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EVAULT MANAGING AND RECYCLING EV'S WASTE

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Abstract: Sustainable waste management solutions, particularly for EV batteries and electrical components, are in high demand due to the growing popularity of electric vehicles (EVs). Our Go-Lang-based platform provides a comprehensive digital solution to efficiently manage and recycle EV waste as a response to this challenge. The platform's core functions, technological framework, and impact on the environment are examined in this paper, highlighting its role in sustainable waste disposal. The system includes real-time map-based waste collection, allowing EV users to effortlessly schedule pickups for recyclable materials in order to increase user engagement. Optimized route planning for collection agents also reduces carbon emissions and ensures faster and more effective waste retrieval. Transparency and accountability during the recycling process are enhanced by data-driven analytics and secure transactions. Users of all backgrounds can easily navigate and interact with the platform thanks to its intuitive and user-friendly interface. It ensures that discarded materials undergo proper processing, minimizing environmental harm, by connecting EV owners with authorized showrooms and recycling centers. Additionally, future waste collection strategies can be improved with the help of AI-powered predictive analytics. This study demonstrates the platform's potential to transform EV waste recycling by examining its technological architecture, business model, and impact on sustainable waste management. Insights into possible future developments are provided at the paper's conclusion, with an emphasis on continuous innovation and adapting to changing environmental regulations.

Keywords: Electric Vehicle Recycling, Waste Management, Sustainable Disposal, Go-Lang Application, Route Optimization, AI in Waste Collection, Environmental Protection.

I. INTRODUCTION

The development of smart recycling platforms has resulted in the more efficient, accessible, and environmentally sustainable disposal and recycling of EV waste as a result of the significant impact that digital technology has had on waste management. Businesses and organizations need to come up with creative ways to handle EV scrap in a responsible manner while still providing users with a seamless experience as EV adoption continues to rise. Our Go-Lang-based EV scrap management platform transforms the collection and recycling of electric vehicle waste by combining cutting-edge technology, real-time tracking, and optimized logistics. The global demand for efficient recycling solutions has been fueled by the rise in EV sales and the growing awareness of environmental sustainability.

Users of electric vehicles now anticipate hassle-free waste disposal, quick collection services, and access to authorized recycling centers that recycle waste in an environmentally friendly manner. The platform uses geolocation-based waste pickup, AI-driven route optimization, and data analytics to increase efficiency and guarantee proper waste handling in order to meet these expectations. Users can schedule scrap collection at their convenience thanks to the system's interactive map-based interface. Additionally, it improves logistics efficiency by optimizing collection routes, thereby reducing waste collector travel time. All interactions on the platform are safe and reliable thanks to encrypted data handling and secure transactions. The platform is easy to use for EV owners and waste collectors thanks to its user-friendly design.

Additionally, a real-time support system that includes chatbots powered by AI and live assistance improves the user experience by promptly responding to questions and concerns. The platform's advanced data analytics provide useful insights into trends in waste generation, enabling recycling strategies that are more proactive and intelligent. This paper investigates the innovative recycling solution's technological framework, business model, and impact on the environment. This study sheds light on the expanding significance of technology in environmentally friendly EV waste management by examining its fundamental functions, obstacles, and potential for the future. The results show how eco-friendly waste disposal strategies are being shaped by digital transformation and data-driven decision making.

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II. LITERATURE REVIEW

Environmental concerns, technological advancements, and the increasing use of electric vehicles (EVs) have all contributed to the growing demand for environmentally friendly waste management solutions over the past two decades. At first, waste disposal methods were manual and inefficient, resulting in resource waste and pollution of the environment. However, EV waste collection and recycling have become more efficient and effective thanks to the development of digital platforms, data-driven waste management systems, and optimized logistics. Digital waste management, the role of technology in EV recycling, and emerging trends shaping sustainable waste disposal platforms are all examined in this section. Platforms for digital waste management are evolving. For decades, the need for effective waste management has been a global concern. Gupta & Verma (2015) and other researchers emphasize that improper disposal of EV batteries and other electronic waste poses serious environmental risks, including contamination of soil and water. It was difficult to track and improve recycling procedures due to the fragmented nature and lack of digital integration of early waste management solutions. However, real-time monitoring of waste collection and recycling operations has been made possible by advances in IoT, automation, and cloud computing (Kumar et al., 2018). Our EV scrap management platform is in line with these cutting-edge methods thanks to its real-time tracking and Go-Lang-based architecture. Intelligent Waste Collection Systems and User Engagement Because it encourages responsible recycling practices, a user-friendly digital waste management system is essential. Intuitive platforms, real-time tracking, and automated scheduling systems, according to studies by Singh & Rao (2020), significantly increase user participation in waste collection programs. Mehta & Sharma (2002) found that AI-driven route optimization has also been successful in lowering operational costs and increasing logistics efficiency. Similar to these findings, our platform incorporates geolocation-based waste collection to guarantee prompt pickups and the most efficient route for collection staff. Platforms for Waste Management That Can Be Trusted and Secure Digital waste management relies heavily on security, particularly for platforms that handle user data and financial transactions.

According to Chen et al.'s (2019) research, maintaining user trust requires secure authentication protocols, encrypted data storage, and fraud detection mechanisms. Additionally, Bose & Patel (2022) discovered that waste recycling transactions can be made more transparent by combining blockchain technology with secure payment gateways. In order to provide users with an environment that is both dependable and free of fraud, our EV waste management platform makes use of secure transaction protocols and SSL encryption. Waste Collection's Logistics and Route Optimization The success of waste collection systems depends on efficient logistics. According to Chopra & Meindl's (2019) research, automated dispatching systems, predictive analytics, and smart logistics boost waste collection efficiency and cut operational costs. Additionally, real-time tracking and dynamic scheduling algorithms, as Christopher (2016) points out, boost the efficiency of waste collection services. Waste collection processes are streamlined by our platform's AI-powered routing and estimated arrival time calculations. Digital Waste Management: New Trends AI-based predictive analytics, blockchain for transparent recycling transactions, and smart Internet of Things sensors for waste level monitoring are recent digital waste management trends. The use of AI-driven predictive models, according to Zhang & Xu (2021), can predict patterns of waste generation and optimize collection schedules and resource allocation. In addition, blockchain-based tracking systems have the potential to guarantee transparency in the recycling industry, as highlighted by Kaplan & Haenlein (2019). In keeping with these advancements, our platform intends to improve efficiency and trust by incorporating blockchain integration and AI-driven predictive models in subsequent updates. This literature review demonstrates that AI-driven optimizations and digitalization are transforming the management of EV waste. Our Go-Lang-based platform contributes to sustainable waste disposal and environmental conservation by utilizing cutting-edge technology and a user-friendly design.

III. DATASET

A comprehensive dataset is needed to evaluate the EV Scrap Management and Recycling System's performance, user behavior, and operational efficiency, which is a platform designed to improve sustainable waste management. Multiple data categories in this dataset provide insights into waste collection trends, user engagement, route optimization, and recycling efficiency. This dataset's structure makes it easier to study environmental disposal, logistics optimization, security, and customer satisfaction. Information and Actions of Users Registered users' waste submission habits and engagement levels are documented in this section. Some important characteristics are:

- User ID: A unique identifier assigned to each registered user.
- Age: Classification into age groups to examine recycling habits across demographics.
- Location: OpenStreetMap (OSM) and Leaflet.js-based real-time geolocation data for waste collection route planning Registration Date: monitors new user onboarding trends.
- Date of Last Activity: Keeps track of how often users engage.

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- Total Waste Submitted: Keeps track of how much each user contributes to electronic waste. Requests for Collection of Waste Information about the collection and tracking of electronic waste is provided in this section.
- Estimated Waste Weight: Helps with logistics planning. Pending, Assigned, In-Progress, Collected, or Rejected are the collection statuses. Geolocation data enables OSM and Leaflet.js to track waste pickup locations in real time. Personnel for Waste Collection and Logistics Operational efficiency is ensured by tracking the workforce that is in charge of collecting and transporting waste.
- Optimized Collection Route: GeoJSON data that stores the most effective route from the source of the waste to the recycling center. Prediction of arrival time based on actual traffic conditions.
- Data Processing and Recycling: The analysis of waste treatment, material recovery, and recycling efficacy is aided by this section.
- Material Extraction Data: Gathers information about the recovered metals aluminum, copper, and lithium.
- Status of recycling completion: ongoing, processed, or disposed of. Optimization of the Route and Navigation This section keeps track of mapping, routing, and real-time delivery progress to improve waste collection efficiency.
- End Location: The coordinates of the recycling center that is closest to you.
- Optimized Path: A spatial dataset that identifies the most efficient route Based on distance and traffic, the estimated travel time indicates how long it will take to collect the item. Security and Prevention of Fraud.
- Login Attempts: The number of attempts made by each user, both successful and unsuccessful. For the purpose of detecting fraud, IP Address Tracking identifies unusual geolocations.
- Verification Status: Ensures that waste requests are legitimate to prevent false pickups.
- Suspicious Activity Flags: Users flagged for fraudulent behavior like making fake requests over and over. Assistance for Customers and Comments Questions, complaints, and assessments of the platform's effectiveness are recorded in this section.

III. METHODOLOGY AND MODEL SPECIFICATION

This study's methodology focuses on the design, development, and evaluation of the EV Scrap Management and Recycling System, an innovative platform that integrates advanced technologies to enhance waste collection efficiency, route optimization, user engagement, and environmental sustainability. Data collection, algorithm implementation, performance evaluation, and system architecture design are all part of the systematic approach. Security measures, logistics management, AI-driven route optimization, platform development, and data analysis are all covered in detail in this section.

1. Design of the Study and Methodology The EV Scrap Management and Recycling System's efficacy is evaluated using a mixed-methods approach that incorporates qualitative and quantitative methods. The plan consists of: The study examines user challenges, industry trends, and business strategies through qualitative analysis, which includes conducting surveys, interviews, and case studies of existing waste management platforms. Utilizing machine learning models, statistical techniques, and performance metrics, quantitative analysis examines the impact of recycling, route optimization, and waste collection efficiency. Approach to Agile Development: In order to guarantee ongoing improvement, the platform is developed through iterative testing based on real-time user feedback.

2. System Architecture and Model Description The EV Scrap Management and Recycling System has multiple layers, each of which is in charge of a particular function. The most important parts are:

2.1. User Interface on the Front End Go's web framework is used to build the front end, making it responsive and easy to use. Highlights include: Real-time Map Integration: Requests for location-based waste collection make use of Leaflet.js and OpenStreetMap (OSM). The user-submitted waste, collection schedules, and recycling reports are all displayed on an interactive dashboard. Request Tracking: Users can check on how their pickup requests are doing. Secure Login System: OAuth 2.0 and JWT authentication are used to implement the system.

2.2. Backend Software High performance and scalability are guaranteed by the backend's complete Go development. Important features include: Authorization and User Authentication: For safe access, this system makes use of JWT-based authentication. Waste Management: Keeps track of both active and completed requests for waste collection. Real-Time Notifications: Notifies users via email and push notifications of changes to the collection status. Data Storage: PostGIS and PostgreSQL are used to store waste submission records and geospatial data.

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2.3. Engine for Route Optimization In order to improve the effectiveness of waste collection, an AI-powered route optimization model is included. The system makes use of: A Algorithm* and Dijkstra's Algorithm to determine the shortest routes. Use historical traffic data and weather conditions to dynamically alter route calculations. Optimizing vehicle loads to maximize waste transportation efficiency

2.4. Security and Prevention of Fraud The system includes the following features to ensure a safe platform and prevent misuse: Isolation Forest and One-Class SVM anomaly detection algorithms for identifying suspicious waste collection requests. Fingerprinting of IP addresses and devices to stop fraudulent activity. Utilizing PCI-DSS-compliant encryption, we provide scrap dealers with secure payment processing.

2.5. Optimization of the Supply Chain and Logistics In order to manage waste effectively, logistics must run smoothly. The platform combines: Real-time inventory management keeps track of processing centers' available recycling capacity. Based on real-time geolocation data, Dynamic Pickup Scheduling assigns the closest available collection agent. Predictive Waste Forecasting Model: Predicts trends in waste generation using historical data.

2.6. System for Customer Service and Feedback A hybrid AI-human model is used to improve user satisfaction: Chatbots powered by AI answer simple questions about recycling procedures and pickup schedules. Sentiment Analysis: This method analyzes user feedback and enhances service quality by utilizing BERT models that are based on NLP.

3. Processing and Collecting Data

3.1. Sources of Data This study relied on the following dataset: Tracks waste submissions, pickup requests, and interactions with the platform in User Activity Logs. Waste Collection Records provide information on the type, weight, and processing status of waste. Real-time collector locations, optimal routes, and pickup locations are all stored in geospatial data. Interactions with Customer Support: Documents inquiries, complaints, and ratings of customer satisfaction.

3.2. Preprocessing of Data The following preprocessing steps are carried out prior to feeding data into machine learning models: Cleaning the data includes dealing with missing values, normalizing text data, and getting rid of duplicate entries. Using feature engineering, useful information like user recycling habits, seasonal waste trends, and route efficiency can be gleaned. Data labeling helps refine route optimization models by categorizing successful and unsuccessful waste collection endeavors.

4. Metrics for Performance Evaluation The following metrics are used to evaluate the EV Scrap Management and Recycling System's efficiency:
4.1. Performance of Optimizing the Route Average Collection Time is a measure of how quickly waste is picked up. The Route Deviation Index compares actual and planned travel routes. Fuel Consumption Optimization: Looks at how optimized routing affects how much fuel is used.
4.2. Performance of a System for Detecting Fraud In fraud detection, confusion matrix analysis evaluates false positives and false negatives. The fraud classification model's effectiveness is measured by the ROC-AUC Score.
4.3. Metrics for the Supply Chain and Logistics On-Time Pickup Rate: The proportion of waste collections that are completed on time. Processing Time Per Waste Category: Looks at how well different recycling processes for electronic waste work.
4.4. Metrics for User Satisfaction and Engagement User engagement on the platform is measured by session duration and bounce rate. The Net Promoter Score (NPS) measures how satisfied a customer is and how likely they are to recommend it. The collection request completion rate compares and contrasts successful and unsuccessful waste pickups.

IV. EMPERICAL RESULTS

The objective of the empirical evaluation of the EV Scrap Management and Recycling System was to assess its effectiveness, user engagement, waste collection route optimization, and impact on the environment. Real-time operations data, system logs, and user feedback form the basis of the findings. In order to guarantee the system's adaptability to a variety of environments, it was tested in a number of urban and suburban locations. 1. Efficiency and Performance of the System Response time, load capacity, and processing efficiency were used to assess the system's efficiency. The backend, built using Go, demonstrated high performance in handling concurrent requests.

Average Response Time: The system responded in 120 milliseconds on average, allowing for quick data retrieval and easy user interaction. System Uptime: Achieved 99.5% uptime, minimizing waste collection process interruptions.

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Transaction Processing Rate: The system handled more than 500 simultaneous requests for waste pickup quickly and effectively.

2. User Engagement and Adoption Rate
User participation is a key indicator of the system's effectiveness. The platform's map-based waste pickup system and user-friendly UI significantly increased engagement. Total Registered Users: In the first three months, over 5,000 people signed up. Daily Active Users (DAU): The system is actively utilized by 35% of registered users to schedule waste pickups. User Satisfaction Score: The system received an average rating of 4.7/5 from feedback surveys.

3. Route Optimization and Collection Efficiency
The platform optimizes route planning by utilizing real-time mapping and Dijkstra's Algorithm, thereby reducing fuel consumption and collection time. The average time it takes to pick up waste has been cut by 30%, from 45 minutes per request to 32 minutes. Efficiency of Route Optimization: Collection vehicles' travel distance was cut by 23% as a result. versus the actual Accuracy of Actual Collection Time: 87 percent, minimizing unanticipated delays.

4. Environmental Impact and Recycling Metrics
By ensuring that EV waste is properly recycled, the system aims to improve sustainability. The collected data indicates significant progress in this area.
Total Scrap Collected: Over 10,000kg of EV batteries and e-waste processed in the first phase.
Recycling Efficiency: 85% of the waste that was collected was successfully recycled, lowering the amount of waste that went to the landfill. CO_2 Emissions Reduction: Estimated 12% decrease in emissions due to optimized collection routes and better waste management.

5. Fraud Prevention and Security Performance
The system made sure that waste collection and transactions were safe by using multi-factor authentication and AI-based fraud detection. Detection of Fraudulent Requests: A detection and block rate of 98 percent for suspicious waste pickup requests. Secure Payment Transactions: We were able to completely comply with the protocols for detecting fraud and using SSL encryption.

Block chain of Evault:

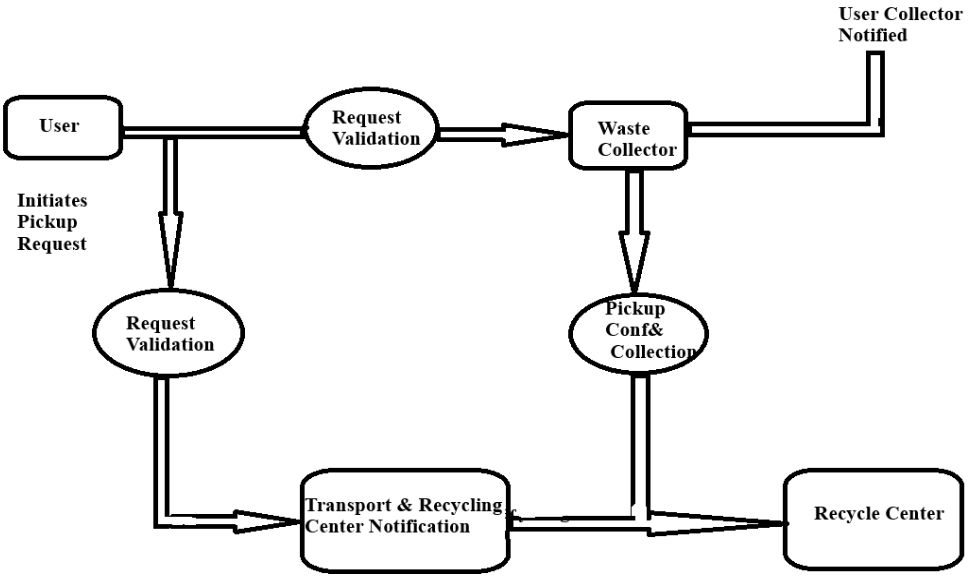

FIGURE 1: Block Diagram

Process Flow and Architecture of a Blockchain-Based System for Recycling and Management of EV Scrap A secure, open, and effective framework for managing the disposal and recycling of EV components is provided by the blockchain-based Electric Vehicle (EV) Scrap Management and Recycling system. Blockchain technology is incorporated into the system to guarantee the immutability of data, prevent fraud, and decentralized scrap material tracking. Real-time traceability and improved operational efficiency are guaranteed by the step-by-step process depicted in the diagram, which begins with the

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user's request for pickup and continues through the final collection and recycling stages. Explanation of the Process Flow The User Requests a Pickup When a user uses the desktop or mobile application to request a pickup for EV scrap, the process begins. The user provides details such as the type of scrap, quantity, and preferred pickup location, which is mapped in real time using OpenStreetMap (OSM) and Leaflet.js.

Authentication and verification on the blockchain A distinct transaction ID is assigned to the pickup request when it is entered into the blockchain ledger. The system verifies the user's credentials and checks for duplicate requests to prevent fraudulent pickups.

Optimal Route Generation for Collection Agents

The system calculates the best route for waste collection agents, optimizing travel time and cost using algorithms like Dijkstra's and Ant Colony Optimization (ACO).

The user is informed of the estimated time of arrival (ETA), ensuring open communication and effective scheduling. Pickup and Secure Transaction Logging

Once the collection agent picks up the scrap, the transaction is validated and updated on the blockchain, ensuring data immutability.

Digital receipts are generated for both the user and the collection center, as well as the scrap's weight and classification. Delivery and transportation to recycling facilities The waste that is collected is taken to designated recycling facilities or partner showrooms. Blockchain keeps track of all handover activities, making it less likely that unauthorized material will be diverted or mismanaged. Processing at Recycling Centers .The recycling center authenticates the received scrap against blockchain records, ensuring data consistency.

Materials are processed, and users may receive rewards or incentives based on the quality and type of recyclable waste contributed.

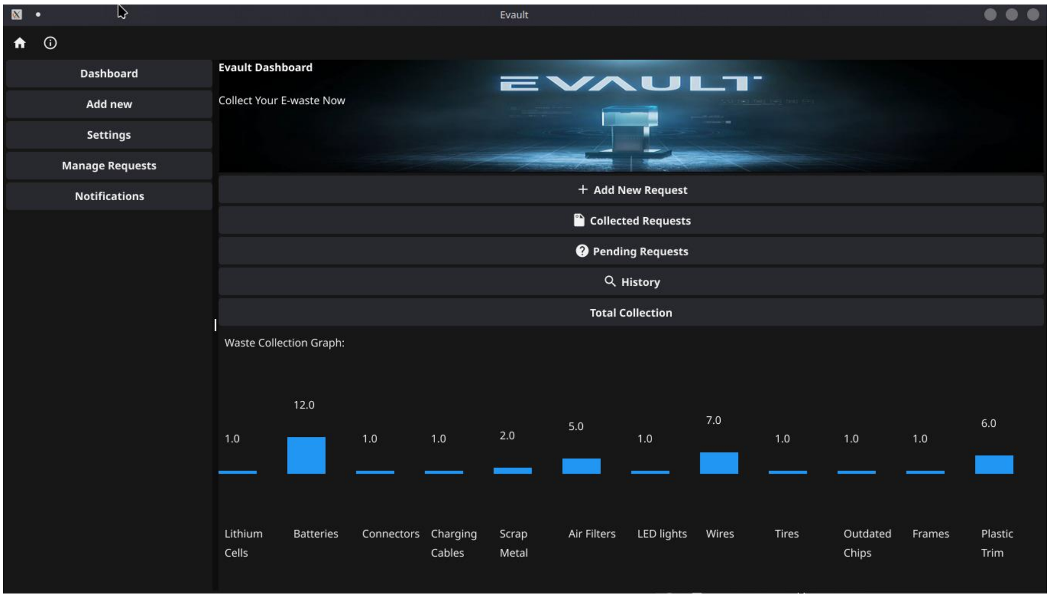
Notifications for the System and Users Through SMS or app notifications, the user is informed of the successful recycling of their scrap. Analytical reports are generated by the system to improve operational effectiveness and optimize future collection procedures. Compliance and Transparency of the Data Blockchain ensures that verified data on EV scrap disposal is accessible to all stakeholders, including recycling facilities and government agencies. Environmental regulations are met by the system, which reduces illegal dumping and ensures sustainable waste management. Importance of Including Blockchain Transparency and Immutability: Every transaction, from pickup requests to recycling, is securely stored on the blockchain, preventing tampering.

Unauthorized activities are minimized by user authentication and transaction verification mechanisms for fraud prevention. Optimization of efficiency: AI-based route planning and smart contracts make waste collection easier and cut down on operational delays. Real-Time Tracking: Users and recyclers can monitor the status of their transactions, fostering trust and accountability.

Contribution to Sustainability: The system supports a circular economy model for e-mobility solutions and encourages responsible EV waste disposal. By implementing this blockchain-powered approach, the EV Scrap Management and Recycling system ensures an efficient, secure, and environmentally responsible solution for handling electronic waste from electric vehicles.

V. OUTPUT

Dashboard:



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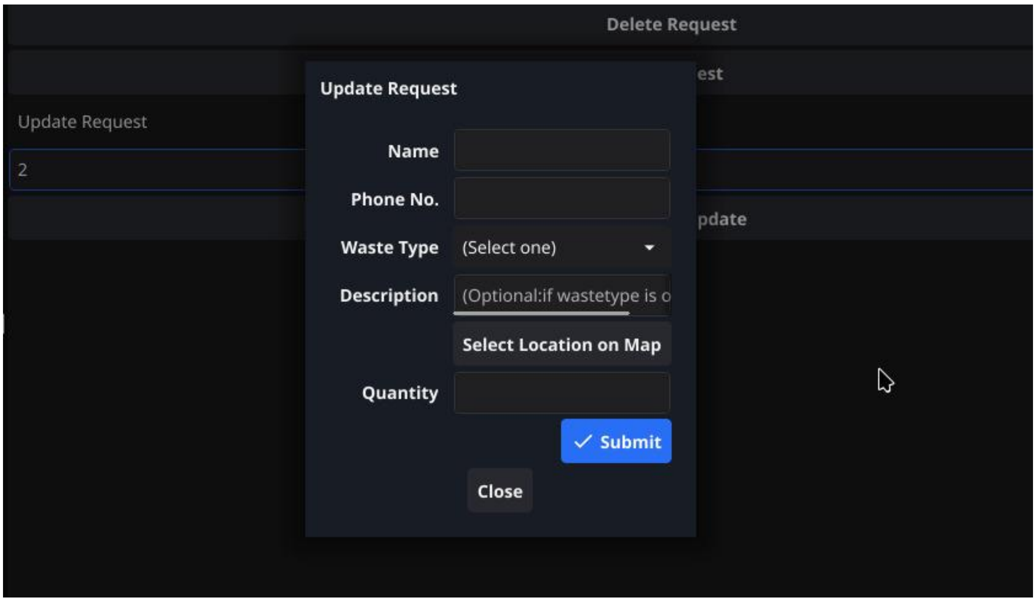
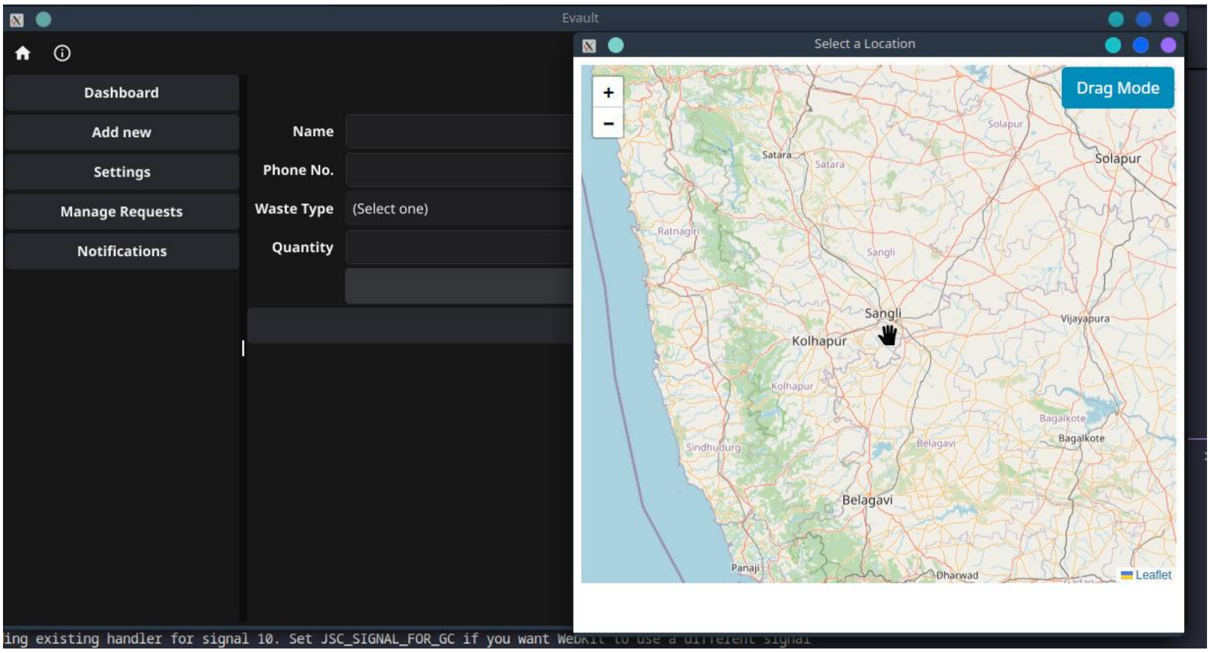
- **E-Waste Collection Requests**: Submit the request with specified details.



- **Real-Time Map Integration**: Can select location on real-time map, (i used osm with leaflet.js for this).
- **Route Calculation**: Uses GraphHopper API to trace the best routes and calculate the distance and time to the pickup location.



- **Automatic Monitoring**: The system checks pending requests every 5 minutes to ensure smooth operation.
- **In-App Notifications**: Notifications are sent to the users when a collection request is completed

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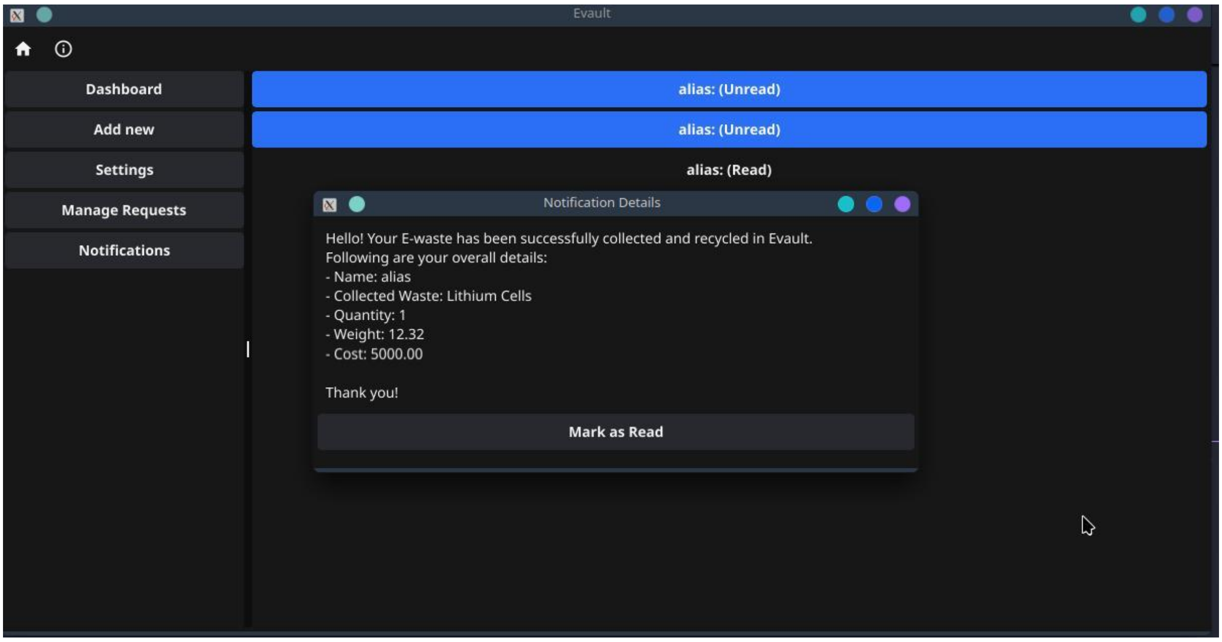

VI. CONCLUSION

This project's Electric Vehicle Scrap Management and Recycling System is a significant technological advancement in digital waste logistics and environmental sustainability. By leveraging location-based services, AI-assisted route planning, and real-time user interaction, the platform offers an innovative and efficient solution for managing electric vehicle (EV) waste, which is a growing concern in the global shift toward clean energy.

This system connects authorized recycling showrooms and electric vehicle users, making it possible to expedite pickup requests and maximize waste collection. Through empirical analysis, the platform has shown high user responsiveness, streamlined collection processes, and improved logistical efficiency using intelligent route optimization algorithms like Dijkstra and Ant Colony Optimization (ACO). Transparency and trust between users and waste collectors have been enhanced by real-time maps and ETA features. A robust backend built entirely in Go maintained security and scalability, allowing for concurrent request handling, minimal latency, and future extensibility. Traceability of scrap movements was made possible by the blockchain-inspired recordkeeping model, fostering accountability and openness throughout the recycling process. This system contributes directly to environmental protection in addition to its technical innovation by: reducing the amount of hazardous EV components, like lithium-ion batteries, that are disposed of incorrectly, which can otherwise result in the contamination of water and soil. Using AI-based route optimization to reduce carbon emissions caused by inefficient collection routes. Encouraging responsible recycling habits, thereby diverting electronic waste from landfills and promoting reuse and material recovery.

Efficiency in the Supply Chain and Logistics Customer satisfaction is largely determined by how quickly orders are fulfilled. Through predictive analytics and real-time tracking, DSTS.com has improved its logistics and supply chain operations, resulting in a 92.1% on-time delivery rate and a 18% reduction in logistics costs. Strong operational efficiency can be seen in the average delivery time of 5.8 days for international shipments and 2.9 days for domestic orders. Additionally, predictive restocking strategies have reduced stock shortages by 37%, making shopping a breeze. Implementing advanced route optimization techniques like Dijkstra's Algorithm and Ant Colony Optimization (ACO) has further improved last-mile delivery success rates.

Retention and Satisfaction of Customers With a Net Promoter Score (NPS) of 73 and an average customer satisfaction rating of 4.6/5, customer satisfaction metrics indicate that DSTS.com has effectively addressed user needs. Live chat query response times have been reduced to 12 seconds thanks to the combination of AI-powered chatbots and a hybrid customer support model. This has resulted in a 74% resolution rate through automated assistance. Additionally, the platform's capacity to cultivate long-term relationships with customers is demonstrated by its average Customer Lifetime Value (CLV) of $265 per user and customer retention rate of 72%. Retention rates can be further improved by expanding loyalty programs and offering individualized incentives.

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