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MULTIUSER WIRELESS SMART PARCEL BOX

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Abstract

The Multiuser Wireless Smart Parcel Box is an innovative solution that addresses the issues of today's parcel distribution system, notably in terms of security, accessibility, and efficiency. This technology offers secure and automated parcel delivery by authenticating the receiver using a QR code, allowing only authorized people to access the parcel box. The integration of a Raspberry Pi, a Firebase database, and a mobile application allows for real-time monitoring and control, with users receiving notifications when parcels arrive. The device includes a servo motor to lock and unlock the box, a camera module for live streaming, and an LED light for visibility in low-light circumstances. HTTP requests provide network connectivity, allowing the mobile application and parcel box to cooperate seamlessly. The use of this smart parcel box lowers the danger of parcel theft, reduces delivery failures owing to recipients absence, and supports contactless and automated delivery procedure. Future developments will include improved security features through encryption, an upgrade to the locking mechanism, and the integration of additional sensors to improve functioning. This project represents a big step forward in upgrading last-mile delivery services by using IoT and smart technology to create a more secure and efficient parcel management system.

Keywords: Real-Time Monitoring, Authentication, Management System, IoT

INTRODUCTION

In the present era of globalization, with the ease that the Internet has offered, individuals prefer to choose to purchase online instead of purchasing in a real store to escape the crowds and to compare prices. The number of online shoppers is increasing rapidly, from groceries, and daily supplies to clothing or luxury products, everything that is needed, you can buy online. It provided the details of Multiuser Wireless Smart Parcel Box. This chapter also covers the project background, problem statement, aim, objectives, and significance that led to this application development. It is designed to solve the increasing issues of parcel delivery in the e-commerce era, such as missing deliveries, package theft, and damaged items. Using Internet of Things (IoT) technology, this intelligent parcel box provides a safe and easy solution for both consumers and delivery people. Real-time notifications are provided to users when a product is delivered, secure entry may be managed by a mobile app and PIN code is possible thanks to integrated sensors and cameras. Optional features include temperature control for critical goods such as groceries or medical supplies. By combining smart technology with user-friendly design, the Multiuser Wireless Smart Parcel Box IoT Project enhances security, convenience, and the overall package delivery experience. In general, the Multiuser Wireless Smart Parcel Box IoT Project offers an intelligent, secure, and easy method for managing parcel delivery. It not only increases package security by preventing theft and damage, but it also improves the whole customer experience by offering real-time information and control over the delivery process. This project integrates IoT technology to develop a better, more efficient solution for modern package management.

Problem Statement

The greatest way People encounter some of the problems with the existing package receiving procedure, although issues are rarely resolved. Courier services often encounter failed first-time home deliveries, which can occur in 12 to 60% of cases worldwide, resulting in wasted time and resources (Z.Guan., 2024).

Additionally, consider this to be the case if the recipient is not at home when the delivery man arrives with their item, the delivery man can leave the parcel in the parcel box or at the doorstep, or he can return later when the recipient is present. If the delivery guys decide

to leave the parcel in the parcel box or on the doorstep (assuming the receiver does not have a parcel box outside the home), the parcel box may be stolen or destroyed (Willems, 2024).

The weather is also one of the issues that might harm the parcel for example, on a rainy-day, an uncollected parcel just occurs to be on the doorstep or inside of a non-waterproof parcel box, the parcel will be destroyed by the rain (TheLifeElevation, 2023). The problem is when the recipient failed to show up to receive parcel delivery and caused failed delivery attempt which is a waste of time and money for the delivery company and the recipient as they have to reschedule the delivery, or the recipient must pick up the parcel at the collection centre (Rai, 2021).

In another example, if the delivery guy decides to return later when the receiver is home, the waiting time and delivery costs rise when the delivery mans will must visit the recipient's residence again. These issues are compounded for recipients who may live in areas with unpredictable weather patterns, making it imperative to develop solutions that ensure the safety and integrity of parcels regardless of external conditions.

Addressing these challenges requires innovative solutions that integrate secure storage, real-time communication, and automation. A Multiuser Wireless Smart Parcel Box system offers a promising approach by combining modern technologies such as IoT, QR codes, and cloud-based platforms. These systems not only enhance the security and accessibility of delivered items but also reduce delivery failures and operational inefficiencies. The integration of such solutions into the delivery ecosystem can significantly improve user convenience, reduce environmental impact, and optimize logistics operations for both consumers and courier services.

Project Objectives

The project was developed with the following objectives:

1. To design and develop a parcel box that avoid the parcel from stolen.
2. To develop mobile application, provide real-time monitoring through a mobile application.
3. To test a system that can secure the parcel and verification procedures used for unlocking the smart parcel box.

Project Scope

This project aims to develop an efficient Multiuser Wireless Smart Parcel Box using a Raspberry Pi 5 and a PC setup to address parcel receipt issues for both delivery personnel and recipients. It is designed to handle small and medium parcels, ensuring a compact, cost-effective solution suitable for residential areas like porches and apartment lobbies. To maintain simplicity and functionality, the prototype is limited to accepting one parcel at a time and supports only one delivery person and one recipient, excluding large or oversized parcels.

Project Significance

The Smart Parcel Box project addresses the growing need for secure and convenient parcel delivery due to the rise of online shopping. By offering an intelligent, automated system for receiving and handling packages, it enhances the delivery experience for customers and couriers. Additionally, the project aims to improve logistics efficiency, reduce theft and lost deliveries, and speed up the delivery process.

LITERATURE REVIEW

Arduino board Microcontroller

Arduino comes with boards, modules, and sensors to build projects or prototypes. Arduino board can be programmed to execute tasks by sending lines of code as an instruction to the microcontroller on the board. To execute the action, Arduino programming language (based on Wiring), and Arduino Software (IDE), based processing are required (Urvi Singh, 2019).

Raspberry Pi Microcontroller

The Raspberry Pi might serve as the foundation for the creation of a smart parcel box. A Raspberry Pi is a tiny, inexpensive computer that does all the functions of a larger computer. Just like any other computer, the Raspberry Pi is sometimes referred to as a single-board computer (Halfacree, 2020). It is constructed on a single printed circuit board but is composed of many parts with an operating system based on Linux, Raspberry Pi functions similarly to a small, multipurpose computer and is capable of multitasking (Gite, 2023).

Comparison between Arduino and Raspberry Pi

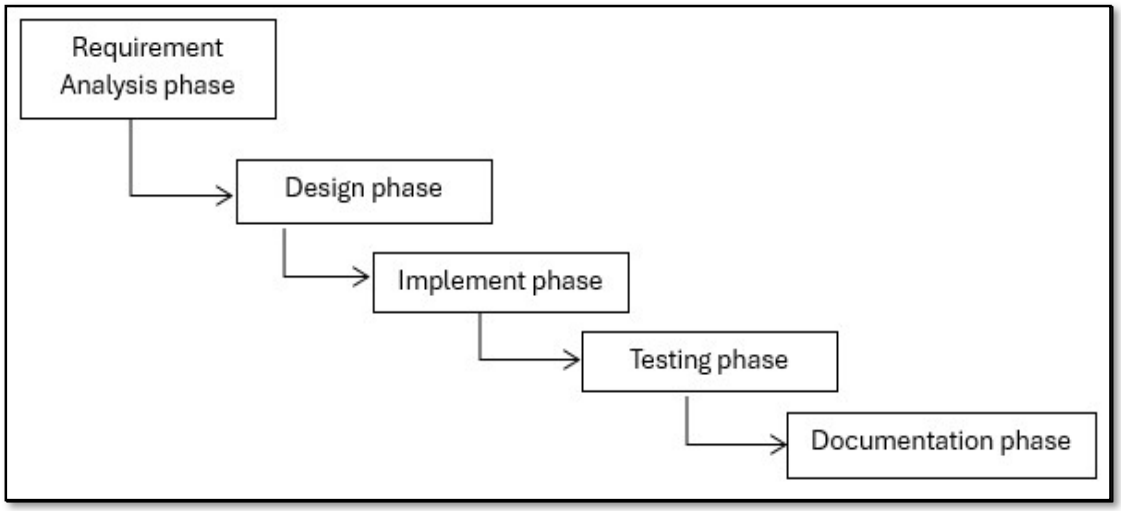
Arduino and Raspberry Pi are both widely used platforms for electronics and IoT projects, but they serve different purposes. Arduino is a microcontroller-based board that excels in real-time control applications, making it ideal for tasks such as sensor monitoring and motor control (Banzi, 2014). Raspberry Pi is a single-board computer that runs a Linux-based operating system, enabling multitasking, networking, and more computationally intensive applications like image processing and artificial intelligence (Halfacree, Software Settings, 2016).

Authentication System

The smart parcel box should be able to identify the parcel correctly and allow access to the delivery personnel to deposit the parcel. To facilitate this, the parcel recipient should be able to send the parcel tracking number to the smart parcel box. For smart parcel box to protect the packages kept inside of them, security is essential. The following are some typical security protocols seen in intelligent package boxes (Maryam Alghfeli, 2022).

METHODOLOGY

An organisational procedure that is standard for carrying out all the tasks required to assess, create, implement, and maintain information systems. A highly detailed plan is being implemented to realise this project as a product that is ready to use and has safety characteristics. Mobile Application Development Life Cycle (MADLC) is a system



development life cycle that is specifically developed to build mobile apps owing to its difficulty and needs as compared to desktop development of applications.

Based on figure 1 Identification, design, development, prototyping, testing, deployment, and maintenance are the seven steps that make up the Mobile Application Development Life Cycle (MADLC) (Zulkhairi Azam, 2016).

Once the system is in the testing phase, it is very difficult to go back and make any changes that were not well documented or managed during the design phase (Ali, 2024). The Mobile Application Development Life Cycle (MADLC), as depicted in the provided diagram, consists of sequential phases that systematically guide the development process of a mobile application. Each phase plays a critical role in ensuring the successful completion of the project while maintaining quality, security, and usability standards. The first phase, the Requirement Analysis Phase, involves gathering and analysing user and system requirements to define the scope and objectives of the application. This phase identifies the specific features needed, such as parcel tracking, QR code authentication, and real-time notifications, ensuring the application meets user needs effectively (Saurav Battacharya, 2024).

For the Design and Development phase, the system architecture is designed, and the mobile application and connectivity between the microcontroller Raspberry Pi 5 Model B and the mobile application are developed. Techniques such as flow charts, use cases, Logical Diagram are used. The outcomes include Logical Diagram, System Circuit, flow chart system, and the system source code. Testing phase involves conducting functionality testing and network performance testing. Figure 2 Overall System Flowchart of Multiuser Wireless Smart Parcel Box.

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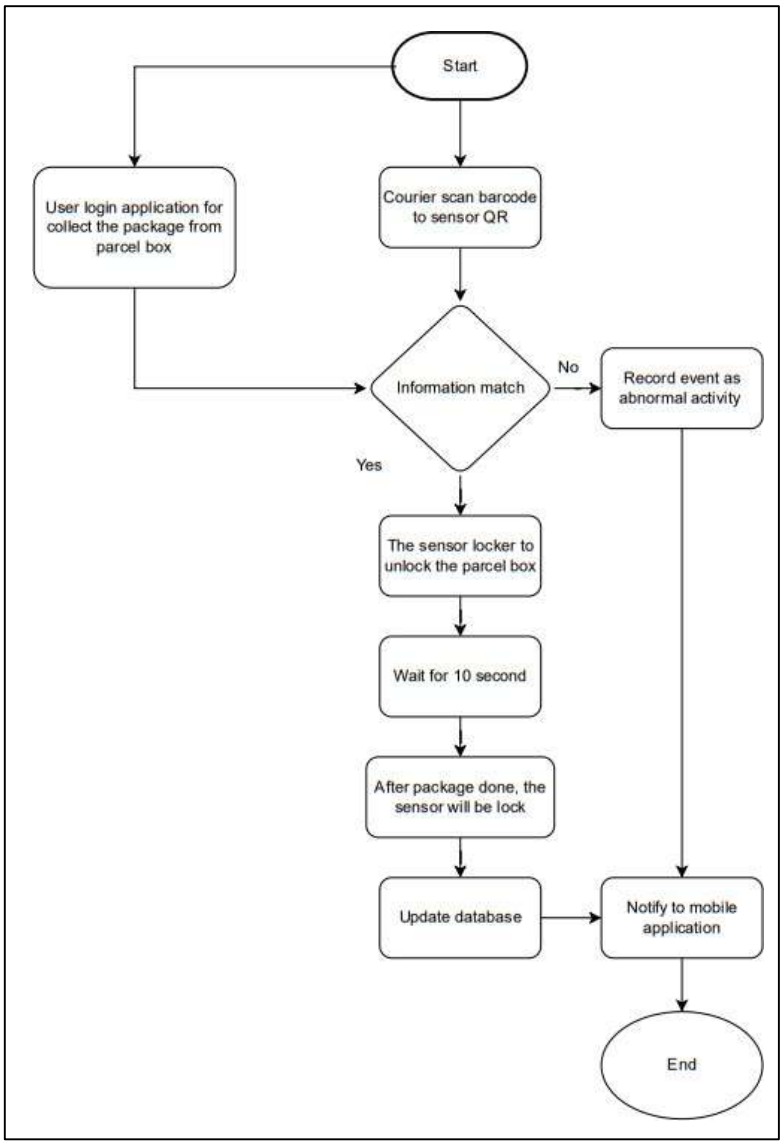

Figure 2 : Flowchart of Multiuser Wireless Smart Parcel Box

Refer to Figure 2 above shows that the overall system of Multiuser Wireless Smart Parcel Box for user and courier. The process begins when a courier scans a barcode on the parcel using a sensor that reads QR codes. The system then verifies whether the scanned information matches the stored data. If the information does not match, the system records the event as an abnormal activity and notifies the mobile application.

If the information matches, the sensor triggers the locker to unlock the parcel box, allowing the courier to place the package inside. The system then waits for 10 seconds before automatically locking the sensor again after the package is placed. Following this, the database is updated to reflect the delivery status. Finally, a notification is sent to the mobile application, informing the recipient that the parcel is ready for collection. The process ends when the user logs into the application to collect the package.

System Design Architecture

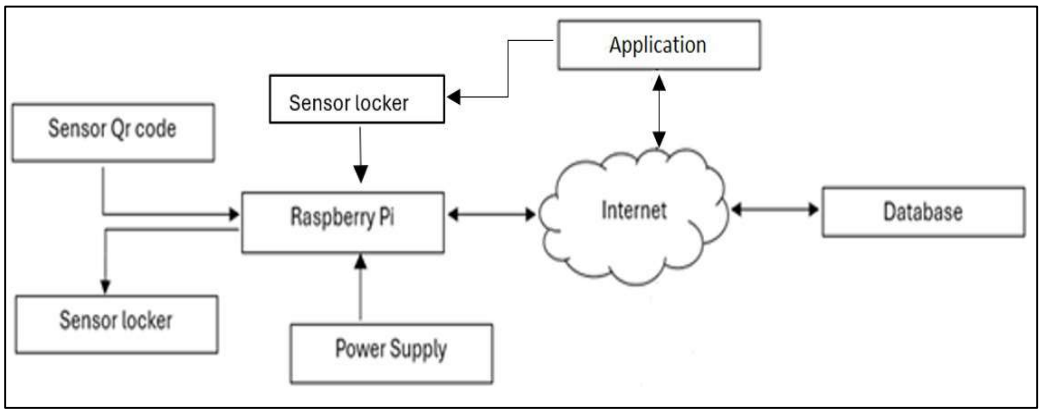

Figure 3 : System Design

The circuit diagram of the project is given in figure 3 shows that the power adapter with a 5V output is connected to the Raspberry Pi 5 Model B. Additionally, have two the SG90 micro servo and sensor Qr code are linked to the Raspberry Pi. The Raspberry Pi controls the SG90 micro servo, which opens and closes the parcel box, while the sensor qr code module scans and reads the data from the QR Code and saves it to firebase. Next, the application for users can control the SG90 micro servo unlock and lock the parcel box to collect packaging parcel inside parcel box.

In addition, Raspberry Pi 5 Model B is linked to the firebase, smartphone, and Internet. When the shipment arrives, users will update the package details in the database using the application and system. The Raspberry Pi will use the Internet to retrieve parcels details from the database then match it to what the sensor qr code is ready. Once the item has been delivered, the firebase update data from the sensor qr code module scanner.

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Wiring Diagram of System

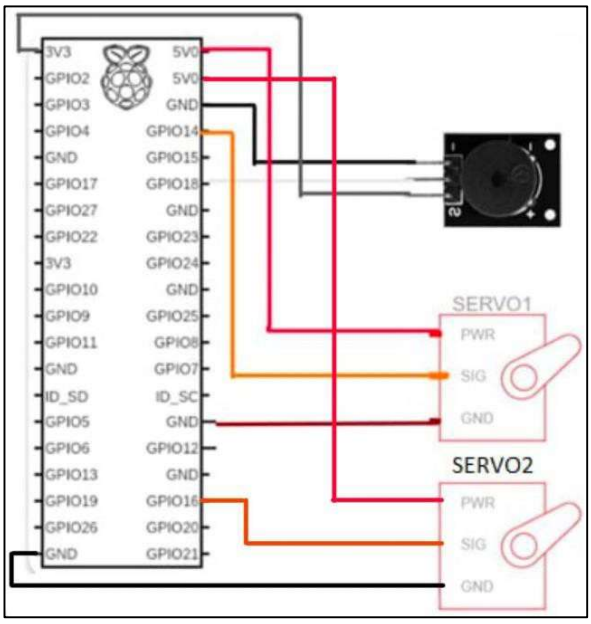

Figure 4 : Wiring Diagram for the project

The Wiring Diagram of the project is given in figure 4 shows that the input stage of the system, the wiring between Raspberry Pi 5 Model B and SG90 Micro Servo, the connection was presented in figure 4 and table 1. The red colour wire of SG90 Micro Servo connects to a 5V pin (GPIO pin 02) and the brown colour wire of SG90 Micro Servo must connect to the ground pin (GPIO pin 30), while the orange colour wire of SG90 Micro Servo needs to connect to a GPIO output pin, which is GPIO pin 08 (also known as GPIO14). The Buzzer KY-006 is needed for this system to inform the camera can detect qr code successfully. The black colour wire of Buzzer KY-006 connects to ground pin (GPIO 06), the white colour wire must connect to the (GPIO pin 18) and the last grey colour wire connect to a 3V pin (GPIO 1).

RESULT AND DISCUSSION

Accuracy and connection are prioritized during the system testing process since this system is involved in wireless and distant communication between applications. To verify the system's accuracy, the Web camera module will be tested for QR code reading accuracy, as well as the parcel box's ability to unlock following QR verification. Furthermore, the accuracy of data updates or inserts into the database, the accuracy of email notifications sent to the recipient,

and accuracy of remotely controlling the Multiuser Wireless mart Parcel Box will all be tested. All tests will be done out ten times.

The system' connection will be tested by scanning the QR code with the Web camera module and unlocking the package box with the servo. The parcel box control's remote connection will also be tested, as will the emails notice delivered to the receiver. All tests will be done out ten times.

Table 1 summarizes the accuracy and detection time for valid and invalid QR codes in normal light and no light. The results indicate that valid QR codes were detected with 100% accuracy in an average time of 0.3435 seconds, while invalid QR codes (such as previously used ones) were correctly rejected with 0% accuracy, taking an average of 0.0713 seconds for detection.

Table 1 : Testing Normal light

QR Code	Accuracy %	Detection (sec)
Valid QR Code	100	0.3435
Invalid QR Code (qr code already used)	0	0.0713

Tables 2 is no light in the surroundings, the QR is unable to detect, there for the accuracy is 0%. None of the QR codes can detect when there is no light, due to the web camera's lack of night vision. The connections findings also show that no detection to check the QR code.

Table 2 : Testing No light

QR Code	Accuracy %	Detection (sec)
Valid QR Code	0	-
Invalid QR Code (qr code already used)	0	-

According to the results in tables 3 and 4, the servo motor has 100% accuracy and an average reaction time of 0.10 to 0.09 seconds following QR verification. In the receiver control scenario, it has 100% accuracy and an average reaction time of 0.096 to 0.09 seconds after the receiver clicks the button on the mobile application.

Table 3 : Testing Verification Qr Code

QR Code	Accuracy %	Detection (sec)
Valid QR Code	100	0.1035
Invalid QR Code (qr code already used)	100	0.0978

Table 4 : Testing Receiver Qr Code

QR Code	Accuracy %	Detection (sec)
Valid QR Code	100	0.0968
Invalid QR Code (qr code already used)	0	0.0900

Thes servo's connectivity in testing two (receiver control) takes longer than in testing one (system verification) because when the receiver is controlled via a mobile application, the signal must travel across the Internet to reach the Raspberry Pi Model B.

Network Testing

Network testing plays a crucial role in ensuring the effective communication between the mobile application and the server for the Smart Parcel Box system. The primary function being tested is the ON/OFF control mechanism, which allows users to remotely activate or deactivate the system using HTTP GET requests.

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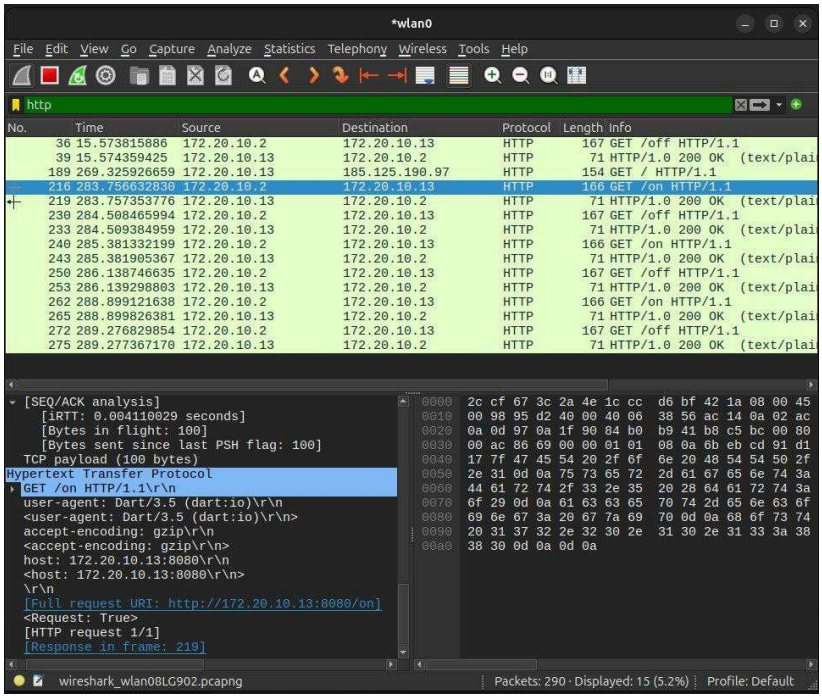

Figure 5 : Capture Data from Wireshark

Wireshark was used to capture and analyse network packets (as shows in figure 5), revealing that the mobile application sends HTTP request from IP 172.20.10.2 to the server at IP 172.20.10.13 on port 8080. The GET requests, GET /on HTTP/1.1 and GET /off HTTP/1.1, allow users to remotely activate or deactivate the system, with the server responding with HTTP/1.0, confirming successful execution.

Network testing methodologies included functional testing, latency analysis, and error handling to evaluate system reliability. The testing process confirmed that the Smart Parcel Box effectively processes remote commands without delays, ensuring seamless interaction between the client and server. Future improvements could include security enhancements such as encryption and authentication to prevent unauthorized access and ensure secure communication between the mobile application and the server.

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CONCLUSION

The Multiuser Wireless Smart Parcel Box is designed to help recipients securely receive and store their parcels. It features an automated system that verifies incoming parcels and ensures that only authorized deliveries are accepted. The front door of the box will only open once the parcel has been verified, preventing unauthorized access. The entire process operates autonomously, eliminating the need for human intervention. The primary objective of this project is to address issues faced by both parcel recipients and delivery personnel in the current delivery process. One major problem is the inconvenience caused by missed deliveries.

Parcel recipients often have to stay at home to receive their deliveries, which can be highly inconvenient if they have other commitments. Similarly, delivery personnel waste time waiting for recipients to answer the door, and if no onesies available, they may have to reschedule the delivery or leave the package in an unsecured location.

Additionally, the risk of parcel theft has become a growing concern, especially in residential areas where unattended packages are vulnerable to being stolen. This project proposes a solution by allowing the Multiuser Wireless Smart Parcel Box to act as a secure recipient for parcels. Since the box is installed outside the house, the delivery personnel can simply interact with it to complete the delivery, eliminating the need for recipients to be present. This ensures that parcels are received safely and reduces the likelihood of theft.

Limitations

The project is being developed by a single individual who serves as both the system developer and user, leading to subjective input and a risk of not fully meeting market requirements. Additionally, setting up the equipment and software posed challenges, particularly due to the limited resources available for configuring the new Raspberry Pi model 5, despite its 8GB RAM supporting advanced coding capabilities.

Future works

The current Multiuser Wireless Smart Parcel Box can be improved with additional features. A Camera Live Stream capability would allow recipients to view real-time footage

via a mobile app, enabling remote control of the parcel box if QR code recognition fails. To address issues with QR detection in low-light conditions, the system could be upgraded with a Night Vision Camera Module or an LED light for better visibility. Additionally, replacing the SG90 Micro Servo with a Solenoid Door Lock would enhance security and convenience, as it automatically locks the parcel box upon closure, eliminating the need for manual system control.

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