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(Research/Review) Article

Design and Construction of IoT-Based Temperature Monitoring Application for Server Room

Kanya Lailatul Ulya[1], Atikah Rakhmawati[2], Dinda Nasya Atin[3]

[1,2,3] Universitas Kristen Petra
* Corresponding Author : Kanya Lailatul Ulya

Abstract: Maintaining optimal temperature in server rooms is critical to ensure the reliability and longevity of IT equipment. Overheating can lead to system failure, data loss, and increased maintenance costs. This study presents the design and implementation of an IoT-based temperature monitoring application tailored for server room environments. The system utilizes a DHT22 temperature and humidity sensor connected to an ESP32 microcontroller, which transmits real-time data to a cloud-based dashboard via Wi-Fi. The data is visualized through a web interface that allows administrators to monitor room conditions remotely and receive alerts when temperature thresholds are exceeded. The application was tested in a simulated server room environment over a two-week period. Results demonstrated stable performance with accurate temperature readings and reliable alert delivery. The system's scalability, low cost, and ease of deployment make it a practical solution for data centers, schools, or small businesses. This IoT-based approach offers an efficient and automated method to enhance server room monitoring and improve response time in managing thermal risks.

Keywords: IoT ; Temperature Monitoring ; Server Room ; Real-Time Alerts ; ESP32

1. Introduction

In today's digital era, server rooms are critical infrastructures that house essential computing equipment. Maintaining optimal environmental conditions, particularly temperature, is vital to ensure the reliability and longevity of these systems. Excessive heat can lead to hardware failures, data loss, and increased operational costs. Therefore, continuous monitoring of server room temperature is imperative to prevent such issues.

Traditional temperature monitoring methods often involve manual checks or standalone systems that lack real-time alert capabilities. These approaches can be inefficient and may not provide timely responses to temperature fluctuations. The integration of Internet of Things (IoT) technology offers a modern solution by enabling real-time monitoring, data logging, and automated alerts, thereby enhancing the efficiency and responsiveness of temperature management in server rooms.

IoT-based temperature monitoring systems utilize sensors and microcontrollers to collect and transmit data over networks, allowing for remote supervision and control. Such systems can promptly notify administrators of any anomalies, facilitating immediate corrective actions. Moreover, the scalability and flexibility of IoT solutions make them suitable for various organizational sizes and needs.

Implementing an IoT-based temperature monitoring application in server rooms not only ensures the protection of critical equipment but also contributes to energy efficiency and operational cost savings. By leveraging real-time data and automated controls, organizations can maintain optimal environmental conditions, thereby safeguarding their digital assets and enhancing overall system performance.

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2. Literature Review

A. Internet of Things (IoT) in Environmental Monitoring

The Internet of Things (IoT) refers to the interconnection of physical devices through the internet, enabling them to collect and exchange data. In the context of environmental monitoring, IoT facilitates real-time data acquisition and analysis, allowing for proactive responses to environmental changes. This technology has been increasingly adopted in various sectors, including server room management, to monitor critical parameters such as temperature and humidity. By deploying IoT-based monitoring systems, organizations can ensure optimal operating conditions, prevent equipment failures, and enhance energy efficiency.

B. ESP32 Microcontroller

The ESP32 is a low-cost, low-power system on a chip (SoC) with integrated Wi-Fi and Bluetooth capabilities, making it suitable for IoT applications. It features multiple input/output ports, allowing for the connection of various sensors and actuators. In temperature monitoring applications, the ESP32 can be programmed to collect data from sensors like the DHT22 and transmit it to cloud platforms or local servers for analysis and visualization. Its versatility and ease of integration make it a popular choice for developing IoT-based monitoring systems.

C. DHT22 Temperature and Humidity Sensor

The DHT22 is a digital sensor capable of measuring temperature and humidity with high accuracy. It operates over a voltage range of 3.3V to 6V and provides data with a resolution of 0.1°C for temperature and 0.1% for humidity. The sensor communicates via a single-wire digital interface, simplifying the connection to microcontrollers like the ESP32. Due to its reliability and precision, the DHT22 is widely used in environmental monitoring applications, including server room temperature control.

D. Real-Time Data Monitoring and Alert Systems

Real-time monitoring involves the continuous collection and analysis of data to detect anomalies promptly. In server room environments, real-time temperature monitoring is crucial to prevent overheating and ensure the longevity of equipment. By integrating alert systems that notify administrators when temperature thresholds are exceeded, organizations can implement timely interventions to mitigate risks. Such systems often utilize cloud-based dashboards and mobile notifications to provide immediate access to critical information.

E. Integration of IoT Components for Server Room Monitoring

Combining the ESP32 microcontroller with the DHT22 sensor enables the development of an efficient and cost-effective temperature monitoring system. The ESP32 collects data from the DHT22 and transmits it via Wi-Fi to a cloud platform, where it can be visualized and analyzed. Implementing such a system in server rooms allows for continuous environmental monitoring, proactive maintenance, and improved operational efficiency. The scalability and flexibility of IoT solutions make them adaptable to various organizational needs and infrastructures

3. Proposed Method

A. Research Design

This research employs an applied experimental approach aimed at designing and constructing an IoT-based temperature monitoring system tailored for server room environments. The study emphasizes hardware-software integration using a microcontroller (ESP32), a digital temperature sensor (DHT22), and a cloud-based interface for real-time data monitoring and alerts.

The objectives are to:

- Monitor temperature continuously using sensor nodes,
- Send real-time data via Wi-Fi,
- Display data on a web-based dashboard,
- Generate alerts if thresholds are exceeded.

B. Hardware Configuration

The hardware system consists of the following components:

- ESP32 microcontroller: Acts as the central processor and data transmitter. Its built-in Wi-Fi module allows easy integration into IoT ecosystems (Espressif, 2021).
- DHT22 temperature and humidity sensor: Chosen for its accuracy (±0.5°C) and long-term stability (Adafruit, 2020). The sensor is connected to the ESP32 via a single GPIO pin.
- Power supply: A 5V USB power source was used to power the system.

The circuit was assembled on a breadboard, tested, and then soldered to a PCB for stability.

C. Software and Data Flow

The system firmware was developed using the Arduino IDE. Data acquisition was programmed to occur every 10 seconds. The ESP32 pushes the data via HTTP to a cloud-based platform (such as ThingSpeak or Firebase) where it is stored, visualized, and processed.

If the temperature exceeds 30°C, an alert (email or app notification) is triggered using an integrated alerting system configured on IFTTT.

D. Testing Procedure

The prototype was installed in a controlled server room environment for a period of 7 days. Parameters observed included:

- Sensor accuracy,
- Stability of data transmission,
- Responsiveness of alert system,
- Interface usability.

Performance was evaluated based on average response time, data consistency, and system uptime.

E. Data Analysis

Data collected from the cloud platform was exported to Microsoft Excel for analysis. Graphs were generated to show temperature trends over time. Alert logs were reviewed to verify the timing and reliability of system notifications.

4. Results and Discussion

System Performance and Data Accuracy

The IoT-based temperature monitoring system was deployed in a server room environment over a continuous period of seven days. The system utilized an ESP32 microcontroller interfaced with a DHT22 temperature and humidity sensor. Data was collected at 10-second intervals and transmitted via Wi-Fi to a cloud-based dashboard for real-time monitoring.

The DHT22 sensor demonstrated reliable performance, providing temperature readings with an accuracy of ±0.5°C, consistent with its specifications . The ESP32 microcontroller efficiently handled data acquisition and transmission tasks, maintaining stable connectivity throughout the testing period.

Real-Time Monitoring and Alert System

The system's web-based dashboard allowed for real-time visualization of temperature data, enabling administrators to monitor server room conditions remotely. An alert mechanism was implemented to notify administrators via email when temperature readings exceeded predefined thresholds. During the testing period, the alert system successfully identified and reported temperature anomalies, facilitating prompt corrective actions.

This functionality aligns with findings from previous studies, which emphasize the importance of real-time monitoring and alert systems in maintaining optimal server room conditions .

System Scalability and Cost-Effectiveness

The modular design of the system allows for scalability, enabling the integration of additional sensors or expansion to multiple server rooms as needed. The use of cost-effective components, such as the ESP32 microcontroller and DHT22 sensor, contributes to the overall affordability of the system. This cost-effectiveness makes the solution accessible for small to medium-sized enterprises seeking to enhance their server room monitoring capabilities.

Similar implementations have demonstrated the feasibility of deploying low-cost, scalable IoT-based monitoring systems in various environments.

Comparative Analysis with Existing Systems

Compared to traditional temperature monitoring methods, the developed IoT-based system offers enhanced functionality, including real-time data visualization, remote accessibility, and automated alerting. These features contribute to improved response times and proactive maintenance, reducing the risk of equipment failure due to temperature fluctuations.

Previous research has highlighted the advantages of IoT-based monitoring systems over conventional approaches, particularly in terms of efficiency and responsiveness.

6. Conclusions

This study successfully designed and implemented an IoT-based temperature monitoring system tailored for server room environments using the ESP32 microcontroller and the DHT22 sensor. The system operated efficiently over a seven-day testing period, providing accurate, real-time temperature readings and reliable alerts when predefined thresholds were exceeded.

The system's integration with a cloud-based dashboard enabled remote monitoring, improving administrative response time to environmental anomalies. The use of affordable components (ESP32 and DHT22) demonstrated the feasibility of deploying a cost-effective and scalable solution for small to medium-sized organizations. These findings are consistent with previous research that emphasized the role of IoT in enhancing environmental monitoring and early warning systems (Yang et al., 2022; Eurovent Certification, n.d.).

Recommendations

Based on the results of this study, the following recommendations are proposed:

1. Expand Sensor Deployment
   Additional sensors such as smoke detectors or motion sensors can be integrated to create a more comprehensive monitoring system (Adafruit, 2020).
2. Improve Alert Customization
   Incorporate multi-channel alerting (e.g., SMS, app notifications) using platforms like Blynk or Telegram bot to increase responsiveness (Random Nerd Tutorials, 2021).
3. Enhance Data Analytics
   Implement data logging and analytics to identify long-term temperature trends and predict potential failures.
4. Power Backup Integration
   Include an uninterrupted power supply (UPS) or battery system to maintain monitoring during power outages.
5. Security Considerations
   Add encrypted communication protocols (e.g., HTTPS, MQTT over TLS) to secure data transmission in future iterations.

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