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IOT-BASED SMART DOOR SELECTOR FOR DOUBLE SECURITY: INTEGRATION OF RFID AND BLYNK APP FOR ECONOMICAL SOLUTION

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ABSTRACT

This research aims to design and develop an Internet of Things (IoT)-based smart door lock system by utilizing Radio Frequency Identification (RFID) technology and the Blynk application. The system is designed to improve the level of home security by providing a variety of flexible access methods, including the use of RFID cards, smartphone apps, and emergency buttons. The prototype method is applied in system development, which involves creating a physical model to evaluate its performance and functionality. The test results showed that the system was operating properly, where RFID only responded to the registered card to unlock, thus increasing access security. Hardware design that is carried out with an economical approach and simple use of components makes this system more affordable compared to commercial smart door lock products on the market. This research shows great potential in increasing efficiency and comfort in managing home security systems and offers ease of implementation in various types of housing. Thus, this research makes a significant contribution to the development of innovative and practical solutions to improve home safety at a lower cost while providing a sense of security for its occupants.

KEYWORDS *smart lock, Internet of Things (IoT), Radio Frequency Identification (RFID), blynk application, economical.*

INTRODUCTION

Security is a crucial aspect of daily life that provides individuals with a sense of security and tranquility. Broadly, the concept of security has a significant impact on personal peace and satisfaction, allowing daily activities to run smoothly without hindrance. Protection of various aspects of life is carried out through the security of various things, including houses, buildings, safes, vehicles, electronic goods, and

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everything that needs protection. The simplest example is room security using door locks, both conventionally (manually) and automatically. Manual door lock systems often have drawbacks, such as difficulty when unlocking and susceptibility to damage, loss, or break-in. In addition, manual lock systems are also prone to duplication, which can reduce the level of security and efficiency of their use (Aisyah et al., 2022). Developments towards more advanced security technologies, such as the Internet of Things (IoT) and electronic access control systems, have been triggered by these vulnerabilities, with the aim of improving the level of security and convenience of access. One of the common applications of IoT technology is in supporting smart home systems. Smart home systems are an example of how IoT architectures operate, where objects in the home are wirelessly connected to a central gateway to communicate with each other and the home's occupants. Smart home systems aim to improve the quality of life of their occupants by increasing convenience, so IoT is widely used to simplify the control and monitoring of devices in the home environment (Adiono et al., 2019).

Previous research has shown improvements in the field of door security using modern technology. For example, a study on a smart door system with a proximity sensor was initiated (Sugihartono et al., 2020), and other research that utilizes the Blynk application as a smart door controller was conducted (Asman et al., 2020). As the need for more efficient and adaptive security solutions at home increases, the implementation of IoT-based smart door locks is a promising alternative. These systems have great potential to change the paradigm of our interactions with physical security systems, providing an additional layer of security (Muzaki et al., 2024).

This research presents a novel smart door system that integrates RFID technology, buzzers, Blynk applications, LCD displays, and solenoid door locks to enhance home security in ways that existing technologies do not. By developing a prototype that employs wireless communication to link a microcontroller with an Android smartphone featuring an RFID sensor, this system significantly improves the effectiveness of preventing home break-ins (Kristyawan & Rizhaldi, 2020). Unlike traditional systems, this smart door not only displays real-time notifications about the status of locked or open doors on an LCD but also allows users to remotely control the Smart Door Latch via a user-friendly smartphone app, enabling activation or deactivation from a distance. This combination of features positions our system as a more accessible and responsive option in the current market landscape.

Although the proposed hardware was developed using the Do-It-Yourself (DIY) method, it still pays attention to the principle that the nodes in a smart home should be compact, easy to install in various types of homes, and comply with consumer electronics standards and attractive packaging aspects (not just random packaging) (Fuada et al., 2023). The benefits of this research include increased accessibility for consumers, reduced installation costs, and enhanced user experience, as the compact design and ease of installation make smart home technology more widely adoptable and appealing to a broader audience.

RESEARCH METHOD

The approach used in system development is the prototyping method, where the process involves creating a physical model of the system's work that serves as an initial version. Using this method, a system prototype will be created as a communication tool between developers and users to interact during the information system development process. Stages in prototyping include requirements gathering, rapid design, prototyping, evaluation, and improvement (Ihsan, 2021). The system needs to have certain properties to create a smart door lock system that can overcome the problems that usually occur with conventional locks. This includes reliability, verifying and managing visitor access, and having an interactive and easy-to-use user interface (Hermawan et al., 2023). The study will test several parameters, starting with the functional test of the prototype of the designed tool, including the RFID function test, the Blynk application function test, and the help button function test. Next, an RSSI (Received Signal Strength Indicator) test is carried out to measure the strength of the signal received by the ESP8266. In addition, a cost analysis will be carried out to compare the price of the tools made in this study with smart locks sold on the market, focusing on the similarities in functions or features

System Design

The smart lock system will be able to manage room access based on an access card. The access card will be identified through the RFID module. Resident identification information will be stored in the database. The Smart Door Latch hardware system consists of five main modules. The ESP8266 Wifi microcontroller is the first module that provides a wireless network kite with a function as a controller. Next is the SRD-05VDC-SL-C relay, which serves as a switch to activate the solenoid "on" or "off". The third part is a 16x2 I2C LCD Display, which functions as a notification of the status of the door lock open or closed. The fourth part is the RFID-RC522 sensor as an opening tool of the Smart Door Latch. The fifth part is a Dc-to-DC converter (MP1584) that converts a 9V DC voltage to a 5VDC voltage to power the ESP8266, the SRD-05VDC-SL-C relay, and the I2C LCD. The proposed system layout of the hardware is shown in Figure 1.

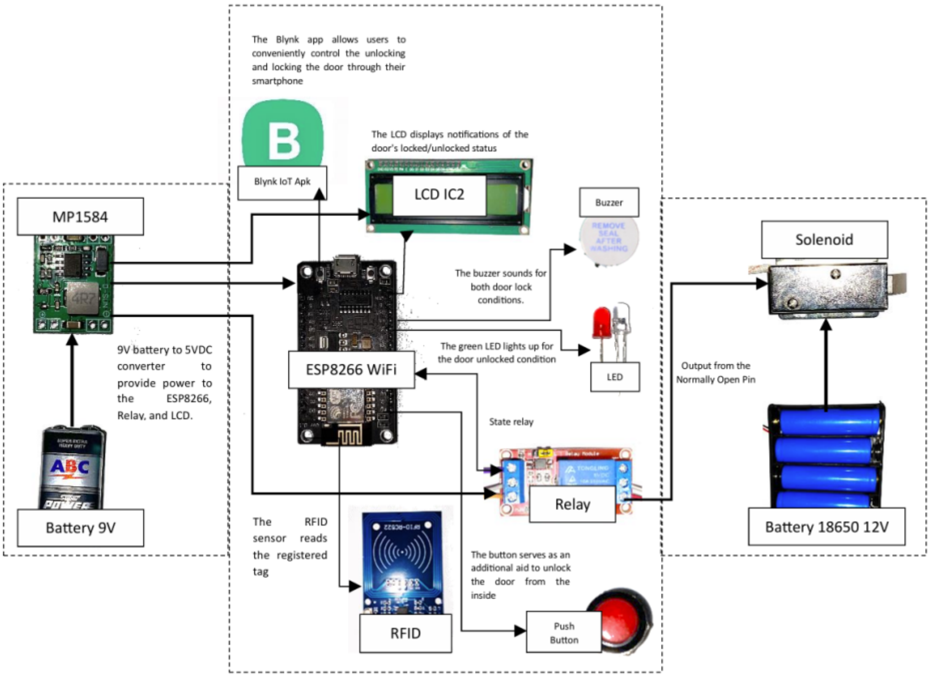


Figure 1. Diagram Smart Door Latch knot block

Hardware Design, Specifications, and Cost

The smart door lock system being developed will apply the concept of the Internet of Things (IoT) concept. IoT is the latest technological innovation that allows devices to connect to a global network and interact with each other (Hermawan et al., 2023). IoT has been applied in various application fields such as smart home monitoring (Wang, 2017), smart city (Khemakhem & Krichen, 2024) smart street lighting (Fuada et al., 2021), smart light sockets (Fuada et al., 2023), and many others. This research will apply a Device-to-Cloud (D2C) communication approach. The D2C concept is a directional connection between Internet of Things (IoT) devices and cloud service platforms to divert data and resources by managing messages and sensors using available communication technologies such as sensor, cloud-based, messaging, IP, and wireless technologies (Souri et al., 2022). The hardware design of this research prototype is illustrated in Figure 2.

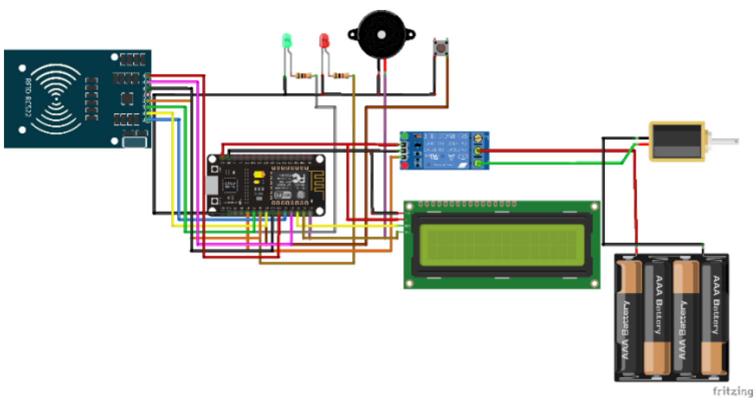


Figure 2. Hardware prototype design

Based on Figure 2, the working mechanism of the tool in this study is that the Smart Door Latch will be given an input voltage in the form of a battery. Then, when the user taps the RFID sensor with the card that has been registered in the system, ESP8266 controls the SRD-05VDC-SL-C relay so that the DC voltage flows to the fitting, thus activating the solenoid or cuts off the voltage to deactivate the solenoid. The relay has a Normally Open (NO) and Normally Close (NC) switch with an output voltage connected to the NO switch which is then connected to the solenoid. The solenoid has two working systems, namely Normally Close (NC) and Normally Open (NO). The main difference lies in the response when it is stressed. In the NC solenoid, when stressed, the solenoid will elongate (closed), and vice versa. When the NO solenoid is applied, the solenoid will shorten (open) [5]. Then, if the solenoid is in the NO state, the I2C LCD will provide a notification display of the door successfully opened with the green LED on and the buzzer sounds, and when the solenoid is in the NC state, the I2C LCD will provide a locked door notification display with the red LED on.

In addition, the Smart Door Latch can be controlled through an app to unlock the lock from the inside or outside. Then, a button will be provided that can be used to unlock the lock from inside the room as an additional aid. So that Smart Door Latch can be accessed in three ways, including: (1) using RFID sensors to unlock the lock only from outside, (2) through an application on a smartphone to control from inside or outside, and (3) using a button to unlock only from indoors.

The process of making a Smart Door Latch requires a number of electronic components that meet the specifications described earlier. Because this research focuses on the cost aspect, Table 1 details the price list of required electronic components and the total cost based on prices from national online store references.

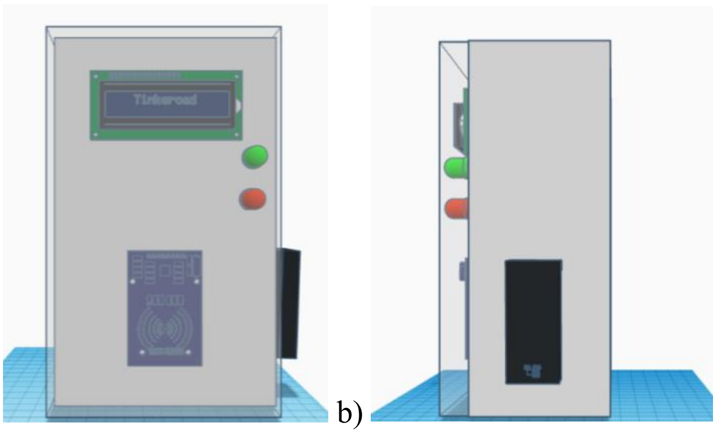
Table 1. List of constituent electronic components and total price

It	Component Name	Sum	Total Price
1	NodeMCU ESP8266	1	IDR 32,800.00
2	RFID-RC522	1	IDR 12,155.00
3	5mm red LED	1	IDR 150.00
4	5mm green LED	1	IDR 210.00
5	1kΩ resistor	2	Rp 500.00
6	Buzzer	1	IDR 1,500.00
7	Push Button 16mm	1	IDR 2,900.00
8	1 Channel Relay (SRD-05VDC-SL-C) with Optocoupler	1	IDR 14,600.00
9	18650 BOX 4S Battery Box	1	IDR 7,225.00
10	16x2 I2C LCD Display	1	IDR 43,350.00
11	PCB Board Matrix	1	IDR 6,500.00
12	18650 Battery	4	IDR 50,320.00
13	Cable Jumper	23	IDR 5,750.00
14	12V Solenoid	1	IDR 55,250.00
15	IP65 Electrical Box	1	IDR 66,853.00

16	DC To DC Converter Step Down (MP158)	1	IDR 9,200.00
17	9V Battery Box 6F22	1	IDR 12,100.00
18	Terminal Screw Proto Shield Breakout Base Board IO for Nodemcu	1	IDR 24,000.00
	Total		IDR 345,363.00

Case Design

To protect the electronic circuit from dust, water splashes, or other dirt, the Smart Door Latch comes with a hard case. In addition, to suppress the display's essence, a simple case is designed using a box with a transparent top. This is done to make it easier for users to see the notification display from the LCD, the color display of the LED light, and the RFID sensor holder so that the user can properly scan the sensor. The box case used has a size of 120mm x 200mm x 75mm. The selection of the size of this case is because it sees that the components needed are quite a lot, with the size of the components not being small, so a large enough case is needed. Figure 3 shows a case designed using TinkerCAD with a customized design size.



a) b)

Figure 3. Simple case design, including (a) front view and (b) side view

Figure 3a shows that the electronic circuit is inside a case box equipped with glass on the front to display components such as LCDs, LED lights, and RFID sensors, as seen in Figure 3b. The material used in making the case is ABS plastic, which is waterproof certainly suitable for outdoor environments, and avoids rust. In addition, the outer side of the case is provided with a battery compartment so that users can easily remove the battery to replace the battery when the battery power has run out.

Creating Apps as Software

The implementation describes the tools for developing the software used in creating the Smart Door Latch prototype, with a focus on leveraging the Arduino IDE and integrating it with the Blynk application to create a modern and connected door control system.

The Blynk application is designed for the Internet of Things (IoT). Some of the advantages of the Blynk app include the ability to control hardware remotely, display sensor data, store data, visualize it, and more. Users can download the Blynk application for free through the Play Store (Wibowo & Susanto, 2024).

Arduino IDE (Integrated Development Environment) is a software development platform designed to program and develop applications on various microcontroller boards, including NodeMCU ESP8266. Microcontrollers refer to semiconductor devices combining a central processing unit (CPU), memory, and input/output (I/O) devices in one single chip. Using the Arduino IDE, the microcontroller acts as the core that controls various diverse electronic projects (Wibowo & Susanto, 2024).

In the application of the Blynk application, the researchers used two switch buttons to change the output status of 1 and 2 through the Wi-Fi network. In addition to Wi-Fi, this system also utilizes a token code as a link between hardware (NodeMCU ESP8266 WiFi) and the Blynk application.

RESULT AND DISCUSSION

System Testing

The designed Smart Door Latch must operate optimally without errors or interruptions. Therefore, system testing is indispensable to ensure that there are no errors during implementation. System testing is an evaluation step carried out to assess the performance and functionality of the Smart Door Latch that has been made. The purpose of this test is to ensure that the system runs according to specifications and can meet the user's needs (Wibowo & Susanto, 2024). The testing process includes several important stages, such as control testing through the Blynk app, RFID testing, and emergency button testing. Figure 4 shows the results of the tool prototype developed in this study.

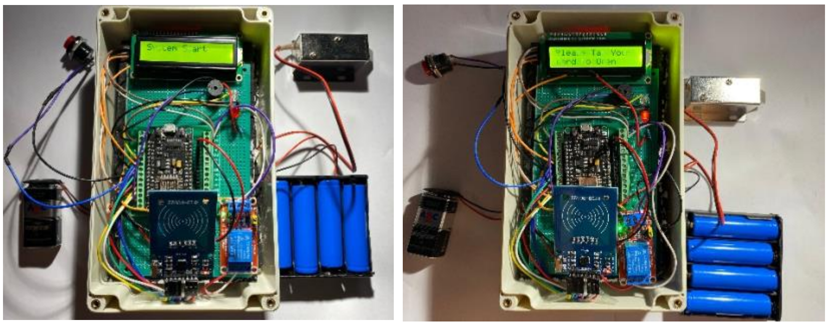


Figure 4. Tool prototype after design

Blynk App Control Testing

Testing the functionality of a mobile app connected to a smart door latch involves verifying the app's ability to control the door lock, both for opening and locking, through testing the Blynk app. The Blynk app features an On and Off button, where the On button is used to unlock the lock and the Off button to lock the door, with controls that can be done at varying distances as long as the Wi-Fi signal remains active. This test shows successful results and is in accordance with the expected function. Figure 5 shows the Blynk application interface used in this study.

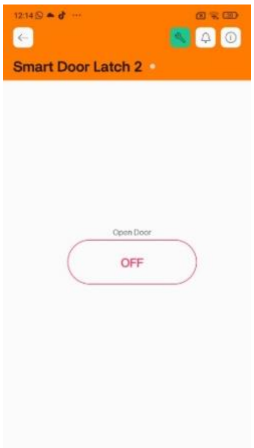


Figure 5. Blynk App

RFID Testing

RFID (Radio-Frequency Identification) tag testing is conducted to evaluate the reliability and performance of RFID tags under various conditions. In this study, access via RFID cards can only be done with the UID of certain tags: A3 F7 FB 27; other cards won't unlock the door. The trial was carried out using several cards that were not registered in the system, such as ID cards and driver's licenses, to check the response of the tested tools. The test results in Table 2 show that the RFID tags are working well and as expected. The state of the device in this study when the registered and unregistered cards are inserted is shown in Figure 5.

Table 2. RFID Tag Testing

Card Types	Door Lock Condition
Registered RFID Cards	Open Lock
Id card	Lock Not Open
SIM	Lock Not Open

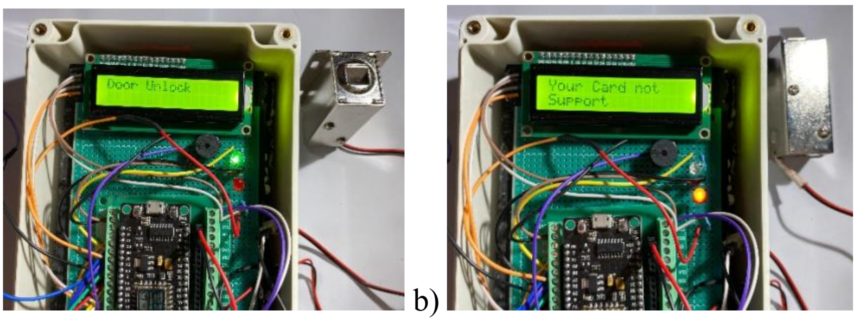
a) b)


Figure 6. The availability of door slots and notifications, including (a) when entered with a registered card and (b) when entered with an unregistered card,

Based on the experiments that have been carried out in Table 2, there are several conclusions:

1). In the first experiment, the lock can be opened or the door unlocked, which shows the advantages of RFID card-based electronic locks.

2). In the second experiment, when using the ID card, the lock does not open, so the door remains locked if it does not use an RFID card. Similar results also occurred during experiments using a driver's license.

Emergency Button Testing

The emergency button or help button is designed as an additional feature to unlock the door from the inside, providing a solution when access through the app is lost due to connection issues. This feature ensures that users can still open the door even if the app can't work. With the emergency button, the device remains operating effectively in emergency situations, improving the overall reliability and ease of use of the system. The implementation of this button guarantees that the tool functions properly under a wide range of conditions, ensuring consistent and secure access.

RSSI Testing

This research utilizes the ESP8266 module as a device for wireless access. Based on references (Restyasari et al., 2023), this Wi-Fi module has a maximum range of up to 70 meters with an RSSI reference of -93 dBm. RSSI is an important indicator used to evaluate the signal strength received by the device (Fuada et al., 2021; Fuada & Hendriyana, 2022), in this case, module ESP8266. Therefore, measurements are made on the ESP8266 module to determine the highest RSSI value capable of accurately controlling the node. The test is carried out outdoors with a straight-line configuration without obstruction, where the signal is received directly. The test distance varied from 5 meters to 30 meters with an interval of every 5 meters, and the test was carried out five times to obtain the average RSSI value in dBm. Table 3 displays the results of distance measurements against RSSI values.

Table 3. RSSI Test Results

Testing	Distance (m)					
	5	10	15	20	25	30
Signal Strength	-49 dBm	-70 dBm	-83 dBm	-87 dBm	-91dBm	-
Information	Very Strong Signal	Signal is Strong Enough	Weak signal	Very weak signal	Barely Connected Signal	Disconnected

Based on the test results in Table 3, it can be concluded that the strength of the Wi-Fi signal is inversely proportional to the distance. At a distance of 5 meters, the signal is in a very strong condition with a value of -49 dBm, but the signal quality begins to decline at a distance of 10 meters with a value of -70 dBm, which is still quite strong. The signal drop was increasingly noticeable at a distance of 15 meters with a value of -83 dBm, and the signal condition continued to deteriorate at a distance of 20 meters and 25 meters until it reached -91 dBm, indicating that the signal was almost disconnected. At a distance of 30 meters, the connection cannot be connected, signifying the effective limit of the signal range of this module. In addition, this function depends on the signal strength emitted by the Wi-Fi provider's device.

Cost Analysis

This section compares the price of smart locks developed in this study with competitors' products. Based on Table 1, the total price of the components used in this study is Rp 345,363.00. Although many smart locks are available in the market, this comparison only covers products sold in Indonesia, as presented in Table 4. Price data is obtained from local online marketplaces such as Shopee and Tokopedia. Table 4 contains information about product names, features, and pricing. The comparison results show that the smart lock designed in this study is more economical than other commercial products. The study compared aspects such as the type of smart lock, the need for a Wi-Fi connection, similar features, and price, while the other advantages of the commercial products listed in the table were not discussed in detail. Complete information about product features can be found on the official website of each product.

Most commercial smart home systems offer many advantages, but they usually come with a compromise in terms of cost. A wide range of smart home products often require integrated control interface standards [4], so it is not always compatible in different countries. The products and applications developed in this study comply with smart home standards and do not violate applicable rules. Therefore, this system is hoped to provide low-cost smart home access because it does not require third-party services or independent systems. This allows offline services to respond more quickly.

Table 4. Comparison of Smart Lock Door with Commercial Competitors

It	Brand	Wi-Fi Requirements	Control Through Apps	Wireless Devices	Price
1.	Evomab	Not Always	Yes	Yes	IDR 1,805,200.00
2.	Bardi	Not Always	Yes	Yes	IDR 1,359,000.00
3.	IT	Not Always	Yes	Yes	IDR 1,600,000.00
4.	Arbit	Not Always	Yes	Yes	IDR 2,699,000.00
5.	Tools studied	Not Always	Yes	Yes	IDR 345,363.00

It should be noted from Table 4 that there are differences in shape and type between the smart locks studied and the brands sold on the market. Nonetheless, the study focuses on smart door slots as an additional security system without compromising the functionality and feature equations offered by the devices used in this study and those sold on the market.

CONCLUSION

This research successfully developed an Internet of Things (IoT) smart door lock system utilizing RFID technology and the Blynk application, aimed at enhancing home security through multiple access methods, including RFID cards, smartphone apps, and emergency buttons. Test results confirm the system operates effectively, with RFID exclusively accepting registered cards for unlocking and reliable app control. The economical hardware design and simple component use make this system more affordable than commercial alternatives. It demonstrates significant potential for increasing efficiency and comfort in home security management, making it suitable for various housing types. While the devices performed as expected, occasional bugs led to suboptimal operation of some components, indicating the need for further evaluation and refinement of the system's performance. Future research could focus on addressing these issues, exploring additional access methods, and enhancing system resilience to ensure robust home security solutions.

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