American International University-Bangladesh (AIUB)
Faculty of Engineering (FE)
Department of Electrical and Electronic Engineering (EEE)

Course Name:	Microprocessor and Embedded Systems	**Course Code:**	EEE 4103
Semester:	Spring 2024-2025	**Section:**	**P**
Faculty Name:	**Prof. Dr. Engr. Muhibul Haque Bhuyan**		

Capstone Project Title:	**IOT Based Patient Health Monitoring on ESP32 Web Server**
Project Group #:	**01**

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Assessment Materials and Marks Allocation:

CO/ CLO Number	CO/CLO Statement	K	P	A	Assessed Program Outcome Indicator	BNQF Indicator	Teaching-Learning Strategy	Assessment Strategy
3	**Demonstrate** a course project using microcontrollers, sensors, actuators, switches, display devices, etc. that can solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research.	**K8**	**P1 P3 P7**		**P.d.1.P3**	**FS.3**	**Discussion**	**Project Report (Literature Review)**
4	**Explain** the complex engineering activities of a course project solving a complex engineering problem of the electrical and electronic engineering discipline through an effective presentation.			**A1 A2**	**P.j.3.A4**	**SS.2**	**Discussion**	**Project Presentation**

Assessment Rubrics:

COs	Excellent to Proficient [5-4]	Good [3]	Acceptable [2]	Unacceptable [1]	No Response [0]	Secured Marks
CO3 P.d.1.P3	The outcome of the project demonstrates a course project utilizing microcontrollers, sensors, actuators, switches, display devices, and more, which can address a complex engineering problem in the electrical and electronic engineering field through appropriate research.	The outcome of the project demonstrates a course project utilizing microcontrollers, sensors, actuators, switches, display devices, etc., and also addresses a complex engineering problem in the electrical and electronic engineering discipline through research.	The outcome of the project demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc. but cannot solve a complex engineering problem properly in the electrical and electronic engineering discipline through appropriate research.	The outcome of the project does not demonstrate a course project using microcontrollers, sensors, actuators, switches, display devices, etc. It also could not solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research.	No Response at all/copied from others/ identical submissions with gross errors/image file printed	
Comments					**Total Marks (5)**	

IOT Based Patient Health Monitoring On ESP32 Web Server

Md.Mosharof Hossain Khan,Md.Saikot Hossain,Rimal Banik,Md Rahidul Islam,Rahat Ahmed

Abstract- This paper presents the design and implementation of an IoT-based Patient Health Monitoring System using the ESP32 microcontroller, aimed at enhancing healthcare delivery through continuous and remote monitoring of patient vitals. The system employs three sensors to collect crucial health data: the DHT11 sensor measures ambient room temperature and humidity, the DS18B20 digital sensor provides accurate readings of the patient's body temperature, and the AD8232 ECG sensor captures electrocardiogram signals, which are further processed to determine heart rate. These sensors interface with the ESP32, which processes the data and transmits it to a web server via Wi-Fi. The collected data is displayed on a real-time dashboard, allowing medical professionals or caregivers to remotely observe patient health status from any location with internet access. An onboard LED serves as a local alert mechanism by blinking when abnormal body temperature is detected. The system is lightweight, portable, and cost-effective, making it suitable for applications in home care, rural health centers, and remote diagnostics—especially during pandemics or in regions with limited medical infrastructure. The modular nature of the system allows for future integration with cloud-based platforms and mobile applications. By combining IoT with biomedical sensing, this project demonstrates a scalable solution that bridges the gap between patients and healthcare providers, enabling proactive health management and timely interventions.

Index Terms: Internet of Things(IOT), Patient monitoring, ESP32 microcontroller, ECG signal processing,Body temperature measurement, Web-based health system.

I .INTRODUCTION

The integration of Internet of Things(IOT) technology into healthcare systems has ushered in a new era of remote patient monitoring and management. In this experiment, we focus on implementing an IoT-based patient health monitoring system utilizing the ESP32 microcontroller platform and a web server framework. This system offers real-time monitoring of vital signs such as pulse rate, temperature, providing healthcare professionals with timely and actionable insights into patient health status. By leveraging wireless connectivity and web-based interfaces, the proposed solution enables seamless data transmission and access, facilitating remote monitoring of patients from any location. The experiment aims to demonstrate the feasibility and effectiveness of utilizing ESP32-based IoT solutions for improving healthcare delivery and patient outcomes.

Background of Study and Motivation:

Traditional healthcare systems often depend on scheduled hospital visits and periodic checkups, which may fail to detect critical health changes that occur between visits. This limitation poses significant challenges, particularly for patients with chronic conditions or those living in remote areas where access to healthcare facilities is limited. As a response to this issue, remote patient monitoring (RPM) has emerged as a practical and efficient solution, allowing continuous tracking of vital signs directly from a patient's home. With the advancement of Internet of Things (IoT) technology, RPM systems can now be implemented in a scalable and cost-effective manner. IoT-enabled health monitoring systems allow for real-time data acquisition, wireless transmission, and cloud-based analysis, making it possible to detect abnormalities early and ensure timely medical intervention. This approach not only enhances the quality of patient care but also reduces the burden on healthcare infrastructure and professionals.

The primary motivation for undertaking this project was to address the growing need for accessible and continuous healthcare monitoring, especially for patients in remote or underserved areas. I wanted to design a system that could enable real-time observation of vital signs without requiring constant physical presence of healthcare professionals. Continuous monitoring of key health indicators like body temperature, humidity, and ECG signals can play a crucial role in early detection of health issues, leading to timely intervention and improved patient outcomes. I also aimed to provide a solution that reduces dependency on frequent hospital visits, thereby lowering overall healthcare costs for both patients and service providers. Additionally, by allowing patients to view and track their own health data, this system encourages greater awareness and involvement in personal health management. The data generated could also support medical research and trend analysis, offering potential for more personalized and predictive healthcare strategies in the future.

The Primary Objectives of this Projects are:

- To design and implement an IoT-based system for real-time monitoring of patient vitals using the ESP32 microcontroller.
- To implement secure Wi-Fi communication for transmitting patient health data from the ESP32 to a web server.
- To measure and transmit room temperature, humidity, body temperature, and ECG data using DHT11, DS18B20, and AD8232 sensors respectively.
- To display collected data on a web interface for remote observation by doctors or family members.
- To incorporate an alert mechanism (LED) for abnormal body temperature detection.

- To ensure the system remains cost-effective, portable, and suitable for home or rural healthcare environments.
- To enable continuous and wireless transmission of biomedical data to both cloud and local servers, thereby ensuring real-time accessibility for healthcare providers and caregivers through platforms such as Blynk and a locally hosted web interface.
- To evaluate the accuracy and performance of the integrated sensors in real-time patient monitoring.

- To validate the accuracy and effectiveness of the system by comparing its performance with established medical standards.

A Brief Outline of the Report:

This report provides a structured overview of the design, development, and evaluation of an IoT-based Patient Health Monitoring System using ESP32 and low-cost sensors. The report is organized into the following key sections:

- Section II-Literature Review: This section presents a review of at least five recent (2019–2025) published journal papers related to IoT-based patient monitoring. It highlights existing technologies, research gaps, and how this project builds upon or differs from previous works.
- Section III-Methodology and Modeling: This section explains the step-by-step methodology followed in the project. It includes the working principle of the system, details of the experimental and simulation processes, descriptions of all hardware components used (such as ESP32, DHT11, DS18B20, AD8232, and LED), and the setup used for testing and validation.
- Section IV-Results and Discussions: This section provides both the simulation/numerical analysis results and the actual experimental data collected during the implementation. A comparison between theoretical and experimental results is made, followed by a cost analysis and discussion of any limitations encountered.
- Section V-Conclusion and Future Endeavors: This section summarizes the key findings, evaluates the overall effectiveness of the project, and outlines possible future improvements and enhancements to the system.
- References: A complete list of all journal papers, technical articles, and other resources cited throughout the report.

II. LITERATURE REVIEW

Monitoring, diagnosing, and managing patient health has been completely transformed by the incorporation of Internet of Things (IoT) technologies into healthcare systems. Continuous, real-time patient vital sign monitoring is made possible by IoT-based health monitoring, which greatly improves clinical effectiveness and patient care. In order to achieve scalable and affordable healthcare solutions, a growing body of research investigates different system architectures and technical implementations.

The authors of [1] suggested a health monitoring system that uses the Arduino UNO microcontroller to record a patient's blood oxygen saturation (SpO_2) and pulse rate. This technology gives the user instant feedback by displaying data on an LCD panel. This model's main benefits are its affordability and ease of use, which make it appropriate for environments with minimal resources or in rural areas. But lack of real-time data accessibility makes it low level technology.

Through the use of remote monitoring capabilities, the study in [2] goes one step further. The ESP8266 Wi-Fi module used by the authors allows the gadget to wirelessly send patient data to a web server or cloud platform. This approach enhances accessibility and scalability, particularly in telemedicine applications, by enabling medical professionals to remotely monitor patients' states and take appropriate action.

The researchers created a more complete Internet of Things gadget in [3] that can measure oxygen levels, pulse rate, and temperature. The addition of a buzzer notification mechanism that notifies users when data collecting is finished is one of the system's noteworthy improvements. By improving user involvement and response time, this feature makes the system more useful in every situation.

Optimizing clinical workflow and doctor-patient interactions is the main goal of the study discussed in [4]. Physicians may effectively monitor numerous patients without being physically present thanks to the system's ability to gather and send patient data in real-time. In addition to saving time, this aids physicians in handling greater patient load, a crucial factor in overworked healthcare systems.

Finally, the study in [5] talks about how important it is to integrate IoT in healthcare systems globally. The authors stress that, particularly in light of expanding populations and a rise in chronic illnesses, IoT technologies are essential for offering adaptable and scalable solutions for health monitoring across multiple geographies. Their work demonstrates how IoT may be used to address global healthcare issues and guarantee ongoing patient care regardless of regional constraints.

The research concludes by highlighting a common belief: IoT technologies have revolutionary potential to improve the healthcare industry through real-time monitoring, remote access, cost effectiveness, enhanced clinical decision-making, and patient empowerment. The systems under examination demonstrate how the field of digital healthcare is developing, with automation and connection serving as major catalysts for advancement and better health outcomes.

Table-01:Comparable Table

Parameters	Our project	Unawane 2021	P. Thapa, B. S. Rai 2023	A. Kumar 2023	J. Ferdous 2023	V. M. Ghodke 2024
Microcontroller	ESP32 Dev kit	Arduino Uno	Arduino Uno	Arduino Uno	ESP32 development kit	Arduino Uno
Room Temperature and Humidity Sensor	DHT11	DHT11	✗	✗	✗	✗
Body Temperature Sensor	DS18B20	✗	✗	✗	Used but not mentioned the model name	LM35
ECG sensor	AD8232	AD8232	✗	✗	✗	✗

III. METHODOLOGY AND MODELING

The integration of Internet of Things (IoT) technology into healthcare systems has emerged as a promising approach for revolutionizing patient monitoring. This project focused on implementing an intelligent healthcare system using IoT technology, specifically targeting the remote monitoring of vital signs such as pulse rate,temperature.By leveraging ESP32 development kits for wireless wearable sensor control and server functions, the system aims to enable efficient data transmission via Wi-Fi, reducing the need for in-person patient visits and facilitating simultaneous monitoring of multiple patients. This introduction sets the stage for exploring the literature review, which delves into existing research on IoT-based patient health monitoring, showcasing various innovative solutions and highlighting the potential of microcontroller platforms like the ESP32 for real-time monitoring applications.

Working Principle of the Proposed Project:

- The system operates continuously by reading vital signs through three sensors connected to the ESP32 microcontroller: DHT11, DS18B20, and AD8232.
- The DHT11 sensor captures ambient temperature and humidity, providing environmental context which may affect patient health.
- The DS18B20 sensor is used for accurate body temperature measurement, suitable for detecting fevers or abnormal temperature conditions.
- The AD8232 ECG module monitors electrical heart activity. It records analog ECG signals which are analyzed to determine heart rate and detect irregularities.
- All sensor data is processed by the ESP32 and transmitted wirelessly via Wi-Fi to the Blynk server, allowing real-time data visualization on the Blynk mobile app.
- The system ensures continuous monitoring without manual input. Once powered, it automatically starts sensing and transmitting data in a loop, enabling remote observation by healthcare professionals or family members.
- The ESP32 also hosts a local web server, allowing users to access live sensor data through a browser on the same network, providing an additional interface for real-time monitoring without relying solely on the cloud platform.

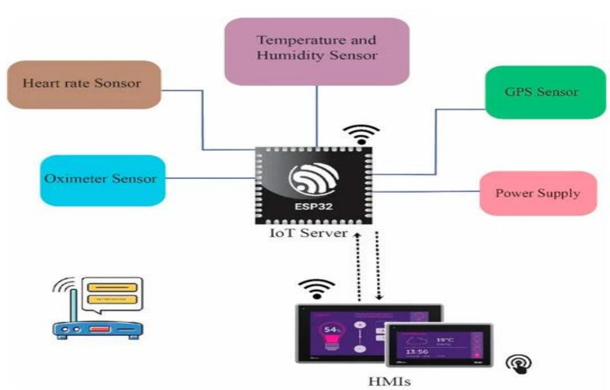

Figure-01:Working principle of the system

Process of work (Experimental):

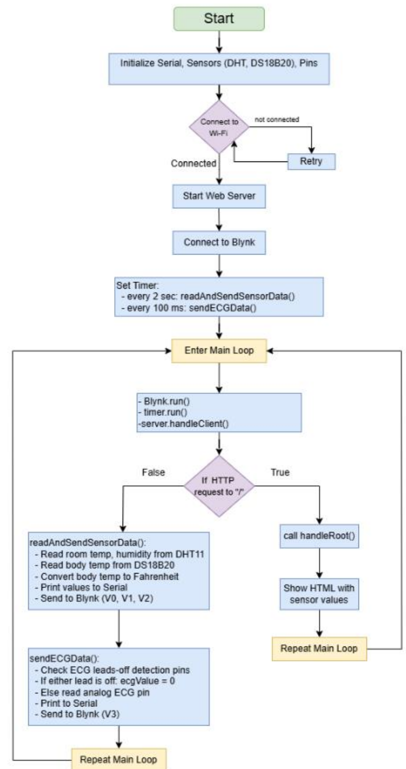

Figure 02:Flow chart

Explanation: The experimental process for the IoT-Based Patient Health Monitoring System revolves around the integration of sensors with the ESP32 microcontroller and real-time data communication using the Blynk IoT platform. The ESP32 is programmed using the Arduino IDE, where necessary libraries such as WiFi.h, BlynkSimpleEsp32.h, DHT.h and DallasTemperature.h are included to support sensor communication and internet connectivity. Three primary sensors are interfaced with the ESP32: the DHT11 sensor for measuring ambient temperature and humidity, the DS18B20 digital temperature sensor for accurately detecting body temperature, and the AD8232 ECG sensor for capturing heart activity. The ESP32 is configured to connect to a Wi-Fi network using predefined SSID and password credentials. Once connected, it authenticates with the Blynk server using a unique authentication token, allowing the system to transmit sensor data to the Blynk mobile application in real-time. In the main loop, sensor readings are collected periodically using a BlynkTimer: temperature and humidity data are updated every 2 seconds, while ECG values are updated every 100 milliseconds. The DHT11 sensor provides room temperature and humidity values, while the DS18B20 sensor outputs body temperature in Celsius, which is converted into Fahrenheit before being transmitted. ECG values are read from the analog pin, provided the leads are properly connected, and then sent to the Blynk dashboard. In addition to the mobile app, a local web server is hosted on the ESP32, displaying live sensor readings through a simple HTML page that can be accessed via the ESP32's IP address. The code execution follows a structured flow: it initializes components, connects to Wi-Fi, starts the sensors, reads and processes sensor data, sends data to the Blynk app and web server, and loops indefinitely to keep updating the information.

Simulation:

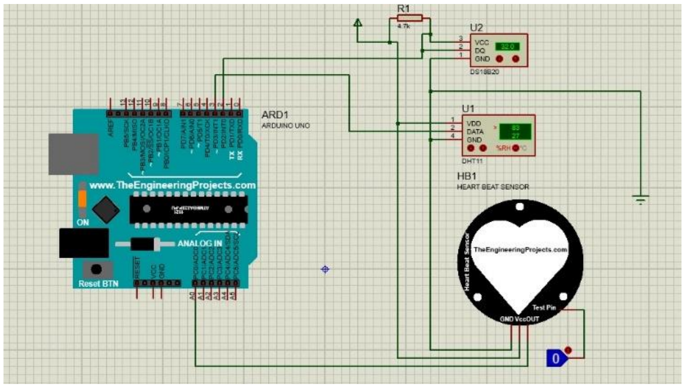

Figure 03: Simulation Setup

Explanation: To validate the system's basic functionality before hardware implementation, a simulation was carried out using Proteus Design Suite with an Arduino Uno board as a substitute for the ESP32. The purpose of this simulation was to verify sensor interfacing, signal flow, and logic execution in a controlled virtual environment. In the simulation, virtual components such as DHT11 (for temperature and humidity), DS18B20 (for body temperature), and an analog ECG waveform generator were connected to the Arduino Uno. The sensors were configured to send varying data to mimic real-world changes. The Arduino was programmed using simplified logic derived from the actual ESP32 code to process the inputs and display outputs accordingly. Serial Monitor was used within the simulation to observe temperature, humidity, body temperature, and ECG signal values. Logic testing included verifying correct data reading intervals, signal stability, and conditional processing (e.g. body temperature conversion). Since Wi-Fi and Blynk integration cannot be simulated in Proteus, those parts were excluded from the simulation phase.

Description of the Components

1.ESP32 Microcontroller: A Wi-Fi and Bluetooth-enabled microcontroller that controls the entire system. It reads data from all sensors and sends it to the Blynk server for remote monitoring. It supports digital and analog interfaces, making it suitable for IoT projects.

2.DHT11 Sensor: A digital sensor that measures room temperature and humidity. It communicates with the ESP32 using a single digital pin and is suitable for basic environmental monitoring.

3.DS18B20 Temperature Sensor: A high-accuracy digital sensor used to measure body temperature. It uses the One-Wire protocol, allowing multiple sensors on one pin and offers reliable output with ±0.5°C accuracy.

4.AD8232 Heart Rate (ECG) Sensor: An analog sensor that captures ECG signals from the human body. It sends heart signal data to the ESP32's analog input, allowing the system to monitor and estimate heart rate.

5.Blynk App and Server: A cloud-based IoT platform that displays real-time data from the ESP32 on a mobile dashboard. It allows users to monitor health parameters remotely via smartphone.

6.Proteus Simulation Software: A circuit design and simulation tool used to test the logic of the system virtually. As ESP32 is not supported, Arduino was used in simulation to validate connections and sensor behavior before hardware setup.

Experimental Setup:

The experimental setup was developed on a breadboard, using the ESP32 microcontroller as the central unit. The DHT11 sensor, used to measure room temperature and humidity, was connected to GPIO 4 of the ESP32. The DS18B20 digital temperature sensor, responsible for measuring body temperature, was connected to GPIO 14 and communicated using the One-Wire protocol. For heart activity monitoring, the AD8232 ECG sensor was interfaced with the ESP32 using GPIO 34 for analog signal output, while the leads-off detection pins were connected to GPIO 25 (LO+) and GPIO 26 (LO–). The ESP32 was powered via a USB connection to a computer and programmed using the Arduino IDE. Wi-Fi credentials and the Blynk authentication token were configured within the code to enable real-time data transmission to the Blynk cloud server. On the Blynk mobile application, virtual pins were set to display live health data: V0 for room temperature, V1 for humidity, V2 for body temperature, and V3 for ECG signal values. The readings were continuously updated using software timers configured in the code.

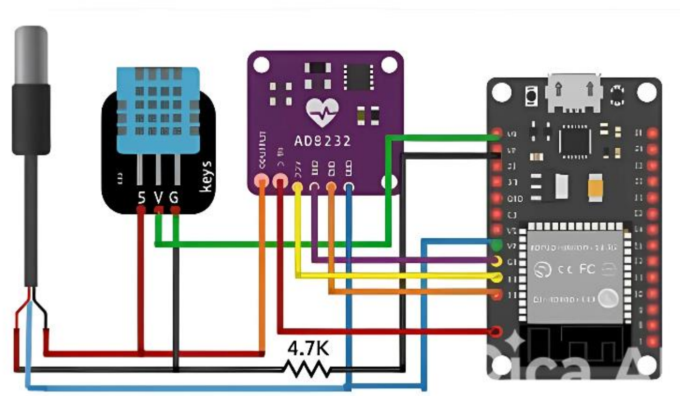

Figure 04: Experimental Setup

Project Timeline and Gantt chart:

To ensure timely completion of the IoT-based patient health monitoring system, a detailed project schedule was prepared using Gantt chart. The chart outlines key milestones, such as sensor interfacing ,coding, testing and report preparation, spread across the project duration. This timeline helped manage tasks efficiently and monitor progress throughout the project lifecycle.

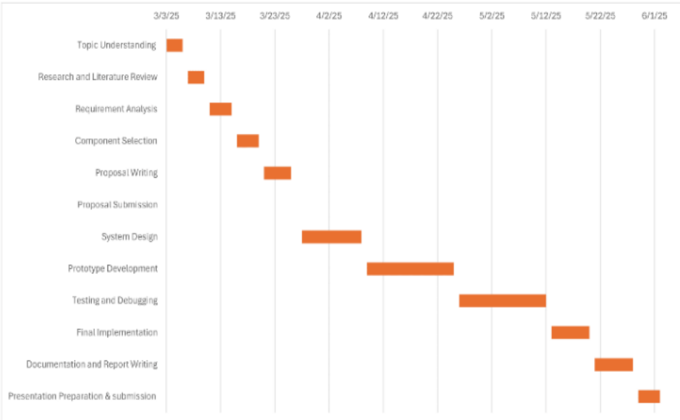

Figure 05: Gantt Chart

Explanation: This Gantt chart outlines the project timeline, starting from topic selection on March 3, 2025, to the final presentation submission on June 1, 2025. It includes key phases such as literature review, component selection, system design, prototype development, testing, and documentation, ensuring a structured and organized workflow throughout the project.

IV. RESULT AND DISCUSSION

Simulation Analysis:

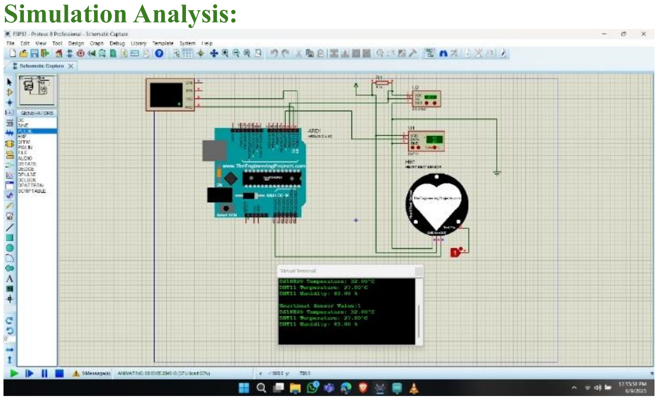

Figure 06: Simulation Result

Explanation: To evaluate the functionality of the IoT-based patient health monitoring system, a detailed simulation was conducted using Proteus 8 Professional. The system was modeled with key components including the ESP32 microcontroller (represented by Arduino UNO due to simulation compatibility), a DS18B20 temperature sensor, a DHT11 temperature and humidity sensor, and a heartbeat sensor. The simulation was configured to visualize data acquisition and communication through a virtual terminal, emulating serial output to a web server. The DS18B20 sensor accurately measured the patient's body temperature, while the DHT11 sensor provided environmental temperature and humidity readings. Simultaneously, the heartbeat sensor captured the pulse rate and generated digital signals corresponding to heartbeat detection. The collected data were successfully transmitted to the virtual terminal, which displayed values such as DS18B20 Temperature: 32.00°C, DHT11 Temperature: 27.00°C, DHT11 Humidity: 83.00%, and Heartbeat Sensor Value: 1, indicating a heartbeat event. These readings were periodically updated, validating the system's real-time monitoring capability. The consistency and accuracy of the results in a controlled virtual environment confirm proper sensor integration and signal processing logic. Overall, the simulation demonstrates that the system can reliably monitor vital health parameters and is capable of transmitting this data to an IoT platform.

Experimental Results:

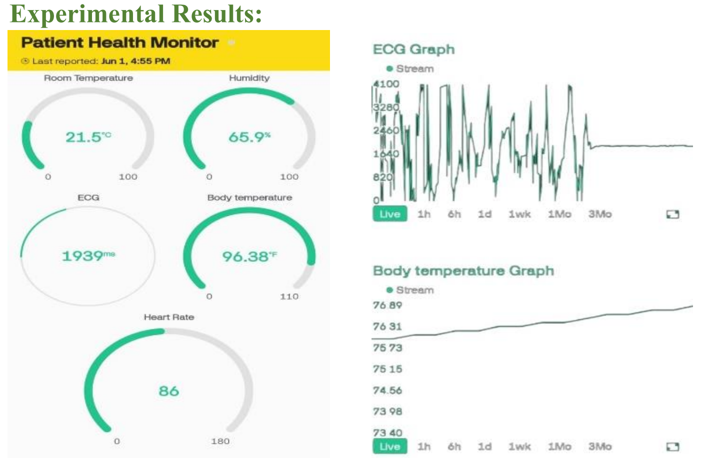

Figure 07: Experimental Results

Explanation: The experimental validation of the IoT-based patient health monitoring system was carried out using the ESP32 microcontroller interfaced with biomedical sensors and the Blynk IoT mobile application as the cloud-based monitoring platform. Real-time physiological data-including body temperature, ambient temperature, humidity, heart rate, and ECG—were collected using DS18B20, DHT11 and ECG sensors. The processed data were transmitted via Wi-Fi to the Blynk app, where a customized dashboard enabled live monitoring of health metrics. The application interface displayed values such as room temperature (21.5 °C), humidity (65.9 %), body temperature (96.38 °F), heart rate (86 bpm), and ECG interval (1939 ms) using intuitive gauge widgets. Furthermore, two graphical plots-ECG and body temperature graphs—provided dynamic visualizations over time. These graphs enabled both patients and healthcare professionals to track physiological trends, detect anomalies, and make informed decisions. The ECG graph clearly showed real-time waveform fluctuations, while the body temperature graph illustrated gradual temperature variations, reflecting the patient's condition. The system demonstrated reliable sensor accuracy, smooth wireless data transmission, and seamless app-based visualization. This experimental setup confirmed the practical applicability of the system for continuous remote health monitoring, especially beneficial for patients requiring regular supervision or remote medical consultation.

Comparison between Simulation and Experimental Results:
A detailed comparison between the numerical (simulation-based) results and the experimental (hardware-based) outcomes confirms the overall reliability and functionality of the proposed IoT-based patient health monitoring system. In the simulation conducted using Proteus 8, the DS18B20 sensor recorded a body temperature of 32.0 °C, while the DHT11 sensor reported an ambient temperature of 27.0 °C and humidity of 83.0%. The heartbeat sensor showed digital pulse detections, validating the signal acquisition logic. In contrast, the real-time experimental setup using the ESP32 microcontroller and Blynk IoT platform measured body temperature at 96.38 °F (equivalent to 35.8 °C), room temperature at 21.5 °C, and humidity at 65.9%. The heart rate was recorded as 86 bpm, and the ECG sensor provided real-time waveform data not present in the simulation stage. The observed deviations between simulated and real-world values are primarily attributed to changes in environmental conditions, sensor calibration, and the lack of analog variability in the simulation environment.
Moreover, while the simulation verified the basic functionality and logic of data collection and serial communication, the experimental results extended the system's capability by integrating real-time wireless data transmission, mobile app-based visualization, and time-series plotting through the Blynk platform. The inclusion of ECG signal monitoring in the hardware prototype added diagnostic value beyond what was possible in simulation. These enhancements highlight the practical applicability of the system in real-world healthcare monitoring scenarios. Overall, the close alignment between simulation and experimental data validates the accuracy of the system design and confirms that the simulation phase served as an effective predictor of real-world performance.

Table 02: Cost Analysis

Products	Units	Cost(Tk)
Connecting wire	-	100
Breadboard	1	220
ESP32 Board	1	650
USB cable	1	500
DHT11	1	120
Resistor	2	4.8
DS18B20	1	209
AD8232	1	755
LED	2	6
Total	-	2564.8

Limitations in the Project:
While the proposed IoT-based patient health monitoring system demonstrates the feasibility of remote physiological monitoring using ESP32 and multiple biomedical sensors, the current implementation has several limitations:

1.Limited Sensor Integration: The system incorporates only basic sensors—DHT11, DS18B20, and AD8232—for temperature, humidity, and ECG monitoring. It lacks more advanced biomedical measurements such as oxygen saturation (SpO_2), blood pressure, or respiratory rate, which are critical for a comprehensive health assessment.
2.Short-Term Data Storage: Although real-time data is displayed on Blynk and a local web server, the project does not support long-term cloud storage or database integration. This limits the ability to track health trends over time or facilitate historical analysis by medical professionals.
3.Wi-Fi Dependency: The system depends entirely on a stable Wi-Fi connection. In areas with poor connectivity or network interruptions, the real-time data transmission and remote monitoring features become unreliable or unusable.
4.No Real Clinical Validation: The prototype has been tested in a controlled environment (e.g., a lab or home setting) but has not been clinically validated. Sensor accuracy and reliability under real-world conditions (e.g., different skin types, motion artifacts, or medical-grade thresholds) remain unverified.
5.Power Supply Limitations: The system currently relies on a USB power source, which restricts mobility and usability in portable or wearable applications. Battery-powered or energy-efficient designs were not implemented in this version.
6.Security and Privacy Concerns: As data is transmitted over the internet to the Blynk cloud, the system could be vulnerable to unauthorized access or data breaches. No encryption or authentication mechanisms were implemented to protect patient health data.

V. CONCLUSION AND FUTURE ENDEAVORS

This project presents the successful design and implementation of an IoT-based patient health monitoring system using the ESP32 microcontroller. The system incorporates three essential biomedical sensors: DHT11 for measuring ambient temperature and humidity, DS18B20 for detecting body temperature, and the AD8232 module for ECG signal acquisition. Real-time physiological data is transmitted wirelessly to both a cloud-based IoT platform (Blynk) and a locally hosted web server, enabling both remote and on-site health monitoring. Experimental results confirm the reliability of sensor interfacing, accurate data acquisition, stable Wi-Fi connectivity, and consistent performance. The integration with the Blynk platform offers a user-friendly interface for visualizing key health metrics, ensuring real-time accessibility for users or caregivers. This low-cost and scalable system demonstrates the potential of IoT technologies in healthcare, particularly for continuous patient observation in home-based or rural settings. The project highlights the importance of accessible, real-time monitoring solutions in reducing dependency on traditional hospital-based systems.

Future Endeavors: To enhance the functionality and impact of the proposed IoT-based health monitoring system, several future improvements are envisioned. The system can be expanded by integrating additional biomedical sensors such as blood oxygen saturation (SpO_2), blood pressure, and respiration rate to provide a more holistic health assessment. Implementing cloud-based data logging and storage would enable long-term trend analysis, which is crucial for remote consultations and medical diagnostics. Moreover, integration with healthcare APIs could allow for seamless communication with medical databases and professionals. Incorporating machine learning algorithms for anomaly detection may enable predictive analytics and intelligent alert systems, improving both accuracy and responsiveness. The Blynk platform can be replaced with a custom-developed mobile application to offer better flexibility, user interface personalization, and offline access. Power optimization techniques, battery integration, or even solar-powered modules can enhance portability and make the system suitable for use in rural or resource-constrained environments. Future prototypes may adopt wearable form factors and be tested in real clinical or home-care settings to validate usability, reliability, and medical effectiveness. These enhancements will strengthen the system's role in advancing smart and accessible healthcare solutions.

VI. REFERENCES

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VI1. Appendix

[1] DHT11 Datasheet:
https://www.mouser.com/datasheet/2/758/DHT11Technical-Data-Sheet-Translated-Version-1143054.pdf
[2]DS18B20Datasheet:
https://www.analog.com/media/en/technicaldocumentation/data-sheets/ad8232.pdf
[3]AD8232 Datasheet:
https://www.analog.com/media/en/technicaldocumentation/data-sheets/ad8232.pdf