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IoT-Based Smart Locker: Innovation in Automatic Package Receipt Integrated with Telegram

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ABSTRACT

The development of E-Commerce in this digital era is increasingly rapid, thus affecting the use of goods delivery services. The problem that often occurs in the delivery process is that the recipient of the goods is traveling. This automatic Smart box system is designed to receive packages automatically remotely using the internet of things via the Telegram application. The system uses an ultrasonic sensor to send notifications to the Telegram bot if a package arrives by reading a distance value between 10 cm. This system also utilizes a servo motor as an actuator that can be controlled to open and close the package box. Meanwhile, to find out if the package has been placed in the package box, a load cell sensor is used to send the package weight value. This system uses an ESP32 microcontroller as the system control center and WiFi network. The system is also equipped with ESP32-CAM which is used as a security tool when goods arrive. The test results show that the tool can work well and all components can run according to their function, and connect to the Telegram bot. However, problems that are sometimes encountered are problems that may occur in the system, namely internet network problems that affect sending messages to the Telegram bot.

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1. INTRODUCTION

Companies engaged in the field of goods delivery continue to compete in the market, especially in the courier service sector. One of the reasons behind this development is the growth of online businesses, which particularly affects the consumption sector [1]. The use of delivery services is also influenced by the support of electronic commerce (e-commerce) platforms. E-commerce covers all activities related to the sale and purchase of goods or services using the internet [2]. As the number of users of delivery services increases, it is not uncommon for many problems to arise in the delivery of goods, such as damaged or lost goods and uncertain delivery times. Another problem that often occurs is that the recipient of the package is not at home at the

time of delivery. When the package cannot be delivered, it is sometimes left with a neighbor. However, if the neighbors are also absent, the package may be delivered the next day or left in a restricted area, potentially damaging its contents [3]. An article on Suara.com on March 16, 2020, recounts a woman who experienced problems with damaged goods during delivery because she was not at home when the goods arrived [4]. To address this issue, a system needs to be designed that can receive packages when the house is empty. Internet of Things (IoT) technology can be a solution, as the concept of the Internet of Things (IoT) can be used for remote monitoring and control via the internet [5].

There has been research on the creation of package receiving devices, including the application of load cell and ultrasonic sensor prototypes to monitor and control website-based package receiving devices [6]. Similar research was conducted by [7], namely a smart mailbox prototype for receiving IoT-based packages. This research uses a website to input the package tracking number so that the package box will automatically open and the package recipient will receive a notification via Telegram. However, this research did not use a camera module for security and remote monitoring of packages. In addition, there is research on the design of a package receiving box using IoT-based barcodes [8]. This research uses the GM66 Barcode module as a key on the device and MIT App Inventor as the basis for creating applications using PHP and MySQL as the database. There is also research on the Prototype of an Automatic Package Receiving Box to Secure Packages Through a Telegram Box Using NodeMCU [9]. However, this research has a weakness in that it does not yet use features for securing goods.

In this research, a smart box system will be designed that can detect incoming packages using an ESP32 microcontroller that can be connected to a smartphone via the Telegram application. An ultrasonic sensor is used to provide notification if a package arrives within a distance of 10 cm. The ultrasonic sensor has two main components, namely a transmitter that emits ultrasonic waves at a frequency of 40KHz and a receiver or receiver of ultrasonic waves reflected from objects within a certain distance [6]. The system also uses a servo motor to open and close the package box. The servo motor consists of a motor, a series of gears, and a potentiometer that functions to adjust the rotation angle limit of the servo motor [10]. To monitor if the package has been placed into the box, the system utilizes a load cell sensor and the HX711 module as an amplifier for the load cell sensor readings. The principle of load cell measurement is to measure the voltage difference between the midpoints of the Wheatstone bridge. Changes in this voltage value can be converted into a weight that can be used to calculate the package weight using ESP32 [11]. As a security medium, this smart box system is equipped with an ESP32-CAM camera module. The IoT platform used in this system is the Telegram application. Telegram is used because it is a messaging application that focuses on speed and security. Telegram can also be used to send all kinds of messages, photos, videos, and files [12]. The Telegram platform is used to remotely control and monitor the smart box system. This automatic package receiving system makes it easier for package recipients to control and monitor incoming packages remotely.

2. METHOD

Research into developing a smartbox monitoring and control system involves several steps. The first step is to analyze the object under study to understand the elements and systems to be developed. Next, prepare the necessary tools and materials. Next, design the electronic component circuit and configure the Telegram bot. Next, program the microcontroller for the monitoring and control system. Once the entire system is designed, the next step is to test it to ensure it functions properly.

ESP32 is a microcontroller that serves as the hub for all components, as shown in the block diagram in Figure 1. The ESP32 is connected to an ultrasonic sensor to detect objects or packages within 10 cm. The ultrasonic sensor transmits data, which is then processed by the ESP32 and sent to the network, enabling notifications to be sent to Telegram. The load cell sensor detects the package's weight and transmits the weight data when the recipient commands the system via

Telegram. A servo motor opens and closes the box door according to commands sent via Telegram from the recipient. ESP32-CAM is directly connected to a 5-volt power source.

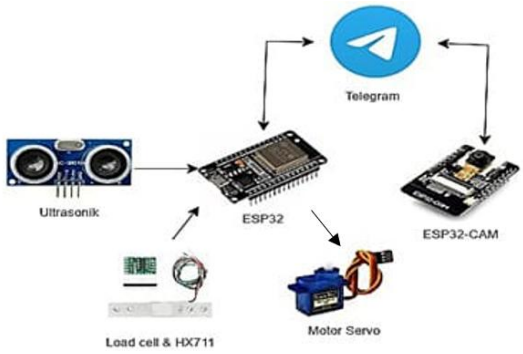

Figure 1. System block diagram.

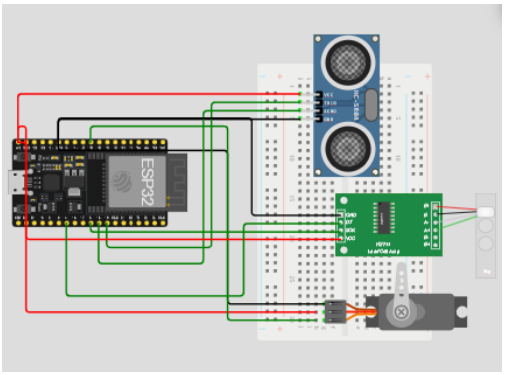

Figure 2. Smart box system design.

Microcontroller design shown in Figure 2 is formed from various circuits connected to each other to create a system. In making a telegram bot, this bot is equipped with several command buttons that have their own specific functions. The bot process begins when the start button is pressed. Next, a reply will appear containing a warm welcome and instructions on how to use it to control electronic devices from ESP32. The available command buttons are the 'Start' button to start running the system, 'Open box' to open the servo motor on the smart box, 'Close box' to close the servo motor on the smart box, 'Weight' to check the presence or absence of a package through the package weight, 'Options' to display the command buttons that can be used, 'Photo' to monitor incoming packages using the ESP32-CAM system, and the 'Flash' button to activate the light on the ESP32-CAM. System testing of this study was carried out by testing the operation of the command buttons according to their function to the commands carried out by the telegram bot and the response time of the telegram bot in sending reply to messages.

3. RESULT AND DISCUSSION

The design results of the automatic package receiving smart box system that has been carried out using two microcontrollers, namely ESP32 and ESP32-CAM, are shown in Figure 3a. The ultrasonic sensor components, load cells, and servo motor actuators are connected to the ESP32 as the system control center. Meanwhile, the ESP32-CAM is used to take pictures when a package arrives, as shown in Figure 3b.

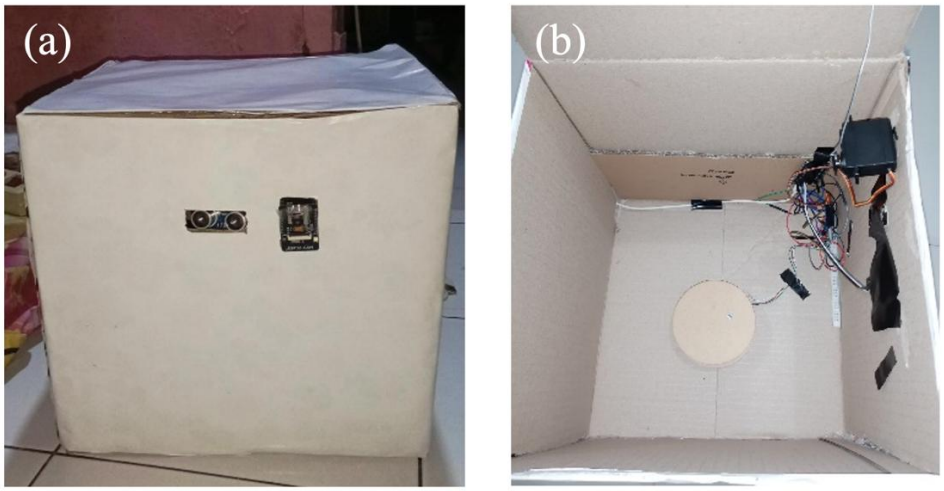

Figure 3. (a) System prototype view, (b) System circuit.

Figure 4 shows a display of the Telegram application, containing commands from the user to the system or device designed for the smart box, which automatically receives packages. Several commands can be used to control and monitor incoming packages. This system uses two microcontrollers that can be run within a single Telegram bot.

Figure 4. Telegram bot interface

Table 1 shows the results of testing the smart box system using the Telegram application. The testing was conducted by running the entire system. In this automatic package receiving smart box system, all connected components functioned properly. The device operates using ultrasonic sensors, load cells, and servo motors connected to the ESP32.

Table 1. Command Button Test Results.

No.	Command button	Main function	Response	
			Yes	Not
1	Start	Starting system	v	
2	Open box	Open the smart box via telegram	v	
3	Clos box	Close the smart box via telegram	v	
4	Weight	Checking the package status and weight via telegram	v	
5	Options	Displaying the command button on the telegram bot	v	
6	/photo	Sending a package photo to the Telegram bot	v	
7	/flash	Activating the light on the ESP32-CAM camera	v	

The system also successfully sent photos and powered on the flash via the ESP32-CAM microcontroller. Response time testing was also conducted to determine how long it took the system to send a reply to the Telegram bot. The results of these tests are as follows.

Table 2. Servo motor control response time test.

No.	Servo box opening time (s) (s)	Message received time (s)	difference (s)	servo close box time (s)	Message received time (s)	difference (s)
1	1,23	1,01	0,22	0,93	1,54	0,61
2	0,91	0,65	0,26	0,85	0,79	0,06
3	0,87	0,68	0,19	1,88	1,23	0,65
4	0,79	0,65	0,14	1,41	0,88	0,53
5	0,97	0,79	0,18	0,97	0,79	0,18
Average	0,95	0,76	0,20	1,21	1,05	0,41

Based on the test results as in Table 2, the servo time data was obtained with an average of 0.95 seconds to open the box, then for the message that the box was open it was received with an average of 0.76 seconds, so there was a difference or delay of 0.20 seconds. Meanwhile, for the servo time to close the box with an average of 1.21 seconds, then for the message that the box has been closed it was received with an average of 1.05 seconds, so there was a difference or delay of 0.41 seconds. There is a difference value of less than 1 second between the time the servo opens the box with the message received and the time the servo closes the box with the message received so it can be said that the system runs smoothly and the delay is fast.

Table 3. Ultrasonic and load cell response time testing.

No.	Package notification time	Time the package weight message was received
1	1,55	2,27
2	0,69	1,66
3	1,13	0,98
4	0,86	0,84
5	0,75	0,88
Rata-rata	1,00	1,33

Response time testing was also conducted on the ultrasonic sensor that sends a message when a package arrives and the load cell that sends a message about the package weight, as shown in Table 3. The test data results show that the average time required to send a package notification is 1 second, while the time required to send a package weight is 1.33 seconds. This indicates that the performance of the message delivery speed is affected by the speed of the network used. The more stable the network used, the faster the delivery of package status notifications.

4. CONCLUSION

The design of an IoT-based automatic smart package receiving box using Telegram has been developed and tested. Test results indicate that the device performs as intended. It can be connected to and controlled using the Telegram platform. However, the system's response time depends on the internet connection used.

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