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Research Paper

Implementation of Mobile Applications and Voice Recognition in an IoT-Based System in the Server Room of PT. Ecocare Indo Pasifik

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Abstract: The progress made on the Internet of Things (IoT) has given an opportunity to people to have control over their home devices from afar using mobile applications. While PT. Ecocare Indo Pasifik (ecoCare) is still in the first few years of its journey through this new digital transformation era, there are some shortcomings on the way it handles its digital assets particularly in server room security aspects. Because IT infrastructure plays a pivotal role in ensuring operational continuity and reliability of company's information systems, maintenance of server room becomes vital. The resolution that can be undertaken would involve developing a system which will take care of the functioning of IoT technology driven by HomeKit for automating and keeping an eye on the server room environment remotely from any distance not specified. In conclusion, this study resulted into development a mobile application and voice recognition system based on IoT (internet of things) for use within the server room at PT. Ecocare Indo Pasifik that monitors temperature, humidity, flame as well as motion detection. Furthermore, it facilitates remote button and voice recognition commands for lighting or fan controls. The test results indicated that when given an input, this built system was operating without errors with good response times.

Keywords: Security; IoT; HomeKit; Control System; Voice recognition

Introduction

Indonesia, a swiftly emerging country, has huge potential to compete in the age of digitalization due to its massive quantity of internet users. The online market for Indonesia is large with an estimated formal e-commerce worth $5 billion and informal deals yielding about $3 billion (McKinsey & Company 2018). In 2017 alone, there were approximately thirty million Indonesians who shopped online out of a population that stands at roughly over two hundred and sixty million people; by 2025, it is predicted that this will generate another three point seven million more jobs. This process could help increase the revenue of Indonesian UKMs (Usaha Kecil & Menengah, Small & Medium Enterprises) by up to 80%, leading to an annual GDP growth rate of around two percent mainly through broadband as well as other technologies.

The Internet of Things (IoT) implementation in firms is a shift from the way businesses are done and value delivered to customers. Through exploiting IoT capabilities, companies can capture real-time information on their operations, streamline processes and improve decision-making. Digitalization has been moving at a fast pace across Indonesia necessitating firms from various sectors to upgrade their digital infrastructure. The design and construction of data center telecommunications infrastructure: specifications and guidelines considered as being important. One of the most important parts of this infrastructure is server rooms which keep essential data and run information systems. Familiarity with server room maintenance and its importance is mandatory for smooth IT operations performance and reliability. EcoCare Indo Pasifik (ecoCare) was established in 2007 as a consultancy company offering hygiene solutions expanded to broader cleaning services as well as pest control services. ecoCare has seen that with entering digital era along with diversified rivals it needed to incorporate digital transformation to sustain its market expansion and position itself in new markets.

In such internal applications, ecoCare has implemented several applications since 2021 for both internal and external use. Their sales targets management, approval forms and business process monitoring are all handled internally through an ERP system and web-based dashboard. TBI's mobile application is the connector between end-users and daily workers. These applications rely on a non- stop working on-premises server room to a great extent. However, there are several ways in which ecoCare's current server room infrastructure lags industry standards such as temperature control, cooling systems, and security. The recommended temperature range for server rooms is typically between 18°C (64.4°F) and 27°C (80.6°F), during which time the temperature of the ecoCare server room is below average. As far as the physical security aspect is concerned, it is important to put in place physical access control system that would stop unauthorized people into the server room. Following the standards of physical security controls, installation of security cameras and intrusion detection systems is recommended to monitor all unauthorized attempts.

Based on these limitations, the use of Internet of Things technology to control and manage the environment in server room can be recommended. Through IoT, space problems and optimal server conditions that are required for temperature, humidity, and airflow can be managed to avoid equipment getting too hot, and system breakdowns. Real time IoT connected sensors can help to optimise cooling or improve operational productivity.

Furthermore, through IoT, the access and the lighting of the server room can also be made more secure and energy wise. Implementation of IoT in this system helps in managing the control of people through the access of secured rooms where special features such as incorporated advanced locks to enhance security measures. Issues related to unauthorized access and unfamiliar operation of manual lighting controls can be solved through the precise use of presence sensors and IoT-embedded electronic locks when lights and access are needed at any time. Owns to this approach, energy is also conserved while the issue of security is also given a solid footprint.

Maintaining a server room according to physical standards demonstrates an organization's commitment to service quality and customer satisfaction. As it is common nowadays that more and more organizations and companies are turning to the internet to link each other, their customers and business partners are demanding high availability and quality of service. This often helps in boosting the confidence of the business partners through delivery of good services and products that meet their needs, thus boosting the image of the organization. Thus, by keeping priorities in the server room area, the ecoCare can be of much more relevance to handle IT issues and, therefore, obtain a competitive advantage in the environment where the work processes are constantly becoming more and more digital.

The paper titled "Implementation of Mobile Applications and Voice Recognition on IoT-Based Systems in the Server Room of PT. Ecocare Indo Pasifik" aims to develop a new concept of IoT system for increasing productivity, security, and ease for ecoCare. The expected result will enhance the company's efficiency of operations and will work towards ecoCare's digital strategy map.

Literature Review

In this study, the researchers reviewed references from previous studies conducted by earlier researchers, as shown in Table 1.

Prior research works have already presented different approaches and technology integration to improve security and effectiveness in connection to IoT and voice control in areas of smart homes and laboratories. For instance, Torkis Nasution et al. (2024) implemented an RFID and voice recognition for door security and access control system; Wahyu Triyoga et al. (2023) used IoT with RCWL, a motion detecting sensor in Laboratories. Unlike these studies, the research that is to be conducted by PT. Ecocare Indo Pasifik's objective is to adopt mobility applications and voice recognition system in an IoT configuration of business server for corporate organizations. This research intends to enhance organisation operate performance and availability of security, temperature control in server rooms, and the lighting control for power efficiency. Moreover, it will employ ESP32 and ESP8266 micro controllers together with HomeKit for remote control which are the aspects not focused on the prior studies

Table 1. Previous Literature

Author	Title	Summary
Torkis Nasution, Herwin, Khuearei Andesa	(RFID and Voice Recognition Based Dual Security System: A Robust Secured Control to Access Through Door Lock Operation)	Based on the results of the tests, the RFID sensor succeeds to identify itself with the cards up to a distance of three cm – a response time that vary between ms 70 up to 1. 32 seconds. The Speech to Text system captures the conversion of voice to text up to the distance of 100 cm and voice features as per the decibel levels. This system can store user data in the terminal and the Python application. The satisfaction rate for the RFID system usage is 93.84%, and for the Speech to Text system, it is 67.04%, based on the questionnaire results. This device aims to unlock doors and determine student seating in the laboratory.
Wahyu Triyoga, Yoedo Ageng Suryo, Rini Puji Astutik	(Design of a Security System for Laboratories Based on the Internet of Things Using RCWL as a Motion Detector)	This device incorporates Wemos D1 board having ESP32-CAM as micro controller, RCWL 0516 PIR motion sensor, RIDF module, magnetic switch, solenoid lock door and functional buzzer. The RCWL 0516 sensor is affordable, energy efficient, reliable, and can easily be modified for home automation use. The disadvantages are RFID only unlocks the solenoid door lock and Wemos does not respond to RFID input when unlocking. Also, the OV5640 camera sensor is not feasible for the ESP32- CAM.
Angshuman Chakrabartty; Ashish Adhikari; Jurisra Sorokhaibam; Nirmala Devi	(Smart Home Implementing IOT Technology with Multilingual Speech Recognition System)	This research therefore presents an efficient, cost effective and easy to use home automation system that outperforms those using Bluetooth technology. Depending on the selected model, the system uses Bluetooth and Wi-Fi modules, supports multiple languages in voice recognition, and phone application allows to join up to 18 devices. During testing the system scored 100% when the range was within 10m using Bluetooth and the Wi-Fi covered a broad area.

Method

The analysis of the tools and materials needed for implementing IoT for building a smart home system for the users with mobility limitations is carried out in the methodology section of the IoT server room research paper. These tools are divided into two categories: The computer always has two correlated components including the hardware and the software.

The primary hardware components utilized in this research include: The components used to develop this project include NodeMCU ESP8266, Relay, Solenoid, DHT 11, IR flame, and PIR Motion Sensor. On the other hand, the main software requirement includes Arduino Integrated Development Environment, including the various sensors' libraries and the home applicant.

The structure of the IoT system in this study is divided into design development, hardware construction, the system's development, integration, and validation. The framework of the proposed voice-controlled device management system together with IoT is presented in Figure 1. This system consists of three modules: input module, control module, more specifically the microprocessor, and the output module.

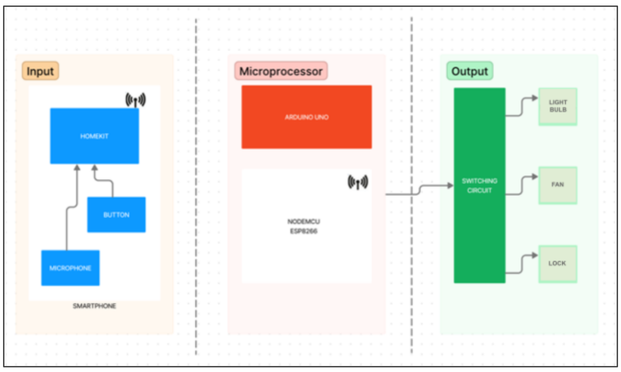

Fig. 1. Device Design Concept hardcopy

As depicted in Figure 2, the setup comprises a NodeMCU8266 microcontroller, and a USB cable directly connected to the ESP8266. The microcontroller acts as a central hub for all the sensors and actuators used in this study since it relays information that can be represented on a dashboard, in this case, HomeKit. Also,

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the setup includes a temperature and humidity sensor DHT11, PIR motion sensor, IR flame sensor, relay actuators for lights and the fan, and relay-solenoid for the lock. Based on an illustratation of the device designed above; to help understanding the logic operates on the device a pseudocode is given below in Table 2.

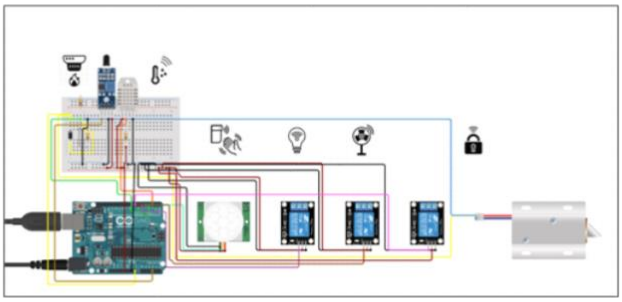

Fig. 2. Device Design Integration

Table 2. Pseudocode of Research Device

```
START

Initiation:
  Include the necessary libraries and configurations
  Connect to Wi-Fi using specified credentials Declare pins for
sensors and relays
  Configure HomeKit accessories
End
Function SetupHomeKit()
  Set up HomeKit communication
    Set initial state of RELAY_PIN and RELAY_PIN2 to OFF
    Define action for controlling lock mechanism
End
Function ControlLock(value)
  Get command from iOS Home app
  if state = 0 to lock and if state = 1 to unlock the door
  Perform corresponding action and Notify HomeKit about the current
lock status
  Log “unsecure” when state =0 and “secure” when state = 1
End
Function ControlLamp(value)
  Get command from iOS Home app
    if boolean = ON then RELAY_PIN = LOW to turn on lamp
    if boolean = OFF then RELAY_PIN = HIGH to turn off lamp
    Adjust lamp state based on the command
End
Function ControlFan(value)
  Get command from iOS Home app
    if boolean = ON then RELAY_PIN2 = LOW to turn on fan
    if boolean = OFF then RELAY_PIN2 = HIGH to turn off fan
  Adjust fan state based on the command
End
Function UpdateSensorData()
  Read temperature, humidity, motion, and flame sensor data
  Update HomeKit with the latest sensor readings
  Log the sensor values
End

END
```

The provided code sets up a HomeKit-enabled system using an ESP8266 microcontroller. All in all, the code currently links to HomeKit, continuously reads values from the sensors, and corresponds with the iOS Home App to perform someone’s commands as a simple home automation with the ESP8266 microcontroller is shown.

Research Instruments

From Table 2, it is illustrated that the pseudocode is created to connect to different sensors and/or actuators from HomeKit through a NodeMCU ESP8266 microcontroller. Among the key items in this configuration, we have a NodeMCU ESP8266 microcontroller, a DHT11 temperature and humidity sensor, a PIR motion sensor, a flame sensor, relays and HomeKit integration for the monitoring and remote control. The general objectives are to increase the security level and monitor the environment of a server room.

The NodeMCU ESP8266 is a popular microcontroller with built-in Wi-Fi, making it ideal for IoT projects. It connects to the server room Wi-Fi network of PT. Ecocare Indo Pasifik, allowing remote interaction via HomeKit. The microcontroller interfaces with DHT11, PIR and relays, reading data and executing commands from the HomeKit app.

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It is suitable to be used in this research as it holds the temperature range from 0 to 50°C, with humidity range of 20% to 90% RH, this sensor is widely used in various applications due to its simplicity and affordability. The DHT11 sensor issuing fundamental information for controlling the environment of the server room. This information is important for managing the conditions needed within the servers’ environment. The code obtains the sensor data at regular intervals and inform HomeKit to keep updating the current value.

In order to ensure high security of the server room, a motion sensor (PIR) is fitted to sense movement within the specific room. It detects motion by measuring changes in infrared radiation levels emitted by surrounding objects. This helps to boost security because administrators are informed of any unspecified movement around the entrance of the server room. The sensor status is monitored and reported to HomeKit, allowing for real-time intrusion detection.

An IR Flame Sensor with 5-channel is designed to detect infrared light emitted by flames. The sensor has five independent channels, each with its own IR detector. This allows for a broader detection angle and higher accuracy in identifying the direction of the flame.

Relays control off-board devices, such as lights and fans. These relays are connected with a lamp and fan in this setup Thanks to HomeKit commands, users can toggle these devices on or off as well, so they never need to stop by the exact position of certain device. This can even be used to control the lighting and airflow in server rooms, thus helping maintain a regulated level of ambient electromagnetic radiation.

HomeKit provides an easy user interface for control and monitoring regarding security and environment in the server room. End-to-end encryption, secure pairing and the ability to integrate with Siri based on HomeKit Accessory Protocol (HAP) share a compatible handling for voice commands. For driver communication between NodeMCU & HomeKit, the arduino_homekit_server library is used. The HomeKit used in this research as it can direct define some characteristics such as temperature, humidity, motion detection, flame detection, and the states to control lamp and fan switch.

Implementation & Experimental

The detailed description entails the hardware setting up for mobile applications and voice recognition systems on a server room of PT. Ecocare Indo Pasifik, which is IoT-based. The installation comprises a NodeMCU V3 microcontroller and several sensors: DHT11 for measuring temperature, PIR for motion detection, IR flame for flame detection, and Solenoid control to support automatic door locking. It also includes two relays for electrical control, like lamps and cooling fans. These hardware components are integrated into a unified system, as illustrated in Figure 3 given below.

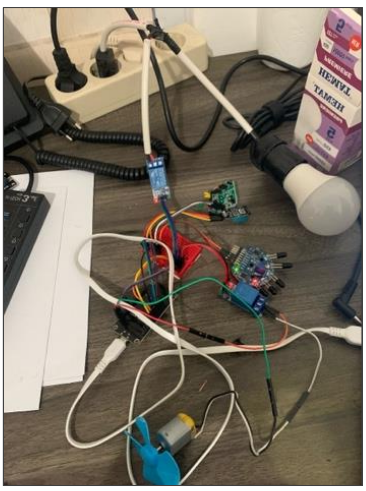

Fig. 3. Hardware Components

The software implementation details the development of software to control the mobile application and the voice recognition on an IoT-based system at the server room of PT. Ecocare Indo Pasifik. Apple HomeKit was utilized as the protocol for smart home control via iOS operating system.

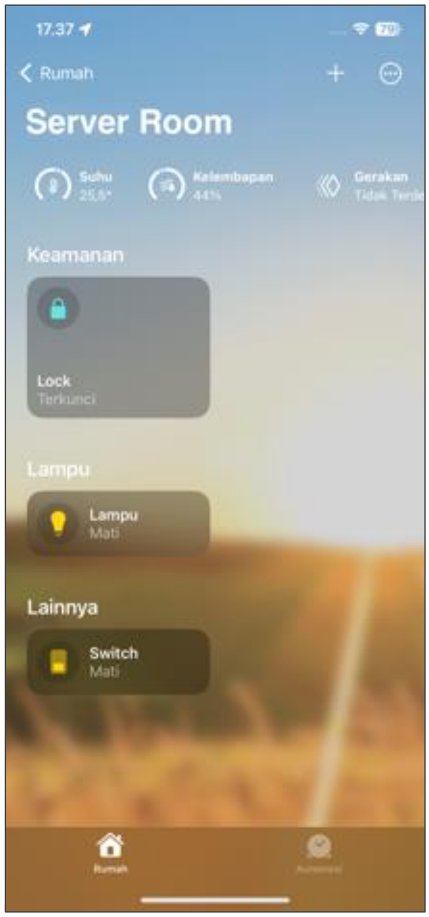

Fig. 4. HomeKit Dashboard View

The actuators, including Solenoid Relay, Lamp Relay, and Fan Relay, along with the motion, and flame sensor all exhibit binary outcomes (0 or 1, HIGH or LOW). However, the DHT11 sensor gives a broader range of results, measuring temperature from 0 to 50 degrees Celsius and humidity. In order for this sensor to be tested accurately, external factors would be introduced to the experiment. For this experiment, the temperature variation on the DHT11 was artificially created with a Hairdryer. This would ensure drastic changes in temperature. Considering the DHT11's temperature reading accuracy of approximately 2-3 degrees Celsius, the hairdryer experiment was chosen due to its average temperature of around 60 degrees Celsius. The results of experiment on DHT11 are given on Table 4.

Results

After completing the implementation phase, the next step is testing. This stage involves constructing devices based on the design outcomes, including both software and hardware. Implementation entails the actual execution of the software and hardware discussed in the preceding chapters.

Hardware Results

Hardware testing was conducted to assess the functionality of the built hardware. The purpose was to measure the success rate of the device. The testing results are as follows in Table 3.

Table 3. Hardware Results

No	Testing Scenario	Expected Outcome	Device Result	Testing Status
1	User press button to LOCK	Door locked	Solenoid locks the door	Success
2	User press button to UNLOCK	Door Unlocked	Solenoid unlocks the door	Success
3	User press lamp button ON	The light is on	The relay supplies current to the lamp, causing it to light up.	Success
4	User press lamp button OFF	The light is off	The relay cut off current to the lamp, causing it to light up.	Success
5	User press *switch* button ON	The fan is on	The relay supplies current to the fan, causing it to spin on.	Success
6	User press *switch* button OFF	The fan is off	The relay cut off current to the fan, causing it to spin off.	Success

Based on hardware testing, it can be concluded that the developed software functions properly without any functional errors. The response time generated from DHT11, relay with solenoid, and relay with lamp averages in less than 1 second, in which delivered closely to real-time response. Meanwhile for DHT11 delivered update of temperature and humidity for every 1 second. The built hardware provides swift responses in accordance with the given inputs.

To further diversify the results for the DHT11 sensor, an experiment concerning temperature manipulation using a hairdryer was conducted. The objective of the experiment was to prove that with a temperature margin of error of ±2°F and humidity of ±5% RH, the sensor can capture prominent changes in temperature. The results of the DHT11 experiment are provided in Table 4 below.

Table 4. DHT11 Experiments

No	Testing Scenario	Expected Outcome	Device Result	Testing Status
1	DHT11 with no hairdyer	Room Temperature	Recorded 24°C	Success
2	DHT11 with low heat hairdyer 1st attempt	>37.5°C	Recorded 46°C	Success
3	DHT11 with low heat hairdyer 2nd attempt	>37.5°C	Recorded 50°C	Success
4	DHT11 with low heat hairdyer 3rd attempt	>37.5°C	Recorded 50°C	Success

Experiments were conducted using a hairdryer set to a low heat mode with an average temperature of 60°C to 70°C. The experiment was carried out four times: once without hairdryer intervention and three times to observe the effect of the hairdryer. The hairdryer intervention was expected to produce temperature outputs above 37.5°C, which is the midpoint of the upper temperature range for the DHT11 (25°C-50°C). The three resulting temperature outputs from the DHT11 were 46°C, 50°C, and 50°C, respectively. It means that it is because of extreme temperatures that the three experiments conducted with the DHT11 were successfully impacted and led to variations of output different from the room temperature.

Software Results

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Do not use abbreviations in the title or headings unless they are unavoidable. Blackbox testing was performed on the system, as it dealt only with the functionality of the developed application. It involves execution of the software and noting down the results to check if they are according to the expected outcomes. Every testing case points to some scenario tested to ensure that system works as expected. The table has numerous columns, such as the testing case, the scenario under which it is tested, the expected result, and the status of whether the test was successful or denied. The results of the software testing are presented in Table 5.

In all cases, the performed actions met expectations for being reliable and effective in controlling and monitoring room environments with manual and voice-activated commands. Based on the software testing conducted, it can be concluded that the developed software functions properly without any functional errors.

Table 5. DHT11 Experiments

Testing Case	Testing Scenario	Expected Result	Status
Display Temperature	User in dashboard view	The system can display room temperature	[√] Success [ ] Denied
Display Humidity	User in dashboard view	The system can display room humidity	[√] Success [ ] Denied
Motion Detection	User in standby mode	The system can detect motion	[√] Success [ ] Denied
Flame Detection	User in standby mode	The system can detect flame	[√] Success [ ] Denied
Lock Security	User presses the button to lock the room door	The system can activate the solenoid to lock the room door	[√] Success [ ] Denied
	User presses the button to unlock the room door	The system can activate the solenoid to unlock the room door	[√] Success [ ] Denied
	User says to Siri, “Turn on door”	The system can activate the solenoid to lock the room door	[√] Success [ ] Denied
	User says to Siri, “Turn off door”	The system can activate the solenoid to unlock the room door	[√] Success [ ] Denied
Light status	User presses the button to turn off the room light	The system can activate the relay to cut the current to the room light, turning it off	[√] Success [ ] Denied
	User presses the button to turn on the room light	The system can activate the relay to provide current to the room light, turning it on	[√] Succss [ ] Denied
	User says to Siri, “Turn off light”	The system can activate the relay to cut the current to the room light, turning it off	[√] Succss [ ] Denied
	User says to Siri, “Turn on light”	The system can activate the relay to provide current to the room light, turning it on	[√] Succss [ ] Denied
Fan Switch	User presses the button to turn off the room switch	The system can activate the relay to cut the current to the room fan/cooler, turning it off	[√] Succss [ ] Denied
	User presses the button to turn on the room switch	The system can activate the relay to provide current to the room fan/cooler, turning it on	[√] Succss [ ] Denied
	User says to Siri, “Turn off fan”	The system can activate the relay to cut the current to the room fan/cooler, turning it off	[√] Succss [ ] Denied
	User says to Siri, “Turn on fan”	The system can activate the relay to provide current to the room fan/cooler, turning it on	[√] Succss [ ] Denied

SUS Evaluation

The SUS measures in a way of evaluation that is to be applied to measure the ease, speed, errors, and satisfaction of users regarding a system. In this study, the application was tested using the SUS questionnaire with 10 respondents, consisting of 10 statements rated on a five-point scale from "Strongly Disagree" to "Strongly Agree." As shown in Figure 5, the scores in SUS are based on the attempt to determine the usability of the application.

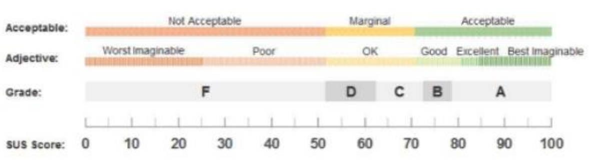

Fig. 5. SUS Score Interpretation

Based on the SUS score obtained, it can be concluded that the SUS score of 89.75 falls within grade B, categorized as Excellent.

Hardware Testing

The hardware tests did validate the success of functionalities related to door locking, light, and fan control via relay, as well as in registering the DHT11 temperature sensor sensitivity in detecting minor changes in temperature. This shows that the hardware works very well with no major functional faults, in line with the original idea of better temperature control and control of access to the server room.

Software Testing

Black box testing of the software system confirms that the system can successfully demonstrate temperature and humidity data and detect movement with relevant warnings. Security controls, such as locking and opening room doors via physical buttons or voice, also run flawlessly. Therefore, these tests confirm the successful implementation of improving operational efficiency and security for ecoCare server rooms.

Conclusion

This study implemented mobile application and voice recognition on an IoT-based system in the server room of PT. Ecocare Indo Pasifik. The findings of this research can be summarized as follows: Firstly, the successful development of mobile application and voice recognition on the IoT-based system provided active sensor monitoring and real-time remote control, overcoming manual monitoring challenges and human errors in maintaining server room security, thus reducing system failure risks. Secondly, the system effectively addressed the issue of unprotected server room doors through motion detection and automatic locking features, enhancing security. Thirdly, temperature fluctuations in the server room were managed through temperature and humidity sensors, with experiments demonstrating the system's ability to regulate temperature effectively, including the option for additional cooling, if necessary, all controllable via software interface for convenience. Fourth, energy wastage from manual light switches was minimized through light switch control features, contributing to temperature regulation and overall server room security, with added functionality to monitor light status. Lastly, the implementation evaluation demonstrates successful hardware testing validated functionalities such as door locking, light control, and fan operation via relays, and the temperature sensor DHT11's sensitivity in detecting temperature changes. Meanwhile, blackbox testing of the software system confirmed its capability to display temperature and humidity data, detect motion, and manage door security effectively. Overall, this implementation has improved operational efficiency and security for the ecoCare server room.

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Author’s Contributions

Both authors contributed equally to the preparation, development, and publication of this manuscript. The first author was primarily responsible for the development of the research, while the second author provided significant guidance and shared broad insights that enriched the study.

Ethics

The results indicate that there should be fingerprint sensors and checking access permission by monitoring can allow access only for users who authorized accessing to server room. Finally, as we successfully integrated flame sensors with NodeMCU but probing smoke first is an important part of precautionary measures hence there are different smoke sensor that can be incorporated to HomeKit. Finally, adding the option to have cameras integrated with HomeKit for room visual monitoring could bolster security enforcement. Lastly, expanding the system's compatibility with other platforms, such as Android devices for control and a website for sensor monitoring, would improve accessibility and usability.

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