emergency alert module is incorporated using an Arduino Nano in conjunction with GPS and GSM communication modules. The system evaluates the sensed data against predefined threshold values to detect abnormal health conditions. Upon detection of such conditions, or through manual activation via an SOS button, an alert is generated and transmitted as an SMS notification to registered contacts. The alert message includes the patient's real-time location in the form of a Google Maps link, enabling prompt response and assistance. The proposed system is cost-effective, portable, and energy-efficient, making it suitable for deployment in remote and resource-constrained environments. By integrating continuous health monitoring with a rapid emergency response mechanism, the system contributes to improved patient safety and reduced response time in critical situations.**

*Index Terms—***IoT, Health Monitoring, ESP32, ThingSpeak, GSM, GPS, SpO_2 Sensor, Emergency Alert, Remote Healthcare.**

I. INTRODUCTION

The rapid advancement of the Internet of Things (IoT) has significantly transformed various sectors, with healthcare being one of the most positively impacted domains. IoT enables seamless connectivity among devices, sensors, and cloud platforms, facilitating continuous acquisition, transmission, and analysis of real-time data. In modern healthcare systems, regular monitoring of critical physiological parameters such as heart rate, blood oxygen saturation (SpO_2), and body temperature plays a vital role in the early detection and prevention of serious medical conditions. However, conventional healthcare approaches primarily rely on periodic check-ups and hospital-based monitoring, which lack the capability for continuous observation of a patient's condition. This limitation often leads to delays in diagnosis and treatment, particularly during emergency situations. The challenge is further intensified for elderly individuals, patients with chronic illnesses, and those residing in rural or remote areas with limited access to healthcare facilities. The absence of real-time monitoring and immediate medical intervention increases the risk of complications and adverse outcomes. In response to these challenges, IoT-based health monitoring systems have emerged as an effective solution. Such systems utilize wearable or portable sensors to collect physiological data and transmit it to cloud-based platforms for real-time analysis and remote access. This enables healthcare professionals and caregivers to monitor patient conditions from any location, thereby supporting timely decision-making and reducing the frequency of hospital visits Despite these advancements, many existing systems lack an integrated mechanism for timely emergency alerts when abnormal conditions are detected. This highlights the need for a comprehensive solution that combines continuous health monitoring with an automated alert system capable of providing accurate location information. To address this requirement, the present work proposes an IoT-based multi-parameter health monitoring system integrated with an intelligent emergency alert feature. The system continuously acquires vital health data through biomedical sensors, processes it using a microcontroller, and uploads it to a cloud platform for real-time monitoring and storage. In the event of abnormal readings or manual activation via an SOS button, an alert message is transmitted through a GSM module, including the patient's real-time location obtained via a GPS module.

The proposed system is designed to be cost-effective, portable, and energy-efficient, making it suitable for deployment in both urban and rural environments. By integrating real-time monitoring, cloud connectivity, and rapid emergency response, the system enhances patient safety and reduces response time during critical situations. Furthermore, this work aligns with the increasing adoption of telemedicine and remote patient monitoring, which have become particularly significant during global health crises. The integration of IoT in healthcare not only improves accessibility but also reduces the burden on medical facilities by enabling remote patient management.

II. RELATED WORKS

In recent years, significant research has been conducted in the field of IoT-based healthcare monitoring systems, with a primary focus on real-time data acquisition, remote monitoring, and emergency response capabilities. Several studies have proposed IoT-enabled solutions utilizing microcontrollers such as ESP32 to continuously monitor vital physiological parameters. For instance, Beri et al. (2022) developed an IoT-based health monitoring system that measures parameters such as heart rate and blood oxygen levels and transmits the data to healthcare professionals through online platforms. Their findings demonstrated the feasibility of low-cost and portable systems for effective remote healthcare monitoring.

In addition to cloud-based systems, mobile-integrated healthcare solutions have also been explored. For example, systems integrated with platforms such as Blynk enable real-time visualization of parameters including heart rate, temperature, and SpO_2 through mobile applications, along with alert notifications for abnormal readings. Similarly, Shah (2024) proposed a GSM-based IoT healthcare system capable of transmitting SMS alerts during emergency situations, particularly targeting usability in rural areas with limited access to medical facilities. This approach highlights the importance of integrating communication technologies to enhance emergency response. Furthermore, several open-source implementations have incorporated GPS modules for real-time location tracking of patients. A study published by MDPI presented a system combining MAX30100 sensors, ESP32, and GPS modules to provide both health monitoring and location-based emergency alerts, thereby enabling faster assistance during critical conditions. Despite these advancements, existing systems still exhibit certain limitations, including inadequate integration between continuous monitoring and automated emergency alert mechanisms, limited portability, and dependence on costly infrastructure. Additionally, some systems focus solely on cloud-based monitoring without incorporating immediate location-based alert features, while others lack the capability to monitor multiple physiological parameters simultaneously. These limitations highlight the need for a more comprehensive and integrated healthcare monitoring solution.

III. MATERIAL AND METHOD

The proposed IoT-based health monitoring system is implemented using an integrated combination of hardware components and cloud-based software platforms to achieve continuous patient monitoring and rapid emergency response. The core of the system is the ESP32 microcontroller, which performs data processing and facilitates wireless communication through its built-in Wi-Fi capability. Physiological parameters are measured using biomedical sensors, where the MAX30100 sensor is utilized for monitoring heart rate and blood oxygen saturation (SpO_2), and the LM35 sensor is employed for accurate body temperature measurement In addition to the primary controller, an Arduino Nano is incorporated within the emergency alert module to manage communication-related operations independently. A GPS module is integrated to provide real-time geographical coordinates of the patient, while a GSM module enables the transmission of SMS alerts during critical conditions. The system also includes an SOS push button, allowing users to manually initiate an emergency alert when required. For cloud-based data storage, visualization, and remote access, the Thing Speak platform is utilized. It supports continuous data uploading, graphical representation, and real-time monitoring of patient health parameters. Additional components such as connecting wires, a breadboard, regulated power supply, and voltage regulators are used to ensure stable and reliable system operation. The overall system functionality is divided into two primary modules: real-time health monitoring via the cloud platform and emergency alert generation using GSM and GPS technologies. During operation, the sensors continuously acquire physiological data from the patient and transmit it to the ESP32 microcontroller for processing. The processed data is then periodically uploaded to the Thing Speak cloud using Wi-Fi, where it is stored and presented in graphical format.

This enables healthcare providers and caregivers to remotely monitor patient conditions, reducing the need for continuous physical supervision and improving system efficiency. Simultaneously, the system evaluates the sensor readings against predefined threshold values to detect abnormal conditions. If any parameter exceeds the safe limits, the emergency alert mechanism is automatically activated. Additionally, the user has the option to manually trigger an alert using the SOS button in case of sudden discomfort or emergency situations. Once an alert is initiated, the Arduino Nano interfaces with the GSM module to send an SMS notification to predefined contacts. The alert message contains a warning along with the patient's real-time location, obtained from the GPS module, and shared as a Google Maps link for easy tracking. The use of remote communication technologies enables both monitoring and emergency response without the need for direct physical interaction. Consequently, the system proves highly beneficial for patients residing in remote or underserved regions. Overall, the integration of continuous monitoring through Thing Speak and immediate alert generation via GSM enhances patient safety, reduces response time, and contributes to more efficient healthcare delivery.

Fig 1: Thing Speak login forum

To deal with the issues of security, Thing Speak provides a login forum as shown in Figure 1 above. The username and password are known only to the patient and doctor or specialist administering medical care to such patient for security purpose and this detail enable them to view data (readings) of patients. This makes it less vulnerable to hacking and leaking of a patient's medical information.

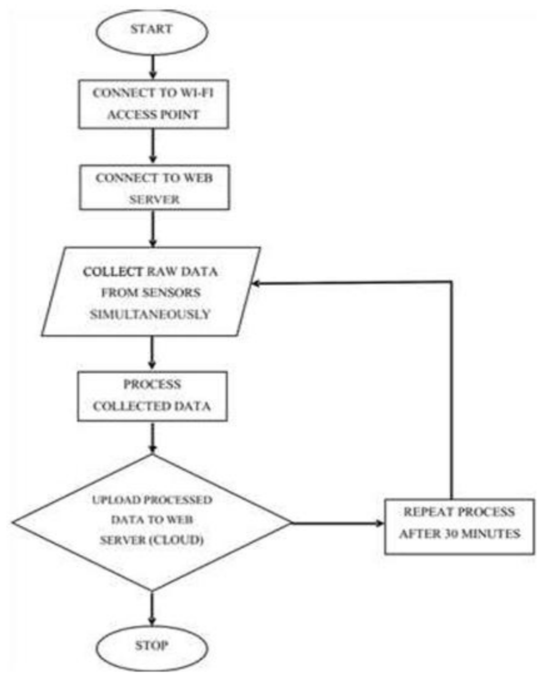

Fig 2: above shows the flowchart that the system follows. The system repeats the process of acquiring new sets of patient's body vitals after every 30 minutes. The set of new data is uploaded to the cloud

automatically after being gathered and processed, it is also saved in the microcontroller memory.

IV. RESULTS

The performance of the proposed system was evaluated under various real-time conditions to assess its accuracy, reliability, and response efficiency. Testing was conducted at multiple locations, including controlled indoor settings and open outdoor environments, to ensure effective operation under both stable and dynamic conditions. The observations recorded during each phase of testing are presented as follows. During the initial phase of testing, carried out in the first week of implementation, the system was evaluated based on 20 observations by simulating different health scenarios. It was found that nearly 60% of the readings remained within the normal range, indicating stable physiological conditions. Around 15% of the cases showed minor deviations beyond the normal limits, which were still considered manageable.

Approximately 10% of the readings exceeded the predefined safety thresholds, and the system successfully detected these as abnormal conditions. In such instances, the emergency alert mechanism was activated, and SMS notifications were sent to the registered contacts along with real-time location information. However, about 15% of the observations were not recorded accurately during the initial stage due to certain limitations, including unstable internet connectivity, improper sensor calibration, and environmental disturbances. In some situations, incorrect placement of sensors also contributed to inaccuracies in the readings. Furthermore, delays in GPS signal acquisition slightly affected the response time of the emergency alert system. After identifying these issues, several improvements were implemented, such as enhanced sensor calibration, improved network stability, and proper arrangement of hardware components.

The System was then tested again following these modifications, and the results demonstrated a noticeable improvement in both accuracy and response time. The updated system provided consistent real-time monitoring through the cloud platform and dependable emergency alert functionality via the GSM module. Overall, the experimental results indicate that the proposed IoT-based health monitoring system operates effectively under real-time conditions. It is capable of accurately tracking health parameters, identifying abnormal situations, and generating immediate alerts, making it suitable for practical healthcare applications, particularly in remote and resource-constrained environments.

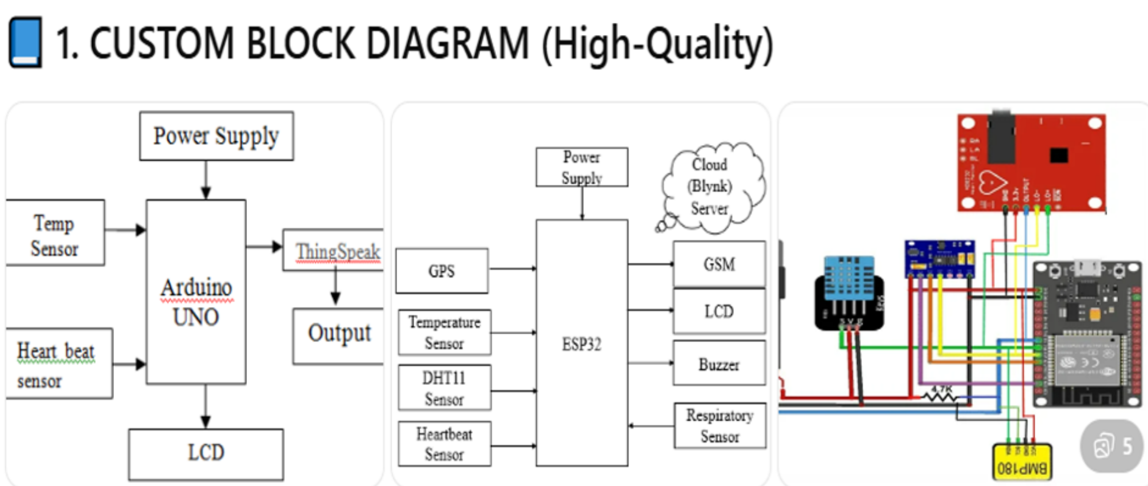

Fig.3. The system flow begins with biomedical sensors such as MAX30100 and LM35, which continuously collect health data like heart rate, SpO_2, and body temperature from the patient. This data is sent to the

ESP32 microcontroller, which processes it and uploads it to the ThingSpeak cloud platform using Wi-Fi for real-time monitoring. At the same time, the Arduino Nano manages the emergency alert system. The GPS module provides live location data, while the GSM module is used to send SMS alerts.If any abnormal condition is detected or the SOS button is pressed, the system immediately triggers an alert. The GSM module sends a message along with a Google Maps link of the patient's location. A buzzer may also activate for local alerts. The system is powered by batteries, making it portable and suitable for remote use. All components are properly connected to ensure reliable and continuous operation. A buzzer or LED indicator acts as a local warning system, alerting the patient or nearby people even without internet or mobile connectivity.

Fig.4: Graphical Representation of Patient's Pulse Rate. Above Figure is an analytical graphical representation of the pulse rate of a patient taken around 10:45 – 11:00, Feb 2, 2026 which is presented in Deci-Beats per Minute and can be further converted to Beats per Minute by dividing it by (10.41909). Scaling Factor = 802.27/77 = 10.41909. This scaling factor 10.41909 was gotten from the comparison with a Samsung S7 pulse rate readings gotten simulteneouly with the designed system pulse rate sensor (SEN/11574). The scaling factor was inputted into the program code to scale it down automatically giving an accurate reading in beats per minute (Bpm).

Fig.5: Graphical Representation of Patient"s Body Temperature.This shows the graphical representation of the body temperature presented in degree Celsius of the same patient also taken around the same interval as the pulse rate readings.

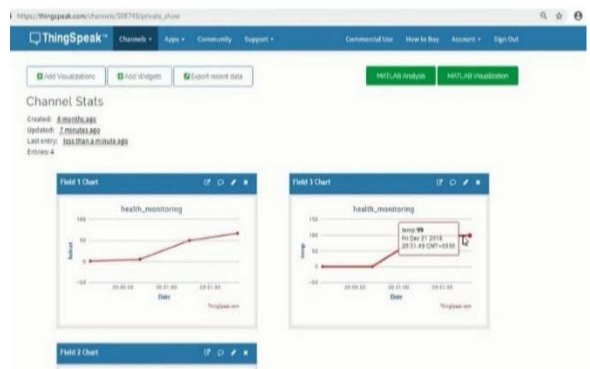

Fig.6: The image shows the Overall Dashboard and real-time health monitoring interface displayed on the ThingSpeak cloud platform. It includes multiple graphical charts representing different physiological parameters such as heart rate, blood oxygen saturation (SpO_2), and body temperature. Each parameter is plotted against time, allowing users to easily observe variations and trends in the patient's health condition. The graphs are clearly labeled with axes, where the x-axis represents time intervals and the y-axis shows the measured values. Different fields are used to separate each parameter for better visualization. The interface also displays channel information, update timestamps, and data entries, indicating continuous data transmission from the ESP32 microcontroller. The smooth curves in the graphs reflect stable readings,

while sudden spikes indicate abnormal conditions. This visual representation helps doctors and caregivers monitor the patient remotely and make quick decisions. Overall, the ThingSpeak dashboard provides a simple, clear, and effective way to track real-time health data. Overall, the interface demonstrates the practical application of cloud computing, IoT, and real-time data analytics in modern healthcare systems. The ThingSpeak dashboard not only improves remote patient monitoring but also contributes to faster diagnosis, timely medical intervention, and efficient healthcare management.

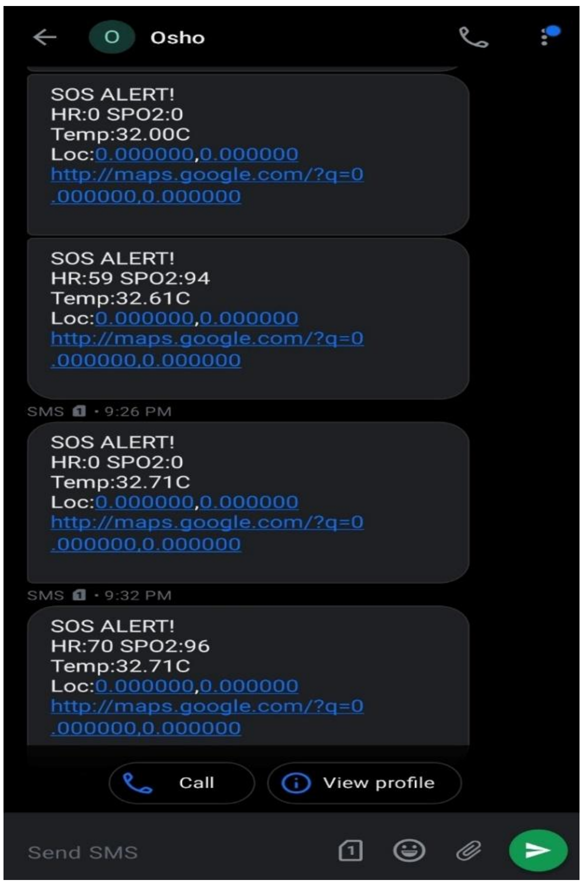

Fig.7: The image displays a mobile phone screen showing an emergency SMS alert sent by the system during a critical condition. The message includes a warning text indicating that the patient's health parameters have crossed safe limits or that the SOS button has been pressed. Along with the alert message, a Google Maps link is provided, which contains the patient's real-time location obtained from the GPS module. This allows the receiver to directly open the location and track the patient easily. The message is sent through the GSM module to predefined emergency contacts such as family members or caregivers. The mobile interface clearly shows the sender number, timestamp, and message content, ensuring authenticity and quick understanding. This feature plays an important role in reducing response time, as immediate action can be taken. Overall, the SOS alert system ensures safety by providing fast and accurate communication during emergencies.

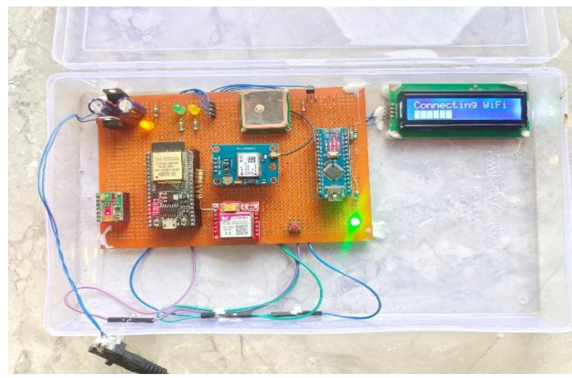

Fig.8: The image shows the complete working model of the IoT-based health monitoring system with an emergency alert mechanism. All components are properly assembled on a compact base, giving a clear view of the hardware setup. At the center, the ESP32 microcontroller is connected to sensors like MAX30100 and LM35, which are used to measure heart rate, SpO_2, and body temperature. An Arduino Nano is also included to handle the emergency alert section. The GPS module is positioned to receive location signals, while the GSM module is connected for sending SMS alerts. A push-button (SOS switch) is placed for manual emergency activation, and a buzzer is included to give instant alerts. The circuit is powered using a battery source, making the system portable. All wires are neatly arranged to avoid loose connections and ensure proper functioning. The overall design is simple, organized, and suitable for real-time health monitoring applications.

V. DISCUSSION

The developed IoT-based health monitoring system, integrated with an emergency alert mechanism, was designed to overcome the limitations of conventional healthcare monitoring methods, particularly in terms of continuous observation and timely response. Based on the experimental results, the system demonstrates effective performance in monitoring essential physiological parameters such as heart rate, SpO_2, and body temperature in real time. The use of sensors such as MAX30100 and LM35 provided sufficiently accurate readings when properly calibrated and positioned, indicating that low-cost components can deliver reliable performance for basic healthcare applications.

A key strength of the system lies in its capability to enable remote monitoring through the ThingSpeak cloud platform. The graphical representation of data simplifies the interpretation process, allowing users and caregivers to understand the patient's condition without requiring advanced technical knowledge. This feature significantly reduces the need for frequent hospital visits, especially for patients requiring continuous monitoring. The integration of Wi-Fi connectivity via ESP32 ensures smooth data transmission under normal conditions, although minor disruptions were observed in areas with limited network availability. The inclusion of an emergency alert mechanism further enhances the system's functionality. By combining GSM and GPS modules, the system is capable of detecting abnormal health conditions and responding promptly by sending alert messages along with the patient's real-time location. This capability is particularly valuable during critical situations where immediate medical attention is required. Additionally, the provision of a manual SOS button improves usability by allowing patients to request assistance even when abnormal conditions are not automatically detected.

Despite its advantages, certain limitations were identified during the implementation and testing phases. The accuracy of sensor readings may be influenced by external factors such as improper placement, patient movement, and environmental noise. Similarly, the effectiveness of the GPS module depends on signal availability, which may introduce delays in location tracking, particularly in indoor environments. Furthermore, the system's reliance on stable internet connectivity for continuous data transmission to the Thing Speak platform may impact performance in rural or low-network Nevertheless, the system achieves a well-balanced integration of affordability, portability, and functionality. It successfully combines real-time health monitoring, cloud-based data management, and rapid emergency response within a single platform. Compared to existing solutions, the proposed system offers both continuous monitoring and immediate alert capabilities, thereby enhancing overall patient safety.

In conclusion, the system demonstrates strong potential for real-world healthcare applications. With further enhancements, such as improved sensor accuracy, advanced connectivity solutions, and integration with mobile applications, the system can be made more robust and user-friendly. It is particularly beneficial for elderly individuals, patients with chronic conditions, and those residing in remote areas with limited access to healthcare services.

VI. CONCLUSION & FUTURE SCOPE

The proposed health monitoring system, integrated with an emergency alert mechanism, is capable of continuously tracking vital physiological parameters and transmitting real-time data to a cloud platform for remote access. This enables effective monitoring of patient health conditions from distant locations.The incorporation of GSM and GPS modules enhances the overall reliability of the system by enabling instant alert notifications along with real-time location tracking during emergency situations. This significantly reduces response time and contributes to improved patient safety.

The system is designed to be cost-effective, portable, and suitable for practical deployment, particularly in rural and remote areas where access to healthcare facilities is limited. However, further improvements can enhance its functionality and usability. One potential enhancement is the integration of a dedicated mobile application, which would provide a more user-friendly interface for patients and caregivers to monitor health data efficiently. Additionally, incorporating advanced sensors such as ECG and blood pressure monitors can expand the system's capability to track a wider range of physiological parameters.

Another important enhancement involves the application of artificial intelligence and machine learning techniques to analyze collected data and predict potential health risks in advance. This would support early diagnosis and preventive healthcare. Improving battery efficiency is also essential to ensure longer operational duration without frequent recharging, especially in remote environments. Furthermore, system reliability can be enhanced by adopting advanced IoT communication protocols to ensure stable network connectivity. Direct integration with hospitals or healthcare professionals would further improve the system's effectiveness, allowing medical experts to access real-time patient data and provide timely assistance. With these advancements, the system can be further optimized to achieve higher efficiency, reliability, and suitability for deployment in modern smart healthcare environments.

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