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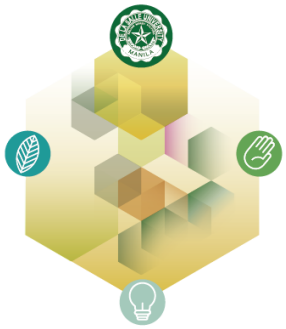

Smart Box Delivery System

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Abstract: Online shopping is a staple in the Philippines which allows Filipinos to shop conveniently in their homes. However, there are times when residents are not available during parcel delivery of the bought item thus aborting the delivery. Although the courier service can leave the parcel at the doorstep this is not secure. In this research, an IoT-enabled delivery box system is developed to provide secure delivery of parcels when residents are not available. The box uses a one-time password that allows the courier / resident to open and place / retrieve the parcel. It also takes pictures of the courier and parcel in the box to ensure actual delivery and can be used later for disputes. The box was tested by several users and was able to function properly during functionality tests of the box.

Key Words: Internet of Things; Smart Delivery Systems; Secure IoT Box

1. INTRODUCTION

Online shopping has become increasingly popular even before the pandemic, and its popularity has only grown during the pandemic. E-commerce sites such as Lazada and Shopee enable users to easily search and purchase products without leaving their homes. Users can create an account on these websites, add products to their virtual cart, and proceed to the payment process.

One of the primary drivers of online shopping is its convenience, as corroborated by various studies (Balderaz & Campos, 2020; Basar et al., 2021; Kumar & Kashyap, 2018; Yeo et al., 2021). Additionally, e-commerce provides access to a wide range of products, enables information accessibility, ensures efficiency, and offers a multitude of payment options (Basar et al., 2021; Kumar & Kashyap, 2018). Furthermore, the significance of parcel delivery cannot be overlooked in the context of the growth of e-commerce, despite its imperfections (Akeb et al., 2018). However, a major impediment to online shopping is that most individuals are not present at their residences during parcel delivery, resulting in an absence of recipients to accept the package (Azri, 2012; Hussain et al., 2019; Mansoor, 2020; Mokhsin et al., 2021; Nonthaputha et al., 2020; Ooi& Tan, 2021).

It is the goal of this research to develop a secure IoT-enabled smart delivery system of parcels at home when residents are away or busy.

2. RELATED WORKS

2.1. Smart Modular Parcel Locker System

As the number of destinations increases, both logistics companies and recipients face significant financial and time-related costs. This study outlines the creation of a suggested system that aims to mitigate the effect by implementing contactless deposit and withdrawal, as well as the deployment of modular style lockers (Ooi& Tan, 2021).

The model developed by Ooi& Tan (2021) includes a Raspberry Pi 3B+ as the main microcontroller; an ESP8266; a DC motor, a DC motor bridge, a push button, and two 18650 battery cells for controlling the box's lock; ultrasonic sensors to detect items within the box; a camera for dimensional scanning; a light tube for lighting; and a QR code reader to determine if the parcels are the ones anticipated. A web application was also utilized for activity reporting, database access, and user-centric procedures such as account registration,

login/logout, parcel registration, parcel status viewing, parcel withdrawal, and so on.

2.2. IoT-Based Parcel Receiving Box System

The COVID-19 pandemic outbreak and the Malaysian government's mobility control order (MCO) have caused a surge in internet purchasing in Malaysia. Unattended parcel delivery, parcel loss, and unsuccessful delivery efforts had caused the home and the delivery business a lot of frustration. Their prototype seeks to solve these problems by accepting deliveries without requiring the receiver to be present and sending a delivery notice to the recipient's home (Mokhsin et al., 2021).

Mokhsin et al. (2021) used a NodeMCU V3 ESP8266 as the main microcontroller, a DC jack for power, and an infrared sensor to identify parcels in their box. The parcel information will be sent to a microcontroller with a Wi-Fi transceiver, which will allow the data to be sent to the firebase via the internet. Aside from that, they used Firebase authentication to verify user emails and passwords before allowing access. An Android mobile application was created for the user interface and delivery notifications.

2.3. Comparative Table of Review of Related Systems

The table below compares the related systems that will be used as a reference for the project.

Table 1. Comparative table of review of related systems

Related Systems	Electronic Controller (SBC)	Lock	Secure Access Code	Keypad	Infrared Sensor	Ultrasonic Sensor	Motion Sensor	Battery	DC Jack	USB	Buzzer	LCD	Camera	Light	QR Code	Mobile Application	Web Application	SMS	Database
Smart Modular Parcel Locker System	✓	✓				✓		✓					✓	✓	✓		✓		✓
IoT-Based Parcel Receiving Box System	✓	✓			✓				✓							✓			✓

3. SMART BOX SYSTEM

Fig. 1 shows an illustration of the box and its components. The length, width, and height for the box is 36 x 30 x 24 in centimeters.

Fig. 1. Prototype of IoT-Enabled Smart Delivery Box

The system design in Fig. 2, uses a microcontroller to gather, analyze, and transfer data sent and received by its associated components. When the courier pushes the button, it signals the microcontroller to notify the resident that a parcel has arrived. A message is sent to the resident through the GSM module or the Android mobile application. Pressing the said button sends a notification to the resident via SMS that the courier is requesting an OTP for the smart delivery box. The microcontroller then sends an OTP (which is good for five minutes) to the resident and sends it to the courier via SMS. A 4x4 matrix keypad is used to enter the One-Time PIN given by the app and is shown on the LCD display. A relay attached to a solenoid lock, activates when the correct PIN is entered, opening the lock. A buzzer is used to indicate that the box's door has been opened, but that no parcel has yet been placed inside. When the door is closed and the parcel is put inside, it deactivates. The infrared sensor is used to detect the package placed inside the box. As long as the infrared sensor detects the presence of the parcel inside the box, and the buzzer is deactivated, the relay triggers the solenoid to lock. A camera, with the capability to take a sequence of images that can be as slow as 1 to 5 frames per second, lets the user monitor the status of the item inside the box. In the event of no internet connection for the user, a text message is sent to the user as an alternative stating that the sensor has detected an item inside the threshold of the smart delivery box. All of the data handled throughout the process is saved in the Firebase database. For the user accounts, an Android mobile application is created, which is utilized for alerts and notifications, as well as tracking and monitoring the box and its contents. The Bluetooth module is used in configuring the microcontroller's Wi-Fi connection and in introducing the user's username in order for it to have access to their information from the database.

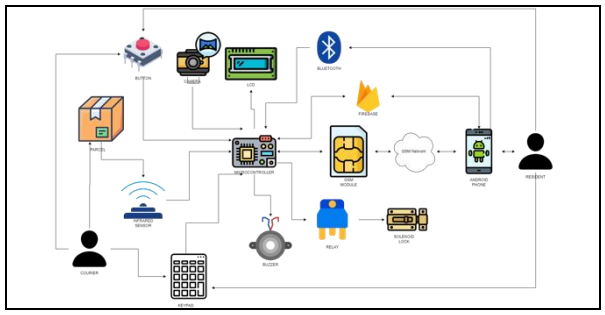


Fig. 2. Design Architecture

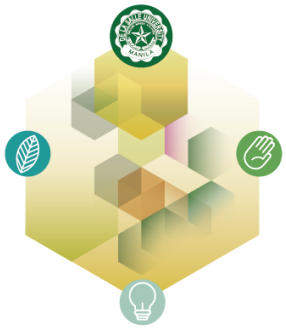
4. ANALYSIS

Upon testing the prototype system internally within the research team, it is deemed working as intended, as shown in Table 2. Both the hardware and software have been proved to be working harmoniously. Using the test cases as a basis on what the prototype should be expected to do, every result from the said test cases has passed without fail.

The research team conducted tests with test users on how to set up the IoT-Enabled Smart Delivery Box. The first test was registration, where users filled in required fields and had their credentials verified to ensure they were valid and unique. The next test was for login, where users entered their email and password and proceeded to the next step if they were correct. The next test was for logging out, which was successful and led the user back to the login page where they needed to input again with their email and password. The Bluetooth module was tested by pairing the user's phone with the box to configure the Wi-Fi SSID and password, and the test was successful. The Camera module undergoes testing each time the box is unlocked and when a parcel is delivered and claimed. Furthermore, the captured photos are examined to confirm their upload to Firebase Storage and their display on the user's mobile app. The lock mechanism is triggered upon closure of the IoT-enabled smart delivery box by the courier, as well as upon entry of a correct OTP or PIN by the user. As for the Notifications module, it underwent testing by verifying the delivery of notifications via both the mobile app and text messaging to the user's phone which can be seen in the scenarios on the table below. The module was checked for prompt display on the LCD, and users were able to enter their preferred responses via the prompts in the text messages.

Table 2. Functionality test results

Notification Module			
Scenario Description	User	Expected Results	Pass/Fail
When the user presses the button	Courier / Resident	The mobile app receives a notification that someone is requesting to open the box	Pass
When the user presses 'B' key	Courier	Box notifies mobile app of courier box access request, then sends OTP via text to resident.	Pass
When the user presses 'D' key	Resident	The mobile app receives a notification when a resident requests to open the box.	Pass
When the user enters the correct OTP	Courier	The mobile app receives a notification that the box is unlocked	Pass
When the user enters the correct PIN	Resident	The mobile app receives a notification that the box is unlocked	Pass
When the user places the parcel inside where the sensors can detect it	Courier	The mobile app receives a notification that a parcel was delivered	Pass
When the user takes out the parcel where the sensors can no longer detect it	Resident	The mobile app receives a notification when the parcel has been claimed and the box is locked.	Pass



5. CONCLUSION

The researchers would like to emphasize that while previous research studies have explored IoT Smart delivery systems, the system stands out by integrating the missing components accumulated from extensive prototype research. This integration includes essential features such as a code, keypad, sensor, buzzer, LCD, camera, interior lighting, a mobile app, and a database. These additions enhance the overall functionality and provide users with a comprehensive solution.

In terms of security, the researchers acknowledge the limitation regarding the absence of an alarm to detect unauthorized access. To address this concern, it is a recommendation to incorporate an accelerometer or motion sensor within the smart delivery box. This sensor can detect changes in movement or acceleration, enabling it to identify when the box is being forcibly moved or lifted abruptly. When such suspicious movements are detected, the sensor can trigger the installed buzzer to emit a loud sound, effectively deterring theft and alerting nearby people.

To address unauthorized access, GPS functionality is recommended. Integrating GPS capabilities allows real-time tracking of the package, adding an extra layer of security. Users can locate their package, even if it falls into unauthorized hands. GPS implementation ensures enhanced security and peace of mind for users.

As many Filipinos have opted for online shopping to have a convenient lifestyle, the researchers have developed a system that makes their lives more convenient by having an IoT-Enabled Smart Delivery Box that can let them monitor their packages remotely and securely. Additionally, the test users were satisfied enough that they have entrusted their online shopping deliveries using the smart delivery box. Users have also understood how simple it is to navigate and control the smart delivery box and allow them to coordinate with couriers remotely.

As various cases have already surfaced on various social media platforms, couriers steal, lose and damage their packages after marking the delivery as “has been delivered”. With all the mentioned cases, residents doing online shopping now have a reliable way to receive their packages while not being present in their homes by using the IoT-Enabled Smart Delivery Box system.

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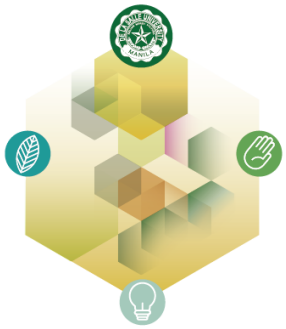

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