The Concept and Implementation of Smart Room using Internet of things (IoT) for Cost Efficiency and Room Security

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Abstract. The Internet of Things (IoT) is a concept where internet connectivity can exchange information with each other with objects around it. The essence of IoT is interconnected devices that produce and exchange observation data, facts, and other data, so that it is available to anyone. In this paper we present how the smart room model is designed using sensors and micro-controllers to automate the use of electronic devices and the security of a room using the concept of the Internet of Things. Implementation of the smart room concept from the results of this study, we hope that the concept in this smart room can be implemented and the automation process in this smart room can have a major impact on the efficiency of operational costs, especially electricity payments and improve home security because there is automatic control.

1. Introduction
Changes in the dynamic times, especially in the field of communication and information technology, can not be avoided by anyone. At present we enter the era of the industrial revolution 4.0 which requires every human being to make dynamic changes in carrying out activities in everyday life. This certainly changes the way of human thinking for the present as well as the future.
Internet of things (IoT) has become one of the most popular technologies. The idea behind this is to have objects from everyday life connected to the internet. This allows objects to continue sending data to the web and can be accessed from anywhere. It will also be possible to interact directly with one another, this is called Machine to Machine communication or M2M. [1]
Nowadays, efficient and sustainable energy usage is an urgent necessity that influences technology development in numerous areas (e.g. building, transport and energy production and conservation systems). In this context, emerging Smart Grid technologies have been developed to reduce the energy consumption of electric devices installed at home, to seek out the lowest rates and contribute to the smooth and efficient functioning of the electric grid. Although many Smart Grid devices today are commercially available, the limited service scalability, the complexity of configuration and the low usability prevent their mass adoption.[2]
A smart home is one that has a highly sophisticated automated system to control multi-media equipment for monitoring and enable the security forces (alarm and alert) associated with the windows and doors, lighting and temperature and many other functions. A smart home appears "intelligent" because of a computer system that can monitoring many aspects of daily life.[3] The conclusion is that
a smart home exists because of a computer system that can monitor many aspects of everyday human life.

Why does that matter? The main reason we make smart rooms for resource efficiency is that many electronic devices that forget to turn off will be on for 24 hours. This is a waste of electricity. Many electronic equipment is still on when there are no lectures. This causes high electricity bills to be paid. Then the background of the importance of smart rooms for home security in particular is the leakage of gas in the house. The house becomes one of the important parts in human life because the house becomes a shelter and also a place to spend time on their daily activities. However, based on statistical data in Figure 1.1 at this time the house is only used as a place to sleep at night and left by the owner in the morning until the evening, making the house empty or uninhabited. Such circumstances make the house vulnerable to danger, both unexpected disasters and security for the items contained in the house. There are many cases of theft and fire in an empty house because the owner left it. It can be seen from Figure 1.1 that the statistics of the number of fires based on their causes from 2014-2019. The cause of the fire in the statistics in Figure 1.1 comes from electricity, cigarettes, stoves and others. This makes us as homeowners must be vigilant at all times.

![Image](image.jpg)

**Figure 1.** Fire Statistics Based on Cause [4]

The solution for solving these problems is a smart room system model using Arduino microcontroller and several sensors such as PIR sensor, temperature sensor, and ultrasonic sensor.

The Arduino is basically open-source electronics prototyping platform that is made up of two essential parts: the hardware, which is the Arduino board, and the software, the Integrated Development Environment (IDE). At the heart of every Arduino board is a Micro-controller Unit (MCU), a type of Integrated Circuit (IC) with a processor, embedded memory, and programmable I/O peripheral devices. [5]

2. Related Work

Research entitled "Smart Home: Architecture, Technologies and Systems" explains that smart home is an important part in the concept of an automatic network. The automation process between humans and electricity can be done in real time. The application of smart home can increase the efficiency of electricity usage due to the increased use of electricity networks and the pattern of users or humans in the use of this electricity network. Broadly speaking, this study describes the architectural design in making the concept of smart home or smart room. Technologies that can be used to implement the
The concept of smart home include the Internet of Things (IoT) platform, computer technology, control technology, image display technology and communication technology.[6]

Another study entitled "Smart homes and the control of indoor air quality" is motivated by global climate change, demographic change, and advanced mechanization of daily life that will go hand in hand with new ways of living. Extreme temperatures, an aging society and higher demands for a comfortable life will lead to the implementation of sensor-based networks to create acceptable and improved living conditions. The idea of smart home mainly serves the efficient use of energy and optimization of ventilation technology that is connected with new ways of building a structure (low energy and passive houses respectively).[7]

Another study entitled "IoT Big Data Analytics for Smart Homes with Fog and Cloud Computing" explains that the analytics of an Internet of Things system is an important means of gaining knowledge and supporting applications for making smart home / smart rooms. The equipment connected to the smart home system generates big data about users and their daily activities. IoT analytics can help personalize applications that benefit both homeowners and industry that can benefit from consumer profiles. This research proposes the use of fog nodes and cloud systems to enable data-based services and overcome the challenges of complexity and resource demands for the processing, storage, and classification of online data and analysis offices.

3. Methodology

3.1. Research Method

In this study we used applied research where we focus on the application of the results of research conducted in the community to solve problems, not to focus on development and the impact that can be felt directly. Applied research is done with the aim of implementing, testing, and evaluating the ability of a theory to be applied in solving practical problems.[8]

Applied research is done a lot to solve practical problems of human life, and applied research usually refers to theories produced by basic research. Researchers who develop certain products have a purpose to solve existing and useful problems in people's lives.[9]

3.2. Groove system

The following is a prototype system flow chart of the smart-home application for home lighting automation, garden lighting, and gas leak detection using sensors and Internet of Things (IoT) technology. The first thing to do is that the user must log in to enter the main menu. After logging in, the user will be able to access the main menu of automation.

In the menu there are several choices of automation buttons namely the on and off button for home lighting, the on and off button for garden lights, and the on and off button for the blower (fan) and also there is a place for notifications. If the homeowner wants to turn on or turn off the lights from outside the house, he can use the Smart-home application, and if the homeowner is at home then he can use an automatic system using sensors.

Furthermore, if a gas leak occurs, the MQ-2 sensor will detect and automatically the buzzer along with the blower (fan) will turn on. After that the system will automatically send notifications to homeowners.
3.3. General system design
In the general design of a smart room system, it can be explained as follows: sensors currently in use such as the MQ-2 Sensor, PIR Sensor, LDR Sensor and fire sensor are inputs that will send data through the node MCU. NodeMCU receives a command and then checks the command in the program. If the command exists, nodeMCU will send commands to Relay and send commands to firebase. The relay will automatically turn on or turn off tools such as home lights, garden lights, fans, and buzzers. Meanwhile firebase will send notifications to the android application. The general system design scheme can be seen in the image below:

4. Results And Discussion
4.1. The design of Smart Home Prototype uses the MCU Node
The prototype design in this study uses the NodeMCU micro-controller as the centre of Controlling. The output processors are motion sensors, light sensors, gas sensors (MQ-2) and fire sensors. The output generated from NodeMCU is in the form of LED (Light Emitting Diode) lights that light up, representing room lights and garden lights. The gas sensor will produce output in the form of a live blower. The following is a design drawing of a prototype smart home using NodeMCU:
Figure 4. NodeMCU Schematic Series

The picture above declares the pins connected to the MCU node from existing devices such as PIR sensor, LDR sensor, MQ-2 sensor, buzzer, blower, male-male and male-female jumper cables, and 1 relay module with a total of 4 channel.

4.2. Coding of Arduino IDE (Integrated Development Environment)

The Arduino IDE application is used to run programs from the results of input devices in the form of sensors to be processed and these tools produce an output. After all the hardware circuits are finished, the Arduino program is run by uploading it to NodeMCU.

In this study Arduino IDE Software (Integrated Development Environment) uses version 1.8.4. By using the Arduino IDE (Integrated Development Environment) we can embed commands into the NodeMCU micro controller. The following is an Arduino 1.8.4 interface:

Figure 5. Arduino IDE Interface Display

To embed commands into Arduino, we use the syntax in Arduino called Sketch.

```cpp
void setup() {
    Serial.begin(9600);
}
```
pinMode(buzzer, OUTPUT);
pinMode(smokeA0, INPUT);
pinMode(inputPin, INPUT);
pinMode(lamp1, OUTPUT);
pinMode(lamp2, OUTPUT);
pinMode(kipas, OUTPUT);
pinMode(ldr, INPUT);
}

4.3. Pre Test on resource efficiency

Electronic devices in each class in the Faculty of Computer Science are 6 lamps, 1 Air Conditioner (AC), and 1 LCD projector.

Estimated power usage:

a. 1 Light : 20 Watt
   1 kWh : Rp 1.400
   Power of 1 day : 20 Watt x 8 hours = 320 Wh = 0.32 kWh
   Power of 1 month : 0.32 kWh x 20 days = 6.4 kWh
   Cost of 1 month : 6.4 kWh x Rp. 1.400 = Rp 8.960/light
   Rp 8.960 x 6 lights = Rp 53.760

b. Air Conditioner (AC)
   1 PK : 750 Watt
   2 PK : 750 Watt x 2 = 1500 Watt
   Power of 1 day : 1500 Watt x 8 hours = 12000 Wh = 12 kWh
   Power of 1 month : 12 kWh x 20 days = 240 kWh
   Cost of 1 month : 240 kWh x Rp 1.400 = Rp 336.000

c. 1 LCD projector : 250 Watt
   Power of 1 day : 250 Watt x 8 hours = 2000 Wh = 2 kWh
   Power of 1 month : 2 kWh x 20 days = 40 kWh
   Fee of 1 month : 40 kWh x Rp 1.400 = Rp 56.000

Total costs incurred : Rp 53.760 + Rp 336.000 + Rp 56.000
                      = Rp 445.760

4.4 Post Test on resource efficiency

Electronic devices in each class in the Faculty of Computer Science are 6 lamps, 1 Air Conditioner (AC), and 1 LCD projector:

Estimated power usage:

a. 1 light : 20 Watt
   1 kWh : Rp 1.400
   Power of 1 day : 20 Watt x 6 hours = 120 Wh = 0,12 kWh
   Power of 1 month : 0,12 kWh x 20 days = 2,4 kWh
   Cost of 1 month : 2,4 kWh x Rp 1.400 = Rp 3.360/light
   Rp 3.360 x 6 lights = Rp 20.160

b. Air Conditioner (AC)
   1 PK : 750 Watt
   2 PK : 750 watt x 2 = 1500 Watt
   Power of 1 day : 1500 Watt x 6 hours = 9000 Wh = 9 kWh
   Power of 1 month : 9 kWh x 20 days = 180 kWh
   Cost of 1 month : 180 kWh x Rp 1.400 = Rp 252.000

c. 1 LCD projector : 250 Watt
   Power of 1 day : 250 Watt x 6 hours = 1500 Wh = 1.5 kWh
Power of 1 month : 1.5 kWh x 20 days = 30 kWh
Cost of 1 month : 30 kWh x Rp 1.400 = Rp 42.000
total costs incurred : Rp 20.160 + Rp 252.000 + Rp 42.000
= Rp 314.160

From the calculation of estimated costs incurred during the month, a comparison can be found in the graph below:

![Comparison of Resource Efficiency Graph]

**Figure 6.** Percentage of Cost Efficiency

5. Conclusion
In the research conducted on automatic control of electronic devices, we draw the conclusion that:

a. Control of electronic devices can automatically manage resources more efficiently.
b. A lamp can be activated automatically when an object (Human) is detected by the camera and can be automatically deactivated when no object (Human) is detected in the room, such as the design in Figure 3.6 Modelling of smart room control. When the camera manages to detect the presence of an object (Human) it will automatically activate the DHT11 sensor as a temperature and humidity sensor which serves as an indicator to activate the B lamp. Then when there are more than 2 objects detected by the camera it can activate the C light.
c. The air conditioner can activate automatically when the room temperature exceeds 250 Celsius, and it will automatically deactivate when the room temperature is below 170 Celsius.
d. The design of the control system on the smartphone can run well based on the results of black box and white box testing.
e. Control of home lights, garden lights, and blowers can be done in 2 ways, namely by automatic systems through sensors and manual systems through smartphone applications.
f. The condition of the gas level can be monitored via smartphone; if it has exceeded the normal limit, then the application will send a notification that a gas leak has occurred.
g. Control of this lamp can make the occupant's working time become efficient and the use of electric power can also be suppressed because residents can monitor the condition of the lights from a smartphone.
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