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Research Article

Development of a Low Cost Intelligent Parcel Box with Enhanced Security

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ABSTRACT

The covid-19 pandemic has accelerated the growth of online shopping and e-commerce. While shopping and e-commerce have made it convenient for customers to purchase products, issues such as failed/delayed delivery and missing parcels need to be addressed to provide a seamless and secure shopping experience for customers. In Malaysia, the implementation of Pos Laju Ezi Box Kiosk as a delivery system still faces challenges such as upfront costs, high cost of maintaining a management system and vulnerabilities in wireless communication. To overcome the aforesaid problem, this paper proposes a low-cost smart parcel box system with enhanced security. All of the designed system's processes were controlled by an Arduino Mega 2560 in this system. The system will start when couriers message the user via applications with the tracking number for the package in order to obtain the password. When the courier's message and the user-specified message match, the password will be given for security reasons. Once the password has been entered, couriers can insert the package into the parcel box. The system provides a convenient and secure solution for the delivery and retrieval of packages, reducing the risk of theft or damage to the packages..

1. Introduction

Online shopping has seen a significant increase in Malaysia in recent years. The rise of e-commerce platforms combined with increased internet access and the convenience of online shopping has contributed to the growth of online in the country. As a result, Malaysia has become one of the fastest-growing e-commerce markets in Southeast Asia [1]. According to data from Statista's Digital Market Outlook survey, the percentage of Malaysians who purchase online has increased by 47% annually, with 14.43 million making purchases at the beginning of 2022 [2]. With the growth of online purchasing, problems with attempted delivery failure and parcel theft have also emerged. Regardless of whether the resident is home or not, the package will still be delivered to save on delivery costs [3].

Home delivery services have become increasingly popular in recent years, and a smart parcel box system is the perfect way to make sure users/customers get their parcels on time. A smart parcel box system is an automated solution that simplifies the process of receiving and delivering packages. It allows customers to manage their orders starting from tracking the item, receiving notifications when their items are delivered, and even arranging for the pick-up or return of parcels [4]. A smart parcel box system is a secure and automated system for receiving and storing packages.

The system typically features a locked box with a touchscreen interface or smartphone apps for tracking and managing deliveries. The system uses advanced technologies such as GPS, real-time notifications and even digital signatures to provide a convenient and secure way to receive packages at any time, without the need to be present at the time of delivery [5]. This solution is especially useful for busy individuals or households who can't always be available to receive packages during regular delivery hours.

There have been several types of smart parcel box systems available in the market such as Amazon hub locker

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[6] which is an amazon branded smart parcel box system that allows users to receive packages from Amazon and other carriers. The other type of smart parcel box system in the market is ParcelPending [7], which provides real-time tracking and notifications. An automated locker system is known as InPost Parcer Lockers [8] for receiving and storing packages with 24/7 access and real-time notifications.

In addition to ready smart parcel box systems in the market, the development of the parcel box system is an ongoing process and researchers are constantly exploring new and innovative ways to improve the system. Moksin et al developed a ParcelRestBox [9], the project development utilize the Mobile Application Development Life Cycle (MADLC) paradigm. The recipient interacts with the ParcelRestBox gadget using the ParcelRestBox smartphone application. Every time a parcel is delivered, the ParcelRestBox device will detect it and send a notification to the ParcelRestBox mobile application to notify the user.

DroParcel suggested by Alghfeli et al [10] consists of a mobile application and an intelligent personal delivery box. By scanning the QR-Code or bar code that contains the tracking number printed on the shipping label of the package, access to the smart box is made easier. This system can also be used to make it easier to access several people instantly by using a common QR code. Smart parcel box using IoT and solar energy technologies were proposed by Kaewsrisuphawong et al [11]. Solar energy are used in this system to offer services to a client. One of the main functions of this system is that when mail or package postings are dropped into the box, notifications or alerts are sent to the recipient using a mobile application called LINE Notify. The average performance of the box was 96% after 50 trials using various mail envelope types and 50 trials using various parcel types.

Automatic Postal Parcel Collector with Pincode-based Segregation was developed by Mahesh et al [12]. By first weighing the item and then requesting the user to provide the pin number, the proposed approach automates the process of item sorting and parcel delivery. Based on the pin code, the packages are divided into several boxes. The price for each box, which is determined by the distance and weight of the package, is displayed on the screen, and the customer easily makes a payment.

However, there are several issues or problems with current smart parcel box systems such as cost, compatibility, size limitations, technical glitches, maintenance and repair and security concerns [13]. The first issue is cost; smart parcel box systems can be expensive which sometimes makes it difficult for some people to afford. The second problem is the compatibility of the box with different delivery services and carriers can vary and some services may not be able to deliver to the parcel box at all. Technical issues such as software/hardware malfunctions can occur, leading to inconvenience and sometimes lost packages. Regular maintenance and repair of the system may be necessary, which can be time-consuming and expensive. Size limitations, the size and weight of the package that can be delivered to the box may be limited, making it difficult to receive larger items. The other issue is security concerns about the safety of the packages stored in the box and vulnerability of the system to hacking or theft.

With the aforementioned challenge, this project proposed a low-cost smart parcel box system with enhanced security which provide a reliable, safe, convenient and energy-efficient intelligent parcel system. The proposed system consists of Arduino Mega 2560, Keypad, an infrared sensor (IR sensor), Liquid Crystal Display (LCD), Global System for Mobile (GSM), a weight sensor and a mobile application. The system enables the person in charge of the delivery to place the package inside the box after a process of authentication. The smart parcel box system is installed with a keypad that is responsible for unlocking the door of the parcel box and giving the couriers access to place the parcel inside. Once the user has received the tracking number for their package from the couriers, they can then provide the password. As part of this initiative, infrared sensors are also utilized to open the parcel box's door after the parcel has been placed and to detect any objects at the door. In order to alert users, the GSM module will then send a notification via SMS to the owner of the Smart Parcel Box System.

2. Methods

2.1. Components

This system will typically be initialised when a direct current (DC) voltage source is applied to the system. At that point, all systems are operational and ready for the next phase. The courier sends the tracking number to the user via apps to get the exact password. Following that, the courier uses the password to get through the system. The parcel box's door will then be unlocked, showing that access has been given due to the exact password, and the person in charge of delivery will be able to place the package inside. As the package is inserted, the door will then automatically close. In order to inform the recipient that the package has been delivered to their home, the GSM module will then send a message to user.

Figure 1 depicts an infrared sensor, an electronic device used to detect specific environmental physiologies. The heat being released by an item can be measured by an infrared sensor, which can also identify infrared. Wavelengths of infrared radiation typically range between 0.75 and 1000 m [14]. It will serve as a sensor in this project to identify the hand of the person in charge of delivering the package. The Arduino Mega 2560 will receive data from it, and the system will run the application.

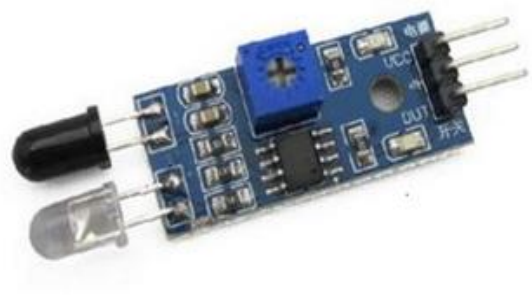

Figure 1: Infrared Sensor

An open source microcontroller known as the Arduino Mega 2560, which is depicted in Figure 2, can be effectively modified, eliminated, and rebuilt at any time [15]. A microcontroller board called the Arduino Mega 2560 is based on the ATmega2560 (datasheet). It contains 16 analogue inputs, 54 digital input/output pins, 14 of which can be utilised as PWM outputs, and more. It comes with everything needed to support the microcontroller; to get started, just plug in a USB cable, an AC-to-DC adapter, or a battery. For the purposes of this project, it will be used to run the programme that controls the door's opening and closed as well as the infrared sensor.

Figure 2: Arduino Mega 2560

As seen in Figure 3, a 4x4 matrix keypad is utilised to input commands and the password to the MCU. There are 16 keys where each key in the matrix is labelled with the operation that it is designated for. Rows 1 through 4 are connected to Port B of the MCU's pins RB3, RB2, RB1, and RB0, respectively. Columns 1 through 4 are connected, correspondingly, to Port B's pins RB4 through RB7 [16]. In this project, the keypad's purpose is to unlock the Smart Parcel Box's door.

Figure 3: Keypad

The GSM module used for communication between a computer and a GSM-GPRS system is seen in Figure 4. This device can be used by attaching a SIM card to a server's GPRS cover and the GSM module to the AVR [17]. When the parcel delivery process is complete, the GSM module will send an SMS to the Smart Parcel Box user as an acknowledgement. Figure 5 depicts a liquid crystal display (LCD), an electrical device used to display programming instructions in the form of software design output [16].

Figure 4: GSM Module

Figure 5: LCD

2.2. System Architecture

The system architecture of the Smart Parcel Box System (SPBS) is depicted in Figure 6. The system will be activated once power is supplied from either house's power supply or from external sources, such a power bank. Before granting permission to unlock the door of the Smart Parcel

Box, the system requests a password from the couriers. A password will be provided by messaging the user via applications with the package's tracking number. The door will then be opened once the message or tracking number have been compared to the message that the user has selected in the apps. When the message it is match, the couriers will then receive the password and be able to unlock the door. The parcel box will be inserted into the parcel box when the door is open, and the infrared sensor will detect the parcel at the same time. When nothing is at the door, an LCD will show instructions on how to close it, and after a a while, the door will be closed. Following that, the GSM module will send the user an SMS notification informing them of the status of their package delivery. Every information provided by the Arduino Mega 2560, such as an incorrect password, a door open or closed, will be displayed on the LCD.

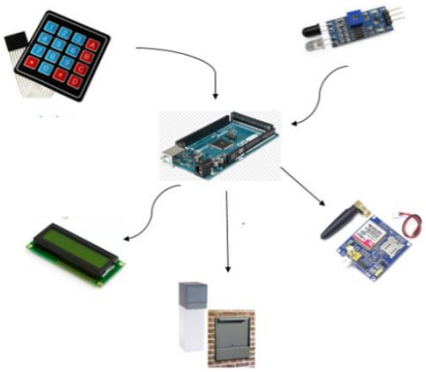

Figure 6: System Architecture of Smart Parcel Box

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2.3 Flowchart

The flowchart of the Smart Parcel Box System is shown in Figure 7. The process begins with the courier sending the recipient via WhatsApp Apps a message with the tracking number of the package.

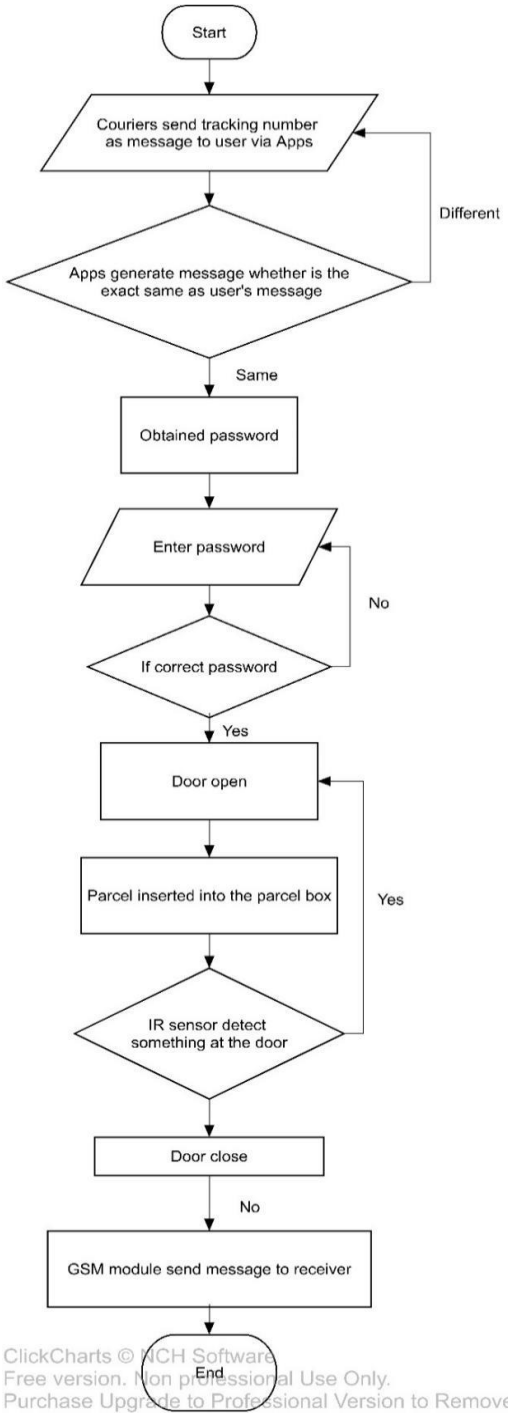

Figure 7: Flowchart of the proposed Smart Parcel Delivery System

In order to determine whether the message is exactly the same as the recipient entered in the application, another programme called AutoResponder WA is utilised. The recipient must enter the package tracking number before the delivery procedure in this application. The courier must then deliver the message directly to the recipient. The message is automatically sent to the courier if the message or tracking

number matches the recipient's message. This indicates that the courier will receive the password needed to open the Smart Parcel Box's door. Couriers can place the package inside the parcel box if the password is accurate. If the IR sensor did not detect anything at the door, the door will close. When the door is closed, the GSM module send the message to let the recipient know that the package has already been delivered to their house.

3. Results and Discussions

The "brain" or central processing unit of the smart parcel box system is the Arduino Mega 2560. Figure 8 depicts the Smart Parcel Box System prototype.

Figure 8: Prototype of Smart Parcel Box System

When a direct current (DC) voltage source is connected to the system, it will be initialised. All of the parts used in the Smart Parcel Box will automatically switch on as soon as the entire system is turned on. As seen in Figure 9, the LCD displayed "Welcome, Please Input Password."

Figure 9: Interface at starting

Figure 10's AutoResponder WA programme requires the owner to enter the purchased package tracking number and the parcel box password before the delivery procedure can begin. The tracking number of the package must be sent to the owner of the parcel in order for the courier to get access to system. After sending the message, the courier will ask the owner for the password. Figure 11 illustrates it by showing the message a courier sends to the owner and how the courier then obtains the password for the parcel box. Correct tracking information must be sent by the courier in order for them to receive the password.

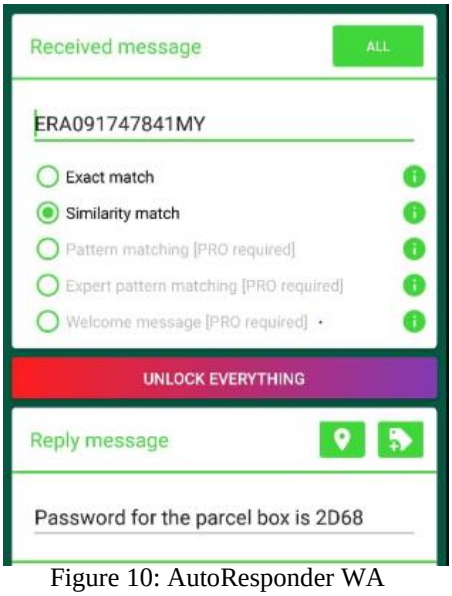

Figure 10: AutoResponder WA

Figure 11: Tracking number and password

Figure 12 demonstrates how two distinct passwords were used to verify the parcel box's security. The first password is the one that will allow the parcel box door to open, but the second password is the incorrect one and cannot be used to unlock the parcel box door. The LCD screen showed "Access Granted, Door will open," as seen in Figure 12. It proves that the courier used the right password to open the package box. Figure 12's LCD, displayed "Access Forbidden, Incorrect Password," indicates that the parcel box's courier must have entered the incorrect password. Because each parcel box has its own password and must first have a parcel tracking number in order to obtain the password, the method employed in this Smart Parcel Box System is highly secure.

Figure 12: Interface on the correct password and the wrong password

The system then controls the door of the parcel box operation. The door will open to receive the package after the system grants permission to do so, as seen in Figure 13. When the courier inserted the parcel, the LCD showed, "Please insert the parcel." The door won't close after the courier has placed the package inside the box. The system also has an infrared sensor installed where the sensor will identify the courier's package in order to ensure that the door is always open when a delivery attempt is made. The door will remain open as soon as the infrared sensor detects an obstruction in front of it and remain open until the delivery person leaves the package box. The system automatically closes the door as illustrated in Figure 13 and locks to ensure that the package is secure in the parcel box once the infrared sensor has identified no other objects. After the package box's door is closed, the LCD displayed "DELIVERY ATTEMPT IS SUCCES", as seen in Figure 13.

Figure 13: Interface on the door operation, parcel and delivery attempt

The door is then closed when the courier has successfully finished his delivery attempt. A message will be sent to the smart parcel box's owner via SMS. The box owner will receive notification from the GSM module that the courier's effort to deliver the package was successful. The information the GSM module sent to the owner of the Smart Parcel Box System is depicted in Figure 14.

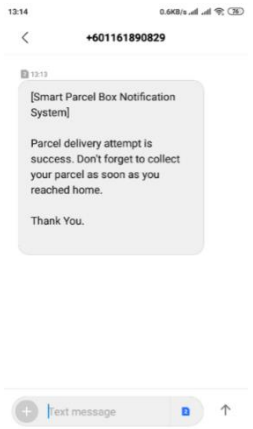

Figure 14: Message sent by the Smart Parcel Box System to the user

4. Conclusion

Home delivery user experience has emerged as a key component of any business' success in the e-commerce era. By offering secure package delivery, increased tracking and visibility, and simple parcel access, a smart parcel box system can assist businesses in improving their home delivery user experience. The proposed Smart Parcel Box System offers users comfort and convenience when making online purchases. With the proposed approach, customers no longer worry as much about lost packages, failed deliveries, or delivery delays. The smart parcel system, which is placed at the customer's home, will keep everything secure. The system also offers user-friendly apps for both parties, allowing couriers to deliver packages by simply sending the recipient the tracking number of the package via the app, who will then receive the password needed to open the package's box. In summary, the smart parcel box system intends to make the delivery procedure easier for the courier by removing the necessity for them to physically knock on the recipient's door or wait for them to be present to receive the package. As a result, the delivery procedure is more effective and more convenient for both the courier and the recipient.

For the recommendation and future enhancement, a new application that is typical for the courier and the owner of the Smart Parcel Box System needs to be invented instead

of the AutoResponder WA application. Nowadays, reducing energy consumption is a key towards green environment, thus, it is advised to utilise solar panels or other energy-harvesting devices rather than direct current so that the energy consumed by the Smart Parcel Box System can be depends on other sources and a more efficient system can be offered.

5. Acknowledgement

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