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Original Article

Smart Classroom Automation System

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Abstract *- With the rapid development of the Internet of Things (IoT) and the need to improve teaching efficiency, this paper proposes a smart classroom automation system leveraging IoT and cloud computing. The system uses Raspberry Pi, Node-RED, and the Favoriot platform to automate and monitor classroom conditions such as lighting, HVAC, and security. Key components include temperature and humidity sensors, motion sensors, NFC readers, and servo motors. The motion sensor initiates environmental monitoring for temperature and humidity. The system detects motion, activates the HVAC when the temperature reaches 32 °C or the humidity reaches 80% and sends notifications via the Favoriot platform. If it detects no motion for five minutes, the system turns off the HVAC. The results demonstrate IoT's potential to optimize resources and enhance educational experiences.*

Keywords *- Smart classroom, Internet of Things, Raspberry Pi, Node-red, System automation.*

1. Introduction

In today's rapidly evolving educational landscape, the use of technology in the classroom is becoming increasingly essential. Smart classroom automation systems are significant advances in this field, providing several benefits that improve the learning experience for students and make educational operations more efficient for teachers. A smart classroom uses modern technologies to establish an interactive and highly efficient learning environment. It incorporates digital technologies like IoT devices and automated systems to improve teaching and learning experiences [1, 2]. In recent times, IoT and Cloud computing have attracted significant attention from academic institutions aiming to create a smart learning environment.

In a Smart Campus, multiple devices and infrastructure are interconnected to provide features such as smart lighting, projection, security, and efficient resource utilization. Smart classrooms, therefore, represent a technology-enhanced approach to education [3]. Enabling a more interactive, secure, and efficient learning atmosphere. Additionally, traditional classrooms heavily rely on physical resources and manual processes, which can be time-consuming and less flexible in accommodating changing educational methods [4]. Recent studies have shown that student attention generally starts to decline approximately 10 minutes into a lecture.

Consequently, the initial 10 minutes allow students to retain approximately 65% of the information presented. However, their ability to retain this information decreases to roughly 25% during the final ten minutes [5]. This highlights the difficulty of sustaining student involvement throughout a presentation, particularly as it nears its conclusion. IoT products in classrooms have successfully provided a comfortable environment and significantly enhanced modern learning, contributing to the global educational landscape.

Many researchers have attempted to design various types of smart classrooms [6, 7]. However, these designs often lack a comprehensive top-level design scheme and fail to utilize existing intelligent terminals and real-time monitoring methods fully. The main purpose of this project is to develop smart and responsive classroom settings that can automatically manage and monitor several aspects of the classroom, including lighting, air conditioning, security, and other environmental considerations. This will be achieved by using Raspberry Pi and Node-RED for the automation

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processes, and the results will be displayed using the Favoriot platform.

Despite advancements in smart classroom automation, many systems continue to demonstrate limited real-time adaptability, particularly in dynamically adjusting environmental conditions based on occupancy and sensor data. Some studies indicate that integrating IoT technologies can significantly enhance classroom automation by optimizing resource usage and occupant comfort. However, current systems often lack full utilization of cloud-based platforms, essential for achieving real-time responsiveness. Implementing the Favoriot platform as part of an adaptive environment enables automatic control of HVAC, lighting, and security systems, effectively leveraging real-time data to enhance both energy efficiency and educational experience. This paper addresses these challenges by proposing an IoT-based smart classroom automation system that utilizes the Favoriot platform to achieve real-time adaptability.

2. Literature Survey

This section summarizes other studies that have explored the use of IoT and software systems to create smart classroom environments. M. A. Rahman et al. (2021) created an IoT-based system to reduce campus electric power consumption by automating educational institutions' facial recognition for attendance, presence detection for appliance control, and smart lighting [8]. The system has demonstrated promising results in terms of accuracy and performance, indicating promises for further advancement in the fields of artificial intelligence and machine learning.

Although it may have limitations in terms of cost, scalability, and accuracy under specific circumstances, it provides an affordable and scalable approach for establishing an intelligent classroom setting in educational institutions.

Mustafa and Duraklar (2022) reported in "Design and Implementation of an IoT-Based Smart Classroom Incubator" that the study focused on the impact of ambient conditions on students' learning efficiency and health. A Smart Classroom Incubator (SCI) was designed to control parameters like temperature, humidity, light, and air quality [9]. The SCI system showed promising results, improving student performance and comfort, with an average score of 85 compared to 74 in a conventional classroom.

Vishnu Priya Reddy Enugala (2018) explored the implementation of a smart classroom system utilizing IoT technologies, an ARM microcontroller, RFID, GSM, and Bluetooth modules to monitor student attendance and seat occupancy [10].

The system utilizes cloud storage to save data and presents it on both a web page and a mobile application. Its primary objective is to streamline classroom administration. The method is useful in educational institutions and other settings requiring resource management and tracking attendance.

In 2022, a Federal University of Agriculture team presented a real-time monitoring system for smart classrooms utilizing Internet-of-Things technology. The paper explores the creation of a classroom seat allocation system that employs Arduino Uno and RFID tags based on IoT technology [3]. The method utilizes automation to allocate seats, resulting in time savings and enhanced accuracy. In areas where temperatures frequently exceed 40°C, a study underscores the need for efficient cooling systems, which directly impacts classroom comfort and energy management [11].

Recent research underscores the significance of intelligent classroom systems that automate cooling processes. These systems can automatically modify fans and lighting settings according to real-time conditions by employing ultrasonic sensors and temperature monitoring, minimizing manual interventions and enhancing energy savings. This adaptable strategy is crucial for establishing conducive learning settings and optimizing energy use, particularly in climates with elevated temperatures.

A thorough investigation reveals the development of a self-optimizing smart lighting system specifically for classrooms [12]. This technology adjusts illumination according to the educational context, optimizing brightness, color temperature, and distribution to improve students' performance and well-being.

It incorporates IoT and sensor technologies for accurate control, automatically adjusting to various teaching circumstances and permitting both human and scheduled modifications. This paper proposes a smart classroom automation system that uses IoT and cloud computing to control classroom conditions, including lighting, HVAC, and security.

Integrating a Raspberry Pi, Node-RED, and the Favoriot platform facilitates automated modifications depending on temperature, humidity, and occupancy sensor data. Technology maximizes energy efficiency while improving comfort and security in educational environments.

3. Methods and Materials

This involves using a Raspberry Pi 3 as the central controller, interfacing with various sensors and devices to automate and enhance the classroom environment. The system includes a temperature and humidity sensor for continuous environmental monitoring.

A motion sensor that detects the presence and triggers actions like activating the ventilation system when necessary, an NFC card reader for managing access control to ensure only authorized individuals enter, and a servomotor to control physical elements such as doors and windows.

Node-RED manages the data flow and executes decision-making processes, while the Favoriot Platform and MQTT broker facilitate efficient data streaming and analysis.

Figure 1 illustrates a smart classroom system where sensors send data to Node-RED for processing. Node-RED communicates with the MQTT broker to relay data to the Favoriot cloud and controls actuators. The Favoriot cloud manages data visualization on the dashboard and system responses.

Figure 2 indicates the system architecture of the smart classroom automation system. It comprises a Raspberry Pi interfaced with temperature, humidity, and motion sensors, along with an NFC module and a servo motor for control.

Node-RED facilitates data flow to the Internet, connecting the setup to the Favoriot platform for monitoring and management. This setup enables real-time data visualization and control of classroom environmental parameters.

Figure 3 illustrates the flowchart for the HVAC system, where motion detection triggers a temperature and humidity check, and sending data to the Favoriot cloud platform. Based on the inputs, the system decides whether to turn the HVAC system on or off.

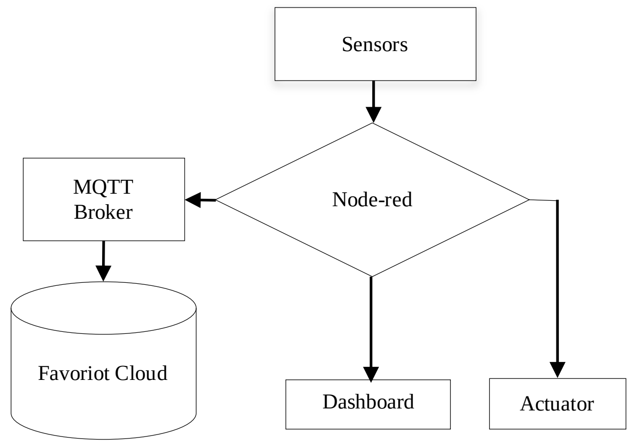

Fig. 1 Node-red system view

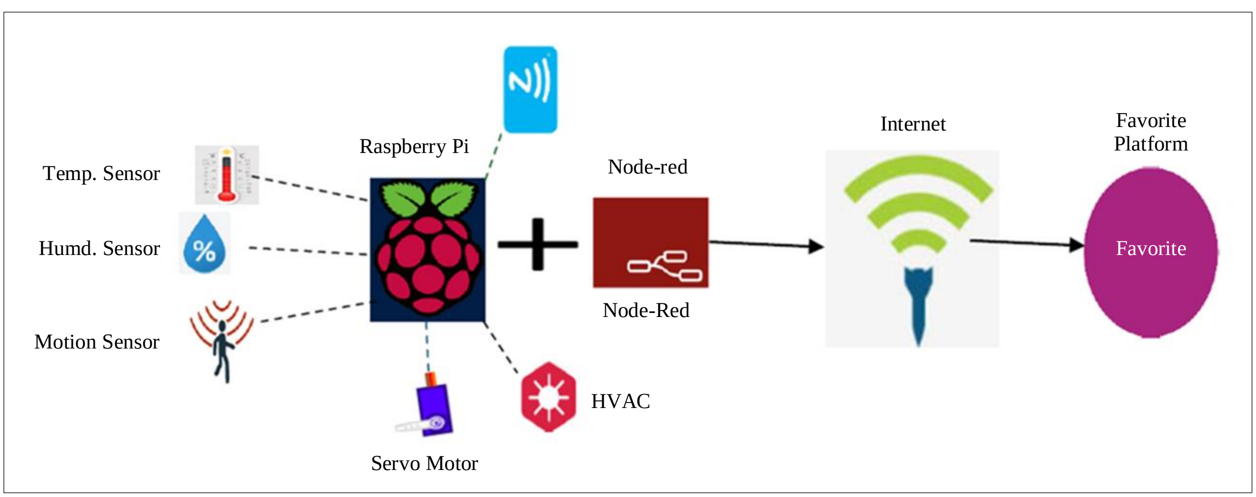

Fig. 2 System architecture of the proposed system

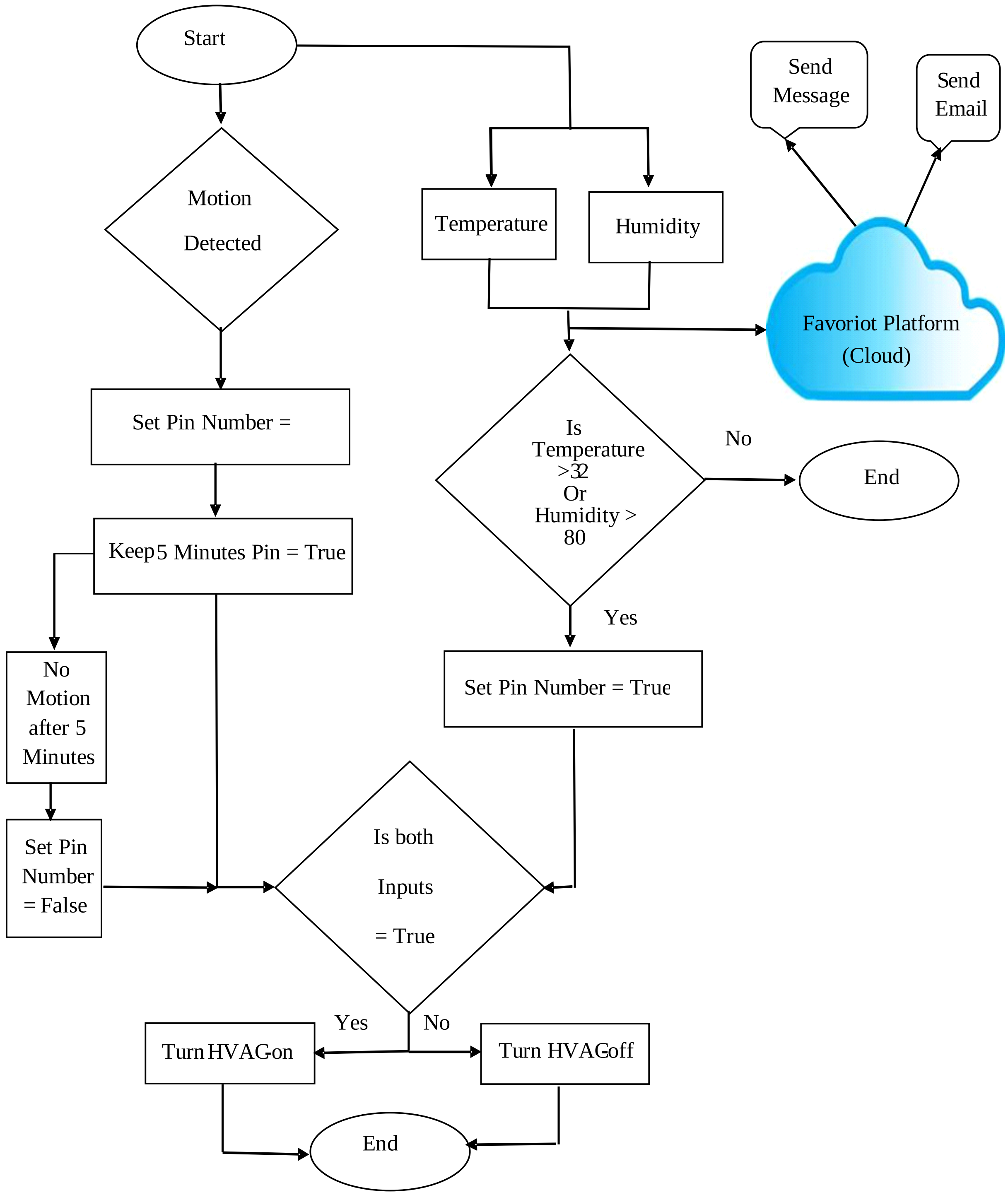

Fig. 3 Flowchart of the smart classroom HVAC system

3.1. Hardware Description

The project consists of a Raspberry Pi connected to a breadboard, which interfaces with various sensors and actuators, such as a motion sensor, NFC reader, and servo motor. This system automates classroom conditions by monitoring environmental data and controlling devices like HVAC based on real-time inputs. The system utilizes Node-RED and the Favoriot platform to monitor data processing and facilitate decision-making.

3.1.1. Raspberry Pi Microcontroller

In this smart classroom automation system, the Raspberry Pi acts as a central Microcontroller, handling sensor data processing and transmitting it to Node-RED. It enables communication with the MQTT broker and the Favoriot cloud platform, as well as controlling the HVAC system and other actuators based on the received data.

The Raspberry Pi 3 Model is a compact, cost-effective single-board computer with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor and 1 GB of RAM, suitable for programming education and IoT project development [13]. It features integrated Wi-Fi, Bluetooth, USB, HDMI, and GPIO ports, enabling diverse connectivity.

3.1.2. Motion Sensor

Smart classroom automation systems frequently use a Passive Infrared (PIR) motion sensor device, like the HC-SR501, to detect the presence or movement of individuals. Upon entering the room, the sensor detects body movement and activates automated responses such as lighting, temperature modifications, or ventilation management [14]. This model efficiently conserves energy by disabling gadgets while the room is unoccupied, improving efficiency and creating a comfortable, flexible environment.

3.1.3. Temperature and Humidity Sensor

This study's temperature and humidity sensor measures the classroom's environmental conditions. It sends data to the Raspberry Pi, which processes it via Node-RED. Based on this data, the system adjusts the HVAC and sends updates to the Favoriot cloud platform. This project is implemented by the DHT11 sensor. Basic environmental monitoring systems frequently employ DHT11, a basic, inexpensive digital sensor for temperature and humidity sensing. It delivers calibrated digital output, facilitating seamless integration with microcontrollers such as NodeMCU and Raspberry Pi [15].

3.1.4. NFC Card and NFC Reader

In this smart classroom automation system, the Near Field Communication (NFC) card acts as a secure, contactless access control mechanism, allowing entry exclusively for authorized individuals. The NFC card interfaces directly with the Raspberry Pi, which serves as a control hub by reading unique card identifiers and comparing them with a database of authorized users [16]. Upon detecting an authorized card, the Raspberry Pi unlocks the door or activates classroom functions, including lighting and system operations.

3.1.5. SG-90 Servo Motor

This project uses the SG-90 servo motor to control actuators, such as door locks, facilitating physical operations driven by sensor data and human inputs. Upon successful NFC card identification, the servo motor rotates to either lock or unlock the door, which allows access. Its exact control facilitates precise angular movements, making it suitable for secure locking systems.

3.1.6. HVAC System

In this project, the HVAC system handles the classroom's heating, cooling, and airflow by responding to the current temperature and humidity levels. It kicks in when the room gets too warm or humid and turns off if no one’s around for a few minutes. This smart approach helps save energy while keeping the classroom comfortable for everyone.

3.2. Software Description

The smart classroom automation system utilizes Node-RED software to deal with sensor data and control actuators. The device communicates with the MQTT broker and the Favoriot cloud platform to facilitate data management and remote monitoring. Furthermore, it incorporates algorithms for changing the environment and informing users about current conditions using current data. Figure 4 shows the Node-red flow of the proposed system. Table 1 shows the truth table of the HVAC system of the smart classroom automation system.

Table 1. Truth table of the HVAC system

Temperature	Humidity	Motion	Temperature + Humidity	(Temperature + Humidity) × Motion
0	0	0	0	0
1	0	0	1	0
0	1	0	1	0
1	1	0	1	0
0	0	1	0	0
1	0	1	1	1
0	1	1	1	1
1	1	1	1	1

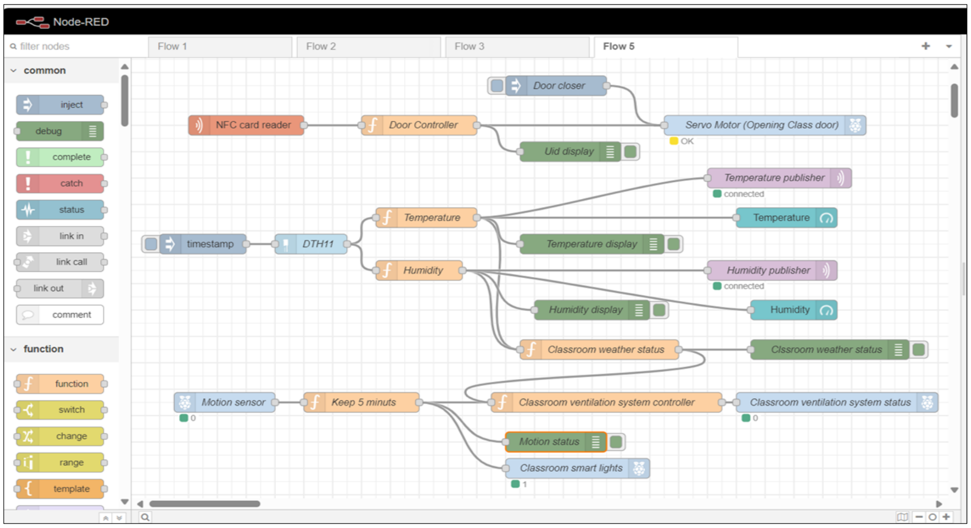

Fig. 4 Node-red flow of the proposed system

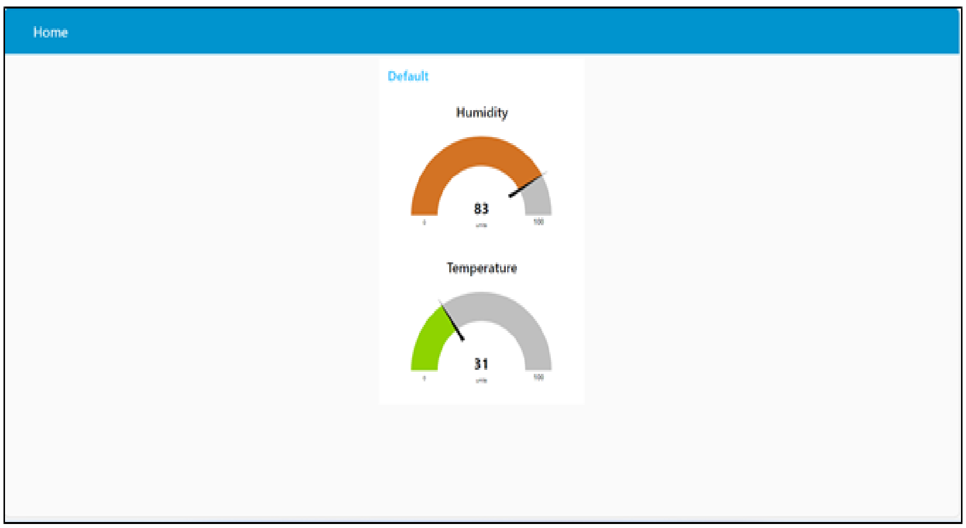

Fig. 5 Temperature and humidity results using gauge dashboards

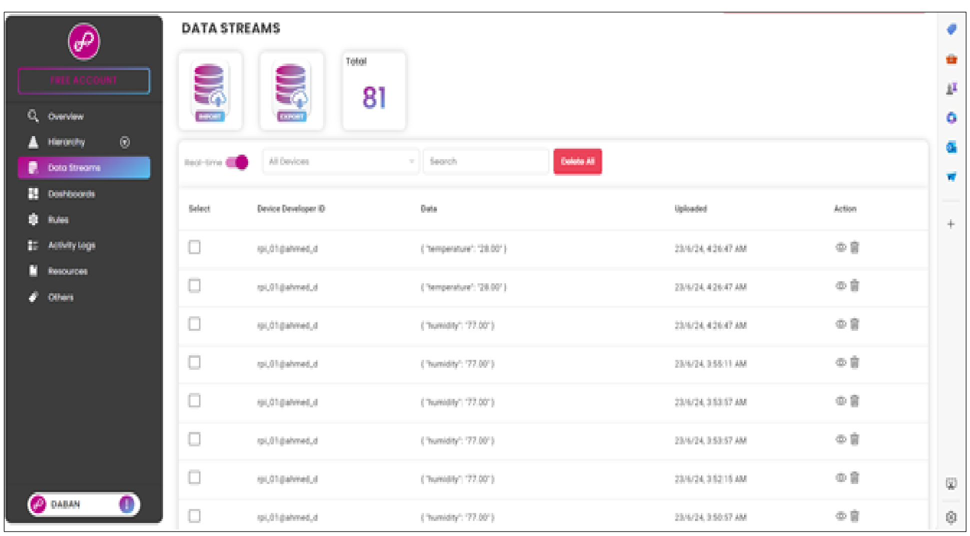

Fig. 6 Sending data favoriot platform

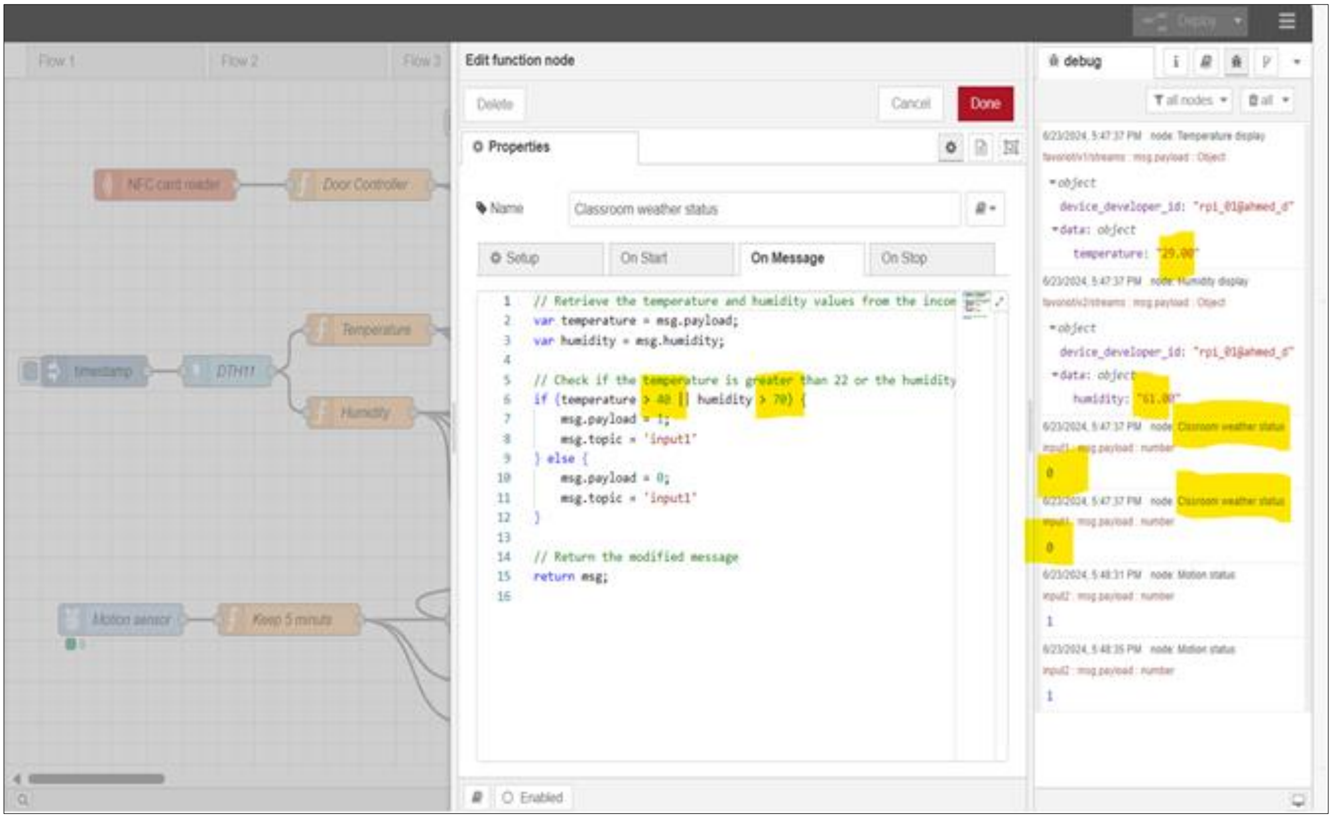

Fig. 7 System debug results

The truth table represents the Smart Classroom Automation System. The process begins with motion detection. The system activates a pin upon detecting motion and checks the temperature and humidity levels. If the temperature exceeds 32 °C or the humidity exceeds 80%, the system sends a notification to the Favoriot cloud platform.

The system automatically sets the pin to false if it detects no movement within five minutes. Only when both temperature and humidity criteria are satisfied does the HVAC system activate; otherwise, it remains inactive. The system can send notifications through either SMS or email, depending on the data provided by the cloud platform.

4. Results and Discussions

Figure 5 shows a dashboard with two-gauge charts displaying environmental data. The first gauge shows humidity at 83%. The second gauge shows the temperature at 31 degrees.

Actuators such as smart locks and LED lights enhance classroom comfort and efficiency. Users can remotely monitor and control the system via a web or mobile interface, with data stored and notifications managed through the Favoriot cloud platform and email, as shown in Figures 6 and 7.

The system detects motion, activates the HVAC when the temperature reaches 32 °C, or the humidity reaches 80%, and sends notifications via the Favoriot platform. If it detects no motion for five minutes, the system turns off the HVAC.

5. Conclusion

In conclusion, the development of the Smart Classroom Automation System demonstrates the significant potential of IoT technology to enhance educational environments. By integrating sensors, actuators, and a Raspberry Pi with Node-RED and the Favoriot Platform, the system successfully improves classroom comfort, productivity, and safety.

Despite challenges such as NFC reader issues, sensor calibration, and Raspberry Pi initialization problems, the system has effectively implemented itself with functional decision-making algorithms. Real-time, data-driven automation of HVAC control significantly boosts energy efficiency.

Additionally, the capability for remote monitoring and notifications ensures proactive management of classroom conditions. This project demonstrates the transformative potential of IoT in converting conventional classrooms into intelligent and adaptable learning spaces.

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