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IoT-Enabled Vital Monitoring System Using Real-Time Notification

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Abstract: *In recent years, the Internet of Things (IoT) has revolutionized healthcare by enabling real-time monitoring and alert systems. This paper presents an IoT-enabled pulse and temperature monitoring system that provides instant notifications for effective remote patient monitoring. The system utilizes pulse and temperature sensors to measure vital health parameters, with data processed by an RP2040 microcontroller and transmitted via a Host 2.4GHz 4G module to a cloud-based dashboard. The system triggers alerts via Telegram notifications when abnormal readings are detected, ensuring timely intervention and enhanced patient care. Experimental results demonstrate the efficiency of the proposed system, with high accuracy in data collection, low latency in transmission, and real- time alerting capabilities. The system is designed to be scalable, cost-effective, and energy-efficient, making it suitable for remote healthcare applications*

Keywords: IoT, Pulse Monitoring, Temperature Monitoring, RP2040 Microcontroller, Real-Time Notification, Healthcare, Telegram Alerts

I. INTRODUCTION

The healthcare industry has experienced a significant transformation with the emergence of the Internet of Things (IoT). IoT-based systems have revolutionized remote patient monitoring, enabling continuous health tracking without the need for frequent hospital visits. Chronic illnesses such as cardiovascular diseases, diabetes, and respiratory disorders require constant monitoring to prevent complications. However, traditional hospital-based monitoring is often inconvenient, time-consuming, and costly. With the increasing adoption of wearable and embedded IoT medical devices, healthcare providers can now remotely track patients' vital signs in real time. This has led to the development of smart healthcare systems that integrate biomedical sensors, microcontrollers, cloud computing, and wireless networks to provide accurate and efficient patient monitoring solutions. According to the World Health Organization (WHO), cardiovascular diseases alone account for nearly 17.9 million deaths annually. A significant percentage of these deaths occur due to delayed diagnosis and treatment. Many medical emergencies, such as heart attacks, strokes, or sudden fevers, could be prevented with early detection and timely intervention.

A. Problem Statement Existing health monitoring systems are costly, inefficient, and require frequent hospital visits. This can lead to delayed interventions in emergencies, increasing the risk of fatal outcomes. A real-time IoT-based monitoring system that continuously tracks vital signs and alerts caregivers can significantly improve healthcare outcomes.

II. SYSTEM ARCHITECTURE AND COMPONENTS

The proposed system consists of hardware and software components that work together to continuously monitor the patient's pulse rate and temperature, send the data to a cloud server, and trigger alerts when necessary.

A. Hardware Components

1. Pulse Sensor Measures the patient's heart rate (bpm).
2. Temperature Sensor Monitors body temperature in real-time.

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3. RP2040 Microcontroller – Acts as the processing unit, collecting and analyzing sensor data.
4. Host 2.4GHz 4G Module – Enables wireless communication between the device and the cloud.
5. 16×2 LCD Display – Shows real-time sensor readings on the device.
6. Power Supply Ensures stable operation of the system.

B. Software Components

1. Cloud Dashboard (Thingspeak/Firebase) – Stores and displays patient health data in real time.
2. Telegram API – Sends instant notifications to caregivers when abnormal readings are detected.
3. Embedded C/Python Programming – Used for microcontroller firmware development.
4. IoT Protocols (MQTT/HTTP) – Facilitates data transmission between the microcontroller and the cloud.

III. METHODOLOGY

The system follows a structured approach to monitor vital parameters:

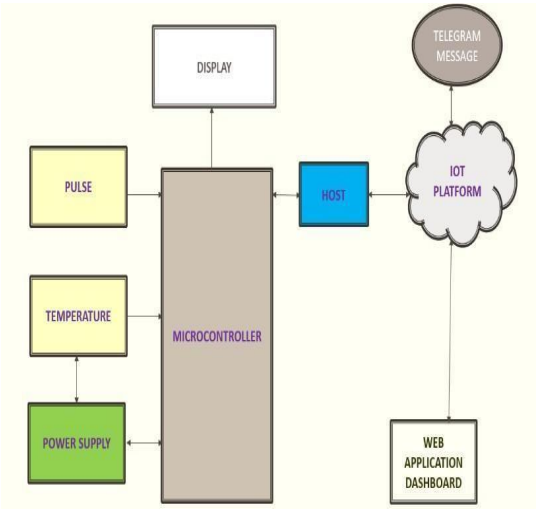

Fig 1: Block Diagram of the IoT monitoring system

1. Develop an IoT-based health monitoring system capable of continuously tracking pulse rate and body temperature.
2. Utilize an RP2040 microcontroller for efficient data processing.
3. Implement 4G-based data transmission for real-time cloud integration.
4. Design a dashboard interface to display health parameters remotely.
5. Enable instant Telegram alerts for timely intervention.
6. The pulse and temperature sensors continuously collect data.
7. The RP2040 microcontroller processes the data and transmits it via the 4G module.
8. The cloud dashboard logs and visualizes the data.
9. When abnormal readings are detected, the system triggers an alert through Telegram.
10. The 16×2 LED display provides live readings for quick reference.

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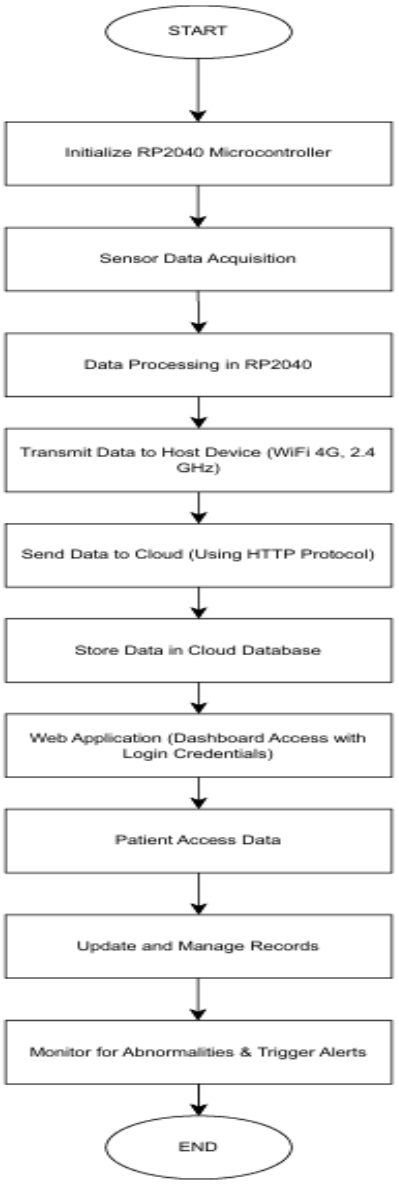

Fig 2: Flowchart of IoT monitoring system

This flowchart represents the process of an IoT- enabled pulse and temperature monitoring system. Here's a step-by-step explanation in simple words:

1. The system begins its operation.
2. Initialize RP2040 Microcontroller the RP2040 microcontroller (a small computer chip) is turned on and set up to work.
3. Sensor Data Acquisition Sensors start measuring pulse rate and body temperature from the patient.
4. Data Processing in RP2040 The microcontroller processes the collected data to check for any unusual values.
5. Transmit Data to Host Device (WiFi 4G, 2.4 GHz) The processed data is sent wirelessly to a host device using WiFi or 4G.

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6. Send Data to Cloud (Using HTTP Protocol) The host device forwards the data to a cloud server using the HTTP protocol (a standard way of sending information over the internet). Store Data in Cloud Database The patient's health data is saved in a secure cloud storage so it can be accessed later.
7. Web Application (Dashboard Access with Login Credentials). The data is displayed on a web dashboard, where only authorized users (like doctors or caregivers) can log in and view it. Patient Access Data Patients and caregivers can check their health data on the dashboard Update and Manage Records. The system keeps updating the stored data and allows users to manage their health records.
8. Monitor for Abnormalities & Trigger Alerts – The system continuously monitors the data. If it detects abnormal pulse or temperature levels, it sends an alert and the system keeps running, monitoring the patient's health in a loop until manually stopped.

IV. RESULTS AND DISCUSSION

The system was tested with multiple subjects under varying environmental conditions. The real-time caregivers via Telegram, ensuring timely intervention. notifications were successfully delivered to The dashboard interface provided clear visualization of health data. The system exhibited high accuracy in pulse and temperature measurement, with a minimal delay in data transmission.

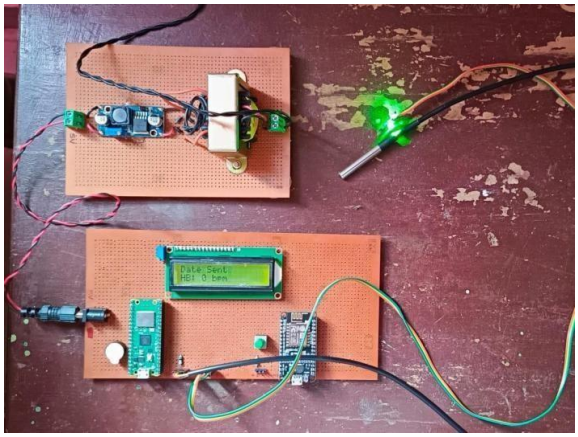

Fig 3: Hardware Setup

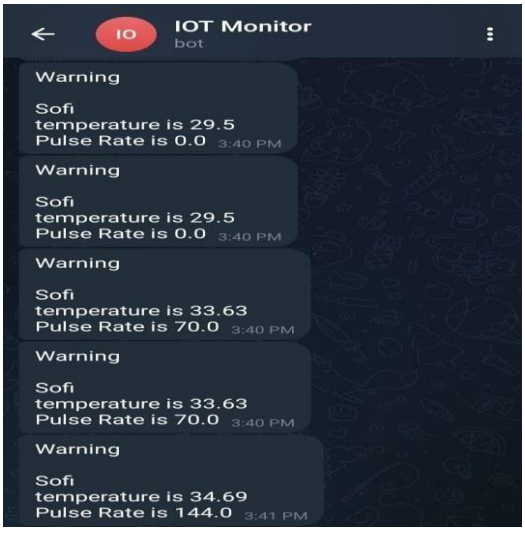

Fig 4: Simulated Output

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V. CONCLUSION

This research demonstrates the effectiveness of an IoT-enabled pulse and temperature monitoring system with real-time notifications. The system is beneficial for remote patient monitoring and can be extended with AI-based predictive analytics for improved healthcare services. Future work may involve integrating additional health parameters and enhancing data security measures.

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