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Smart Secure Locker System

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Abstract: The paper's focus is on revolutionizing the delivery of parcels by creating a streamlined delivery approach that emphasizes customer experience, precision, data safety, and altering the delivery framework. Automated locker allocations and modern delivery tracking, as well as automated notifications, all contribute to heightened efficiency for delivery partners. This efficiency is also translated to the customers who can now enjoy convenient self-service kiosks, secure parcel storage, an automated customer dashboard, and unprecedented control over the delivery process. Customer data is protected within the system through encryption, firewalls, and strict access guidelines which block all outside paths to sensitive customer information. The strategy focuses on the integration of new age technologies and design elements focused on the end user to ensure easy and unbreachable eco-delivery systems.

Keywords: Automation, User-centric design, Parcel delivery, Delivery ecosystem, tracking systems, Real-time delivery notifications.

I. INTRODUCTION

In the ever-evolving landscape of parcel delivery services, the need for a transformative and technologically advanced approach is paramount. Customer convenience is a central focus, achieved through the provision of flexible pickup options, secure parcel storage solutions, and a user-friendly customer dashboard. The research aims to emerge technologies such as the Internet of Things (IOT) and blockchain to redefine the delivery experience. It can be done by utilizing QR/barcode Scanning access control [1] which ensures parcel retrieval. This access to multiple users which provides a seamless, contact-free delivery experience. As in the traditional delivery the user should remain home to receive the order. Which causes a lot of trouble to the users who are not always available to collect. If the parcel is left out at the door step, there might be a chance of theft or damage to the items inside the package. To resolve many issues related to the security issues lockers are built like mail boxes to store any kind of package until the user opens it. Without the use of any kind of key or password the system can assist of using Bluetooth Low Energy (BLE) which deals [2] with the accuracy for the user in opening the locker. There are various methods including electronic locks [3] and secure access through biometric authentication. For a lot more convenience RFID cards are used which can be read quickly and accurately, allowing for faster and more efficient way for opening the lockers [4]. Any unauthorized access triggers an alert via SMS to the user's respective mail. It works great for detection tampering which enhances security with biometric [3] authentications and continuous monitoring. Sometimes a package or a parcel can be in a larger size compared to the assigned locker, which creates a new problem for many delivery agents to make if fit in any of the compartments available. In cases like rather building large lockers, logistic companies can work together and build a confined place for dropping of multiple parcels at a time which saves time of delivery agents and makes it simple for the users to collect their large parcels without being damaged in the transmit from one place to other [6] the larger lockers can be accessed by using a password or RFID card.

II. RELATED WORK

Smart locker systems have been suggested globally to solve these issues. As an example, Sharma et al. [1] developed a fingerprint-based smart locker system which utilized biometrics in place of conventional keys and passwords. Their design concentrated separately on enhancing reliability and averting the dangers posed by lost keys or forgotten PINs. Focusing on a different problem, Ooi and Tan [2] had developed IoT modular lockers with QR code Base authentication. This system is highly fascinating because it enables the scaling up or down of demand for its lockers which is very useful in overcrowded metropolitan cities where there is a need for space optimization. On the other hand, Alghfeli and her group [3] with their smart box linked with a mobile application took care of the problem of doorstep parcel theft.

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Users can track their parcels in real time and even grant temporary access through secure codes. The design showed that mobile integration is one of the main components that needs to be considered for modern delivery systems. Security innovation didn't stop there. Combining OTP, fingerprint verification, and image capturing, Bachhav et al. [4] developed a system which uses both for real time alerts and gives users an extra layer of protection about any other unauthorized access. Prochazka and Plasilova [5] had a brilliant idea which has way more likely to be a broader view of how the smart delivery boxes can contribute the development of smart cities. This resulted in cutting down delivery traffic and many more. A way more realistic approach was done by Naik er al.[7], where facial recognition locker system was developed for real-time alerts and if any un-authorized person tries to unlock or tamper with the locker, the system immediately sends a security alert to the user and the managing admin.

III. SYSTEM DESIGN

A. Design

The customer first chooses a locker and then finds the product they want to purchase in the Firebase database. Once they have found the product, they enter the product details into the Firebase database and then receive an OTP. The customer then enters the OTP into the smart locker to open it and collect their purchase. The system design can be broken down as few important components as "Customer side" where the customer side of the system consists of a mobile app or website that allows the customer to choose a locker, find products, enter product details, and receive OTPs. A "Firebasedatabase" which stores the information about the lockers, products, and customer orders safely and securely. And a "Smart locker hardware" consists of a physical locker with a lock and a display. The display is used to show the customer the locker number and the OTP.The system isdesigned to be simple and easy to use for customers. It also provides a number of benefits as the Customers can collect their products from the smart locker at any time of day or night which is more convenient. The smart locker is locked until the customer enters the correct OTPhelps to prevent theft which is way more secured.

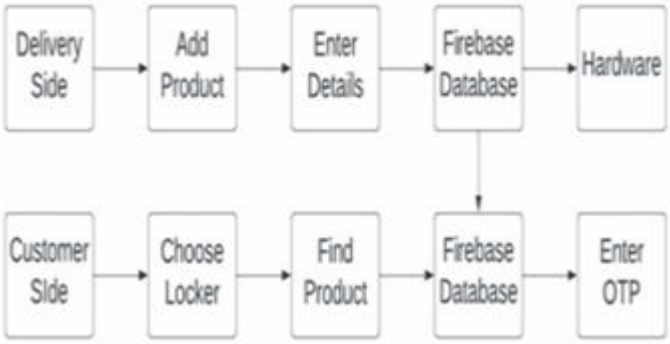

Fig.1. System Architecture

B. System Architecture

The Fig.1 shows the process that happens on both customer and delivery agent side. The Smart Secure Locker System has been created with an elegant two-sided subsystem that interfaces with delivery workers and customers, enabling secure deposit and retrieval of parcels. The Delivery Side commences with the addition of a product to the system. The delivery Agents login to the mobile application and provide the necessary details of the parcel which includes product id, the specific locker number, and deliverydetails. Such information is stored in the Fire base Database which serves as a centralized storage in the cloud. Firebase guarantees real time updates with respect to users, devices, and system state. Once the information is entered, commands are relayed to the hardware level, particularly to the ESP32 microcontroller responsible for the solenoid locks, to unlock a specific locker so that the parcel can be deposited in it. On the Customer Side, the system can be navigated primarily from the mobile application by the user. The customers start with picking a free locker among the selection of those available "Free" and "Occupied" are the descriptions used to show current status of the locker and is fetched from the Firebase Database in real time. When the locker is selected, the customer needs to identify the product using either the Product ID or booking details provided during delivery. To ensure that the package can only be accessed by the right person, customers are required to provide an OTP sent to them during confirmation of the parcel.

IV. METHODOLOGY

The methodology is broken down into three different stages which can be illustrated in Fig.2

A. Delivery Process

The delivery process begins when the delivery agent reaches the locker with a package. Unlike the use of conventional keys or inputting numbers into a keypad, the agent simply opens the mobile application and securely logs in. Once the agent's authentication credentials are accepted, the agent is able to remotely unlock a vacant locker through the Firebase cloud database in real-time. Subsequently, the delivery agent manually places the parcel into the locker. At this point, the proximity sensor which is situated inside the locker automatically verifies if the package has indeed been placed correctly. If the sensor fails to detect the package, the system goes into a waiting mode until proper placement is provided, minimizing the chances of erroneous actions.

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B. Otp Generation And Assignment

After the system confirms that a parcel has been placed in the locker, the next critical step of OTP generation is activated. Automated generation associates a specific OTP with the customer's profile and the locker ID, which serves as a digital key ensuring that only the identified customer can unlock the locker. The OTP is transmitted without delay through the registered mobile number or email of the customer. The notification is sent instantaneously due to Firebase's real-time communication capabilities, thus enabling ease of mind for customers that their package is intact.

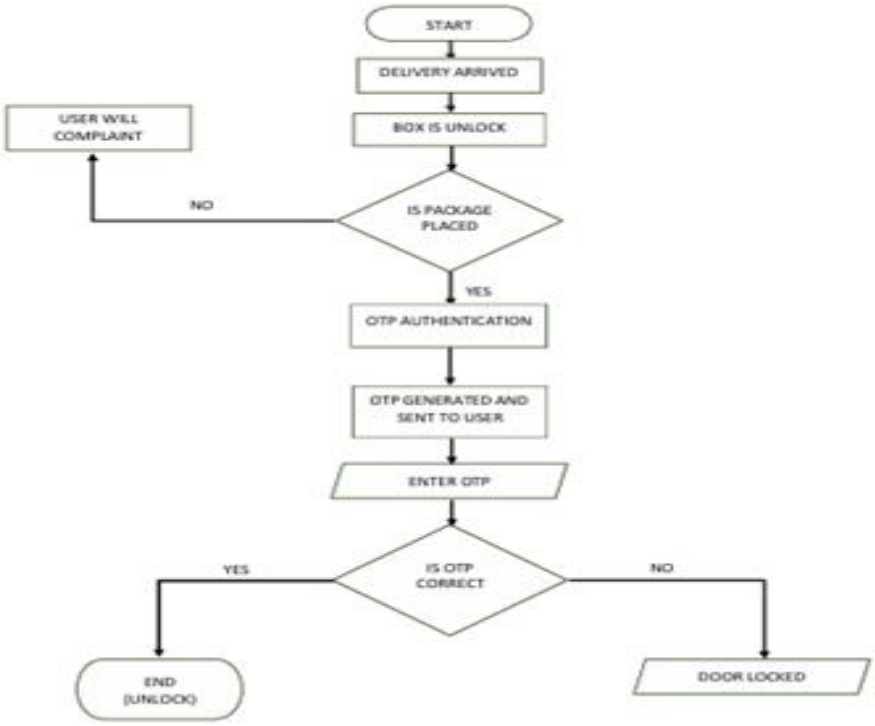

Fig.2. Work flow of Smart Secure Locker System

C. Customer Authentication and Parcel Retrieval

After receiving the OTP, the customer opens the mobile app, and checks with the locker number and the OTP which is received to the user email, after checking everything the customer enters the OTP into the system.The Firebase backend is used to match the entered OTP with the one stored during delivery. If the OTP matches, the system sends a command to the ESP32 microcontroller, which triggers the solenoid lock mechanism to unlock the correct locker. If the password is not correct the locker remains closed as shown in the Fig.2. The customer can then simply open the locker door and collect their parcel without any issues.

D. Cloud Logging and Security Monitoring

Behind the scenes, every action taken by both delivery agents and customers is logged automatically into the Firebase cloud database. These logs include timestamps for locker unlocks, parcel placements, OTP generation, retrieval attempts, and complaints raised. If any issue arises, administrators can easily review the transaction history to understand exactly what happened, when, and why.By relying on a cloud-based backend and IoT-enabled devices, the Smart Secure Locker System ensures that the entire parcel lifecycle is transparent, traceable, and protected against security threats while keeping the user experience simple and smooth.

V. EVALUATION AND RESULTS

The evaluation process of Smart Secure Locker System underwent too many testing processes that ensures that it meets the goals of security, reliability, user-friendliness, and real-time responsiveness while being used. The testing process was carried out under different conditions such as including normal operations, network fluctuations, stress loads, and user authentication scenarios in different conditions. The evaluation was not only about to validating functionality but it also ensure the performance metrics for the real-world deployment.

A. Mobile Application

The Smart Secure Locker system mobile app has a big impact on safe and quick parcel handling. Users start with the Login Screen where Firebase checks their identity to keep things secure for delivery people and customers. After they log in, customers see the Enter OTP screen. This simple layout lets them type in the one-time code they got when their package was dropped off. This setup helps users grab their stuff fast without getting mixed up. The Delivery person who log in see the Choose Locker Screen. This shows them which lockers are free, synced up with the Firebase database in real-time. It's easy to use, so delivery people can put parcels in empty lockers without messing up. The whole time, Firebase keeps everything in sync right away. The Fig.3 shows that there were 2 lockers presently at the location of the user, they both are empty and are ready for the item to be placed.

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And it also shows that how the customer can retrieve the parcel from the locker by entering the required credentials. This means when someone puts in an OTP or picks a locker, it shows up across the system keeping users, hardware, and the cloud all on the same page.The app also lets people report problems through the Complaint Registration Screen. It saves all the details about complaints in the Firebase cloud so admins can look at them and fix issues .

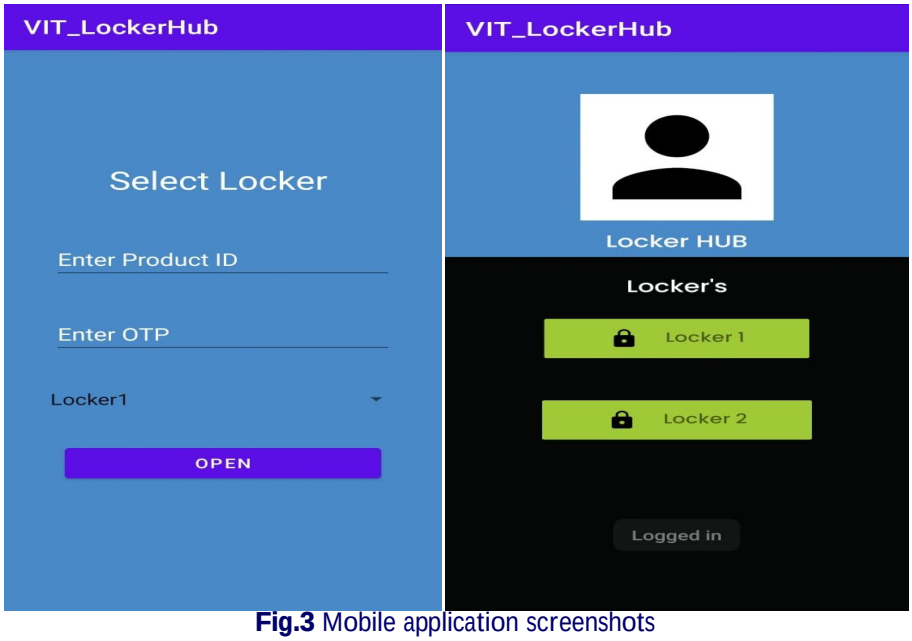

Fig.3 Mobile application screenshots

B. Testing Mthodology

Testing for the Smart Secure Locker System was conducted across multiple dimensions and the main focus areas included in it are:

- Functional Testing: Checking if each main feature's like putting in parcels, making OTPs, getting parcels out, and locking/unlocking lockers worked right in the whole process.
- Security Testing: Making sure that no one could try to open the locker without permission through OTP checks, and that alerts went off for any odd activities or for any other issues.
- Performance Testing: Testing the time how fast lockers responded and cloud updates happened during the process.

C. Test Results

Table I. shows the testing outcomes for few cases for smart secure locker system for ensuring the performance of the application during the process.

TABLE I. TEST CASES

Test Case	Expected Result	Result
User Registration	OTP is sent,and user is registered	Successful
Locker Reservation	Locker is assigned and status updated	Successful
Locker Unlocking	Locker opens after the authentication	Successful
Notification System	User recevies real-time OTP for the E-mail	Successful

a) Functional Reliability:The system proved reliable in functional tests. The ESP32 microcontroller took 2-3 seconds on average to respond to lock and unlock commands. Proximity sensors spotted parcel placements with near-perfect accuracy cutting down on human mistakes like locking an empty locker.

b) OTP Authentication and Security:The OTP authentication system stood out as a key strength. It blocked unauthorized locker access with a 95% success rate in tests. weak mobile signals, like in underground parking, caused slight OTP delays. Even then, retrying led to successful deliveries.

c) Real-Time Tracking and Updates: The Firebase database made sure the mobile app showed locker status right away. The time between locker events and user alerts was under 1 second, which works well for instant updates.

d) User Feedback and Satisfaction: More than 90% of users said the mobile app was easy to use. They liked the clear locker status displays and simple OTP entry screens. Few users felt lost. Some asked for extras like Dark Mode and support for multiple languages, which might be added later.

CONCLUSION

The Smart Secure Locker System is built to solve major problems in last-mile parcel delivery. These problems include safety ease of access, and being able to check availability. The system uses IoT tools such as ESP32 microcontrollers solenoid locks, and proximity sensors. It connects these to a cloud-based Firebase backend and a mobile app that is simple to use. This setup makes sure packages stay secure and are managed. Tests in different situations showed the system works well for safe logins fast locker use, and live status updates.The project enhances traditional delivery methods and provides a solution that works well in homes, workplaces, and community areas.

By emphasizing automation, safety, and ease of use, the Smart Secure Locker System sets the stage to improve how parcels are managed in smarter ways later on.

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