OPEN ACCESS

International Journal of Emerging Science and Engineering (IJESE)
ISSN: 2319–6378 (Online), Volume-12 Issue-8, July 2024

Encrypt Express: Security Enhancement, Maximizing Load Utilization in Cargo Transport through IoT and Algorithmic Solutions

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***Abstract:** The Encrypt Express model revolutionizes cargo logistics by leveraging IoT technology to improve safety, security, and efficiency. It integrates the DHT11 sensor to monitor environmental conditions such as temperature and humidity, ensuring optimal storage of goods. Using one-time password (OTP) access for the doors significantly enhances security, while the cargo compartment is divided into two slots for better cargo management. The features of the model include distance-based pricing, optimizing costs based on journey length. To improve user experience and tracking, an intuitive user interface (UI) is combined with the Leaflet Maps application programming interface (API), providing real-time location data and easy navigation. Additionally, the system allows alerts to be sent via email if parameters such as temperature or humidity exceed defined thresholds, ensuring quick intervention and cargo security. This comprehensive approach offers many benefits such as security through OTP access, enhanced environmental monitoring through sensors, cost-effective pricing through distance-based calculation and managing goods effectively with divided compartments. The user-friendly UI and powerful tracking capabilities further enhance the system, making "ENCRYPT EXPRESS" a promising solution for the future of cargo logistics. By modernizing cargo operations, it sets new standards in reliability, efficiency, and customer satisfaction, transforming the way cargo is managed and transported in the logistics industry.*

***Keywords**: Cargo Delivery, Efficiency, OTP Access, distance-based Pricing, Partitioned Compartments, Alert Mails, Leaflet Maps API.*

I. INTRODUCTION

Technological developments have constantly changed the global landscape of transportation logistics, reshaping the way things are moved.

Manuscript received on 29 May 2024 | Revised Manuscript received on 04 July 2024 | Manuscript Accepted on 15 July 2024 | Manuscript published on 30 July 2024.
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From the steam locomotives of the industrial revolution to the digital automation period of today, every innovation has brought about revolutionary developments that have improved efficiency and streamlined supply chain operations. Notwithstanding these advancements, obstacles still exist, especially in the domain of commodities delivery networks. The proposed model explores the complexities of contemporary cargo systems while paying close attention to fixing flaws found in earlier versions of IoT-based transportation models.

IoT technology has advanced quickly in recent years and has great promise to transform the movement, tracking, and handling of commodities. These networked systems make use of a network of sensors, actuators, and communication technologies to offer real-time information on several cargo transportation-related topics, such as logistics, safety, and environmental conditions. IoT-based transportation systems hold great potential, but several obstacles stand in the way of their successful and broad adoption. Security breaches represent a major concern. Unauthorized entry into shipping containers puts both businesses and consumers at danger as the value and fragility of items rise. Goods are vulnerable while in transit because conventional lock-and-key systems frequently fall short against cunning theft attempts. Moreover, one other crucial problem with early IoT transportation models is insufficient environmental monitoring. Temperature and humidity variations have a negative impact on perishable items and medications, which can result in losses of money and noncompliance with regulations.

The problems that IoT transportation networks face is made worse by inefficient cargo management techniques. Inefficient cargo compartment design wastes room and increases emissions and fuel consumption. In addition to reducing operational efficiency, suboptimal load allocation contributes to environmental deterioration because it requires more energy from vehicles to move fewer commodities over longer distances. Industry surveys and publications offer insightful information to help understand the extent and significance of these difficulties. According to a poll done by a well-known transportation group, 68% of participants had at least one security breach in the previous year, with 34% of those breaches resulting in losses more than $100,000. For 52% of the organizations questioned, cargo theft was identified as their primary security concern, underscoring the urgent need for improved security measures and authentication systems.

Accidents and the loss of products are also significantly influenced by environmental conditions. Over 40% of recorded crashes, according to the National Transportation Safety Board (NTSB), are caused by external factors including weather and temperature variations. These mishaps put the integrity of the cargo at risk and endanger drivers and other road users. The proposed system, "ENCRYPT EXPRESS" tackles these issues by fixing the flaws in earlier IoT transport models. The methods used in this system ensure the1` integrity and quality of commodities by integrating temperature and humidity sensors for real-time environmental monitoring. OTP authentication is one of the security features that improves access control and transparency during the shipping process. Furthermore, by logically segmenting cargo compartments and optimizing loading capacity, and dynamic pricing methodology minimizes environmental impact and optimizes cargo management.

II. LITERATURE SURVEY

The literature review offers a thorough summary of the studies and advancements that have been made in cargo logistics, emphasizing significant contributions, difficulties, and areas for growth. Numerous writers have examined how IoT technology can be integrated into different facets of cargo logistics, emphasizing how it can enhance sustainability, efficiency, and security throughout the supply chain. The Internet of Ships (IoS) is introduced by Sheraz Aslam et al., who also show how it might increase data exchange among maritime stakeholders and improve the effectiveness and safety of marine transport operations [1]. Salman Mahmood et al., talked on how IoT technology is affecting logistics and transportation in a big way, especially by making it possible to track and monitor shipping conditions in real time. To improve shipping routes and monitor containers, Hyung Rim Choi et al. suggested an Internet of Things-based container tracking system framework, highlighting the significance of hardware and software integration [2][3][4].

By developing the "ENCRYPT EXPRESS" smart products delivery system, which incorporates IoT technologies to enhance efficiency, security, and monitoring, the proposed system expands on earlier research [5][6-18]. Key difficulties described in the literature, such as cargo security, environmental monitoring, price optimization, and load management, are addressed by the system through the integration of temperature and humidity sensors, an OTP access system, distance-based pricing, and segregated cargo bays. The proposed system also makes use of mapping technologies using the leaflet map API to enhance user experience and offer real-time cargo tracking.

III. METHODOLOGY

The architecture of the cargo security detection system smoothly combines several parts to guarantee reliable operation and user involvement. The system architecture is designed as shown in the below Fig 3.1.

An intuitive user interface for cargo security management is provided by Angular UI, which is used in the system's UI design. Angular UI makes it simple for users to keep an eye on and manage system functions including handling container state, presenting sensor data, and getting alerts. Data storage and user authentication are handled by the firebase API. Users may safely log in and access their account information.

When it comes to processing data from sensors kept in cargo containers, the NodeMCU server is crucial. The server is outfitted with a NodeMCU board, an Internet of Things

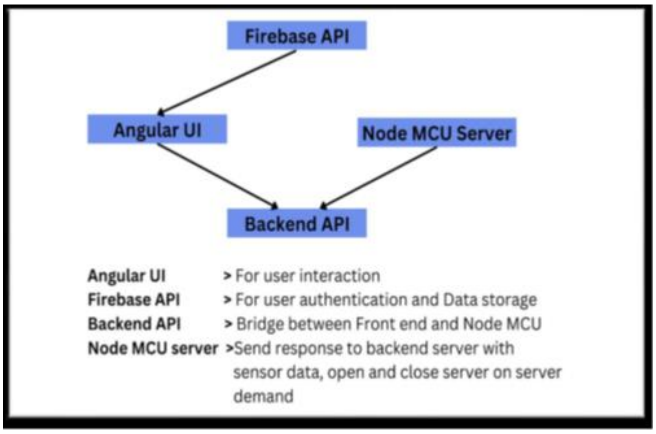

Fig 3.1: System Architecture

development platform that leverages the ESP8266 microcontroller to gather real-time sensor data like temperature, and humidity. To carry out additional operations, it processes this data and connects with the backend API. The cargo container's servo motors are controlled by the NodeMCU server to open and close them. To provide security and authorization, this process is started using OTP authentication. The NodeMCU server will cause the servo motor to execute the desired action, opening or closing the associated container door, upon receiving the OTP from the frontend UI. Between the NodeMCU server and the frontend UI, the backend API serves as a bridge. It enables smooth data interchange and communication between these parts, enabling real-time execution. These elements work together to provide a comprehensive and efficient solution for guaranteeing security and monitoring of goods during transport.

IV. ALGORITHMS IMPLEMENTED

A. Software

Using the login credentials, the user login to the system. Following submission, the system uses Firebase authentication to verify the user's credentials. This procedure guarantees safe access to system functions and confirms the legitimacy of user credentials. Users can begin a new shipment by navigating to the cargo slot booking section after successfully logging in. It includes information about the source, destination, kind of container, delivery date, and amount of delivery of the products. The system uses mapping API or geographic data to determine the distance between the chosen source and destination. The technology determines the shipping cost based on the distance. Based on the availability of slots, the system will be finalizing the booking. The shipment will be successfully dispatched once all information has been verified and authenticated.

Retrieval Number: 100.1/ijese.E449013050624
DOI: 10.35940/ijese.E4490.12080724
Journal Website: www.ijese.org

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The software-side workflow of the model entails user login and authentication, distance and pricing calculations, booking shipments with the source, destination, and other variables selected, status checks for slot availability, and booking completion. Users can safely schedule and manage their shipments with this workflow as depicted in Fig 4.1, which guarantees an open and effective process.

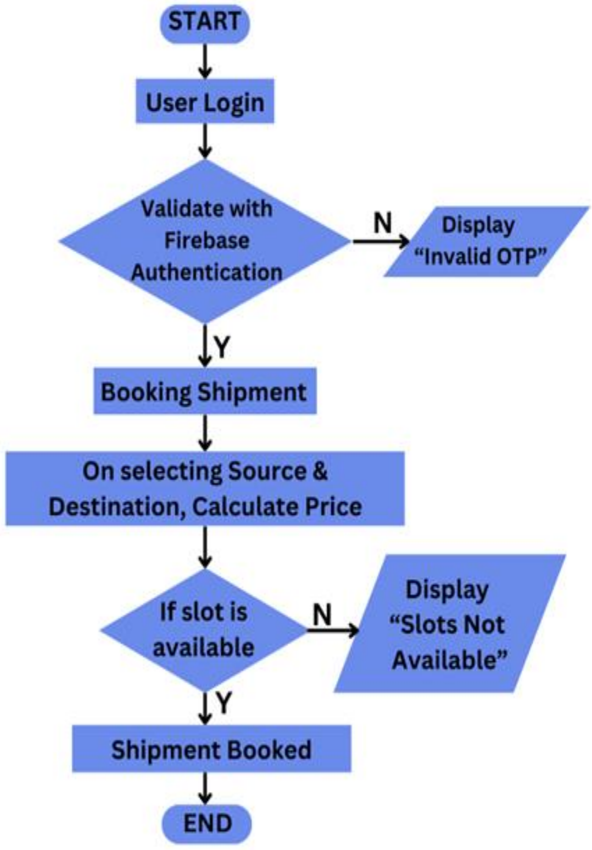

Fig 4.1: Software Workflow

B. Hardware

To begin the process of opening the cargo container door, the user needs to pass the OTP, shown in UI to delivery agent. The system verifies the OTP it receives from the user to authenticate and authorize them. By making sure the OTP matches the one created for that user and their slot, the system will instruct the NodeMCU server to run the servo motor that operates the cargo container door to open. The system waits for the signal indicating that the container door has closed after opening. The completion of the loading or unloading procedure is indicated by this signal. The present action's involvement in loading or unloading cargo into or out of a container is determined by the system. To guarantee the safety of the items, it measures environmental factors like temperature and humidity to see if they are within the set threshold. The system sends an alert to facilitate prompt action if parameter's threshold is breached. The goods will be continuously monitored by the system to identify any deviations. The hardware-side workflow as shown in Fig 4.2 entails getting the user's OTP, validating it, signaling NodeMCU to open the cargo container doors, confirming that the doors are closed, and repeating the procedure for more requests.

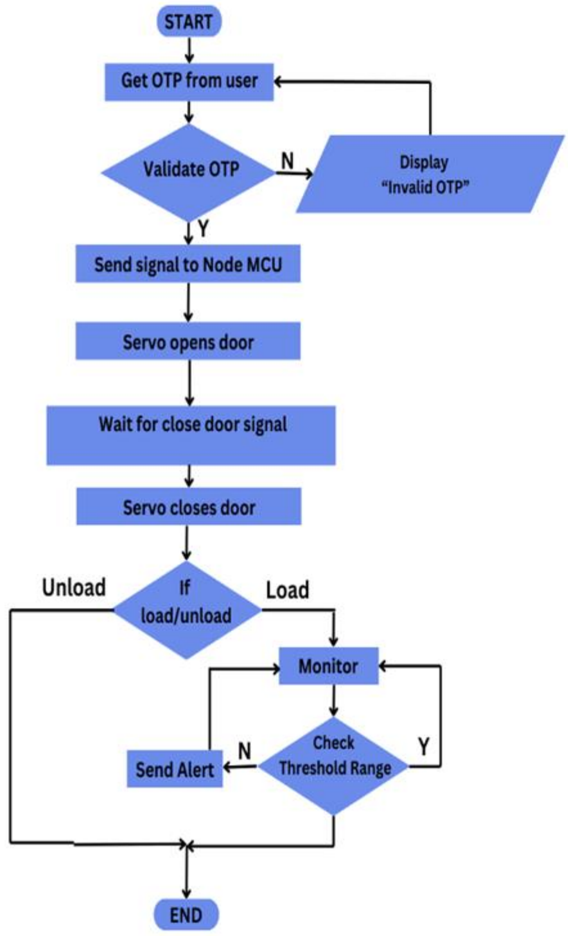

Fig 4.2: Hardware Workflow

V. RESULT AND DISCUSSION

The proposed system "ENCRYPT EXPRESS", looks most aligning with initial idea and imagination, which uses wooden planks for the body of the container. Unlike the regular containers, which have doors on the front side (along the width of the container), this container has the doors on both the longer sides (along the length of the container) of it as shown in Fig 5.1. This is done, because it is easy to divide the whole container into two logically independent slots. By this way, ensuring load optimization. And the slots are partitioned with a wooden plank along the length of the container. The doors are attached with the micro servo motors to open and close. Inside the container there are DHT11 sensors in both the slots and both the doors operate with motor actuation. These sensors and actuators are managed by NodeMCU microcontroller, which receives inputs from the client through the user interface created which will be discussed in software part results and does the programmed work. It also monitors the data collected by sensors and acts on it accordingly. When the client needs to load/unload the goods into the slots the doors need to be opened. To do so, the delivery agent requests for opening the door of the respective slot through the user interface. Then requesting for the OTP which will be only visible to the client. The client needs to pass that OTP to the delivery agent to open the door which is shown.

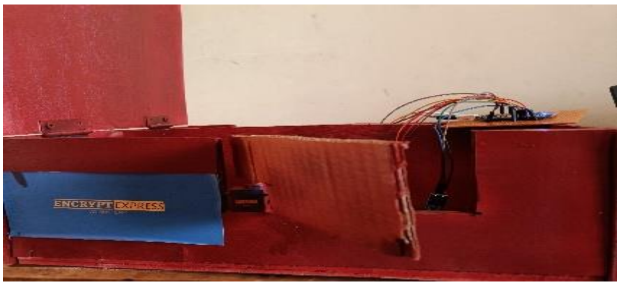

Fig 5.1: Cross Sectional View of Container

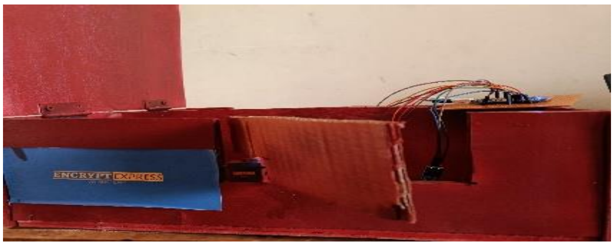

Fig 5.2: Door Open State

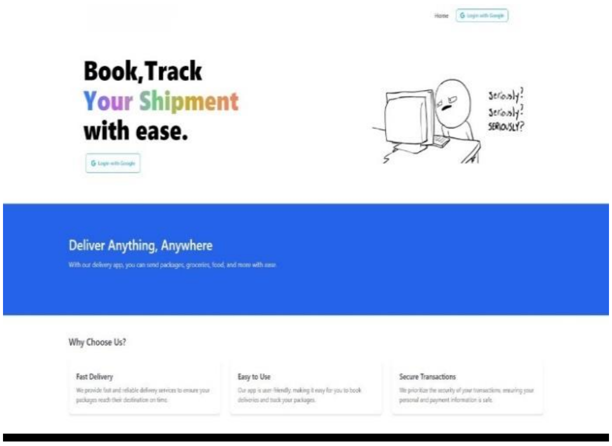

Fig 5.3: Login Page

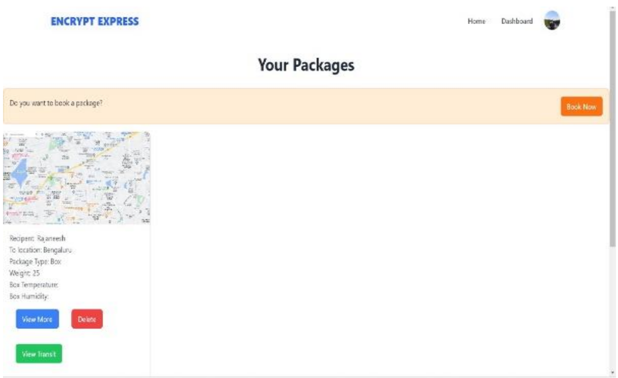

Fig 5.4: Client-Side Dashboard

in Fig 5.2. After the load/unload of the goods is finished, the delivery agent can press the close door button in user interface. Then the NodeMCU will send signal to micro servo motor to close door.

To increase the usability of the system by creating user friendly interface where the clients can login, book, and view their shipments. The login page of the UI is shown in Fig 5.3.

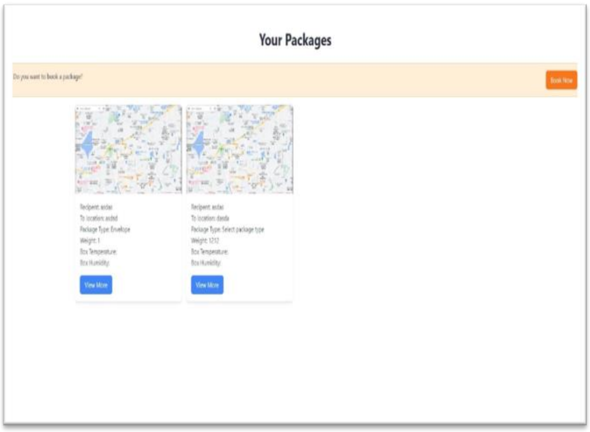

Fig 5.5: Delivery Agent-Side Dashboard

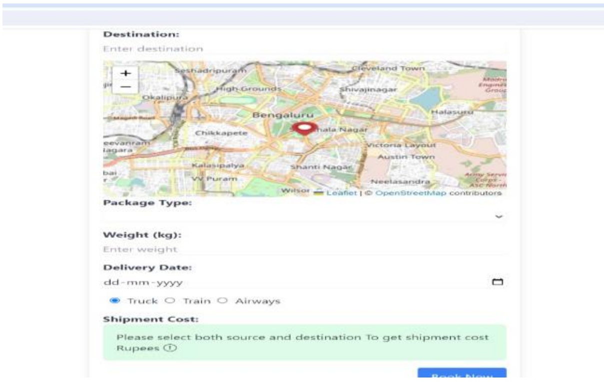

Fig 5.6: Booking Tab

When the client login to the website, they can book packages by clicking on “Book Now” and can also see if there are any ongoing bookings in the “Dashboard”. When the delivery agent login to the website, can see packages available for delivery in the “Dashboard”. This is shown in Fig 5.4 and Fig 5.5. When the client login and want to book packages there are some steps need to be completed before successful booking. The data like name, source & destination, locating addresses on map, pacakage type, delivery mode, delivery date, weight, and view the cost of the shipment. If the bookings are full and no slots available then the package will not be booked for the client. This process is shown in Fig 5.6, Fig 5.7, and Fig 5.8.

After the booking of package is done succesfully there are certain functionalities to be made available for the client to provide the seamless shipment experience. Such as viewing the transit as shown in Fig 5.9, viewing the environmental parameters of the goods, viewing of OTP to open the doors as shown in Fig 5.10 which enables security of the shipment, and deleting of the shipment after completion.

As the OTP is entered to open the doors as shown in Fig 5.11, and if the OTP is correct it will lead to successful door opening otherwise on entering the incorrect OTP the door opening process will fail. This is shown in Fig 5.12.

During the shipment of the goods if the threshold is breached of the parameters like temperature and humidity then the alert mails are sent to the client and delivery agent. This is shown in Fig 5.13.

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International Journal of Emerging Science and Engineering (IJESE)
ISSN: 2319–6378 (Online), Volume-12 Issue-8, July 2024

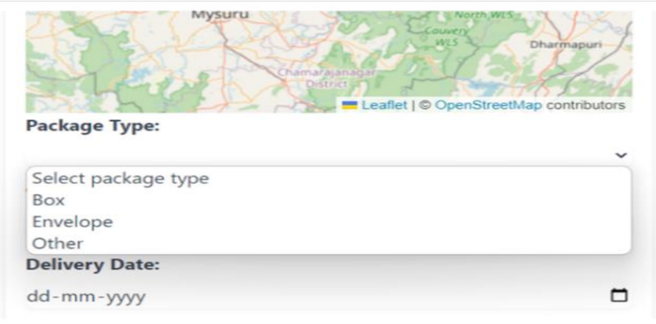

Fig 5.7: Selecting Package Type

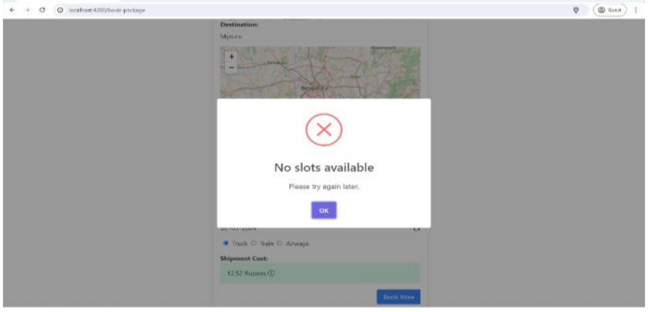

Fig 5.8: No Slots Available Pop-Up

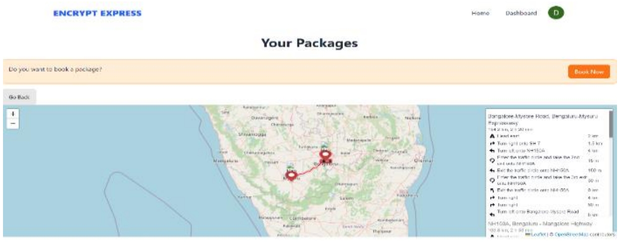

Fig 5.9: Delivery Transit via Leaflet Maps Api

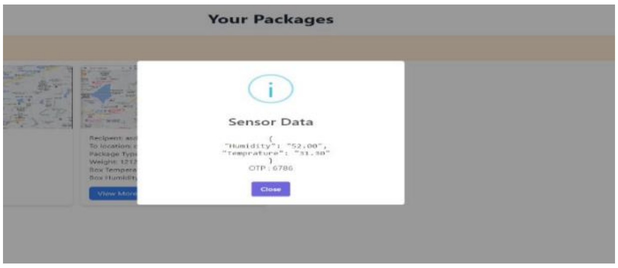

Fig 5.10: OTP & Sensor Data Viewing

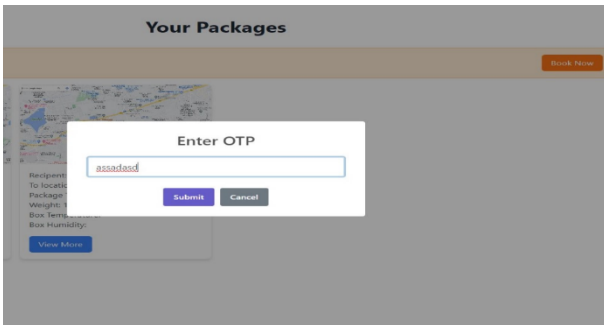

Fig 5.11: Entering OTP

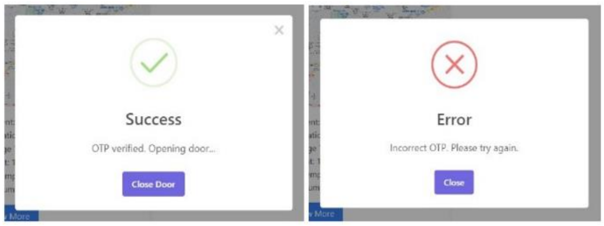

Fig 5.12: Correct and Incorrect OTP Scenarios

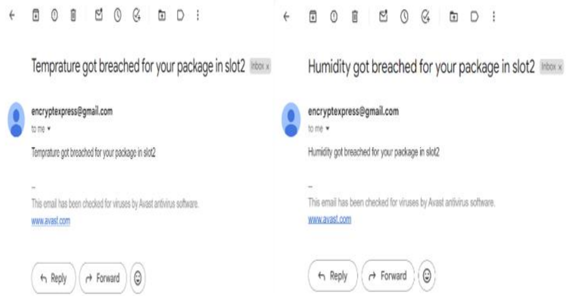

Fig 5.13: Alert Mails Received

While implementing all this on a user interface there is a need to maintain the data provided in the user interface into a database. For this, making use of Firebase Cloud functionality which is Firestore Database. In the firebase, created the proposed system's database and used it to store client's credentials and all the data entered while booking of a shipment as shown in the Fig 5.14. This data can be fetched by the administrator whenever it is needed.

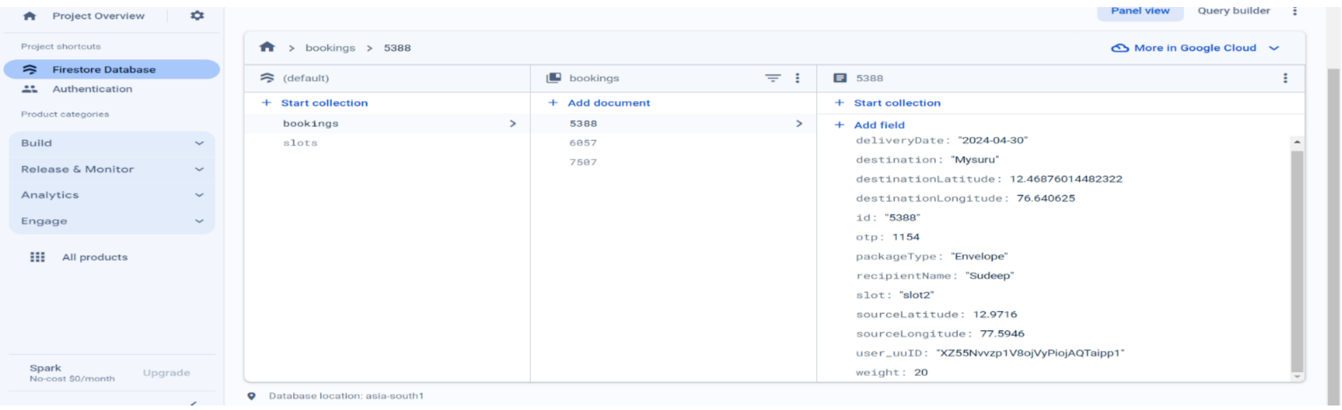

Fig 5.14: Snap of the Database

Retrieval Number: 100.1/ijese.E449013050624
DOI: 10.35940/ijese.E4490.12080724
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VI. CONCLUSION

The dynamic landscape of transportation logistics is being significantly advanced by IoT technology, which is expected to bring revolutionary changes to cargo delivery systems. However, challenges remain, including safety violations, inadequate environmental monitoring, and inefficient charging management. The innovative "ENCRYPT EXPRESS" comprehensively solves these shortcomings. The solutions integrate real-time environmental monitoring, advanced safety features, and dynamic load management to ensure cargo integrity, increase safety, and promote efficiency and sustainability in transportation logistics. Through continuous improvement and adoption, "ENCRYPT EXPRESS" will bring a future where cargo transportation is safer, more efficient, and greener, benefiting businesses, consumers and the global ecosystem alike.

DECLARATION STATEMENT

Funding	No, I did not receive.
Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant.
Authors Contribution	All the authors have equal participation in this article.

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