Journal of Engineering Technology and Applied Physics

IoT-Enabled Temperature Controlled Room for Patients

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https://doi.org/10.33093/jetap.2025.7.2.15

Manuscript Received: 31 July 2025, Accepted: 18 August 2025, Published: 15 September 2025

***Abstract*—The physical environment in healthcare settings is considered important for patient comfort and recovery. Among other environmental factors, room temperature is recognized as a crucial environmental factor that can significantly affect the patient's health. Changes in room temperature can cause discomfort, making it harder for patients to heal and reducing the patient's satisfaction with the care provided. In Malaysian hospitals, discomfort may be experienced by patients with sensitive skin due to humidity and temperature fluctuations. A device capable of measuring room temperature for sick patients is available; however, its requirement for manual monitoring complicates the maintenance of an appropriate environment. Consequently, a simple yet effective project has been designed to continuously control room temperature according to individual comfort levels. This system is designed to assist nurses and caregivers by adjusting automatically the room temperature and enabling remote monitoring through mobile applications or a web interface, implemented via the Internet of Things (IoT). The proposed system consists of a DS18B20 temperature sensor for temperature readings, along with an exhaust fan and ceiling fan or stand fan to decrease the temperature. This project uses Wemos D1 R1, a microcontroller that is based on the ESP8266, to enable IoT functionality. For the user interface, the Blynk application is utilized as the primary graphical interface for interaction with the IoT system.**

Keywords*—Patient comfort, Temperature control, Wireless monitoring.

I. INTRODUCTION

In the early days of internet development, it only can be used for information and communication sharing among researchers, scientists and academic institutions. Along with the Google founded in 1998, the invention of smartphones in 2007 contributed significantly to the rise of mobile internet usage. The period from 2010 and 2015, marked a significant leap in internet evolution, as cloud computing gained traction and IoT integration began to take shape across various industries. In healthcare, IoT also has become increasingly important. By 2025, it is projected that approximately 75.44 billion devices are expected to be connected worldwide [1]. Among the key advantages of adopting IoT healthcare are enhanced remote care, enabling real-time monitoring and rapid access to medical data. These improvements contribute to better outcomes and more efficient healthcare operations.

A study conducted by Hossain *et al.* [2] explored IoT-based healthcare solutions, proposing a system that incorporates microcontrollers, mobile phone, and sensor technologies. The primary goal of the project is to develop an economical and technologically viable framework that enhances healthcare accessibility for all patients, while also addressing potential challenges associated with implementing IoT in real-world medical environments. Christopher *et al.* in another study [3], developed an IoT-enabled temperature monitoring sensor that automates fan control. The system integrates a DHT11 temperature sensor and an ESP32 Wi-Fi module to automatically adjust fan speed in real time, based on outdoor temperature data.

The Internet of Things (IoT) has facilitated patients' monitoring by enabling physicians to observe vital signs such as blood pressure, heart rate, body temperature, and oxygen saturation in real time [4, 5]. A study related to healthcare that utilized IoT functionality for health monitoring purposes uses Raspberry Pi or Arduino microcontrollers that gather, process, and transmit data to the healthcare providers via cloud or mobile applications [4, 5]. Patients with internet connectivity yet living in remote areas and facing challenges accessing hospitals, can also benefit from video consultations. Through video conferencing

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they can receive medical advice on the severity of their injuries from doctors. This technology enhances healthcare delivery by saving time, thus reducing overall cost. Additionally, patients can utilize smartphones to record and track their health for better management [6]. Temperature plays a critical role in patient health, influencing physiological processes and potentially leading to adverse health outcome where both extreme temperatures; hypothermia (low body temperature) and hyperthermia (high body temperature), can have significant clinical implications [7, 8]. The negative consequences of these extreme temperatures emphasized the need for precise temperature control to promote faster recovery, reduce infection risks, and improve survival rates, particularly in critical care and postoperative settings [9, 10].

Temperature management is a crucial aspect of patient care, significantly influencing recovery outcomes. Maintaining optimal body temperature is essential to prevent hypothermia and hyperthermia, both of which can impair immune function and delay healing [11]. Effective fever management is also vital to avoid complications [12]. Targeted Temperature Management (TTM) is now standard practice to lower neurological damage and enhance survival. This treatment keeps a person's body temperature between 32°C and 36°C for 24 hours to protect the brain and improve outcomes after events like cardiac arrest or stroke [13]. Mubarakah *et al.* [14] conducted a research that uses AM2301 sensors, an OLED screen and the Blynk application to control room humidity and temperature. This project aims to keep the room to a comfortable temperature around 18 - 26 °C and within 40 – 60% of relative humidity such as recommended by the health authorities. Subsequently, this will help the low-cost air conditioners (ACs) to work better and more efficiently.

The major purpose of this project is to control the atmosphere surrounding patients, thereby eliminating the need for manual adjustments by healthcare professionals. A DS18B20 temperature sensor is employed as the primary input, while an exhaust fan and an AC fan are utilized together to cool the room. The main controller used in this project is the Wemos D1 R1, a microcontroller based on the ESP8266 that can perform IoT functions. This setup allows healthcare professionals to monitor and control everything wirelessly. This system is used to keep the room at the right temperature and humidity, which allows patients to be more comfortable thus helps them heal faster.

II. METHODOLOGY

A. Block Diagram

Figure 1 shows the overall project block diagram. The primary input for this project is the DS18B20 temperature sensor that measures the ambient room temperature. The temperature sensor captures the room temperature and displays the value on the monitoring appliances; mobile phone or computers, via the Blynk applications that require internet connection for functionality. If the temperature exceeds the predetermined threshold which is 30 ^{O}C, both exhaust motor fan and the AC ceiling fan will be activated to cool the room. When the temperature drops to or below this set value, both the exhaust fan and ceiling fan will be turn off, effectively managing the room's climate.

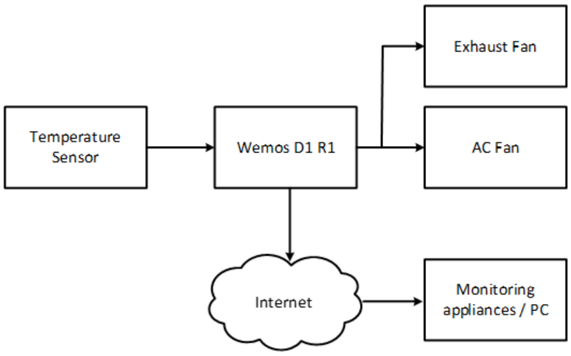


Fig. 1. Project block diagram.

B. Project Simulation

Figure 2 illustrates the project's simulation. The Arduino Uno was chosen because the TinkerCad simulator does not support the ESP8266 microcontroller. The system primarily consists of five main components; the Arduino UNO module, a temperature sensor, two DC fans representing both ceiling/stand fan and an exhaust fan, as well as a LCD display to show the temperature readings. The simulation aims to demonstrate the project's operational conditions under high and low temperature scenarios.

The ESP8266 microcontroller provides several advantages over the ATmega328P used in the Arduino Uno. The ESP8266 microcontroller offers built-in Wi-Fi functionality, making it well-suited for Internet of Things (IoT) projects, whereas the Arduino Uno's ATmega328P microcontroller requires additional hardware to enable wireless connectivity [15, 16].

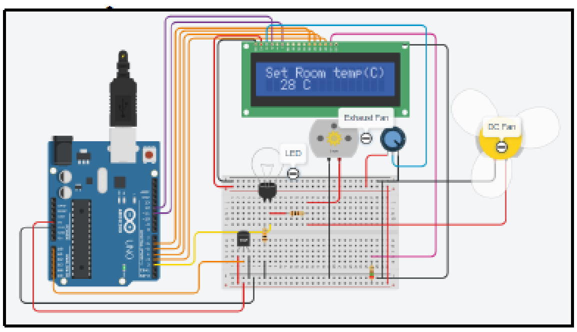


Fig. 2. Software simulation.

III. RESULTS AND DISCUSSION

A. Hardware Design and Implementation

Figure 3 illustrates the main controller setup for this project. The main controller box is connected to a DS18B20 temperature sensor, and two socket outlets are connected from the main controller box to control the exhaust fan and the AC fan.

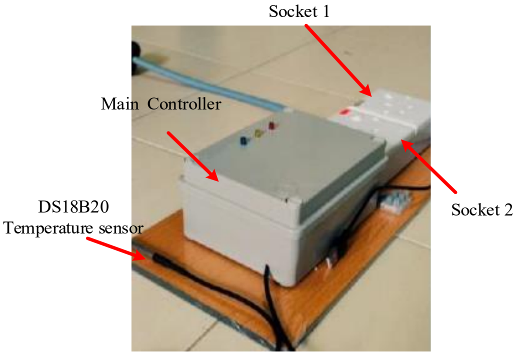


Fig. 3. Main controller setup.

Figure 4 illustrates the complete experimental setup for the project. Inside the main controller box, the Wemos D1 R1 microcontroller and the circuit switching relays are housed. The switching relays are connected to two socket plugs, to which both the stand fan and exhaust fan are joined. As aforementioned, when a temperature value ≥ 30°C is detected by the DS18B20 sensor, a notification is sent to the user through the Blynk application, and both fans are activated by the system.

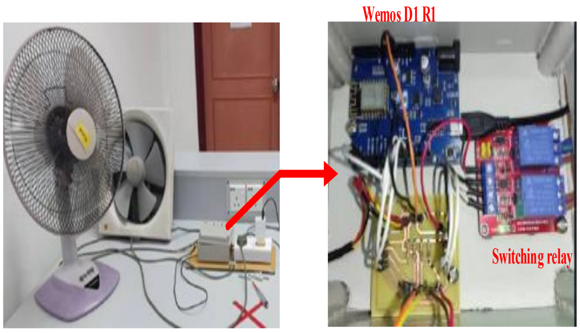


Fig. 4. Experimental setup.

Table I. Operational conditions summary.

Experimental Temperature	AC Fan Status	Exhaust Fan Status
≥ 30 °C	On	On
< 30 °C	Off	Off

A temperature of 30°C is selected for this project and configured via the Blynk application. The activation of both the AC fan and the exhaust fan is triggered by temperatures exceeding this set point. Conversely, the deactivation of both fans occurs when the temperature falls below the set point. The results are summarized in Table I, which presents the operational settings for the exhaust fan and the AC stand fan.

The response time of the system during temperature fluctuations is determined by its activation and deactivation delays, which are essential for maintaining temperature stability and energy efficiency. With a set point of 30°C, the system response time operation is shown in Table II.

Table II. System response time during temperature fluctuations.

Parameter	Description	Response Time
Activation Delay	Time taken to activate AC and exhaust fans when temperature ≥ 30°C.	< 2 second
Deactivation Delay	Time taken to deactivate AC and exhaust when temperature < 30°C.	< 2 second

B. *Software Design and Implementation*

Figure 5 shows the selected IoT application for this project is the Blynk application. This IoT application has been utilized in many studies related to environmental issues, agriculture, smart homes, food and beverages, and even in heating, ventilation, and air conditioning (HVAC) systems. The Blynk app is available in both web-based and mobile mobile formats [17 - 19].

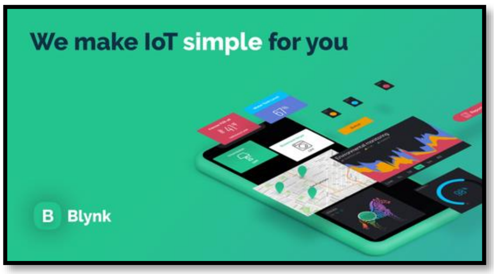
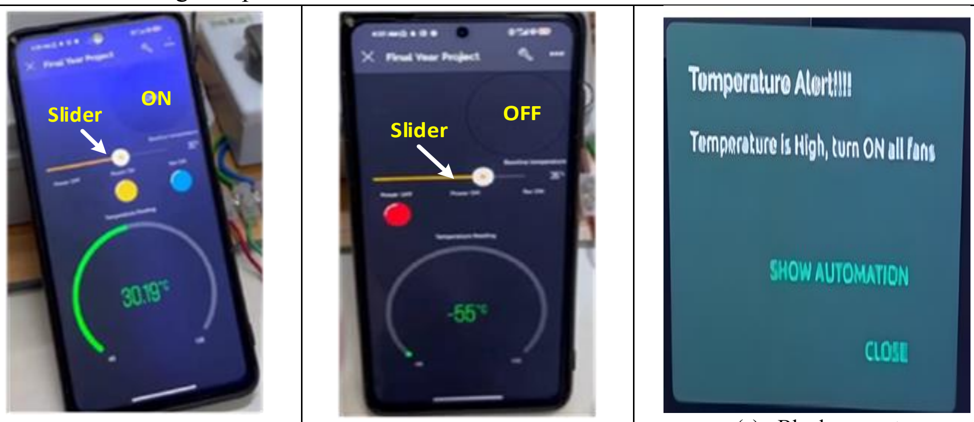


Fig. 5. Main controller setup.

Figure 6(a) illustrates the project interface utilizing the Blynk application. The current room temperature is displayed by the Blynk application's temperature gauge. An alert notification is triggered when the measured temperature reaches or exceeds the set value of 30°C, as illustrated in Fig. 6(c). Figure 6(b) shows that the Blynk temperature gauge indicates a room temperature below 30°C, signifying a comfortable environment, and no alert notification is triggered. A slider function is included in the Blynk application to allow users to set the baseline temperature based on patient requirements or conditions.

IV. CONCLUSION AND RECOMENDATIONS

When it comes to ensuring patient comfort and recovery in hospitals, maintaining an appropriate room temperature is crucial. The challenges associated with manual monitoring can be addressed through an automated, Internet of Things (IoT)-based system utilizing the DS18B20 sensor, ESP8266 microcontroller, and the Blynk application. This system is expected to offer a simple and efficient solution for healthcare professionals to control room temperature, allowing it to be customized according to each patient's needs to support the recovery process. As a recommendation for future improvements, the use of the Blynk application can be replaced with Telegram application for motor control and temperature monitoring. This is because Telegram offers several advantages over Blynk, particularly in terms of ease of use and cost-effectiveness. Telegram's messaging functionality allows direct command execution and easy data retrieval, making it suitable for IoT projects involving motor control or temperature readings. Additionally, notifications can be easily configured to alert users when the temperature exceeds a certain threshold. While Blynk is more suitable for building complex dashboards and real-time data visualization, Telegram is a more practical choice for basic IoT projects due to its simplicity and free access.



(a) ON condition (b) OFF condition (c) Blynk pop out (ON condition only)

Fig. 6. Project user interface using Blynk application.

ACKNOWLEDGEMENT

The author wishes to extend sincere appreciation to all individuals and institutions for their direct or indirect support in contributing to the successful completion of this publication.

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