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Enhanced IoT-Based Patient Health Monitoring System Using ESP32 and Blynk

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Abstract: ***The proposed research work develops an enhanced IoT-based patient health monitoring system using an ESP32 microcontroller and the Blynk mobile application for real-time and remote healthcare monitoring. The system constantly monitors vital physiological and environmental parameters such as heart rate, blood oxygen saturation (SpO2), body temperature, ambient temperature, and humidity. The MAX30100 sensor is used to measure the heart rate and SpO_2. The DS18B20 sensor is used to measure the body temperature, while the DHT11 sensor is used to measure the ambient temperature and humidity. The main processing and control unit used is the ESP32, which collects and processes the sensor measurements and then transmits the data to the Blynk cloud platform through its integrated Wi-Fi connectivity. The collected health parameters are displayed in real-time at the Blynk mobile application, and the health condition of a patient can be monitored remotely by the doctors, caregivers, and authorized users. The system generates an alert on the Blynk application whenever any monitored parameter exceeds the predefined threshold values, thereby enabling timely medical intervention. The hardware prototype is implemented on the Zero PCB to achieve a compact, reliable, and cost-effective design. The proposed system offers an efficient IoT-based solution for continuous patient monitoring and can be used in home healthcare, elderly care, hospitals, and remote healthcare environments.***

Keywords: Internet of things; ESP32, Blynk, patient monitoring, MAX30100, DHT11, DS18B20.

I. INTRODUCTION

The importance of ongoing surveillance of patients' health conditions has increased in modern healthcare, especially for elderly patients and patients who require regular observation of vital physiological parameters. Conventional monitoring strategies, which are based on the constant presence of doctors or caregivers, increase their workload and may delay the recognition of abnormal conditions. The Internet of Things (IoT) has emerged as an effective solution to bypass such limitations by enabling real-time, remote, and automated health monitoring. IoT-enabled healthcare systems use sensors, microcontrollers, wireless communication, and cloud platforms to collect and send patient information from any location. These systems can reduce the monitoring burden and allow faster responses to abnormal health conditions. Previous patient monitoring systems based on IoT have used controllers based on Arduino to measure parameters such as body temperature and heart rate, but these systems were typically limited to local visualization of the measured values. Later systems employed Wi-Fi-enabled controllers such as ESP8266 and ESP32 to facilitate cloud-based data transmission, although some approaches monitored a limited number of physiological parameters and did not incorporate oxygen-level measurement [1]. Recent techniques have integrated multiple sensors such as MAX30100 with mobile and cloud platforms like Blynk, enabling real-time monitoring [2].

To overcome these limitations, this research suggests an Enhanced IoT-Based Patient Health Monitoring System using ESP32 and Blynk. The system uses the MAX30100 sensor for measuring heart rate and SpO_2, the DS18B20 sensor for measuring body temperature, and the DHT11 sensor for monitoring ambient temperature and humidity. The sensor data is collected and processed by the ESP32, and measurements are sent to the Blynk cloud using its onboard Wi-Fi capability. The Blynk application offers real-time visualization with digital gauges and graphs and sends notifications when predefined parameter limits are breached[3]. The hardware is implemented on a Zero PCB to improve connection stability and to provide a compact and durable prototype. Figure 1 shows the overview of the research work. The main contributions of this work are the following:

- Using MAX30100, DS18B20 and DHT11 sensors together, the device can monitor heart rate, SpO_2, body temperature, ambient temperature and humidity simultaneously.
- ESP32-based processing and connectivity: The ESP32 is used as a central processing unit and transfers the collected health data to the Blynk cloud platform using its own Wi-Fi feature.
- Live remote monitoring: The Blynk-based dashboard allows for the visualization of patient health parameters in real-time, allowing doctors and caregivers to monitor patients remotely.
- Abnormal-condition alerting: Blynk notifications are generated when the monitored parameters exceed the specified limits using predefined threshold values for timely intervention.
- Compact hardware implementation: The whole circuit is implemented on a Zero PCB, providing stable and permanent sensor connections, increasing the reliability and durability of the prototype.
- The proposed system is an IoT-enabled system that combines multi-sensor health monitoring with processing using ESP32, communication via Wi-Fi, cloud connectivity, real-time visualization, and alert generation in a single system. The developed prototype aims to provide a cost-effective, portable, and accessible solution for continuous patient monitoring in home healthcare, elderly care, hospitals, and remote healthcare settings.

The rest of this paper is organized as follows. Section II is the

literature review. Section III details the methodology. Section IV discusses the hardware realization and system integration. Section V shows the results and discussion. Section VI concludes the paper and discusses future enhancements.

II. RELATED WORKS

Multiple patient health monitoring systems based on IoT have been developed to allow remote monitoring of essential health parameters. The early approaches commonly used Arduino-based controllers to measure parameters such as body temperature and heart rate, but these systems mainly provided local display facilities and offered limited remote accessibility[4]. Subsequent studies implemented Wi-Fi-enabled microcontrollers such as ESP8266 and ESP32 to transmit health data to cloud platforms. Although these approaches improved remote monitoring, some of the systems were limited to a few physiological parameters and did not include SpO_2 monitoring[5]. Recent research has been focusing on the integration of multiple sensors with IoT and mobile-cloud platforms. The MAX30100 sensor has been used for measuring simultaneous heart rate, and SpO_2 and temperature sensors have been used for measuring patient and environmental conditions. Blynk-based systems further improve accessibility by enabling real-time visualization of sensor measurements through mobile applications[6].

However, the current methods in the analyzed research reveal the need for integrated systems that can monitor several physiological and environmental parameters and offer real-time cloud transmission and automatic alerts. The proposed work addresses these constraints by integrating ESP32, MAX30100, DS18B20, DHT11, and the Blynk platform into a unified patient monitoring framework. The system provides multi-parameter sensing, real-time remote visualization, threshold-based alerts, and compact Zero PCB implementation, which improve the practicality and accessibility of IoT-based patient health monitoring[7].

III. PROPOSED METHODOLOGY

The proposed methodology offers a continuous patient health monitoring system based on IoT by integrating multiple sensors with an ESP32 microcontroller and the Blynk cloud platform. The MAX30100 sensor is used to detect the patient's heart rate and blood oxygen saturation (SpO2). The DS18B20 sensor detects body temperature. The DHT11 sensor detects ambient temperature and humidity. These sensors obtain the required physiological and environmental parameters continuously and provide the measured data to the microcontroller ESP32. The main processing and communication unit is the ESP32. It takes sensor readings, processes the raw measurements, and transforms them into meaningful health parameters[8]. The ESP32 sends the processed data to the Blynk cloud server using the built-in Wi-Fi module. No separate communication module is needed. The Blynk platform is configured with simulated pins to display the sensor values separately on digital gauges and graphical interfaces.

The proposed system also has an alert mechanism and remote monitoring. The Blynk mobile application allows doctors, caregivers, or authorized users to view the patient's health parameters in real time from a remote location. The parameters measured have established normal ranges. When a measured value is above the predefined threshold, the Blynk application automatically creates an alert notification, and timely attention can be paid to a possibly abnormal state. The entire hardware circuit is carried out on a Zero PCB to provide a permanent and stable connection between the ESP32 and sensor modules. The system has three main stages: data sensing and acquisition, data processing and transmission, and remote monitoring and alert generation. This integrated approach allows for continuous acquisition, wireless transmission, visualization, and notification of patient health information within a single IoT-based framework.

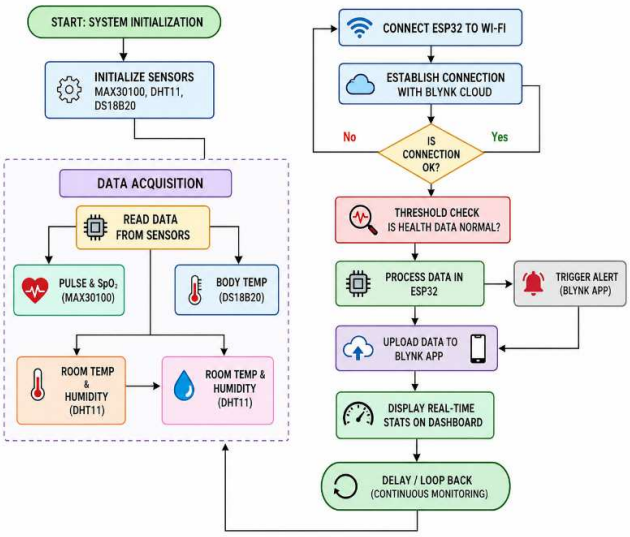

Figure 1 : Overview of proposed research framework

3.1 Working principle

The working principle of the proposed IoT-based patient health monitoring system is based on real-time sensing, data processing, wireless communication, cloud storage, and remote visualization. The ESP32 microcontroller is initialized at the beginning, and communication with the MAX30100, DHT11, and DS18B20 sensors is configured. The DS18B20 measures body temperature, and the MAX30100 continuously measures the patient's pulse rate and blood oxygen saturation (SpO2). The DHT11 sensor measures the ambient temperature and humidity. Once the sensor readings are collected, the ESP32 processes the raw data and converts them into relevant health parameters. The processed information is then sent to the Blynk cloud platform by the built-in Wi-Fi module of the ESP32, eliminating the requirement of an extra communication module. Figure 2 shows the workflow of the proposed framework.

The Blynk application offers a dashboard to visualize the parameters collected by utilizing digital gauges and graphs. Therefore, doctors, caregivers, or authorized users can remotely observe the patient's health status in real-time. The system also carries out a threshold-based health status check. In the event of

any monitored parameter exceeding its pre-defined normal range, an alert notification is generated through the Blynk application to enable timely attention. This whole process is repeated continuously at set time intervals, thus enabling ongoing surveillance of patients. The hardware is implemented on a Zero PCB, which makes stable and permanent connections between the ESP32 and the sensor modules. Hence, the working principle is in four major stages: sensor data acquisition, ESP32-based processing, wireless transmission to Blynk, and real-time monitoring with alert generation.

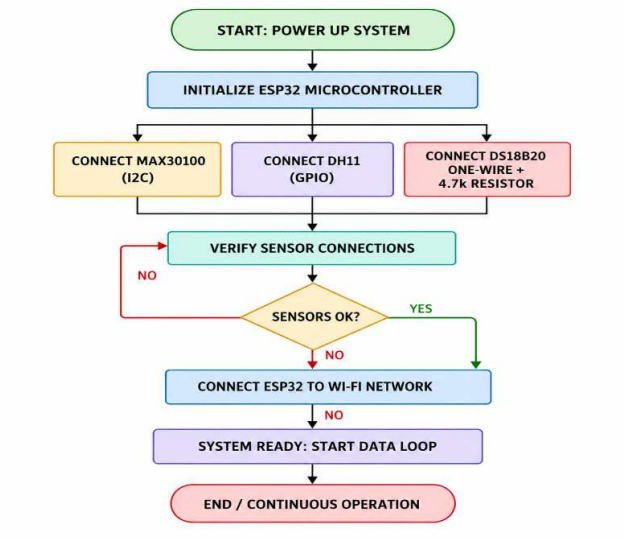

Figure 2: Workflow of the proposed framework

IV. PERFORMANCE ANALYSIS AND IMPLEMENTATION

The proposed patient health monitoring system is implemented using an ESP32 microcontroller as a central processing and communication unit. The ESP32 interfaces with the MAX30100, DS18B20, and DHT11 sensors to obtain the required physiological and environmental parameters. The MAX30100 is used to measure the heart rate and blood oxygen saturation (SpO2), the DS18B20 is used to measure the body temperature of the patient, and the DHT11 is used to measure the ambient temperature and humidity. All the sensors are well connected to the ESP32, which constantly collects and processes the sensors' readings. The processed health information is sent to the Blynk IoT platform by the ESP32 using the built-in Wi-Fi module. The acquired parameters can be monitored remotely on the Blynk mobile application[9].

The full hardware circuit is mounted on a Zero PCB, which provides permanent and stable connections between the ESP32 and the sensor modules. This implementation reduces the possibility of a loose connection and increases the durability and reliability of the prototype. The ESP32 and the sensor modules are fed from a regulated power supply to get the desired voltage levels. Wiring and insulation are also appropriate to support safe and reliable operation. The integrated hardware design allows continuous acquisition, processing, and wireless transmission of patient health information. The compact implementation makes the system portable, easy to maintain, and suitable for real-time remote health monitoring. To summarize, the hardware setup offers a stable basis for gathering various health data and sending it to the Blynk cloud for remote monitoring and alerting. Figure 3 shows the interfacing of sensors used in the present research work.

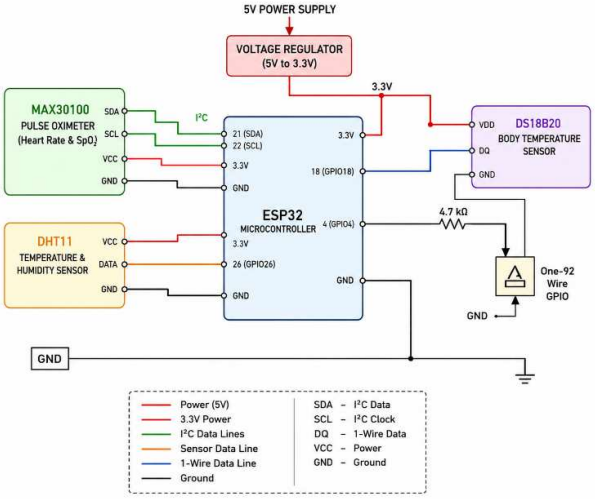

Figure 3 : Interfacing of Sensors with ESP32 Microcontroller

V. RESULTS AND DISCUSSION

The developed Enhanced IoT-Based Patient Health Monitoring System was tested for real-time remote acquisition, processing, transmission, and display of patient health parameters. The experimental observations confirm that the integrated sensors provided the desired measurements successfully. Heart rate and SpO_2 readings were obtained using MAX30100, body-temperature measurements were provided by DS18B20, and ambient temperature and humidity were successfully measured using DHT11. The ESP32, via the integrated Wi-Fi connectivity, could fetch the sensor measurements and send the processed data to the Blynk mobile application. The health parameters were shown in the Blynk dashboard, which can be monitored remotely from various places. This validates that the integration of ESP32 with the Blynk cloud platform is an effective solution for real-time health visualization of data and remote patient monitoring[10]. The proposed system demonstrated an alert generation capability for abnormal health conditions. If the monitored values exceed the predefined threshold limits, the Blynk application generated notifications so that caregivers or authorized users could identify potentially abnormal conditions and respond promptly. The use of a Zero PCB also helped to have stable and permanent hardware connections, which resulted in reliable system operation.

VI. CONCLUSION

An Efficient and Cost-Effective Solution for Continuous Remote Monitoring of Patient Health Conditions Using Enhanced IoT-

Based Patient Health Monitoring System Using ESP32 and Blynk Combining MAX30100, DS18B20 and DHT11, the system can monitor heart rate, SpO_2, body temperature, ambient temperature, and humidity. The ESP32 was able to process the sensor data and send it over Wi-Fi to the Blynk platform, where the parameters can be visualized in real time. The threshold-based alert mechanism also helps in timely identification of abnormal health conditions. We have stable and durable hardware connections in the Zero PCB implementation.

However, the proposed system suffers from some limitations. Cloud-based monitoring depends on reliable Wi-Fi and a continuous Internet connection. The system is currently only able to track a limited range of health metrics and is unable to do complex clinical measurements or predictive analysis. The threshold-based alert mechanism also gives condition-based notifications, not intelligent health prediction. Future work will include integration of an ECG sensor to analyze the heart in more detail, GPS to track the location of the patient, and a GSM module to send emergency notifications through SMS. Moreover, an AI-based health prediction system can be integrated to analyze the historical data of patients and predict the potential health risks early on.

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