A Low-Cost Smart Parcel Box System with Enhanced Security

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Abstract

A global pandemic of covid-19 has hastened the growth of online shopping or E-commerce. Nowadays, E-commerce transactions provide various products from luxury goods and services to everyday necessities. While the popularity of online shopping has grown fast, there are several common issues that shoppers experience. Common problems that customers experienced are failed delivery, missing parcels and even the criminal case. Malaysia has introduced Pos Laju Ezi Box Kiosk, but still contemporary Kiosk type approach for the delivery system has some problems such as high initial installation cost, the expense of management system and especially security weaknesses in the wireless communication. To overcome the aforementioned problems, this paper proposes a low-cost smart parcel box system that will be installed at individual homes with enhanced security. This system used Arduino Mega 2560 to control all the processes of the developed system. The system will be initiated when couriers send the parcel's tracking number as a message to the user via applications to get the password. For security purpose, password will be provided once the courier's message is the same as the message specified by the user. Couriers then can enter the password provided and insert the parcel into the smart parcel box. The proposed low-cost smart parcel box system ensures that parcels are delivered safely and securely to the customer's door.

Keywords: smart parcel, Arduino mega 2560, infrared sensor (IR), Internet of Things.

1 INTRODUCTION

The coronavirus outbreak has accelerated the shift towards a more digital trends and initiated changes in E-commerce or online shopping behavior. Based on survey managed by Rakuten Insight [1], within Malaysia, almost 64% of female's customer expand their online shopping due to reason minimizing chances to meet people as well as adapting social distancing. In addition to that, purchasing anything on websites such as Shopee, Amazon, Lelong, and others is more convenient for the customer. Among all those benefits, there are also several major problems that occurring nowadays [2]. Sometime the parcel is being lost or even damaged due to not properly put in place.

Nowadays, most of parcel/letter box are now in the regular and manual forms. Therefore, it will be less secure if someone leave the parcel for a long period in the box. There are some difficulties that might be faced, mostly in condo, office and apartment buildings where residents have limited time to check mail or parcel due to the central location of mailboxes. In addition to that, Although the parcel is delivered successfully by the couriers, the condition of the parcel is still unsafe even the parcel is inside the mailbox. This is because the mailbox can still be opened by thief even it locked with key or padlock. So, the parcel could be potential to get stolen if the parcel were left inside the mailbox.

Thus, the parcel that did not delivered will be returned back to the post office and will be categorized as 'failed on delivery'. There is some case which is frequently happened by clients where some items went missing when it returned back to the post office. As a result, customer will incur losses due to the missing items. Negligence caused by the courier company will cause a lot of bad impact towards the courier and postal world. Moreover, the recipient will give bad comment and rate to the seller because of the missing item.

Problems such as failed deliveries, loss of packages, and late delivery processes are not only faced by people in Malaysia but also across the country. As stated in the article [3], in Japan, the strict business regulations were barriers for operators' innovative ideas and network expansion effort in the process of development in the parcel delivery market. On the other hand, some operators caused problems such as cargo accidents, delivery delays, and leaving items to neighborhood without permission when receiver was not at home [3]. This means that some operators could not deliver the parcel by hand to hand to the customer with the secure packaging. When this happened, parcel will be delayed and it would exceed the time limit of the delivery process. This will get worse if the parcel missing.

In another article written by Castle, J. [4] the paper state that, "a quarter of parcel-receiving in Australian experienced a failure to be delivered. The author mentioned that the delivery delays problem has been around since 2008, when the Postal Industry Ombudsman (PIO) says it has seen a significant increase in the number of complaints relating to delivery and notification cards. That said, it has also seen an increase in complaints overall. To overcome problems encountered by couriers and online shoppers, in Malaysia, few solutions were proposed such as Pos Laju Ezibox Parcel Lockers, Pos Laju Ezidrop Self-Service Machines and Pos Laju Kiosks. It enables customers to collect or post their parcels any time at their convenience[3]. Even when customers were not at home during delivery process, they just can get their parcel through the nearest Pos Laju Ezibox Parcel Lockers or Kiosk to claim their parcel. However, during this pandemic of Covid-19, people are trying to minimize time going out of home and avoiding crowded places. Thus, it would be an advantage if the parcel box is placed at customer's home.

However, based on author knowledge, there is none of the proposed solutions installed at home instead of at specific locations. Devi Pujari, A. et al[5] developed a system which is smart letter box system using obstacle sensor to notify users via Android applications. The android application is used to get the warning out of the pack. A web association SIM card is also included in the equipment unit. The unit is given reinforcement of the battery to avoid the power disappointment issue. This will store the information using the MySQL database. The information that stores the letter check will be dropped in the letter box which is the place where the letter was received. This framework is IoT's best methodology.

Nowadays people rarely available at home during the day especially employee because they went out to work. When the parcel out for delivery (normally on office hour), they were not even at home. So, their parcel is simply left in the lobby for pick up. This case often happening in the apartment residential because their mailboxes located at the ground floor of each block. All residents' mailbox was located there and there was no security in that area. Thus, it will be creating concerns about security, high risk of losing parcel and re-delivery attempts for those who are not at home during the item out for delivery

Based on the aforementioned problem, Smart Parcel Box System is invented to reduce the problems encountered by the courier and customers. This project is also designed in providing reliable, safe, convenience and energy efficient intelligent parcel system. This Smart Parcel Box System will be operating by using Arduino Mega 2560, Keypad, Infrared sensor (IR sensor), Liquid Crystal Display (LCD), Global System for Mobile (GSM), Weight sensor and Application (App). This Smart Parcel Box System provides user with three main features which are keypad for security and smart notification system (GSM module and Application).

The parcel box is placed on specific place (in front of the house gate) at home. The system is responsible to allow the person in charge for delivery process to deliver the parcel into the parcel box. Smart Parcel Box System is installed with keypad that is responsible to unlock the door of the parcel box after the password entered by couriers is correct and allow couriers to gain access to insert the parcel into the parcel box. Password can only be given once the couriers sent the tracking number of the parcel to the user. Infrared sensors are also used in this project to detect incoming parcel and to detect any object or heat at the parcel box's door in order to close the door after the parcel has been placed. Following that, GSM module will send the notification to the owner of Smart Parcel Box System through short messaging system (SMS) to notify

2 METHODS

2.1. Components

Generally, this system will be initialized when voltage source is supplied from the direct current (DC) to the system. At that time, all systems start up and ready to operate for the next step. The system will identify the password entered by couriers or the person in charge for delivery whether is the same as it programmed or not. The password can be obtained by sending the tracking number of the parcel as message to the recipient via apps. Then, it will automatically receive the password if the tracking number is the same as the recipient specified in apps. If one of the tracking number characters missing or does not follow the message characteristics specified by the recipient, the password will not be given and the person in charge for delivery need to send the tracking number again. Next, the door of the parcel box will be open indicating that the access was granted due to correct password and allowing the person in charge for delivery to insert the parcel into the parcel box. After that, the door will automatically be closed as the parcel is inserted. Finally, the GSM module will send a message to the recipient to give information that the parcel had been sent to their home.

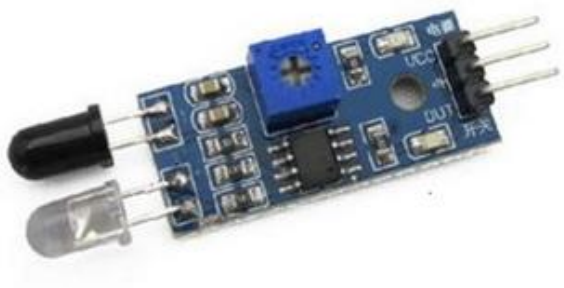

Fig. 1. Infrared Sensor

An infrared sensor is an electronic device that is used to sense certain physiognomies of its surroundings. Infrared sensor is capable of measuring the heat being emitted by an object and detecting Infrared. Infrared waves usually have wavelengths of 0.75 and 1000μm somewhere [6]. In this project, it will act as the sensor to detect the hand of the person in charge to deliver the parcel. It will send information to the Arduino Mega 2560 and the system will execute the program.

Fig. 2. Arduino Mega 2560

Arduino Mega 2560 is an open source microcontroller which can be effectively customized, eradicated and reconstructed at any moment of time [7]. The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, and more. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. For this project, it will function to execute the program inside it such as opening and closing of the door, and the infrared sensor.

Fig. 3. Keypad

A 4×4 matrix keypad is used to give commands and the password to the MCU. It consists of 16 keys (S2-S17 arranged in the form of a square matrix of four rows and four columns). Each key in the matrix is labeled according to the operation assigned to it. Rows 1 through 4 are connected to pins RB3, RB2, RB1 and RB0 of Port B of the MCU, respectively. Columns 1 through 4 are connected to pins RB4 through RB7 of Port B respectively [8]. The function of keypad in this project is to unlock the door of the Smart Parcel Box.

Fig. 4. GSM Module

GSM module is applied for the communication between a computer and a GSM-GPRS system. This device can be performed by connecting the GSM module to the AVR and connecting a SIM card to a server's GPRS cover [9]. GSM module will send SMS as notification to the user of the Smart Parcel Box, as the parcel delivery process is successful.

Fig. 5. LCD

Liquid Crystal Display (LCD) is an electronic device that is used to display instruction that programmed in the form of output of software designing. It is made by liquid

crystal. enveloped in a glass cover [10] LCD will be used to show every program executed and also instruction on the screen. This LCD usage might give a lot of help to the person in charge for delivery process.

2.2. System Architecture

Figure 6 below shows the System Architecture of Smart Parcel Box System (SPBS) Using Arduino. Basically, the system will be initialized when the power supply from the house or from other sources such as power bank to the system. The system require password from the couriers first before the system gives permission unlock the door of Smart Parcel Box. Password can be provided by sending the tracking number of the parcel as message to the user via apps. Next, the door will be open when the information on the message or tracking number is tallied with the message which is specified by user in the apps. Then, the couriers will get the password and can unlock the door when the message is the same. When the door is open, the parcel box will be insert into the parcel box and at the same time, the infrared sensor will detect the parcel. Once there is nothing at the door, LCD will display information to close the door and the door will be closed after a few seconds. After that, GSM module will send the notification in SMS form to notify the user on the parcel delivery status. LCD will display all information given by the Arduino Mega 2560 such as wrong password, door open or door close.

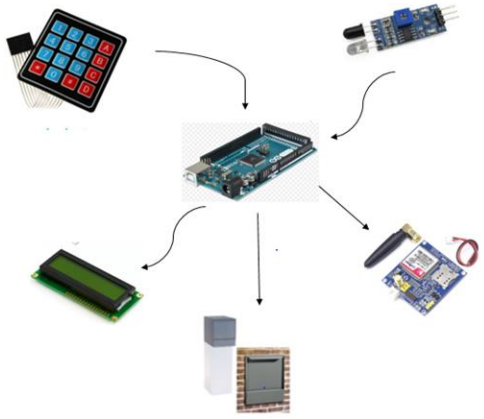

Fig. 6. System Architecture of Smart Parcel Box

2.3 Flowchart

Figure 7 shows the flowchart of the whole process for created Smart Parcel Box System. The system starts with courier send the tracking number of the parcel as a message to the recipient via Whatsapp Applications. Another application called AutoResponder WA is used to generate message whether the message is exactly the same as the recipient specified in the application. This application requires the recipient to fill out the parcel tracking number purchased before the delivery process. This is to ensure the courier can access the parcel box and to facilitate courier work. Then, courier need to send the message specifically to the recipient otherwise the courier could not receive the message from the recipient and need to send the tracking number again. If the message or tracking number is the same as the recipient's message, automatically the message is send to the courier. Means that the courier will get the password to unlock the door of the Smart Parcel Box. Following that, when the courier enters the password given, the Arduino will generate coding whether is the same as it programmed or not. If the password is correct, couriers can insert the parcel into the parcel box. The door will close if the IR sensor did not detect anything at the door. Once the door is close, GSM module will be instructed to send the message as notification to the recipient knowing that the parcel is already delivered to his/her home.

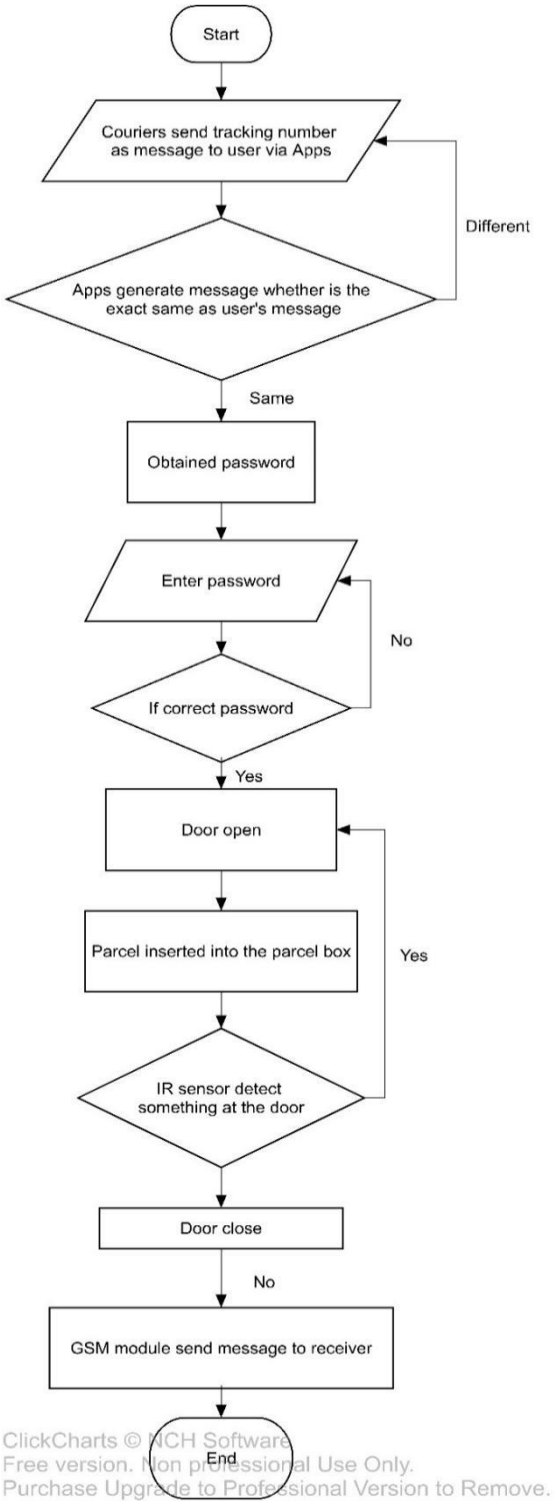

Fig. 7. Flowchart of the proposed Smart Parcel Delivery System

3 RESULTS AND DISCUSSIONS

Arduino Mega 2560 is the brain for Smart Parcel Box System. If the Arduino is damaged or the system failed, all components might not work properly and thus will cause the system failed to operate. Fig. 8 shows the prototype of the Smart Parcel Box System.

Fig. 8. Prototype of Smart Parcel Box System

This system will be initialized when voltage source is supplied from the direct current (DC) to the system. As soon as the whole system start up, all components used in the Smart Parcel Box will automatically turn on. First, the LCD displayed "Welcome, Please Enter Password" as shown in Fig. 9.

Fig. 9. Interface at starting

Before delivery process, the owner need to fill out the parcel tracking number purchased and the password for the parcel box through application called AutoResponder WA, which is shown in Fig. 10. In order for the courier to gain access to the parcel box, courier need to send the tracking number of the parcel to the owner of the parcel box specifically. Then, courier will get the password from the owner after the courier sent the message. It can be seen in the Fig. 11 for example, shows that the courier sent the message to the owner and following that the courier gets the password for the parcel box. Courier must send the tracking number correctly otherwise the couriers will not get the password.

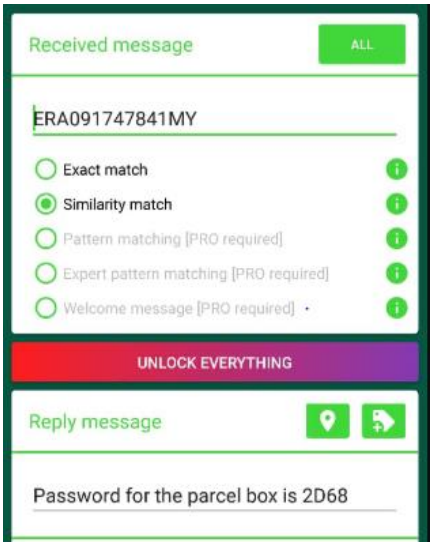

Fig. 10. AutoResponder WA

Fig. 11. Tracking number and password

Fig. 12 shows that the security of the parcel box has been checked by entering two different passwords. The first password is the correct password that will allow the door of the parcel box to open while the other password is the wrong password which cannot be used to open the door of the parcel box. As shown in Fig. 12, the LCD displayed “Access Granted, Door will open”. It indicates that the courier has entered the correct password for the parcel box. In Fig. 12, the LCD also displayed “Access Denied, Wrong Password”, shows that the courier must have entered the wrong password for the parcel box. The system used in this Smart Parcel Box System is very safe because every parcel box has its own password and need to have the parcel tracking number purchased first to get the password.

Fig. 12. Interface on the correct password and the wrong password

Next, the door of the parcel box operation depends on the system. As the system granted access to open the door, the door will open to receive the parcel which is as shown in Fig. 13. The LCD displayed “Please insert the parcel” when the courier inserting the parcel. The door will be opened until the courier finished inserted the parcel into the parcel box. The infrared sensor also had been installed in the system. To make sure that the door always open when the delivery attempt occurs, the sensor will detect the present of the courier or something in front of it. As the infrared sensor detect obstacle in front of it, it will cause the door to stay open until the courier leave the parcel box. Once there is no object detected by the infrared sensor, the system automatically closes the door as shown in Fig. 13 and lock to make sure that the parcel is safe in the parcel box. The LCD will display “DELIVERY ATTEMPT IS SUCCES”, as shown in Fig. 13, after the door of the parcel box is closed.

Fig. 13. Interface on the door operation, parcel and delivery attempt

Then, after delivery attempt completed by the courier, the door is closed. The owner of the smart parcel box will receive a message via SMS. GSM module will send a message to the box owner that the courier's attempt to deliver the parcel is successful. Fig. 14 shows the message sent by the GSM module to the owner of the Smart Parcel Box System.

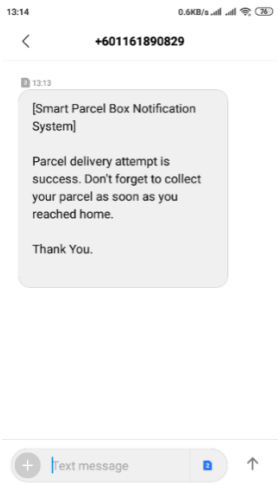

Fig. 14. Message sent by the Smart Parcel Box System to the user

4 CONCLUSION

The proposed Smart Parcel Box System provides user comfort and conveniences to buy item through online platform. With this system, customer become less worried about missing parcel, failed delivery of delay of delivery. Everything will be secured inside the smart parcel system which will be installed at customer's house. The system also provides user friendly apps for both parties where couriers only need to send the message which is the tracking number of the parcel to the recipient via app, and automatically get the password to gain access for the parcel box to deliver the parcel. This means that the Smart Parcel Box System ease the couriers work such as they do not need to knock on the door house or call the customer to wait for someone at their home to pick up their parcel.

For the recommendation and future improvement, it is suggested that instead of using AutoResponder WA application, a new application which typical for the courier company and the owner of the Smart Parcel Box System need to be invented. Nowadays, energy consumption is very important. So instead of using direct current, it is recommended to use solar panel or something that can harvest energy so that the energy used by Smart Parcel Box System is not from direct current.

5 ACKNOWLEDGEMENT

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