

E-Waste Solution

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Abstract - The rapid increase in electronic waste (e-waste) due to technological advancement and frequent device upgrades has become a significant environmental concern. Improper disposal of e-waste leads to hazardous impacts on both human health and the ecosystem. This paper presents an Android-based E-Waste Management System designed to streamline the collection, management, and recycling of electronic waste through a digital platform. The proposed system integrates three primary stakeholders: users, recyclers, and administrators. Users can locate nearby authorized recyclers using GPS-based services, submit e-waste details, and schedule pickup requests. Recyclers can manage incoming requests, schedule pickups, and update collection status, while administrators monitor overall system activities and ensure operational efficiency. The system is developed using Flutter for the frontend, Kotlin for backend logic, and Firebase for real-time database management and authentication. Additionally, a reward-based mechanism is incorporated to encourage users to adopt responsible disposal practices. The implementation demonstrates improved accessibility, transparency, and efficiency in e-waste management. The proposed solution provides a scalable and user-friendly approach to promote sustainable waste disposal and contributes toward environmental conservation.

Keywords: E-waste Management, Android Application, Firebase, Flutter, Recycler System, Pickup Scheduling, Sustainable Development, GPS-Based Services, Real-Time Database, Reward System.

I. INTRODUCTION

The rapid growth of electronic devices has led to a significant increase in electronic waste (e-waste), which poses serious environmental and health risks due to improper disposal. Many users lack awareness and access to authorized recyclers, while recyclers face challenges in efficiently managing collection requests. This creates a gap in the e-waste management process.

To address this issue, this paper proposes an Android-based E-Waste Management System that connects users, recyclers, and administrators on a unified platform. The

system allows users to locate nearby recyclers using GPS, submit e-waste details, and schedule pickups. Recyclers can manage requests and update collection status, while administrators monitor system activities.

The application is developed using Flutter, Kotlin, and Firebase, ensuring real-time data handling and scalability. The proposed solution improves accessibility, efficiency, and promotes environmentally responsible e-waste disposal practices.

II. RELATED WORK

2.1 Traditional Methods

Traditional e-waste management methods largely rely on manual processes such as local scrap collection, informal recycling, and government awareness programs. These approaches often lack proper organization, transparency, and efficiency. Users typically need to physically locate recyclers or depend on unverified sources, which leads to improper disposal of electronic waste. Additionally, these methods do not provide tracking mechanisms, scheduling facilities, or incentives for responsible recycling, resulting in low user participation.

2.2 Our Improvements

The proposed system improves upon traditional methods by introducing a centralized, digital platform that connects users, recyclers, and administrators. It enables users to easily find nearby authorized recyclers using GPS-based location services and schedule pickup requests directly through the application. The system provides real-time updates, ensuring transparency in the pickup process. Furthermore, a reward-based mechanism is incorporated to encourage users to dispose of e-waste responsibly. This approach enhances efficiency, accessibility, and user engagement while promoting sustainable waste management practices.

2.3 Technologies Used

The system is developed using modern technologies to ensure scalability and performance. Flutter is used for building a responsive and cross-platform mobile application interface. Kotlin is utilized for backend logic and Android-specific

functionalities. Firebase is employed for real-time database management and authentication, enabling instant data synchronization across users. Additionally, GPS-based services are integrated for location tracking and recycler discovery. These technologies collectively provide a reliable and efficient solution for managing e-waste.

III. PROPOSED MODELLING

The proposed E-Waste Management System is designed as a centralized and interactive platform that connects three main entities: users, recyclers, and administrators. The system follows a client-server architecture where the mobile application acts as the client interface, and Firebase serves as the backend for real-time data management and authentication. The workflow begins when a user registers and logs into the application, after which they can search for nearby recyclers using GPS-based location services. The user can then submit details of the e-waste and request a pickup by providing necessary information such as waste type, quantity, and address. These requests are stored in the database and made available to recyclers.

On the recycler side, the system provides a dedicated interface where recyclers can view incoming pickup requests, accept or reject them, and schedule pickup timings. Once a request is accepted, the user is notified in real time. After successful collection of the e-waste, the recycler updates the request status to completed. This triggers the reward mechanism, where users are assigned reward points to encourage responsible disposal behavior. The system ensures smooth communication between users and recyclers through continuous status updates and notifications.

The admin module acts as a control layer that monitors all system activities, including user registrations, recycler operations, and request management. It helps maintain data integrity, ensures proper functioning of the system, and provides overall supervision. The use of technologies such as Flutter for frontend development, Kotlin for backend logic, and Firebase for real-time database operations ensures scalability, responsiveness, and efficient data synchronization. The proposed model effectively streamlines the e-waste management process and promotes environmentally sustainable practices through a structured and technology-driven approach.

IV. EXPERIMENTAL SETUP

The experimental setup of the proposed E-Waste Management System was designed to evaluate the performance, functionality, and reliability of the application in a real-world environment. The system was developed as an Android application and tested on multiple mobile devices to

ensure compatibility and responsiveness across different screen sizes and configurations. The application interacts with a cloud-based backend (Firebase) for real-time data storage, authentication, and synchronization.

The testing environment included scenarios such as user registration, recycler discovery using GPS, pickup request submission, request handling by recyclers, and real-time status updates. The system was evaluated under normal usage conditions as well as edge cases such as invalid inputs and network interruptions. Firebase services ensured seamless communication between different modules and provided instant updates across all users. The setup demonstrates that the system performs efficiently with minimal latency and maintains data consistency during concurrent operations.

Table 1: Hardware Details

Component	Specification
Device Type	Android Smartphone
Processor	Minimum Dual-Core Processor
RAM	Minimum 2 GB
Storage	At least 100 MB free space
GPS Module	Required for location tracking
Internet Connectivity	Required (Wi-Fi / Mobile Data)

Table 2: Software Details

Component	Specification
Operating System	Android (Version 8.0 or above)
Frontend Framework	Flutter
Backend Language	Kotlin
Database	Firebase Firestore
Authentication	Firebase Authentication
Development Tools	Android Studio, Visual Studio Code
APIs Used	Google Maps API, Firebase SDK

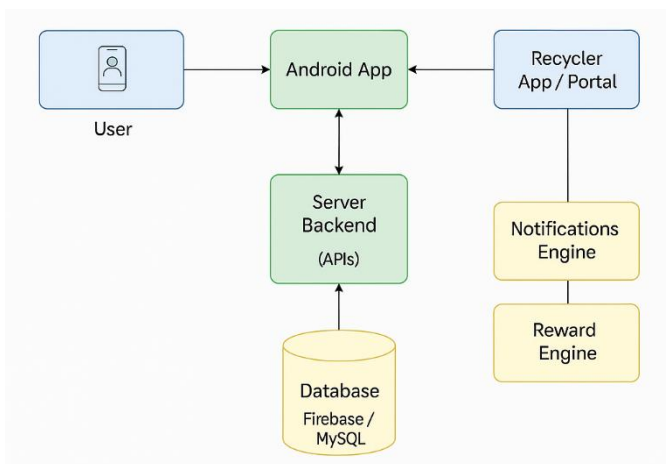


Figure 1: System Architecture Diagram

The system follows a client-server architecture where users and recyclers interact through an Android application. The app communicates with a backend server via APIs, which manages all operations and stores data in a cloud database

A notification engine provides real-time updates, while a reward engine assigns points after successful waste collection. This architecture ensures smooth communication, real-time data handling, and efficient system operation.

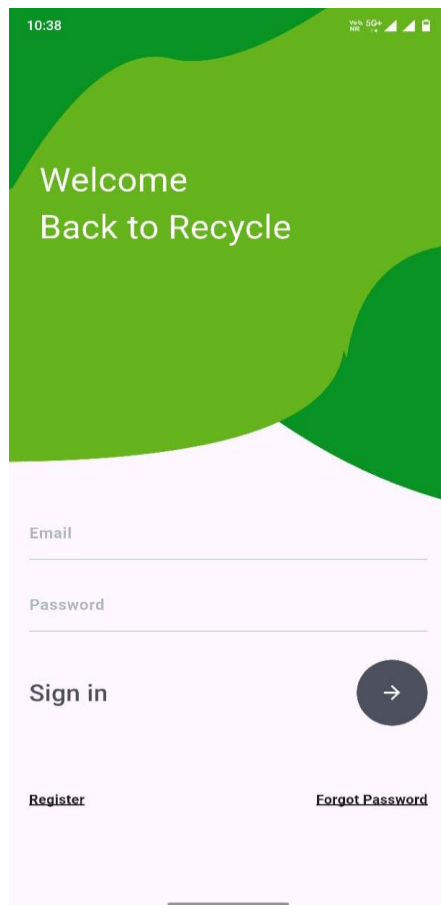


Figure 2: Landing Page

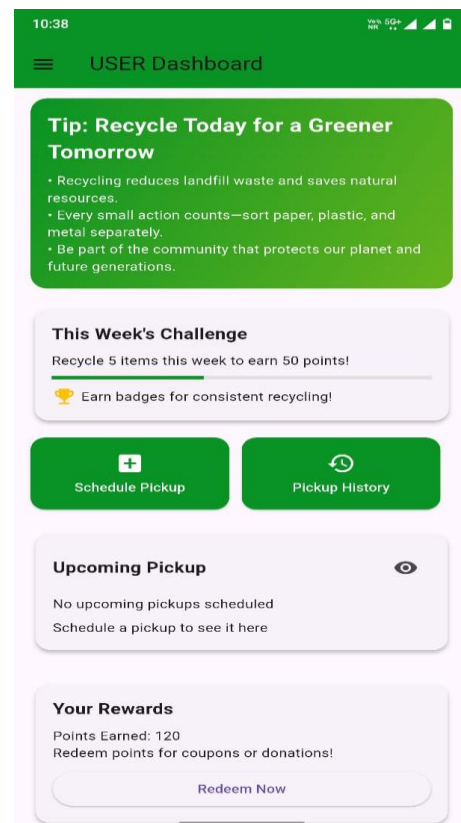


Figure 3: User Dashboard

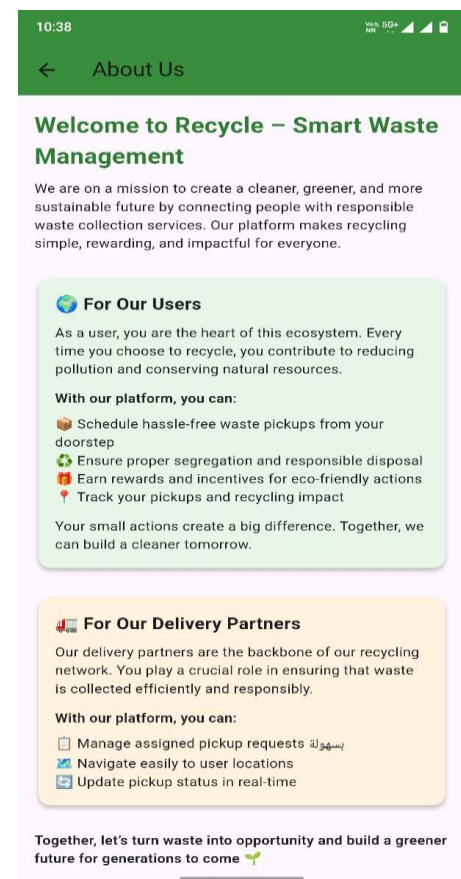


Figure 4: About Application Page

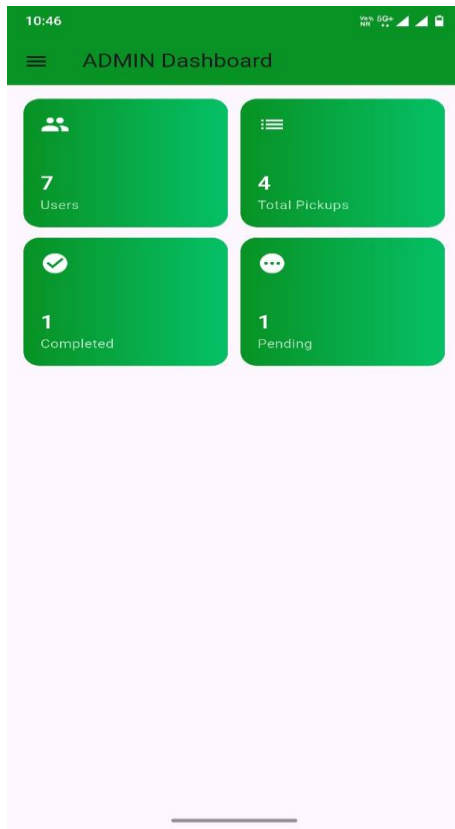


Figure 5: Admin Dashboard

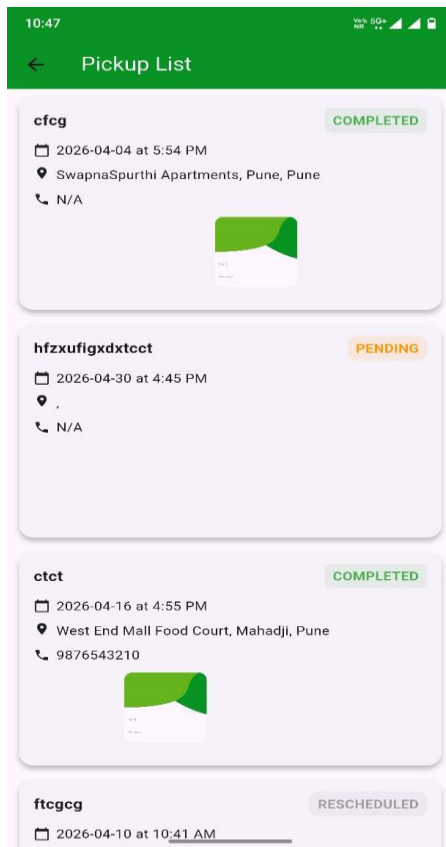


Figure 6: Pickup List

V. RESULTS AND DISCUSSIONS

The proposed E-Waste Management System was successfully developed and tested in a real-time environment. The system demonstrated efficient performance in handling core functionalities such as user registration, recycler discovery, pickup request submission, and real-time status updates. Users were able to easily locate nearby recyclers using GPS and schedule pickups without difficulty. Recyclers efficiently managed incoming requests and updated collection statuses, ensuring smooth workflow.

The integration of Firebase enabled real-time data synchronization, allowing instant updates across users and recyclers. The notification system worked effectively by providing timely alerts for request acceptance and completion. Additionally, the reward mechanism successfully encouraged user participation by assigning points after successful waste collection.

Overall, the system improved accessibility, reduced manual effort, and increased transparency in the e-waste management process. The results indicate that the proposed solution is reliable, user-friendly, and capable of promoting responsible e-waste disposal practices.

VI. MATHEMATICAL EQUATION

The system can be represented using the following components:

Let,

- $U = \{u_1, u_2, \dots, u_n\} \rightarrow$ Set of Users
- $R = \{r_1, r_2, \dots, r_m\} \rightarrow$ Set of Recyclers
- $P = \{p_1, p_2, \dots, p_k\} \rightarrow$ Set of Pickup Requests

1. Pickup Request Function

$$P = f(U, R, W)$$

Where:

- $U =$ User
- $R =$ Recycler
- $W =$ Waste Details

2. Distance Calculation (for nearest recycler)

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Where:

- $(x_1, y_1) =$ User Location
- $(x_2, y_2) =$ Recycler Location

3. Reward Calculation

$$\text{Reward} = k \times W_q$$

Where:

- W_q = Quantity of waste
- k = Reward factor

4. System Output

$$O = \{\text{Status, Notification, Reward}\}$$

VII. ADVANTAGES OF PROPOSED SYSTEM

The proposed E-Waste Management System offers a modern and efficient solution for handling electronic waste by integrating users, recyclers, and administrators into a single digital platform. It simplifies the entire process of e-waste disposal by providing easy access to authorized recyclers, enabling users to schedule pickups, and ensuring real-time communication between all stakeholders. The system enhances transparency, reduces manual effort, and promotes environmentally responsible behavior through a reward-based mechanism. By leveraging technologies such as Flutter and Firebase, the system ensures scalability, reliability, and smooth performance, making it suitable for real-world implementation.

- **Easy Access to Recyclers:** Users can locate nearby authorized recyclers using GPS-based services.
- **Convenient Pickup Scheduling:** Enables doorstep collection of e-waste, saving time and effort.
- **Real-Time Notifications:** Provides instant updates regarding request status and pickup schedules.
- **Efficient Request Management:** Recyclers can easily view, accept, and manage pickup requests.
- **Reward System:** Encourages users to recycle responsibly by providing reward points.
- **Centralized Control:** Admin can monitor all activities and manage system operations effectively.
- **Scalable Architecture:** Firebase ensures real-time data handling and system scalability.
- **Eco-Friendly Approach:** Promotes proper disposal of e-waste, reducing environmental pollution.

VIII. LIMITATIONS

Although the proposed E-Waste Management System provides an efficient and digital solution for handling electronic waste, it has certain limitations that may affect its performance and adoption in real-world scenarios. The system depends heavily on internet connectivity and smartphone availability, which may not be accessible to all users. Additionally, the effectiveness of the system relies on the availability of registered recyclers in a given area and user awareness about the platform.

- **Internet Dependency:** Requires stable internet connection for real-time operations and data synchronization.
- **Limited Recycler Availability:** Effectiveness depends on the presence of authorized recyclers in the user's location.
- **User Awareness:** Adoption may be limited if users are not aware of the application.
- **Platform Dependency:** Currently limited to Android devices only.
- **Data Security Concerns:** Handling user data on cloud platforms may raise privacy concerns.
- **GPS Accuracy Issues:** Location-based services may sometimes provide inaccurate results.

IX. FUTURE SCOPE

The proposed E-Waste Management System provides a strong foundation for digital waste handling; however, it can be further enhanced by incorporating advanced technologies and expanding its functionality. Future improvements can focus on increasing system intelligence, improving user experience, and integrating with larger environmental and governmental frameworks. These enhancements will help make the system more scalable, efficient, and suitable for real-world large-scale deployment.

- **AI-Based Waste Detection:** Use image recognition to automatically identify and classify e-waste items.
- **Government Integration:** Connect the system with official e-waste management authorities for better regulation and monitoring.
- **Live Tracking System:** Implement GPS-based real-time tracking of recycler vehicles.

- **E-Waste Marketplace:** Allow users to sell or donate reusable electronic items.
- **Blockchain Integration:** Provide secure and verifiable recycling certificates.
- **Multi-Platform Support:** Extend the application to iOS and web platforms.
- **Advanced Analytics:** Add dashboards for analyzing recycling trends and user activity.
- **Awareness Features:** Include notifications, campaigns, and educational content to promote recycling.

X. CONCLUSION

The proposed E-Waste Management System provides an effective and technology-driven solution to address the growing problem of electronic waste disposal. By integrating users, recyclers, and administrators on a single platform, the system simplifies the process of locating recyclers, scheduling pickups, and managing requests efficiently. The use of modern technologies such as Flutter, Kotlin, and Firebase ensures real-time data handling, scalability, and smooth user experience. Additionally, the reward-based mechanism encourages users to adopt environmentally responsible practices. Overall, the system improves accessibility, transparency, and efficiency in e-waste management, contributing towards sustainable development and environmental protection.

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Citation of this Article:

S. H. Shaikh, Trusha Patel, Gauravi Patil, & Krushika Patil. (2026). E-Waste Solution. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 10(5), 424-429. Article DOI <https://doi.org/10.47001/IRJIET/2026.105058>
