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Real-Time Web-Based Monitoring System for Temperature, Humidity, and Solar Panels in Ramie Drying Facilities

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Abstract.
Purpose: To address the manual monitoring challenges in processing ramie fibers, especially during drying. The purpose is to create a monitoring system that oversees room temperature, humidity, and the status of solar panels, crucial factors in ramie productivity.
Methods: Real-time web-based system development that monitors room temperature, humidity, and the performance of solar panels in a ramie drying room using the Internet of Things architecture ESP32 with communication through GSM SIM 800L in rural areas.
Results: The system can display real-time information such as temperature data, humidity, and electrical energy parameters derived from the solar panel's utilization in the ramie drying room. By doing so, users gain efficiency and effectiveness in obtaining information, significantly enhancing ramie fiber productivity.
Novelty: Integration of sensor instruments, low-power ESP32 microcontrollers, GSM Telecommunication, Solar Cell Energy as a power source, and a real-time web-based Monitoring Information System implemented in a ramie drying dome. This simplifies the monitoring process and optimizes limited resources such as space, energy, telecommunications, and human resources, which are typically constrained infrastructure in the ramie fiber agricultural system.

Keywords: Ramie, Website, ESP 32, SIM 800L, MySQL
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INTRODUCTION

Technology has become a necessity, and it cannot be separated from the lifestyle of human development, which is increasingly dependent on technology [1]. The development of technology in the present era has progressed rapidly [2], especially in the field of agriculture [3]. Agriculture plays a crucial role in advancing the economy of society. The agricultural sector in Indonesia is constantly confronted with issues that make it difficult for farmers every year. With the advancement of technology in the agricultural sector, it is hoped to enhance the quality of agricultural products and make it easier for agricultural sector managers to achieve optimal results [4], [5].

Ramie plant is a perennial plant with the scientific name Boemeria Nivea L. Gaud, cultivated in several locations, including Central Java, West Java, Lampung, and South Sumatra. Still, ramie farming efforts have been established the longest in the fourth year in Wonosobo Regency, Central Java Province [6]. Ramie bears a resemblance to cotton, as it produces comfortable-to-wear textile fibers [7]. Research findings indicate that ramie fibers can be used as a supplement to cotton or blended with other natural and synthetic fiber materials. The natural fibers produced are then processed, starting from the ramie bark separation (decortication) process, combing, degumming, and drying the ramie fibers in a specialized room or dome [8]. Ramie fiber drying requires room temperature and humidity monitoring to enhance ramie productivity. The current monitoring process is conducted manually. The Admin user requires a system remotely monitoring room temperature and humidity performance.

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Research on ramie development in Wonosobo Regency is essential due to its significant ramie production, which holds high economic potential in industries like textiles and paper. Wonosobo's climate and environment are conducive to ramie growth, making it an ideal location for research to enhance production and quality. Additionally, involving the experienced local ramie farming community can provide valuable insights and promote sustainable development.

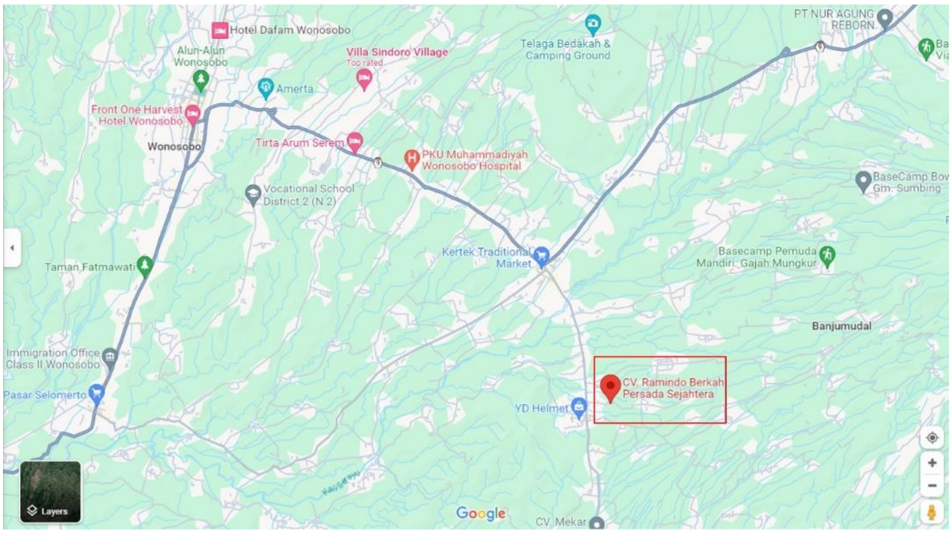

Figure 1. Location map of ramie plant research in Central Java, Indonesia

Based on the provided background, a monitoring system is necessary to oversee room temperature and humidity [9], [10]. In this research, the proposed solution is to develop a real-time web-based monitoring system titled "Real-time Web-Based Monitoring System for Temperature, Humidity, and Solar Panel in Ramie Drying Room." This system will display monitoring information such as temperature, humidity data, and electrical energy parameters obtained from the real-time application of solar panels in the ramie drying room. This system is expected to provide users with efficiency and effectiveness in obtaining information [11], [12].

Several studies regarding temperature and humidity monitoring systems have been conducted. One of the previous research case examples is related to onion drying, where a discussion took place regarding a temperature and humidity monitoring system in a red onion drying room using a web-based platform. Using the Raspberry Pi 3 model B+ as the microprocessor, the DHT22 temperature and humidity sensor was employed for detecting temperature and humidity, along with the Logitech c270 Webcam for monitoring the drying room's condition [13]. The system design comprises three main parts: input, process, and output [14].The input section comprises the DHT22 sensor and the Logitech c270 Webcam camera sensor. The process involves reading the temperature, humidity, and camera sensor data, which are sent to the Raspberry Pi 3 server and then forwarded to the web server [15]. The output section of the system is a website that displays graphical data of temperature and humidity in the onion drying room. The drying room's displayed temperature and humidity data are obtained from the stored database.

In contrast, the real-time video monitoring data of the onion drying room's condition is directly obtained from the camera sensor readings via Raspberry Pi 3. Based on the conducted testing, the successful sensor readings meet the monitoring requirements for the drying room's condition [16]. However, in this study, the website only supports monitoring, and the monitoring data cannot be downloaded yet.

Other research related to the development of IoT-based temperature and humidity monitoring systems in server rooms. This study discusses a temperature and humidity monitoring system in a server room using ESP8266 Node MCU as the central controller and DHT11 sensor for temperature and humidity sensing. NodeMCUESP32 isconnectedtovoltage,currentandrelay sensors [17]. The collected data is then transmitted to the Telegram application installed on a smartphone [18]–[20]. The monitoring system aims to provide real-time room temperature and humidity monitoring to reduce hardware and other damages. The workflow of this monitoring system begins with the calibration of DHT11 and MQ-2 sensors. The DHT11 sensor reads temperature and humidity data in the server room, which the NodeMcu ESP8266 module processes [21]–[23]. The data obtained from the DHT11 sensor readings is then sent to the Telegram application on a smartphone, and the output data is displayed on a 16x2 LCD screen [24], [25]. The MQ-2 sensor detects smoke in the server room, triggering a buzzer to sound ten times as a warning notification. Testing results indicate that the monitoring system operates well for 24 data collection cycles, with an accuracy of 90%. However, this study has not yet incorporated multiple sensors for increased responsiveness and lacks a data storage feature for displaying reports within the system [26]–[28].

Another study has been developed in the case study of the prototype development of automatic temperature and humidity measurement devices. This device can be integrated into a web-based monitoring system to enhance scalability, making it more effective and efficient. The system employs two methodologies: hardware architecture using a DHT22 sensor, Arduino Uno, and Ethernet Shield and software architecture that displays temperature and humidity data on the web and an LCD [29], [30]. The web-based measurement results display continuously updated data according to the input data from the measuring device, with a delay corresponding to the time needed for the measuring device to transmit the measurement data. The functionality of the web as software can be tested based on the proper functioning of each webpage according to its purpose [31].

After discussing several temperature and humidity monitoring systems studies, some still lack integration with the Internet of Things (IoT) and do not yet have additional features. The displayed data is not very detailed. Thus, in this research, the focus is on creating a real-time web-based monitoring system for temperature, humidity, and solar panels within a drying chamber integrated with the Internet of Things (IoT). This system will be able to display data in graphs and tables, showing the solar panel temperature, humidity, and parameters. This data can be processed for effective and efficient ramie productivity inventory. In this research, the contribution lies in designing a monitoring system that involves multiple sensors connected to the ESP32 device, equipped with the GSM800L SIM module, with an Internet of Things (IoT) architecture. In the location, there are challenges in designing IoT due to it being situated in a rural area; therefore, the IoT architecture is designed using Narrowband IoT (NB-IoT). A novel approach is introduced that leverages session data from users to improve the recommendations for the next web page they might visit. This hybrid page ranking model is the result of merging two different page ranking techniques [32]–[34].

METHODS

Hardware and Software Materials

At the system design stage, the design process begins with the hardware and software design to be used, as well as time management for creating a web-based system for monitoring temperature, humidity, and solar panels [35]. The system designed uses hardware components including ESP32, Sim 800L, General Packet Radio Service (GPRS), Analog to Digital Converter (ADC), Inter-Integrated Circuit (I2C), solar panels, BH1750 light intensity sensor, DC voltage sensor, ACS712 current sensor, INA219 sensor, relay, Liquid Crystal Display (LCD), battery, Solar Charge Controller, Power Supply, DHT 22, and a fan. The software used includes the CodeIgniter Framework, MVC (Model-View-Controller), MySQL, PHP, CSS (Cascading Style Sheet), XAMPP, HTML5, and a Database Management System (DBMS).

Internet of Things Architecture

The architecture developed for the Rami drying dome consists of several components. The first part is the Device, which comprises a microcontroller device, the ESP 32, serving as the input and output sensor control unit. The second part is Connectivity, which includes the GSM Sim 800L for data communication between the device and the GSM base station. The third part is the Database, utilizing MySQL as the data storage solution. The fourth part is the User Apps, serving as the user interface for controlling the system.

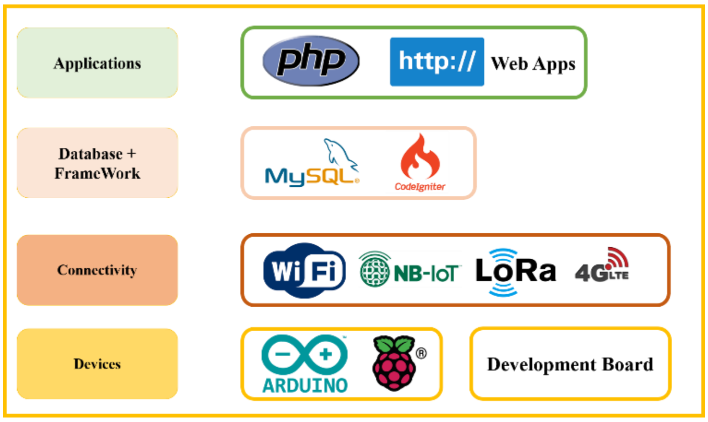

Figure 2. Internet of things architecture

Block Diagram of The Overall Ramie Drying System

The design of the system in this temperature, humidity, and solar panel monitoring system consists of three parts. The first part is a monitoring system for air temperature, air humidity, and Ramie humidity parameters inside the Ramie drying room using the Node MCU and transmitting the data to the ESP32 microcontroller with SIM 800L. The second part is an outdoor solar panel parameter monitoring system using a Solar Charge Controller that limits the charging of various solar panel parameter sensors. The third part is a web-based monitoring system that displays data in the form of graphs and tables from the monitoring and serves as the output of the database. Figure 3 is the system design for the solar panel parameter monitoring system up to the website and android application.

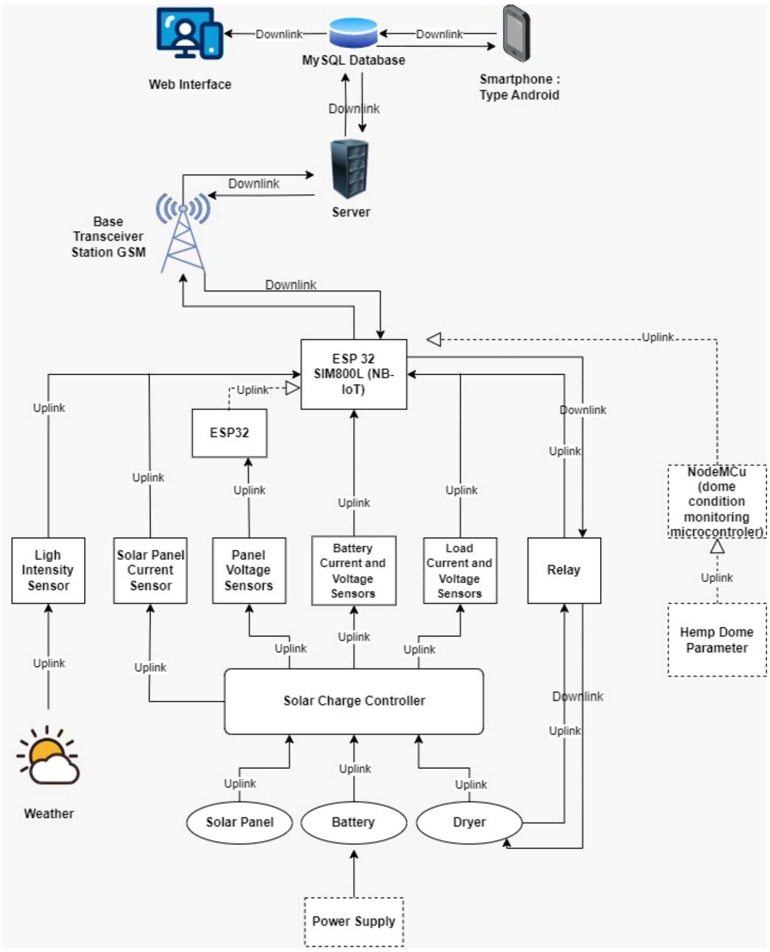

Figure 3. Design of temperature, humidity, and solar panel monitoring system

System Use Case Design

The use case diagram illustrates how the admin user interacts with the system, including login, accessing the admin dashboard, and monitoring temperature, humidity, and solar panel parameters. It also involves managing inventory, sensors, and users. This diagram helps in understanding the system's functionality and data retrieval. Creating this temperature, humidity, and solar panel monitoring system involves developing a web program using HTML, PHP, CSS, and Javascript programming languages. Preparing all the software requirements, such as Notepad++ and XAMPP is the first stage in creating this system's web monitoring. The system workflow from the database to the user starts when input data from the system is received. The web administrator will store and manage the database, turning it into an information system accessible through the web. Users can access the web via PC desktops, laptops, or smartphones connected to the internet.

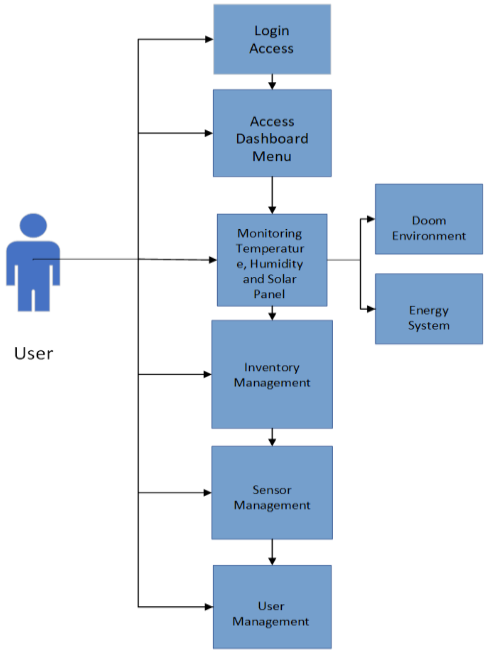

Figure 4. Use case diagram

The system design includes a login process requiring users to enter their credentials to access the dashboard. The dashboard provides access to two main sections: "Dome Environment" for monitoring temperature, humidity, and Ramie data, and "Energy System" for monitoring solar panel parameters. Users can view, download, and analyze data in the form of customizable date ranges, graphs, and tables. Additionally, the system offers inventory management, enabling users to input and search Ramie data, sensor management for sensor configuration, and user management for user access control.

Monitoring System Flow Diagram

There are two devices: the ESP32, which functions as a controller for input and output sensors, and the ESP32 SIM800L for serial communication with the cloud. For the ESP32Sim800L, the process starts with receiving data from the ESP32 and reading battery voltage using a voltage sensor, load voltage using a load voltage sensor, solar panel current using the ACS712 sensor, battery current using the ACS712 sensor, load current using the ACS712 sensor, and then light intensity data using the BH1750 sensor. Subsequently, the data readings are displayed on a 20x4 LCD. After appearing on the LCD, the ESP32Sim800L attempts to connect to the internet. If the internet connection is successful, the data is sent to the database.

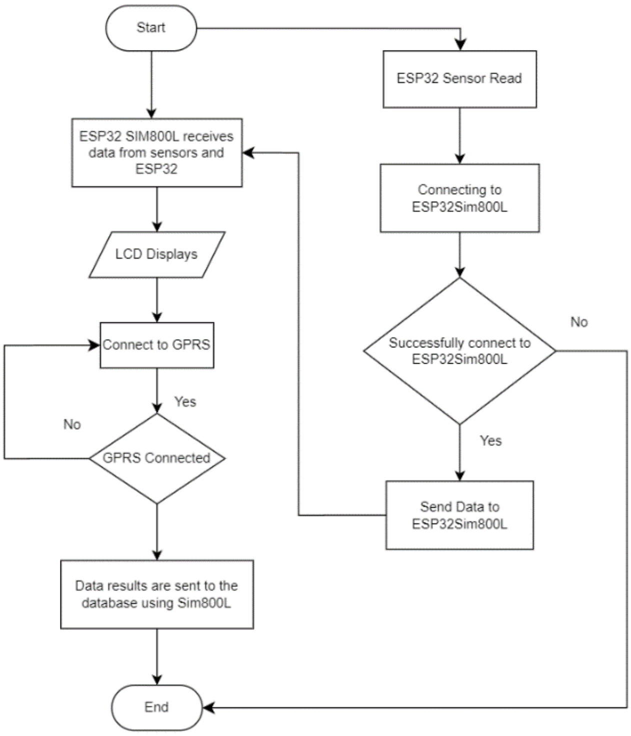

Figure 5. Flowchart monitoring system

Database Table Design

The database serves as a storage place for data that will be further processed, and it can coordinate data. Thus, the data is protected from unclear, complicated, and duplication. The inde5891_rami database has tables: rami, users, sensor_values, massa_rami, outputs, control, list_sensor, and control. The database tables are shown in Figure 5.

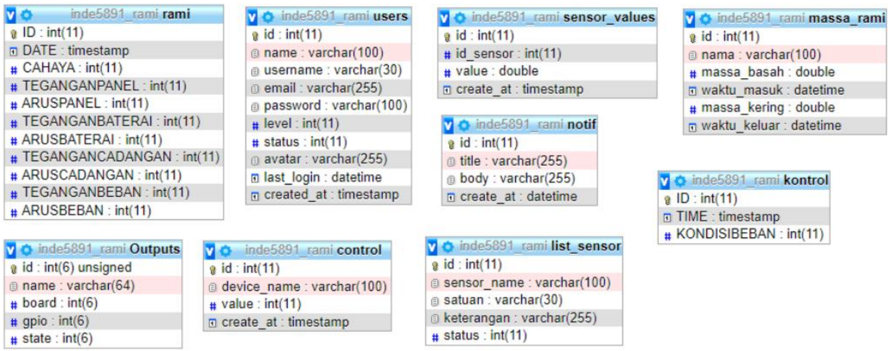

Figure 6. Image of the PHPMyAdmin database table for temperature, humidity, and solar panel monitoring data

RESULTS AND DISCUSSIONS

The Web-Based IoT System designed for Real-Time Ramie Drying Room can function effectively as per the design. It aids in monitoring temperature, humidity, and solar panels with accurate, real-time data, enabling the display of real-time monitoring data with graphs and tables. Here are the test results.

Testing the web monitoring system, testing web page load time, and testing the synchronization of temperature, humidity, and solar panel data from tables and graphs to the database are part of the testing and data analysis from the experiments conducted with the testing results on this system. The Url of The System is https://simomi.indigief.com/.

Interface Of The Website

Figure 7. Login page website

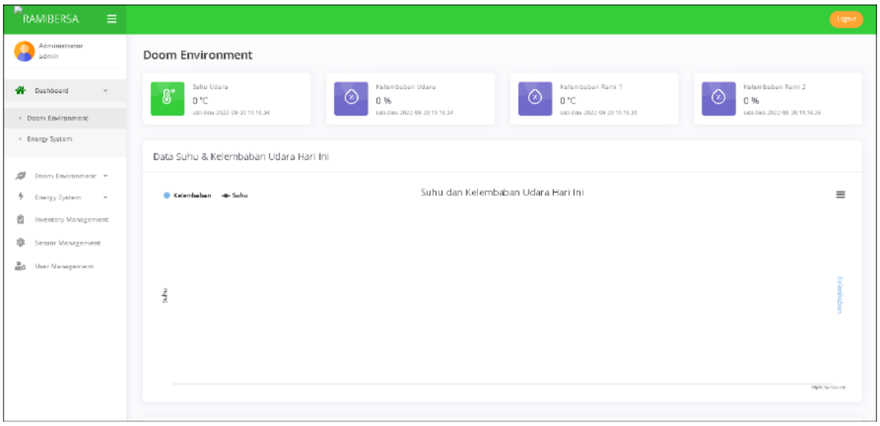

Figure 8. Dashboard

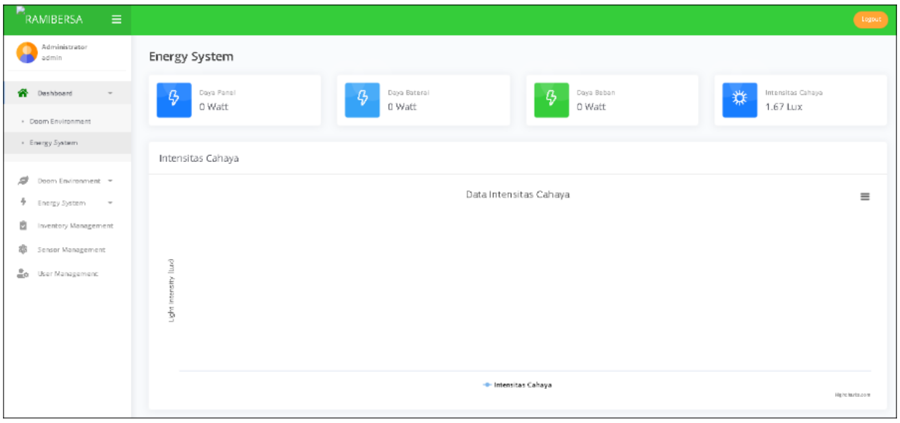

Figure 9. Energy data

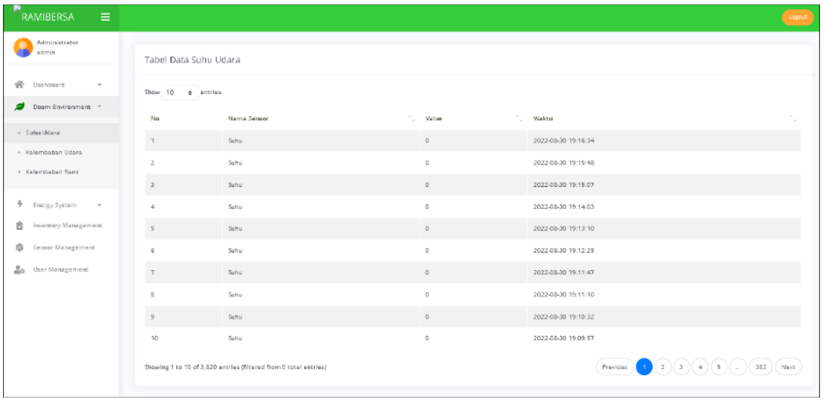

Figure 10. Temperature data

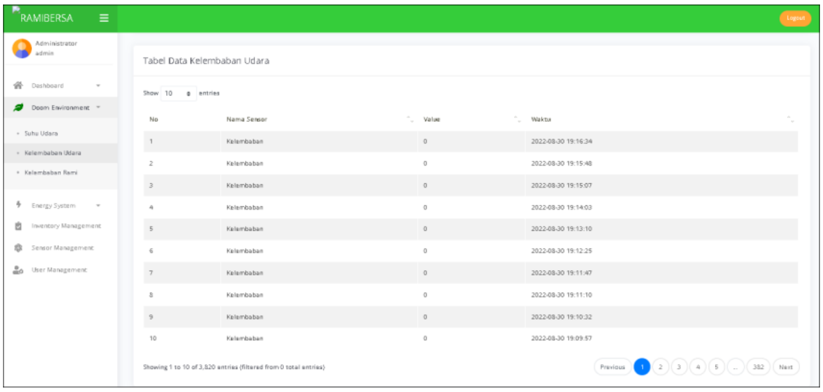

Figure 11. Humidity data

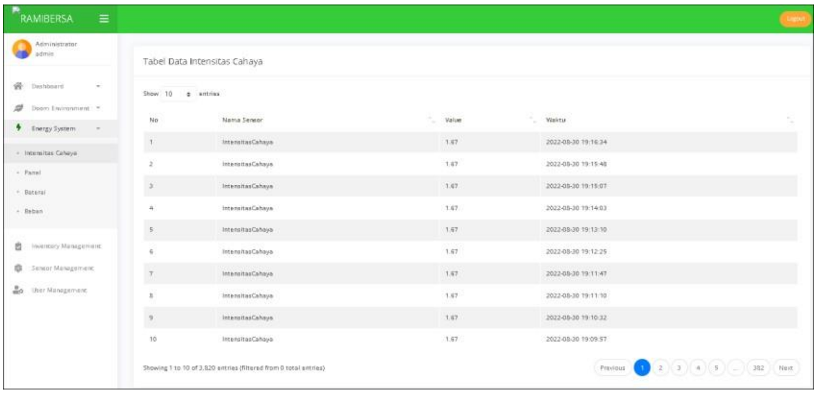

Figure 12. Light intensity data

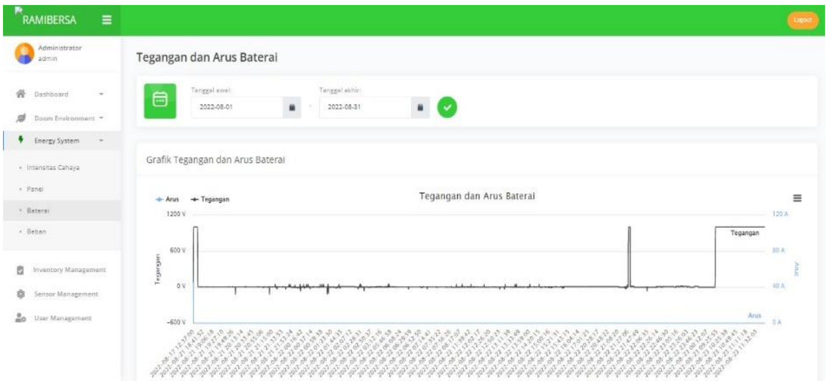

Figure 13. Voltage and ampere data

Web Page Load Time Test Results

Software developers may create a set of input conditions that will test a program's functional requirements by using the black box testing method which focuses on functional and software requirements. The results of testing the temperature, humidity, and solar panel web monitoring system show that it can work according to the procedural preparation and testing plan. The overall system testing yields results as expected [36], [37]. Load time testing of the web page is performed using two different internet connections. The system will be tested by inspecting the network to determine the time required when accessing the web interface. Load time results are obtained by comparing the time required for each internet connection to access the web interface. The load time value of this web page is influenced by the internet access speed and the size of documents, such as CSS elements, HTML elements, and images [38].

Figure 14. Speedtest with wifi network

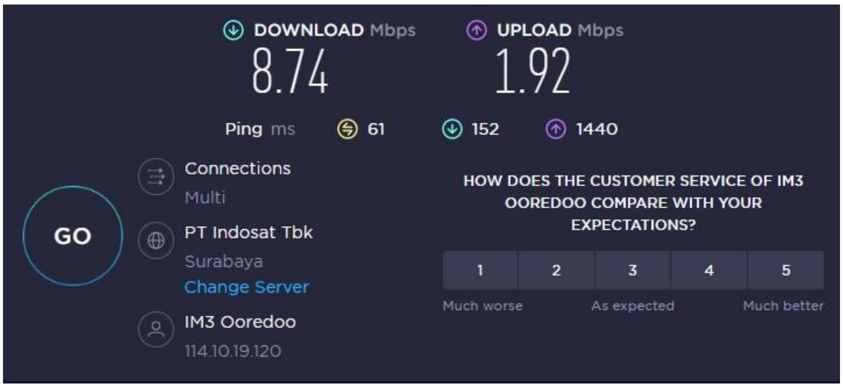

Figure 15. Speedtest with network provider

Analisys of System

In this study, intelligent traffic light data monitoring for vehicle density based on the web will be developed. The system is designed with the following specifications: The programming languages used to create the system interface are HTML, CSS, PHP, and Javascript. The system can monitor temperature, humidity, and parameters on the solar panel in the ramie drying room. The data communication between the monitoring and control systems is done through a wireless WiFi network, enabling connection and communication without cables. Data from the monitoring system will be stored in a database. The monitoring system can be accessed through a browser in real time. Hardware and software: Hardware - Laptop, Software - Xampp and Notepad++. This web-based monitoring system will display real-time graphs and tables of monitoring results for room environment and energy system parameters. Administrators can access the temperature, humidity, and solar panel monitoring system website. The design of the web interface for monitoring temperature, humidity, and solar panels is the process of depicting the appearance (interface) of the system. This web displays the monitoring results of temperature, humidity, and solar panels obtained from the ramie drying room. The temperature, humidity, and solar panel monitoring web is designed with a user-friendly interface, making it easier for users to access the web. Users can access the web through browsers on laptops, computers, smartphones, and tablets connected to the internet [39], [40].

Figure 16. Formed IoT system and rami dome

In Figure 16, it illustrates the outcomes of the formed device and the hemp drying system. The IoT-based drying system represents a significant breakthrough in hemp farming that can lead to a substantial increase in hemp crop production at the farmer level. By leveraging online-connected IoT technology, farmers can monitor real-time temperature, humidity, and solar panel usage, providing invaluable information to optimize their farming processes. Furthermore, this system also supports the transition to the Industry 4.0 era, marked by the integration of advanced technology across various economic sectors. By adopting IoT technology, farmers can take advantage of more efficient automation and data collection potential, which, in turn, can lead to increased productivity and the quality of their hemp farming products. Therefore, this IoT-based drying system plays a key role in enhancing hemp farming production at the farmer level and fully harnessing the benefits of the Industry 4.0 era.

CONCLUSION

Based on the design and testing, several conclusions about the web-based temperature, humidity, and panel monitoring system can be drawn. The conclusions are as follows: The Temperature, Humidity, and Solar Panel Monitoring System can operate effectively by the designed framework, facilitating real-time monitoring of parameters. The black-box testing of the temperature, humidity, and solar panel monitoring system produced results consistent with the predetermined design specifications. In addition, examining web page load times under varying network speeds, specifically at 69.2 Mbps and 6.48 Mbps as determined by speed test applications, led to the conclusion that network speed significantly impacts web page access time. As shown in Figure 5, the speed test results over WiFi indicate that better network speed results in faster loading of web page content. As shown in Figure 6, the speed test results over the cellular network indicate that the development and implementation of this system can significantly improve the accessibility of information and the productivity of the ramie fiber. A suggested avenue for further research from this study is to improve the informativeness of the home page regarding ramie, as this could attract more engagement to the website. Role IDs could also be extended to include different levels of users, thereby assigning different access rights to users and improving the overall user experience. From the development of the ramie drying monitoring system, it is evident that there is a need for improved sensor accuracy, the creation of a more user-friendly interface, and the availability of longer-term monitoring data.

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