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Research and implementation a contactless delivery system utilizing IoT technology

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Abstract: *With the rapid development of e-commerce, the demand for fast, flexible, and convenient delivery services is higher than ever. While traditional direct delivery methods remain popular, they present limitations such as dependency on recipients and lack of flexibility in delivery time selection. To address these challenges, this study proposes the design and implementation of a contactless delivery system utilizing IoT technology. The system integrates mobile applications, IoT-based control modules, and physical storage cabinets to automate the delivery and reception process. This approach enhances real-time monitoring, reduces labor dependence, and improves operational efficiency. By allowing users to interact with the system through an application to send and receive packages without direct contact, the system not only optimizes delivery operations but also meets the growing expectations for service quality in a competitive logistics environment. The project aims to contribute to the digital transformation of logistics by providing a modern, secure, and user-friendly delivery solution.*

.***Keywords:*** *Contactless Delivery, IoT Technology, Smart Locker System, Mobile Application.*

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I. INTRODUCTION

Traditional delivery methods—direct delivery—have become increasingly popular today, especially in the context of the robust growth of e-commerce. The rapid rise of online shopping platforms has driven customer demand for fast and convenient delivery services. However, this method still has some drawbacks, such as dependence on the recipient and a lack of flexibility in choosing delivery times.

To enhance service quality and optimize processes, the application of IoT technology in the delivery and reception process not only helps automate procedures but also strengthens the ability to monitor and manage goods in real-time. As a result, businesses can streamline their delivery processes, offer multiple flexible delivery options for users to choose from, while simultaneously reducing operational costs and dependence on labor.

Implementing a contactless delivery system through IoT technology not only flexibly meets the diverse needs of customers but also contributes to improving the operational efficiency of businesses in the logistics industry. This is particularly important in the context of fierce competition and high demands for service quality. Recognizing the necessity and alignment with current development trends, that is why I have chosen the topic "Research and Implementation a Contactless Delivery System utilizing IoT Technology".

The goal of this study is to build and develop a contactless delivery system, which optimizes the delivery process between the sender and the recipient. The system uses IoT technology, mobile applications, and physical storage cabinets to enhance safety, convenience, and efficiency in the delivery process, while enhancing the user experience in the context of strong e-commerce.

II. SYSTEM ARCHITECTURE

2.1 System architecture

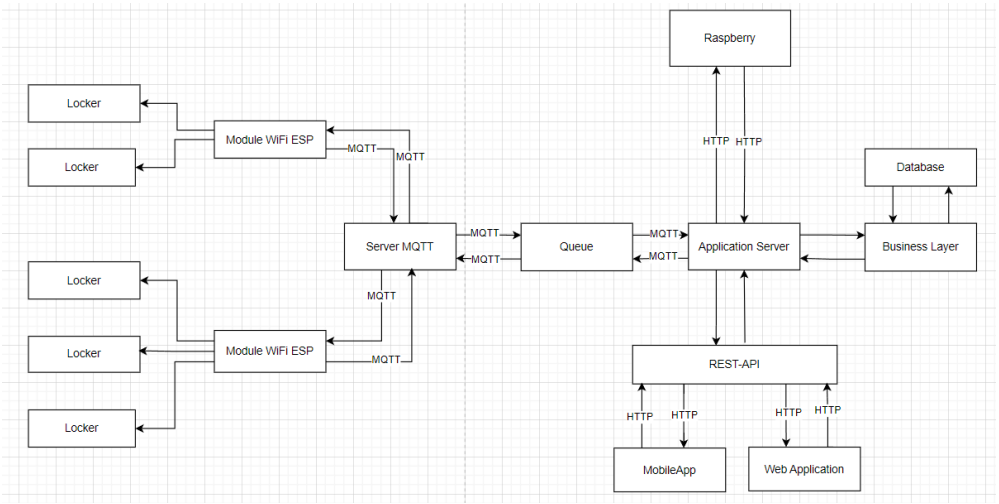

Figure 1 System Architecture Overview

The implemented system model includes a number of prominent components such as:

- Queue: RabbitMQ
- Database: PostgreSQL
- REST-API: FastAPI
- Transport Protocols: MQTT, HTTP

III. HARDWARE DESIGN

3.1. Cabinet

3.1.1. Cabinet control circuit design

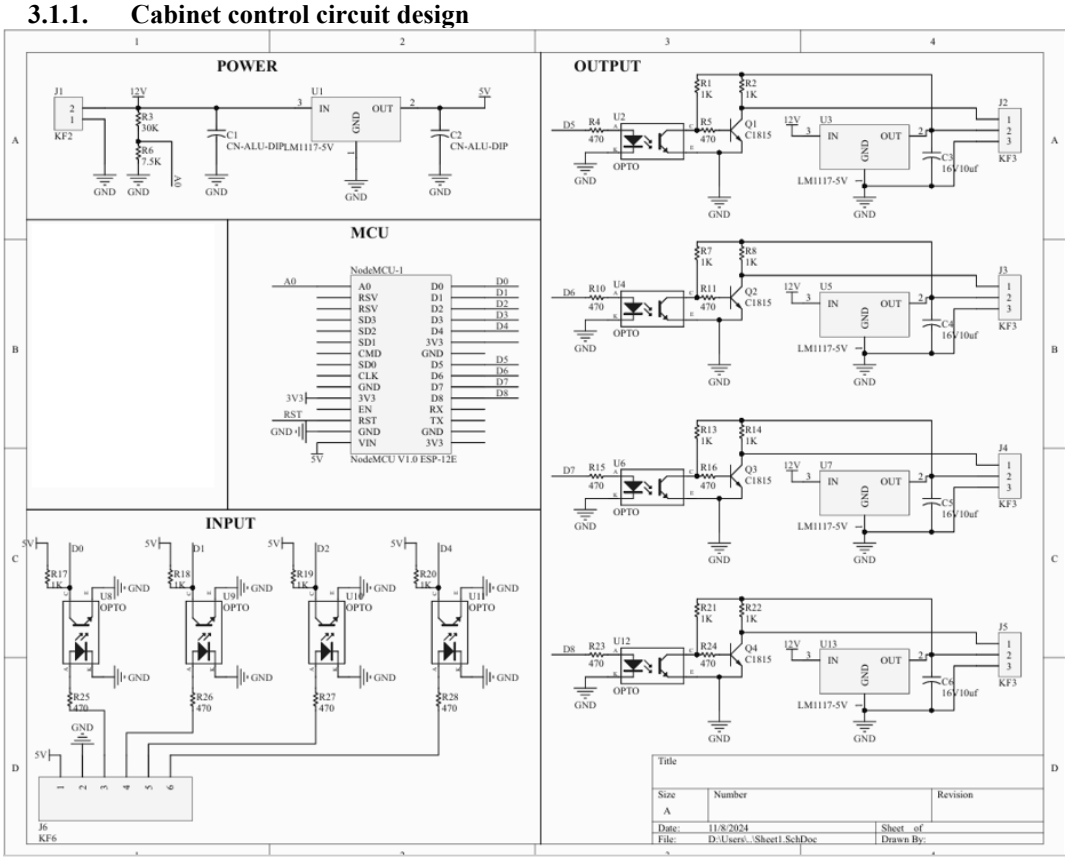

*Figure **Error! No text of specified style in document.** Diagram of the principle of the cabinet control circuit*

3.1.2. Cabinet design

We will use the software to design the hinge part for the cabinet opening and closing, below is the accompanying design picture.

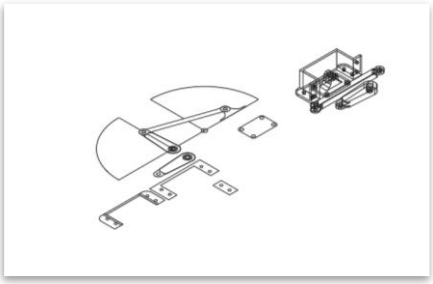

Figure 3 2D image of cabinet hinge

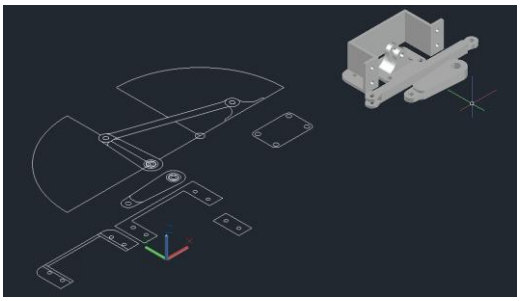

Figure 4 3D image of cabinet hinge

ABS plastic boxes (200mm x 200mm x 80mm) are used in the project as models to simulate lockers in a contactless delivery system. These boxes represent actual cabinets used for storing utensils or packages. Made from durable ABS material, each box includes a hinge mechanism for convenient opening and closing, ensuring the protection of stored items during operation.

The MG996R servo motor is used to open and close the cabinet door in the system. It is a high-quality motor known for its precise control and high torque, making it ideal for robotics, modeling, and automation applications. As an upgraded version of the MG995, the MG996R offers improved performance and greater accuracy, ensuring reliable cabinet operation.

Figure 5 Cabinet with 3D-printed hinge and servo (exterior)

Figure 6 cabinet with 3D-printed hinge and servo (interior)

Mechanism of operation :

- The cabinet uses servo motor to control the swing arm, which realizes the lifting and lowering of the cabinet cover automatically, based on the lever mechanism through the hinge.
- The conductor inside the cabinet connects the servo motor with the power supply and external control system, ensuring stable and synchronous operation.
- When the servo rotates, the force transmitted through the lever arm helps the cabinet lid to open or close completely, according to the control signals from the system.

3.1.3. Flowchart for cabinet system

The cabinet system operates under the control of a cabinet handling block, which manages the physical opening and closing of motorized storage cabinets. These cabinets receive commands through a processing block that communicates with the central monitoring system. Users can control cabinet actions via an application interface, allowing for secure and contactless package pickup. The system ensures precise cabinet operation through coordinated control between the motors and handling unit. Each control unit can manage up to four cabinets, allowing scalability. To use the system, users must register via the application, enabling both order management and system tracking. When a recipient attempts to collect a package, the system verifies whether the order belongs to them before allowing access.

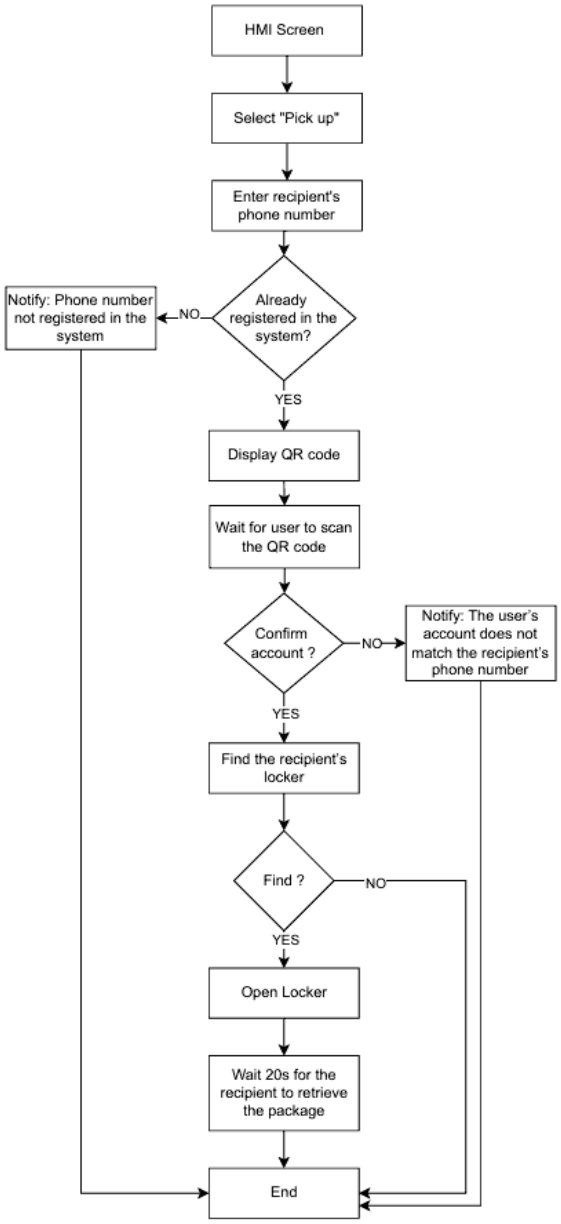

Figure 7 The flowchart of the system for users receiving their packages

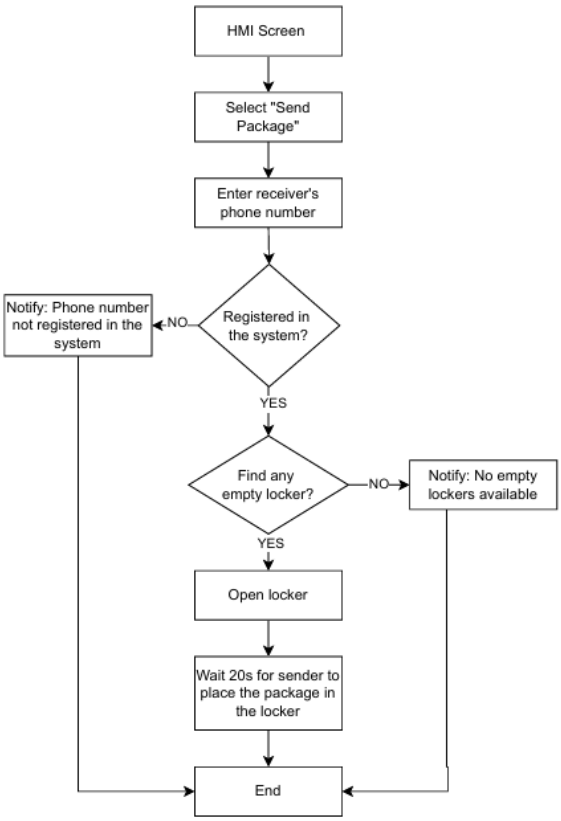

Figure 8 The flowchart of the system for processing user-sent packages

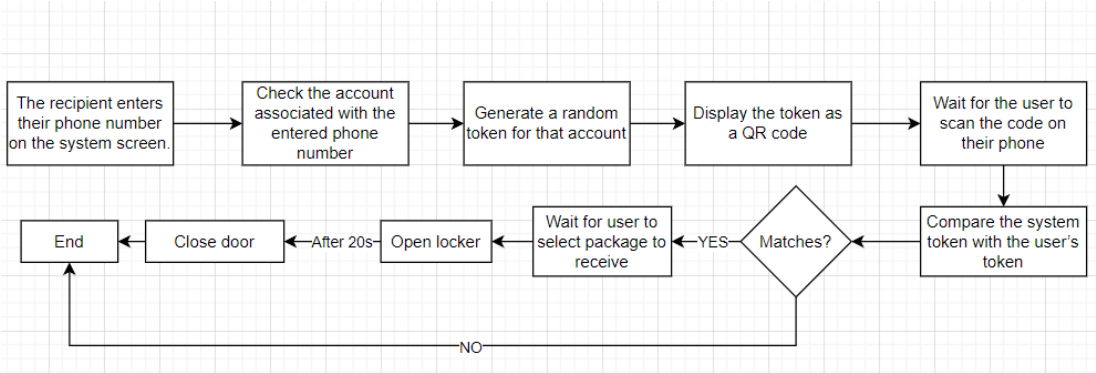

Figure 9 Receipt verification process

IV. SOFTWARE DESIGN

4.1 Apps for users

The user application includes several key use cases as Figure 10. Users can sign up for an account by entering their phone number and password, which are authenticated via Firebase. Once registered, users can log in to the system to access its features. They can pick up goods by scanning a QR code at the cabinet, where the system verifies the order and updates its status to "Received". Users can also view their pickup history, check unreceived or received orders, and receive real-time notifications when a new order arrives. Each function requires the user to be logged in, and the system provides feedback in case of invalid inputs or failed operations.

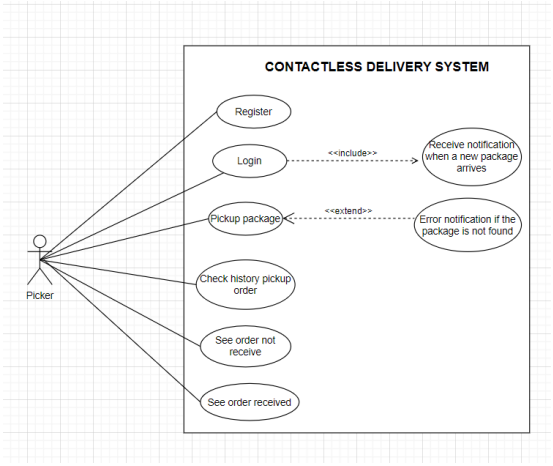

Figure 10 General Usecase for User Applications

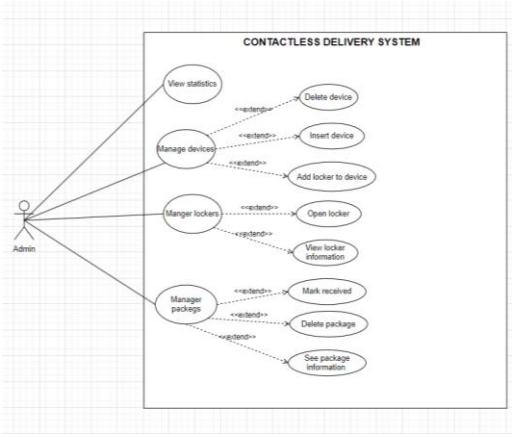

Figure 11 General Usecases for System Management Applications

4.2 System management application (dashboard)

The system management application provides administrators with key features to monitor and control system operations as Figure 11. Admin users can view statistics related to package volume, shipping activity, and order trends over the past 7 or 30 days. They can also manage devices by adding, deleting, or editing device information. Cabinet management includes functions to add new cabinets, open existing ones, and view detailed cabinet information. Additionally, admins can manage packages by marking them as received, deleting them, or checking their details. All operations require administrative login and result in real-time updates and system feedback.

4.3 HMI Interface for Cabinet System

HMI Locker is a man-machine interface integrated on a smart cabinet, allowing users to perform operations directly with the cabinet system. This interface is usually designed in the form of a touchscreen or control panel followed as Figure 12, 13.

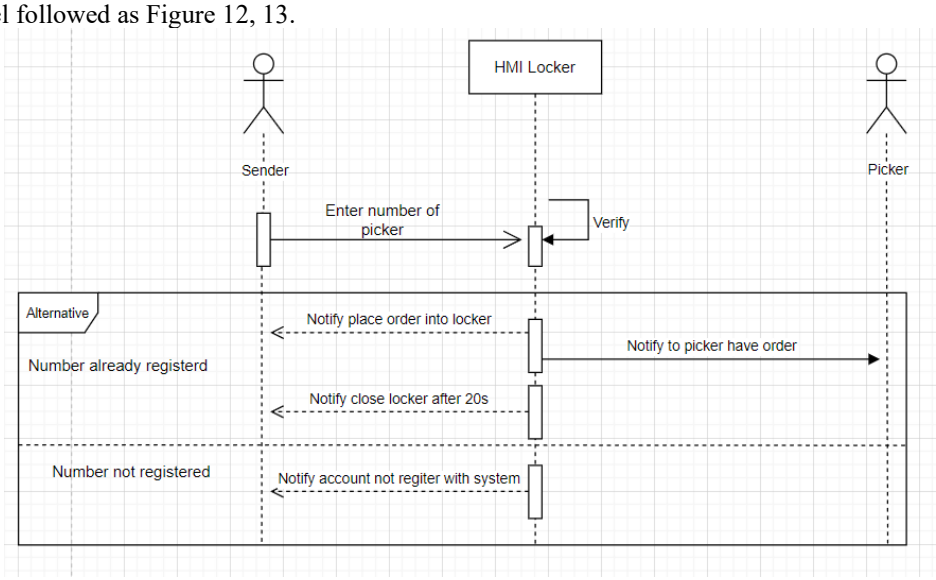

Figure 12 Chart of HMI processing flow handling pickups from sender

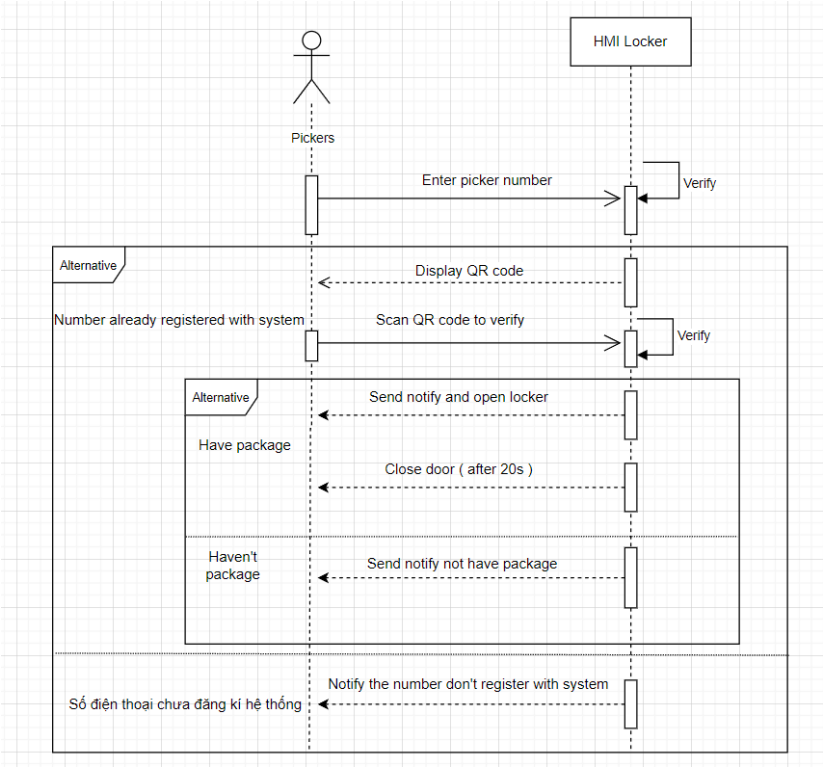

Figure 13 HMI flow diagram for delivery the delivery to the recipient

V. RESULTS

The implemented contactless delivery system consists of three main components: a smart cabinet system, a mobile application for users, and a dashboard interface for administrators. The cabinet system was constructed using ABS plastic boxes and servo motors (MG996R), controlled via ESP8266 modules and integrated with a Raspberry Pi for the HMI (Human-Machine Interface). The system enables cabinet door control through QR code scanning, user authentication, and real-time status updates.

The mobile application supports account registration, login, order tracking, and QR-based pickup. Users receive real-time notifications when new packages arrive, and can access their pickup history or view uncollected items. All communication between the app, cabinet, and server is handled through a combination of MQTT and REST APIs.

The dashboard application provides administrative functionalities such as cabinet creation, device monitoring, package status management, and statistical reports (e.g., package volume over 7 and 30 days). Administrators can remotely open/close cabinets and manage up to four cabinets per device node.

During testing, the system operated reliably in controlling cabinet access, synchronizing package status, and processing user commands. The integration of IoT technologies significantly reduced manual operations, improved delivery security, and provided a flexible framework for expanding cabinet-based delivery services in high-traffic areas such as campuses or residential zones.

4.1. Cabinet system

a. Control Circuit

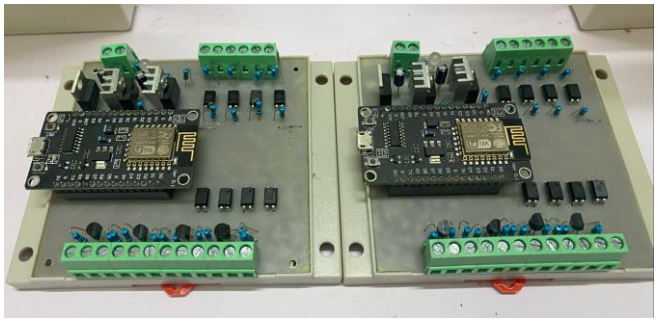

Figure 14 Cabinet Control Circuit

b. Folding cabinet and entire cabinet system

Figure 15 Cabinet with servo motor can be closed

Figure 16 The entire physical cabinet system

4.2. HMI Interface

a. Home screen

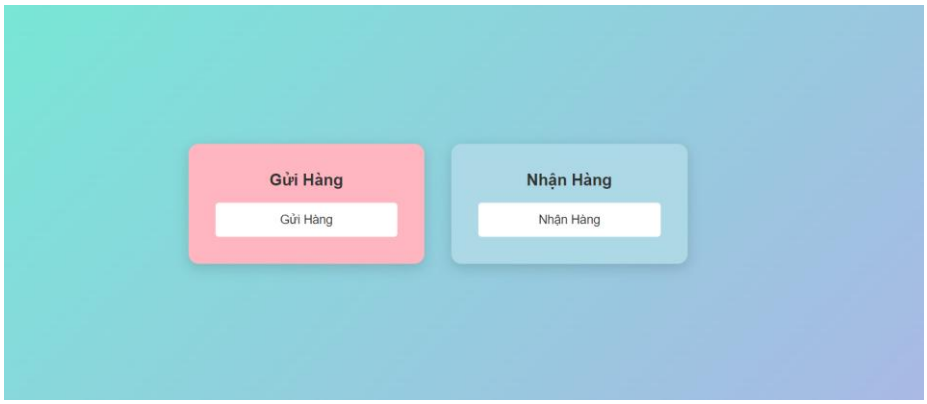

Figure 17 Main Screen HMI Interface

b. Phone number entry screen to send or receive goods and shipping unit selection screen

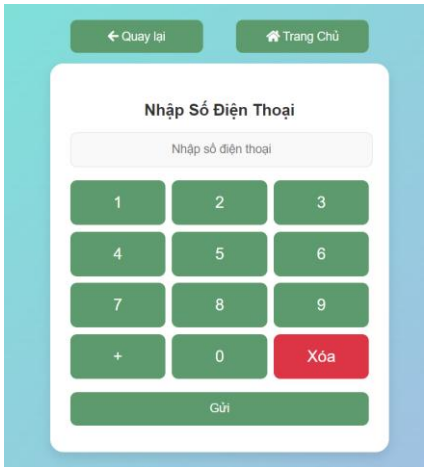

Figure 18 HMI Interface Phone Number Input Screen

Figure 19 HMI Interface Carrier Selection Screen

c. Scan QR code for pickup

Figure 20 HMI Interface QR Code Scan Screen for Pickup

4.3. Application interface for users

Figure 21 Login screen

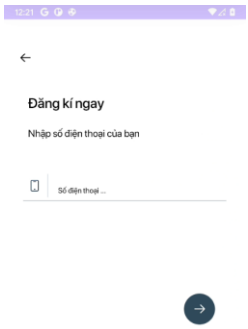

Figure 22 Registration Screen

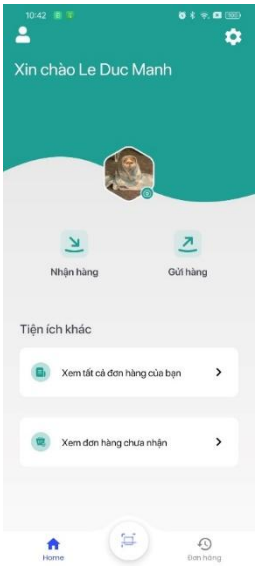

Figure 23 Home Screen

Figure 24 Order screen

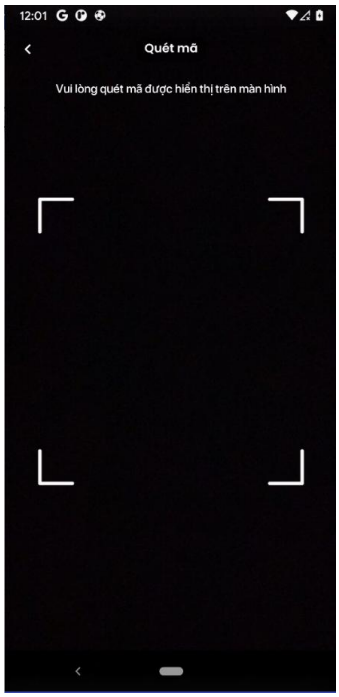

Figure 25 QR code scanning screen

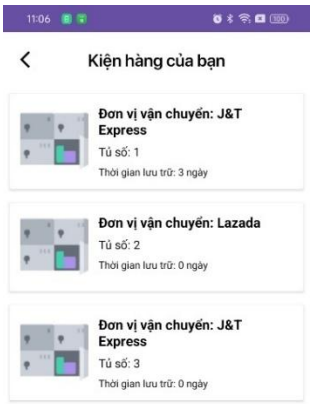

Figure 26 Select the order you want to receive

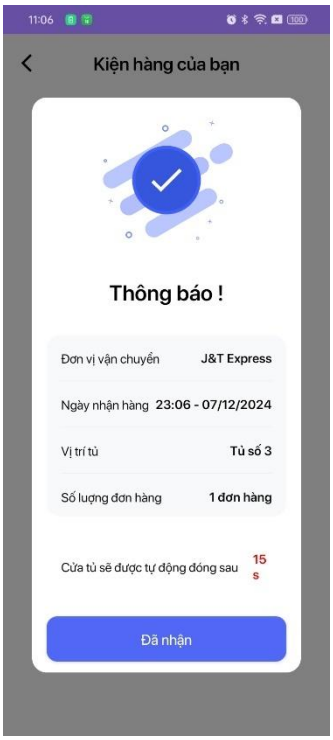

Figure 27 Successful order notification screen

Figure 28 Order not found notification screen

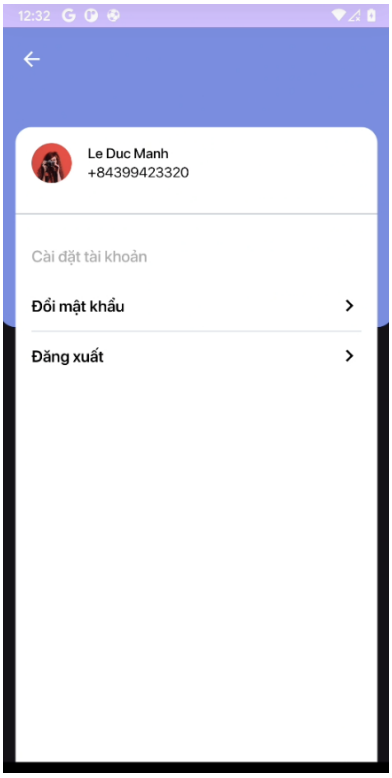

Figure 29 Installation screen

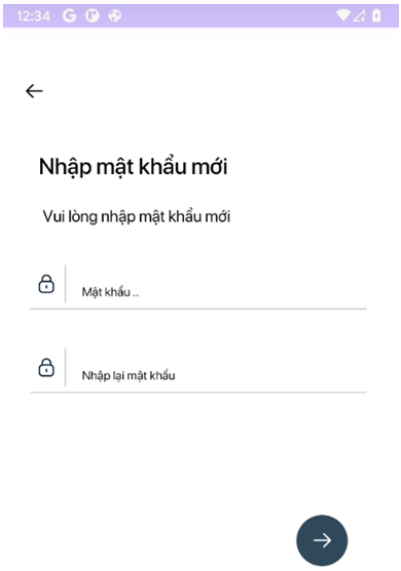

Figure 30 Password change screen

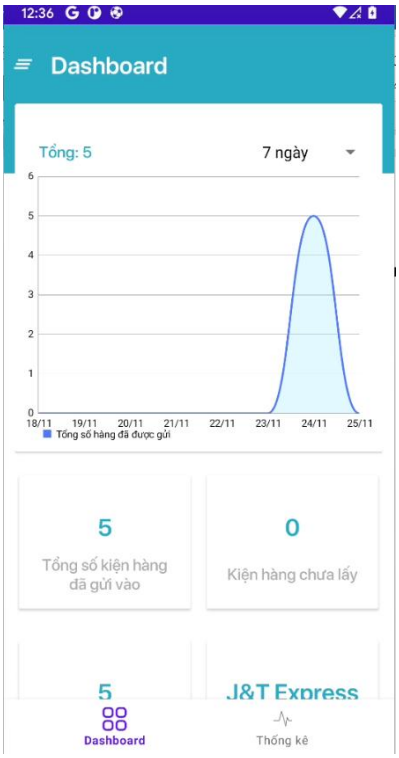

*Figure **Error! No text of specified style in document.**1 Home dashboard screen*

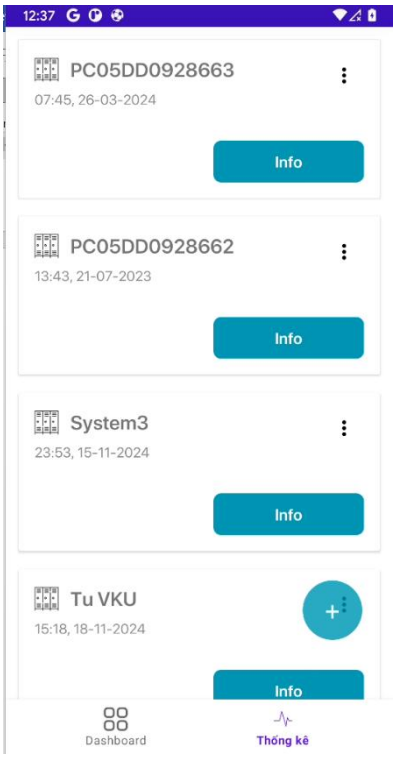

*Figure **Error! No text of specified style in document.**2 Cabinet list dashboard screen*

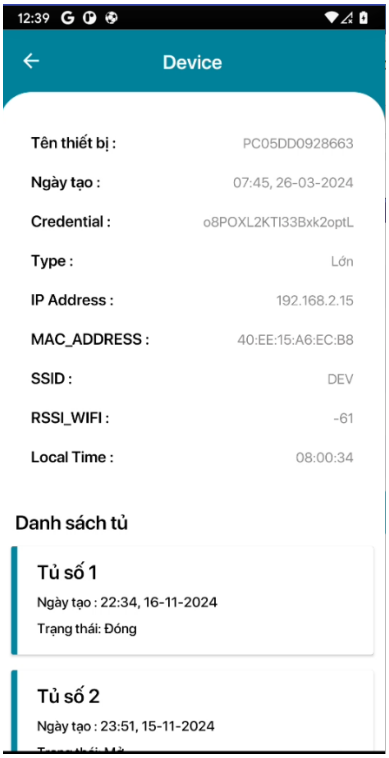

*Figure **Error! No text of specified style in document.**3 Cabinet detail dashboard screen*

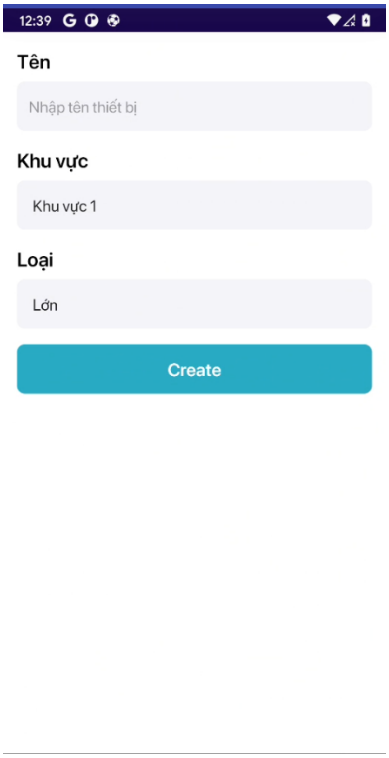

*Figure **Error! No text of specified style in document.**4 Dashboard screen creates a new cabinet*

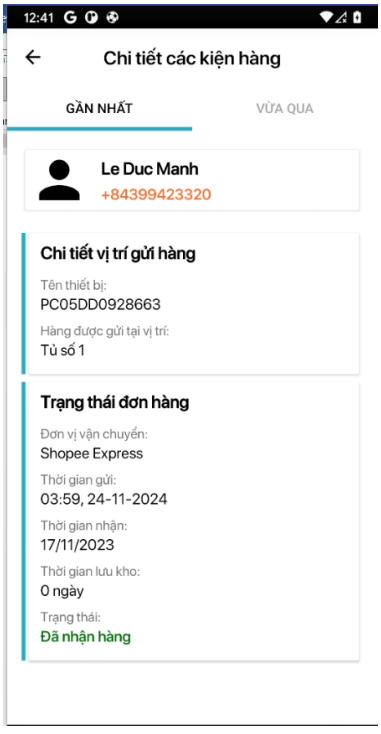

*Figure **Error! No text of specified style in document.**5 Detailed dashboard screen of packages at the cabinets (the latest)*

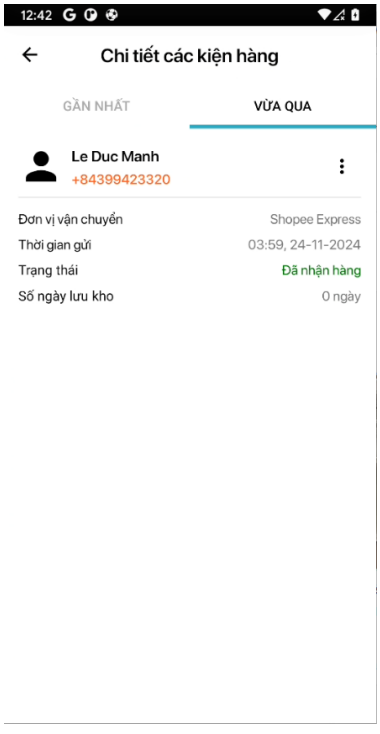

*Figure **Error! No text of specified style in document.**6 Detailed dashboard of packages in cabinets (recent)*

*Figure **Error! No text of specified style in document.**7 Dashboard screen closes/opens*

*Figure **Error! No text of specified style in document.**8 Clear/bookmark dashboard screen*

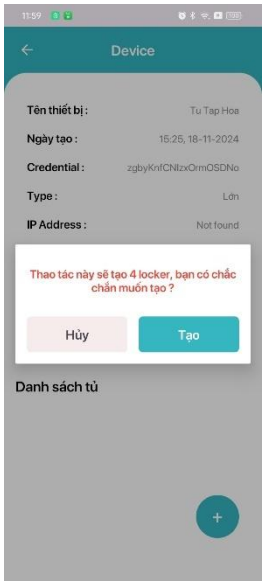

*Figure **Error! No text of specified style in document.**9 Dashboard screen to create 4 cabinets*

VI. CONCLUSION

This paper presented the design and implementation of a contactless delivery system leveraging IoT technology to improve the flexibility, security, and efficiency of the last-mile delivery process. By integrating hardware components such as servo-controlled smart lockers with a mobile application and a centralized management dashboard, the proposed system enables users to send and receive goods without direct human interaction. Experimental results show that the system functions reliably in authenticating users, opening cabinets via QR codes, and updating delivery status in real time. The proposed solution addresses common challenges in traditional delivery methods, such as time constraints and the risk of package misplacement, while enhancing user convenience and operational cost-efficiency. Future work will focus on improving the cabinet design, integrating with third-party logistics services, and expanding system scalability to support broader deployment in smart cities and campus environments.

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