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Control and Monitoring System for Lighting Through Timing Based on The Internet of Things

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ABSTRACT

This study aims to develop and implement a time-based lighting control and monitoring system using the Internet of Things (IoT). In today's digitally connected environment, efficient lighting control is essential to improve user comfort and optimize energy use. The proposed approach leverages light sensors and IoT hardware to automatically adjust lighting levels based on time and user needs. The system is designed to provide users with the ability to control lighting remotely via a mobile application or web interface. In addition, the collected lighting data can be analyzed to understand lighting usage patterns and improve energy efficiency. The research methodology includes system design, hardware and software development, and implementation trials in a real environment. Testing was carried out by varying lighting scenarios and monitoring the system's response to these changes. The results showed that the system was able to optimize room lighting according to user preferences and environmental conditions efficiently. In addition, the remote monitoring and control capabilities provide greater flexibility for users to adjust lighting according to their needs. This study contributes to the field of time-based lighting control by utilizing the advantages of IoT as remote control and monitoring.

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INTRODUCTION

In the increasingly developing digital era, the Internet of Things (IoT) has become a paradigm that changes the way we interact with our surroundings. One area that is greatly influenced by this development is lighting control in various spaces, from households to commercial and office buildings. Proper lighting not only affects the comfort and productivity of occupants, but also has a significant impact on energy consumption (Utomo, 2019).

Lighting plays an important role in the comfort and productivity of the environment, be it in office spaces, homes, or public facilities. Proper lighting settings can improve the quality of life of occupants and optimize energy use. However, manual lighting control is often less efficient and less responsive to changes in environmental conditions and user needs. In an effort to overcome this challenge, the concept of the Internet of Things (IoT) has emerged as a promising solution for building intelligent lighting control and monitoring systems (Faiz & Sanjaya, 2023).

The Internet of Things, which is a network of devices that are interconnected via the internet and can communicate and exchange data, offers great potential in increasing the efficiency and convenience of lighting control. By utilizing connected sensors and hardware, IoT-based lighting control systems can automatically adjust lighting levels according to time and other conditions (Lestari, Syahwin, & Haramaini, 2023).

Previous studies have explored the concept of IoT-based lighting control, but there is still much potential to improve system performance and expand its practical applications. This study aims to improve this performance by developing and implementing an efficient and responsive Internet of Things-based time-based lighting control and monitoring system. This study will develop a more complex and sustainable solution for Internet of Things-based time-based lighting control and monitoring.

LITERATURE REVIEW

In developing a time-based lighting control and monitoring system based on the Internet of Things (IoT), it is important to understand the background of the research and previous contributions in the scope of this research which aims to be a reference and benchmark for previous studies.

Efficient and integrated lighting systems are an important aspect of energy management, especially in the modern era that is increasingly focused on sustainability and automation. One of the innovative solutions that is developing is the application of the Internet of Things (IoT) in lighting control and monitoring systems. IoT technology allows electronic devices to be connected via the internet network, so that they can communicate and interact without the need for intensive human intervention. In the context of lighting, IoT can be used to optimize energy use through automatic and intelligent settings (Putri, Abdullah, & Cholish, 2021).

IoT-based lighting control systems allow for the regulation of light intensity, light on and off times, and real-time monitoring of lighting conditions. Through the use of sensors, microcontrollers, and software, this system can be set to operate according to a specific schedule or based on environmental detection, such as natural light or user presence. With the integrated timer capability, this system provides flexibility for users to adjust lighting according to needs, save energy, and increase efficiency (Putri et al., 2023). The implementation of IoT in time-based lighting settings is very relevant for commercial buildings, public facilities, and smart homes. Users can set the time when the lights turn on and off according to their activity schedule, which in addition to reducing energy waste also increases comfort and safety. Thus, this system offers a solution that is not only energy efficient but also environmentally friendly and economical.

A. Real Time Clock Module as Time Setting

Real Time Clock (RTC) module is an electronic device used to store time and date information accurately and continuously (Banjaransari, Nuha, & Yulianto, 2022). RTC is very important in time-based control systems, such as in automatic lighting settings, because it can maintain time independently even if the main device loses power. In the research "Lighting Control and Monitoring System Through Integrated Internet of Things Time Setting", RTC plays a key role in ensuring that lighting can be controlled based on the set time with high accuracy. The RTC module is designed to provide time information precisely and continuously, be it hours, minutes, seconds, to the date, month, and year. Its main feature is its ability to keep running even if the connected device is turned off, thanks to the presence of a small backup battery that keeps the time count running (Pramudya, 2021).

In the context of lighting settings, RTC is used to determine when the lights should be turned on or off automatically based on a pre-set schedule. This module ensures that the system can carry out its tasks with precision, including daily, weekly settings, or according to a certain time cycle. The RTC module works by utilizing a crystal oscillator that produces a very stable high-frequency signal. This signal is used to accurately count seconds, minutes, and hours. A backup battery allows the RTC to continue counting time even when the main power source is turned off, ensuring that the time does not need to be reset when the device is turned back on. In integrated IoT applications, such as automatic lighting control, the RTC module is synchronized with a microprocessor or microcontroller device, which then controls actuators (such as light switches) based on the time provided by the RTC (Sujito, Mardika, & Nugroho, 2022).

In an IoT-integrated automatic lighting control system, the RTC plays a critical role in maintaining the accuracy and continuity of the time setting. Here are some important functions of the RTC in a lighting system: Determining the Operating Schedule: The RTC allows the system to automatically turn lights on and off at specific times. Users can set when the lights should turn on (for example, at sunset) and when they should turn off (for example, at sunrise or when they are no longer needed), Stable Time Synchronization: Although the lighting system may be connected to an IoT network, which can retrieve time data over the internet, the RTC is still important as a backup mechanism in the event of a network outage or system failure. With RTC, the system will continue to run according to schedule even if there is no internet connection, Precise Timing: RTC ensures that any changes in lighting schedules (e.g., changing from daylight saving to winter time) can be applied accurately and automatically without the need for manual intervention and Energy Efficiency: By utilizing RTC, the lights only turn on according to the needs of the predetermined time, which helps save energy and extend the life of the lights. The lights will not stay on longer than necessary (Handoko, Abdullah, & Toyib, 2021).

B. Internet of Things (IoT)

Internet of Things (IoT) is a concept where various physical devices, such as sensors, actuator devices, and other intelligent devices, are interconnected through the internet network and can communicate and exchange data independently. In the context of "Time-Based Lighting Control and Monitoring System Based on Internet of Things," IoT plays a key role in creating a smart and responsive environment to regulate lighting.

Sensors will be connected to the IoT network can be used to monitor environmental conditions such as light levels, temperature, and humidity. In a lighting control system, a light sensor can detect the intensity of light in a room. Automatic control with continuous connectivity and data collected by sensors, IoT systems enable automatic lighting control. When the light sensor detects a decrease in light intensity in a room, the IoT system can adjust the lighting to adjust the lighting automatically. The ability of the IoT-based lighting control system has the adaptive ability to adjust lighting according to the time of day and user needs. For example, during the day, the system can automatically reduce the intensity of the lights to take advantage of sufficient natural light. IoT allows easy integration between various devices, including light sensors, lighting controllers, and energy management software. This enables the development of a comprehensive, connected lighting control system (Pandey, Srivastav, & Chaurasia, 2022).

The main advantage of IoT is its ability to be accessed and controlled remotely. Users can monitor and adjust the lighting in a room or building in real time via a mobile app or web interface, providing greater flexibility and convenience. In lighting systems integrated with the Internet of Things (IoT), the RTC works in conjunction with sensors and microprocessor devices. The microcontroller connected to the RTC module will retrieve time data to automatically adjust the operation of the lights. In addition, the IoT system allows users to monitor and control the lighting via a remote app, which can retrieve data from the RTC to ensure that the lights operate according to schedule, even when there are changes in time or special situations. Thus, IoT plays a crucial role in developing a “Time-Based Lighting Control and Monitoring System.” By leveraging extensive connectivity, intelligent sensors, and data analysis capabilities, this system can optimize energy usage, improve user comfort, and create a more efficient and sustainable environment (Susilo, Sari, & Krisna, 2021).

C. Controller, Input and Output

The Arduino platform, which utilizes microcontrollers, is highly developed today. Its open source nature, which makes it easy for users to access and use the libraries needed to simplify and program the system, is one of the reasons for its popularity. Arduino combines hardware and software to create a highly interactive platform. Along with the hardware, the Arduino platform offers an Integrated Development Environment (IDE) that is always evolving. Because it combines a program editor, compiler, and uploader into one environment, this IDE simplifies the development process (Banzi & Shiloh, 2022).

Both inputs and outputs are connected to the Arduino. four BH1750 type lux sensors are used as inputs. These sensors can measure the amount of light in a room or space. The selection of these sensors is adjusted to the varying lighting needs of different rooms. A room used for work or study, for example, requires brighter lighting than a room used for resting. The photocells on the BH1750 type lux sensor record the light it receives. By using data from these four lux sensors, you can measure the lighting level of a room precisely (Wahyu, Syafaat, Yuliana, & Meliyani, 2021).

The Arduino is connected to sixteen lamps for output. The mapping idea will be used to adjust these lights according to the required light level. In addition, the WiFi module Esp8266 is placed into the Arduino, allowing connectivity between the prototype hardware and communication devices such as mobile phones. This allows for joint control and monitoring across IoT or internet-based networks. The Arduino Mega 2560 is used in this study because, according to the prototype design requirements, it has a sufficient number of input and output pins. Halogen, LED, and TL (neon) lamps are often used in lighting. Each type of lamp has unique qualities. As an illustration, TL lamps use fluorescent gas and a fluorescent coating to produce light when electricity is applied, LED lamps convert electrical energy into light energy, and halogen lamps, which function similarly to incandescent lamps but are mostly used for decorative lighting, are another type of lamp (Ismailov & Jo'Rayev, 2022).

METHODOLOGY

This research implements the Internet of Things in a time-based lighting management and monitoring system by combining hardware and software components. The combination of mechanical and electronic designs forms the hardware. On the other hand, the software component consists of the application features of the Internet of Things-based process control and monitoring and programming needs such as timing and light control techniques.

A. Hardware design

Mechanical design and electronic design are two main phases in hardware development. Creating the concept, shape, and design of the system to be built is the goal of the mechanical design stage. Visualizing the operation of the system is the goal of this stage. On the other hand, the focus of the electronic design stage is to create the system's electronic devices, including WiFi modules, controllers, sensors, and other electronic components. Thick plywood, acrylic, and PVC pipes are examples of materials chosen for the mechanical design above because they are strong and easy to shape. The following figure shows a block diagram for the entire system.

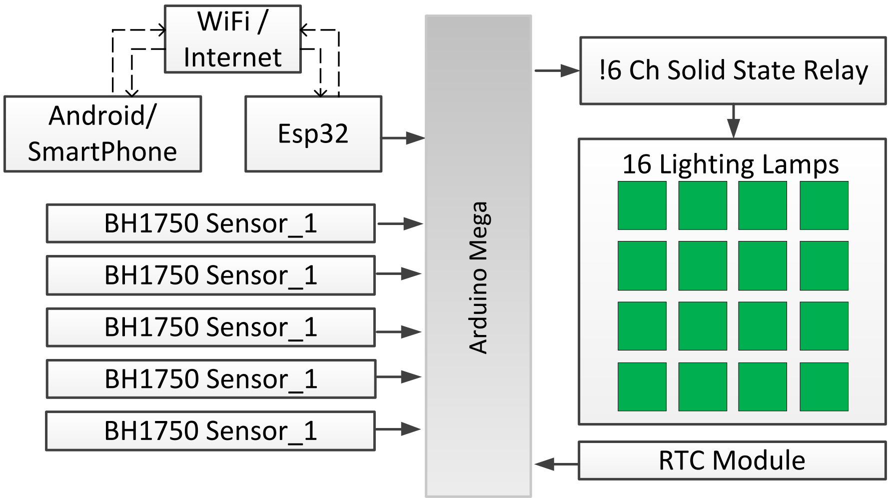


Figure 1. Overall system hardware block diagram

Based on the block diagram above, the main component of this research design is the Arduino Mega, which processes all input and output data. The input used in this research design is four (4) Lux sensors from the BH1750 series. To ensure that the measured Lux values are accurate, these four sensors are evenly placed throughout the building to produce an average value of indoor lighting intensity. While the Esp32 module acts as the system design WiFi module, providing integrated control and monitoring as well as communication between the system and the Smartphone application, the DS3231 RTC module performs accurate real-time calculations. The room lighting requirements determine the output of the Arduino Mega, which regulates the brightness of each of the 16 indoor lighting lamps. This indicates that the two remotely controlled spotlights, as well as the mapping of lights on and off, light strength, and lighting time settings, are all controlled by the algorithm used to program the Arduino programmer.

By using time-based settings to adjust building lighting as needed, this research focuses on integrating the Internet of Things with the room lighting control and monitoring system. This includes working out when the lights should be used, mapping and changing the working time as needed, and whether remote manual control options can be used. It also involves determining how intense the room lights should be used. Every feature of the system, including remote control and time monitoring, has been connected to the Internet of Things. This includes the ability to display the light intensity measurements of each lux sensor reading. By using an Internet of Things-based application, this lighting control and monitoring technique allows it to work as needed or can be set automatically based on the desired room lux value and time settings, allowing for necessary adjustments to the lighting duration of the lights, monitoring the light mapping process, recording the time value of the lights used, and turning the lights on and off manually according to the amount of lighting needed.

B. Software design

Software design refers to the software requirements needed to build the developed system. Several software are used in the system, such as the BLYNK application and Arduino_IDE. The C language application is created and uploaded using the Arduino_IDE software. After using this software to build the system program, a USB connection will be used to upload it to the Arduino controller. This allows the Arduino controller to process the system input and output according to the intended function.

The BLYNK application is an integrated Internet of Things application. This application functions as a system interface that makes remote monitoring easier. Android Smartphone device users can connect to the application, allowing flexible system monitoring and control. As a result, time monitoring can be done using sensor data that has been processed by the controller. Figures 2 the presentation of the software used in this study.

Figure 2. Arduino IDE software display and Blynk Application software

C. Research Stages

The stages in this research begin with a literature survey to collect related references. After obtaining these references, the design for the mechanical and foundation is made to ensure an accurate design and according to the calculations. In addition, the design of the lighting electrical installation is carried out for the purposes of system implementation to ensure that the electronic circuit (circuit modules, sensors, and other supporting components) are truly in accordance with the system design needs. After the tool is designed, the tool will be tested to ensure that the tool functions as it should. This will be done using a program algorithm that is in line with the functionality of the tool, mechanical design, electrical installation, and the needs of the identified electronic components. The mechanical design, installation, and electronic circuit needs of the system are still in the process. This means that if there are still deficiencies or errors, they will be checked and corrected, if not, then it will proceed to the data presentation stage for analysis and validation. Writing publications and reports is the final step in this process.

RESEARCH RESULT

The results and discussion of the research on the Lighting Control and Monitoring System Through Internet of Things-Based Timing consist of three tests, namely Lighting control testing based on timing for one state, Lighting control testing based on timing for two states and Lighting monitoring testing based on the Internet of Things.

A. Lighting control testing based on timing for one state

The lighting control testing based on timing for one state shows the work of timing from the input of the light mapping pattern with the light mapping when the time is up (all lights are off).

Tabel.1 Lighting control testing based on timing for one state

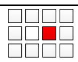
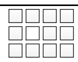
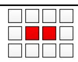
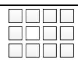
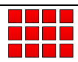
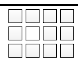
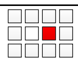
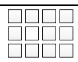
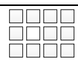
No.	Light Mapping Pattern Input	Time Setting		Light Mapping When Time Ends
		Start	Stop	
1		08:00	09:00	
2		13:00	14:00	
3		17:00	18:00	

Table 1. illustrates the operation of one time setting, namely starting from the initial input setting of the light mapping pattern, then setting the duration of the initial pattern until all the lights turn off, so that through this test, the use of lighting can be made more efficient so that it can work according to needs (according to the settings made).

B. Testing of lighting control based on time settings for two conditions

Testing of lighting control based on time settings for these two conditions shows the operation of the time settings from the input of the first light mapping pattern then the second light mapping pattern and ends with the light mapping when the time is up (all lights are off).

Tabel. 2 Testing of lighting control based on time settings for two conditions

No.	Light Mapping Pattern Input 1	Time Setting		Light Mapping Pattern Input 2	Time Setting		Light Mapping When Time Ends
		Start	Stop		Start	Stop	
1		08:00	09:00		-	-	

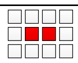
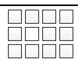
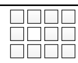
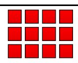
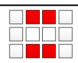
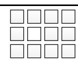
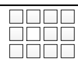
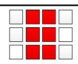
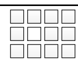
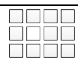
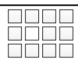
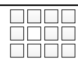
2		13:00	14:00		-	-	
3		17:00	18:00		11.00	12.00	
4	-	-			14.00	16.00	
5	-	-			-	-	

Table 2, illustrates the operation of two time settings, namely starting from the first light mapping pattern input setting, then setting the duration of the first light pattern, then changing to the second light mapping pattern input setting, then setting the duration of the second light pattern until all the light patterns are off, so that through this test, the use of lighting can be made more efficient so that it can work according to needs (according to the settings made).

C. Testing of Internet of Things-based lighting monitoring

In the Internet of Things-based lighting monitoring test, the function is to find out that the entire control and monitoring process can be carried out remotely.

Figure 3. Internet of Things-based lighting monitoring

From the test results of the readings of the five Lux BH1750 sensors through the Internet of Things application, it can be seen that the system has worked well through IoT-based real-time monitoring so that the monitoring and control system can be carried out flexibly.

DISCUSSION

Efficient use of building lighting in terms of electricity consumption by implementing a system to manage and monitor hall lighting using a mapping algorithm. This allows building lighting adjustments to be set according to needs, including how many lights are turned on, how much light intensity, and how long the lights are used. In addition, this system is integrated with the Internet of Things to provide automatic and manual control as well as remote real-time monitoring.

CONCLUSIONS AND RECOMMENDATIONS

The integration of IoT technology into the lighting system enables automatic and efficient lighting control and monitoring. Programmable timing and connection to the IoT network facilitates centralized lighting management, reduces unnecessary energy use, and increases user comfort. The system also enables real-time monitoring of lighting status, which supports energy efficiency, safety, and flexibility in adjusting lighting according to environmental needs. The result is a more structured and energy-efficient lighting management.

ADVANCED RESEARCH

Research can be conducted with a more complex research design and concentrated on the efficient use of electrical energy and power quality in lighting arrangements in the building hall. The main objective of the next stage plan is to implement an intelligent control system that uses a computerized algorithm integrated with the Internet of Things to optimize power usage in electronic devices in the building. After the system is designed, data will be collected to analyze the quality of the power produced and the amount of electrical energy used, so that the effectiveness and efficiency of the system can be known.

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