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ANDROID-BASED SCRAP METAL COLLECTION SYSTEM WITH LIVE-LOCATION TRACKING: A PROTOTYPE APPROACH IN MANADO CITY

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Abstract

This research aims to design and develop an Android-based application integrated with real-time location tracking to support scrap metal pickup services. The system was developed using the Prototype method. The application was built with Flutter and Dart, using Firebase as the backend and the Google Maps API for GPS-based real-time location tracking and map visualization. The system offers features for both customers and collectors. Customers can request pickup services, enter information about the scrap they have, choose a collector, and track the collector's location. Collectors get the request, check the service details, and go to the customer's location. These features enable users to communicate and work together on a single digital platform. System testing was conducted using Black-Box Testing with the Equivalence Partitioning technique, with alpha testing involving 6 participants. From 126 test cases, 124 were successful, resulting in a Task Success Rate (TSR) of 98%. These results indicate that the system is functionally reliable in supporting the main processes of scrap metal pickup services. Furthermore, the developed application is expected to facilitate interaction between customers and collectors, provide visibility of collector locations through real-time tracking, and support the implementation of a digital-based scrap metal pickup service.

Keywords: Android Application, Live Location Tracking, Scrap Metal Pickup, Prototype Method, Google Maps

INTRODUCTION

Sustainability concerns are leading more people to adopt a circular economy approach, which focuses on reducing consumption, reusing items, repairing and remanufacturing products, and recycling materials [1], [2]. Steel plays an important role in this process as it can be recycled without losing its quality [3]. Recycling helps reduce carbon emissions significantly. Instead of making steel from new materials, which creates 1.99 tons of CO_2 per ton of steel, using scrap metal produces only 0.27 tons of CO_2. This means recycling can lower emissions by as much as 86% to 87% [2], [4].

In Indonesia, about 80% of the steel produced still uses outdated methods, and as steel demand grows, the country ends up buying more from abroad, even though plenty of scrap metal is available at home [5]. However, the use of scrap metal remains limited due to poor infrastructure and collection methods [6].

In Manado City, people still collect scrap metal by hand. Collectors go from house to house looking for customers, but they are not sure if anyone will be there. Residents also do not have easy ways to talk directly to the collectors [7]. This situation leads to inefficiencies in time, fuel, and coordination. These challenges are further influenced by the city's hilly geographical conditions [8].

The advancement of mobile technology and real-time location tracking offers a chance to enhance service efficiency. These systems have been shown to reduce operating costs and improve management efficiency [9]. Manado also has a good digital setup, with 95.4% of the area covered by 4G [10].

As a result, this study suggests an Android application for live location tracking to assist scrap metal pickup services, aiming to increase efficiency, minimize fuel consumption, and improve communication between collectors and clients.

Research Question

How to create and develop an Android app integrated with location tracking features for ordering scrap metal pickup services?

Research Objectives

This research aims to design and develop an Android application integrated with location tracking features for ordering scrap metal pickup services.

Research Significance

The general benefit of this research is to develop an Android-based application prototype to improve scrap metal pickup efficiency. The specific benefits are:

1. This study provides practical development experience.
2. Contributes as a reference for future research.
3. Facilitates collectors' management of orders and routes.
4. Enables residents to access pickup services more easily.
5. Supports better scrap management for environmental sustainability.

Previous Studies

Earlier research has examined how mobile apps can enhance scrap management and collection methods. A pertinent example is Scrapify, which created an Android app to modernize scrap selling by enabling users to enter details about their scrap, such as category, images, and pickup location. The system then forwards this information to collectors through an intermediary administrator, who distributes requests via notifications and SMS that include customer details and location links [11]. The study found that the system can help collectors save time when locating customers. However, the system still relies on an administrator as an intermediary, resulting in indirect communication between customers and collectors. In addition, the interaction is not done in real time because information is sent through SMS, which can make it harder to coordinate and respond quickly.

Another study, RENIA, developed an Android app that supports recyclable waste collection by allowing users to request pickups and monitor collectors' locations. The system includes several parts, such as user authentication, selecting the right scrap, handling pickup requests, and tracking the location on a map. When a request is made, the collectors are informed and assigned the responsibility of retrieving the item, and users have the ability to track the item's status through a map interface [12]. The system has location tracking functionality but lacks several important operational features such as input for estimated scrap weight, vehicle selection, and detailed transaction records.

From these studies, it is clear that earlier systems have not fully combined direct interaction and extensive service capabilities into a single platform. Some systems still rely on intermediaries, while others offer only basic features for handling service details and user interactions.

Therefore, there is a research gap: a system capable of combining real-time location tracking, direct communication between customers and collectors, and other operational functions such as entering scrap details, selecting vehicles, and recording transactions, all within a single application. In response to this gap, this study proposes an Android-based application that enables direct interaction between customers and collectors without intermediaries, supports real-time location tracking, and provides additional features to manage service information.

LITERATURE REVIEW

Scrap Metal

Scrap metal is a metallic material derived from products that have reached the end of their useful life or from industrial production waste. Recycling scrap metal produces new steel while maintaining the material's quality [2]. This recycling process helps reduce the use of new raw materials and lower carbon emissions in the steel industry.

Android-Based Mobile Apps

Android is a Linux-based mobile operating system developed by Google for devices such as smartphones and tablets. Android provides an open platform that enables developers to create a wide range of mobile applications by leveraging available services and APIs [13].

Flutter

Flutter is a free, open-source framework developed by Google that enables developers to create applications for various platforms with a unified codebase. Flutter uses the Dart programming language and provides a widget system that enables the development of responsive and interactive user interfaces [14].

Firebase

Firebase is a cloud-based backend platform that provides services such as user authentication, real-time databases, and data storage. Firebase allows developers to build applications without managing server infrastructure directly [15].

Google Maps API

The Google Maps API is a digital mapping service that enables the integration of mapping features into applications. This API provides various features such as location detection, route navigation, and real-time user location tracking [16].

RESEARCH METHODOLOGY

Data Collection

The data used in this study consists of two types, namely:

1. Primary Data
   Primary data was collected through interviews with scrap metal collectors and residents of Manado to understand the current scrap metal collection process and the challenges faced.
2. Secondary Data
   Secondary data were collected through a literature review of books, academic journals, and official documents on mobile application technology, scrap metal management, and location tracking systems.

System Development Methods

The Prototype method was selected because it enables iterative development based on user feedback, which is well-suited to systems with evolving requirements, such as mobile service applications. This approach enables early validation of system features, particularly for user interaction and real-time tracking functionality.

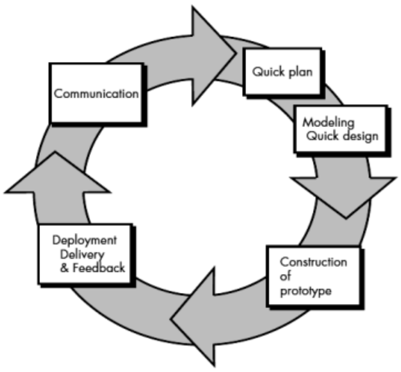

Figure 1. Prototype Method [17]

The prototype approach includes a number of phases, specifically:

1. Communication
   This phase aims to identify user needs through interviews and observations. Researchers interact directly with scrap metal collectors and the community in Manado to understand the current scrap metal collection process, identify key challenges, and determine necessary features such as service booking and location tracking.
2. Quick Plan
   This phase involves initial system planning based on user feedback. The researchers identify the application's key features, design the ordering and location-tracking workflows, and develop an initial testing plan. Planning is flexible to ensure prototype development proceeds quickly and aligns with user needs.
3. Modeling Quick Design
   This stage emphasizes the system's primary design and its application interface. Researchers develop wireframes and flowcharts to depict the system's organization, navigation, and application interface. This design acts as the basis for prototype creation to verify that it meets user requirements.
4. Construction of Prototype
   This phase involves developing the prototype based on the previous planning and design. The application is built with Flutter, using Firebase for the backend and the Google Maps API for location services. Key features developed include user registration, service booking, and real-time location tracking, resulting in a prototype ready for testing.
5. Deployment and Feedback
   This stage aims to assess the prototype and gather user feedback. The application was launched on Android and examined by a select group of six users during the Alpha Testing phase. Each participant ran specific test cases, and the results were recorded and analyzed to evaluate the system's performance and reliability. The findings and user feedback are then used as the basis for further system improvement and development.

SYSTEM ANALYSIS

Analysis of the Current System

The current scrap metal collection system is still manual. Collectors go around various neighborhoods looking for people who want to sell scrap metal.

This process has several drawbacks, including a lack of a clear communication system between customers and collectors, uncertain pickup schedules, high fuel consumption, and a lack of a location tracking system. The current system workflow can be seen in Figure 2.

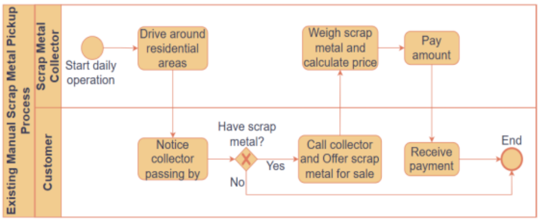

Figure 2. As-Is Business Process

Analysis of the Proposed System

The proposed system is an Android-based mobile app that connects customers and scrap metal collectors via a digital platform. Customers can request scrap metal pickup through the app, while collectors can accept these requests and view customers' locations in real time. The proposed system flowchart can be viewed in Figure 3.

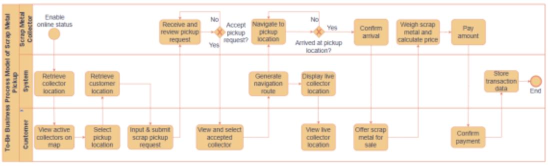

Figure 3. To-Be Business Process

A comparison between the traditional and suggested systems reveals differences in how services are handled. In the manual method, communication between collectors and customers is not direct, pickup times are not clear, and there is no way to track the location. In contrast, the proposed system supports direct communication, real-time tracking, and structured service requests, enabling interaction and coordination through a digital platform.

Feature Requirements

Based on the interview analysis and business process modeling, the main system functions of the proposed application are as follows:

a. Customer Features

The system provides features that enable customers to request scrap metal pickup services digitally, including:

1. Register and log in.
2. Set pickup location via map.
3. Input scrap details (type and weight).
4. Submit pickup requests.
5. Select available collectors.
6. Track the collector location in real-time.
7. Confirm transaction.

b. Scrap Metal Collector Features

The system supports collectors in managing pickup services through:

1. Register and verify an account.
2. Activate online status.
3. Receive and review requests.
4. Accept requests and navigate to the location.
5. Complete transaction.

SYSTEM DESIGN / DEVELOPMENT

System Architecture

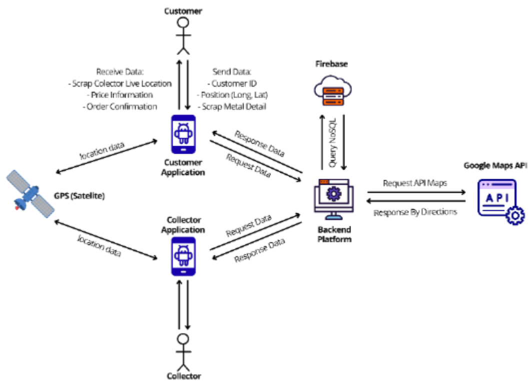

Figure 4. System Architecture

The system was built using a client-server architecture that includes several important parts: a customer application, a collector application, a backend powered by Firebase, the Google Maps API, and device GPS. The real-time tracking system works by constantly getting GPS coordinates from the collector's mobile phone. These coordinates are transmitted to the Firebase

Realtime Database, where they are saved and continuously updated as changes occur. The customer application retrieves this information and displays the collector's current location using the Google Maps API. This system allows customers to track the collector's location in real time, enhancing clarity and teamwork throughout the collection process.

Use Case Diagram

A use case diagram shows the interactions between users and the system under development.

Figure 5. Use case diagram of scrap metal pickup system

In this system, two primary participants are present: customers and scrap collectors. Customers submit scrap metal collection requests and follow the service procedures, whereas scrap collectors receive these requests, visit the customer's site, and complete the transaction. The Use Case Diagram provides an overview of the system's main functions and the relationships between the actors and the system.

Class Diagram

Class diagrams are used to model data structures and relationships between classes within a system. Even though the system uses Firebase, which is NoSQL-based, these diagrams are still necessary to define key objects such as Customer, Scrap Metal Collector, Admin, and Ride Request to support authentication, service requests, location tracking, and transactions.

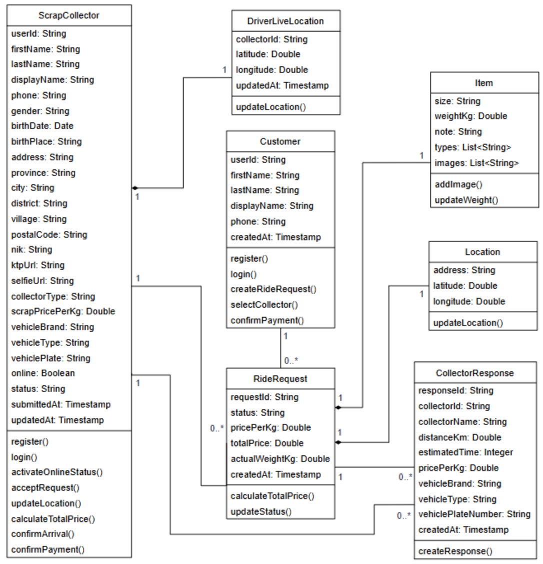

Figure 6. Class Diagram of the Scrap Metal Pickup System

IMPLEMENTATION AND DISCUSSION

The use of a mobile application is considered appropriate due to its accessibility and its capability to integrate with device hardware such as GPS sensors [18]. This enables real-time location tracking, which is not supported in conventional manual systems. The integration of mobile technology and location-based services allows the system to facilitate user interaction and coordination.

The application was created with the Flutter framework and written in Dart. For user authentication and data storage, Firebase serves as the backend service. The Google Maps API is employed to display maps and track locations in real time. The following are the results of the application design.

User Authentication and Main Interface

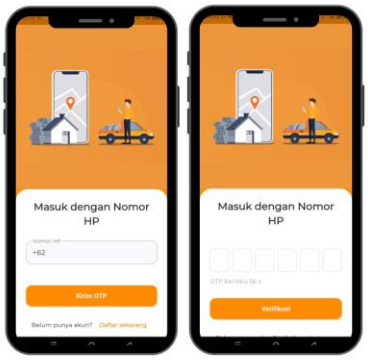

Figure 7. Login and OTP Verification Page

Figure 7 shows the user authentication process and the application's main interface. Users log in via phone number verification with OTP, and after successful authentication, they are directed to the main dashboard, which displays their current location and available features.

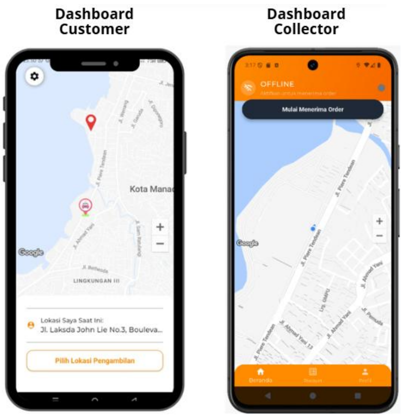

Figure 8. Dashboard Collector and Customer

Figure 8 shows the main dashboard for both collectors and customers. Collectors can activate their online status to receive pickup requests, while customers can view available collectors and select the pickup location through the map interface.

Scrap Pickup Request Process

Figure 9 illustrates the scrap pickup request process. Users select a pickup location in the map interface and enter scrap details, such as type, estimated weight, and additional information, before submitting the request.

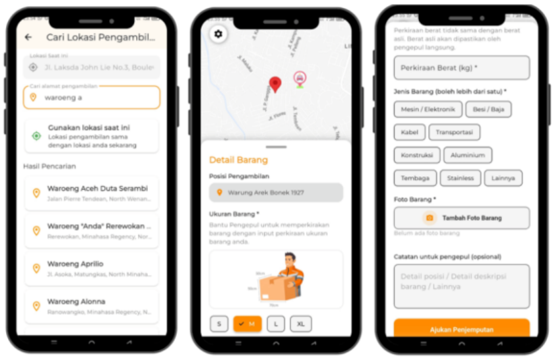

Figure 9. Scrap Pickup Request Process

Collector Selection and Real-Time Tracking

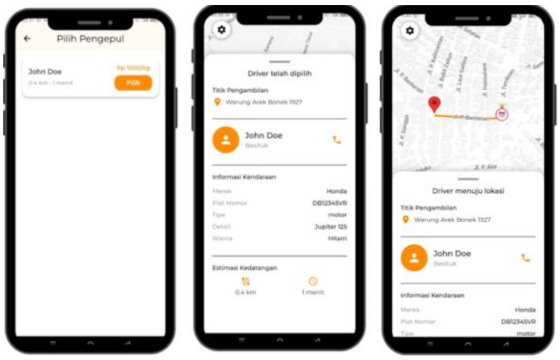

Figure 10. Customer Scrap Pickup Request Process

Figure 10 illustrates the scrap pickup request process. Users select a pickup location in the map interface and enter scrap details, such as type, estimated weight, and additional information, before submitting the request.

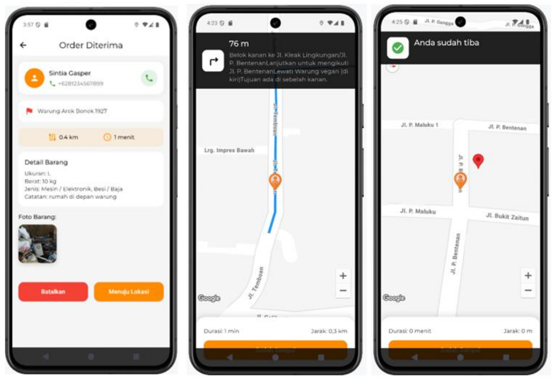

Figure 11. Collector Scrap Pickup Request

Process and Navigation

This figure illustrates the process collectors use to handle scrap pickup requests, including receiving request details and navigating to the customer's location using the integrated map and real-time location-tracking system.

Transaction and Service Completion

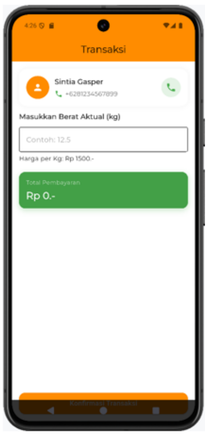

Figure 12. Collector Transaction Page

Displays the transaction page where the collector inputs the total price based on the actual weight of the collected scrap and requests confirmation from the customer.

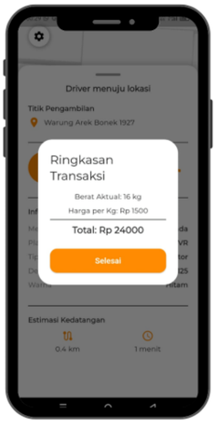

Figure 13. Customer Confirmation Price

Shows the process where the customer reviews and confirms the calculated transaction price before completing the service.

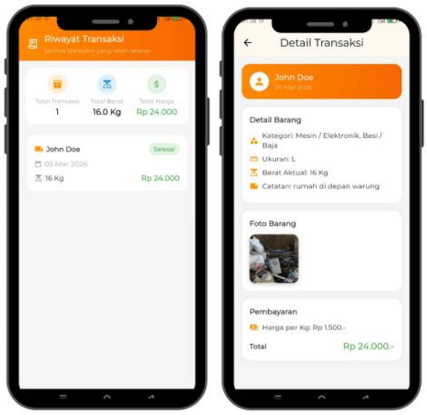

Figure 14. Transaction History

Presents the transaction history, allowing users to view records of previous scrap pickup activities and their details.

System Testing and Evaluation

System testing was conducted using Black-Box Testing with the Equivalence Partitioning technique via Alpha Testing, involving six respondents: three collectors and three customers. The testing process included designing test cases, determining input boundaries or partitions, executing tests based on the established partitions, and analyzing the results [19]. Each respondent executed predefined test cases covering all main system functionalities.

Table 1. Scrap Metal Collector Test Case Design

Test Case ID	Feature / Function Tested	Testing Objective
COL-01	Login (Phone & OTP)	To validate the collector authentication process
COL-02	Registration Step 1: Basic Information	To verify the input validation of personal data
COL-03	Registration Step 2: OTP Verification	To ensure the OTP verification mechanism works correctly
COL-04	Registration Step 3: Vehicle Type Selection	To validate vehicle selection functionality
COL-05	Registration Step 4: Selfie Upload	To verify the image upload validation process
COL-06	Registration Step 5: ID Card Upload	To ensure ID verification uploads function properly

COL-07	Registration Step 6: Scrap Status & Price Input	To validate scrap price input and status selection
COL-08	Registration Step 7: Vehicle Data Input	Registration Step 7 – Vehicle Data Input
COL-09	Registration Step 8: Submit for Approval	To ensure the registration submission process functions correctly
COL-10	Online Activation	To verify GPS retrieval and online status activation
COL-11	Accept Pickup Request	To validate the request acceptance process
COL-12	Actual Weight Input	To verify the price calculation based on weight
COL-13	Payment Confirmation	To ensure the completion of the transaction process

The table presents the main test cases for the collector application, covering authentication, registration, request handling, and transaction processes to ensure all core functionalities operate as intended.

Table 2. Customer Test Case Design

Test Case ID	Feature / Function Tested	Testing Objective
CUS-01	Login (Phone & OTP)	To validate the customer authentication process
CUS -02	Registration Basic Data	To verify customer registration validation
CUS -03	Registration OTP Verification	To ensure the OTP verification mechanism works correctly
CUS -04	Pickup Location Selection	To validate the location selection feature
CUS -05	Submit Pickup Request	To validate the pickup request submission process
CUS -06	Collector Selection	To verify selected collector is stored correctly
CUS -07	Live Tracking	To ensure real-time tracking functionality operates properly
CUS -08	Transaction Confirmation	To validate transaction completion from the customer side

The table describes the test scenarios for the customer application, covering authentication, submitting a pickup request, selecting a collector, real-time tracking, and confirming the transaction to ensure the system works as intended.

Table 3. Collector Partition Table

Test Case ID	Partition Code	Partition	Test Scenario	Expected Result
COL-01	COL-01-1	Valid	Enter the registered phone number and correct OTP	System grants access to homescreen
	COL-01-2	Invalid	Enter an incorrect or empty OTP	The system displays an error message
COL-02	COL-02-3	Valid	Enter all required personal data in a valid format	Data accepted and proceed to the next step
	COL-02-4	Invalid	Leave one or more required fields empty	The system prevents submission
COL-03	COL-03-5	Valid	Enter the correct and non-expired OTP	OTP verified
	COL-03-6	Invalid	Enter expired or incorrect OTP	System rejects OTP
COL-04	COL-04-7	Valid	Select one available vehicle type	Selection saved
	COL-04-8	Invalid	Proceed without selecting vehicle type	The system prevents submission
COL-05	COL-05-9	Valid	Upload image	Image uploaded successfully
	COL-05-10	Invalid	Skip image upload	The system prevents continuation
COL-06	COL-06-11	Valid	Upload a valid ID image	Data saved successfully
	COL-06-12	Invalid	Do not upload an ID card	The system prevents submission
COL-07	COL-07-13	Valid	Enter price per kg greater than zero	Price accepted
	COL-07-14	Invalid	Enter price per kg greater than zero	System rejects input
COL-08	COL-08-15	Valid	Enter complete vehicle data	Data stored successfully
	COL-08-16	Invalid	Leave vehicle data incomplete	The system prevents submission
COL-09	COL-09-17	Valid	Submit registration after	Status changed to

			completing all steps	waiting for approval
	COL-09-18	Invalid	Attempt to submit with incomplete data	Submission blocked
COL-10	COL-10-19	Valid	Activate online status with GPS and internet-enabled devices	Online status activated
	COL-10-20	Invalid	Activate online status with GPS disabled	Error message displayed
COL-11	COL-11-21	Valid	Accept pickup request while online	Status updated to accepted
	COL-11-22	Invalid	Attempt to accept the request while offline	The system prevents acceptance
COL-12	COL-12-23	Valid	Enter an actual weight greater than zero	Total price calculated correctly
	COL-12-24	Invalid	Enter zero or an empty weight value	System rejects input
COL-13	COL-13-25	Valid	Confirm payment after the transaction	Status changed to completed
	COL-13-26	Invalid	Do not confirm payment	The transaction remains pending

The table shows the classification of valid and invalid input partitions for the collector application, used to verify system responses under different input conditions and ensure proper input validation.

Table 4. Customer Partition Table

Test Case ID	Partition Code	Partition	Test Scenario	Expected Result
CUS-01	CUS - 01-1	Valid	Enter the registered phone number and correct OTP	Access granted and homescreen displayed
	CUS - 01-2	Invalid	Enter an incorrect or empty OTP	Error message displayed
CUS-02	CUS - 02-3	Valid	Enter all required fields correctly	Registration successful
	CUS - 02-4	Invalid	Leave the required fields empty	The system prevents submission
CUS-03	CUS - 03-5	Valid	Enter the correct and non-expired OTP	OTP verified
	CUS - 03-6	Invalid	Enter expired or incorrect OTP	System rejects OTP
CUS-04	CUS - 04-7	Valid	Select a location on the map	Location saved
	CUS - 04-8	Invalid	Attempt to submit without selecting a location	Submission prevented
CUS-05	CUS - 05-9	Valid	Submit the form with complete data	Data accepted
	CUS-05-10	Invalid	Submit the incomplete form	System rejects input
CUS-06	CUS-06-11	Valid	Select one collector from the list	Collector assigned
	CUS-06-12	Invalid	Proceed without selecting the collector	Cannot proceed
CUS-07	CUS-07-13	Valid	Enable GPS and internet connection	Location updates in real-time
	CUS-07-14	Invalid	Disable GPS or the internet	The system shows a location error
CUS-08	CUS-08-15	Valid	Confirm transaction completion	Status updated to completed
	CUS-08-16	Invalid	Do not confirm the transaction	The transaction remains pending

The table outlines valid and invalid input partitions for the customer application, ensuring the system can effectively manage both correct and erroneous inputs across all features.

Table 5. Collector Execution Table (R1–R3)

Partition Code	R1	R2	R3
COL-01-1	Success	Success	Success
COL-01-2	Success	Success	Success
COL-02-3	Success	Success	Success
COL-02-4	Success	Success	Success
COL-03-5	Success	Success	Success

COL-03-6	Success	Success	Success
COL-04-7	Success	Success	Success
COL-04-8	Success	Success	Success
COL-05-9	Success	Success	Success
COL-05-10	Success	Success	Success
COL-06-11	Success	Success	Success
COL-06-12	Success	Fail	Success
COL-07-13	Success	Success	Success
COL-07-14	Success	Success	Success
COL-08-15	Success	Success	Success
COL-08-16	Success	Success	Fail
COL-09-17	Success	Success	Success
COL-09-18	Success	Success	Success
COL-10-19	Success	Success	Success
COL-10-20	Success	Success	Success
COL-11-21	Success	Success	Success
COL-11-22	Success	Success	Success
COL-12-23	Success	Success	Success
COL-12-24	Success	Success	Success
COL-13-25	Success	Success	Success
COL-13-26	Success	Success	Success

Testing on the scrap metal collector side was conducted by three respondents (R1, R2, and R3). Each respondent ran all test scenarios to ensure consistency of results across different user backgrounds. The test results show how the system responds to valid and invalid inputs for each feature.

Table 6. Customer Execution Table (R4–R6)

Partition Code	R4	R5	R6
CUS -01-1	Success	Success	Success
CUS -01-2	Success	Success	Success
CUS -02-3	Success	Success	Success
CUS -02-4	Success	Success	Success
CUS -03-5	Success	Success	Success
CUS -03-6	Success	Success	Success
CUS -04-7	Success	Success	Success
CUS -04-8	Success	Success	Success
CUS -05-9	Success	Success	Success
CUS-05-10	Success	Success	Success
CUS-06-11	Success	Success	Success
CUS-06-12	Success	Success	Success
CUS-07-13	Success	Success	Success
CUS-07-14	Success	Success	Success
CUS-08-15	Success	Success	Success
CUS-08-16	Success	Success	Success

Testing on the customer side was conducted by three respondents (R4, R5, and R6). This process aimed to ensure that the request submission, collector selection, location tracking, and transaction confirmation features could run properly under various usage conditions.

Table 7. Task Success Rate (TSR) Calculation Results

Actor	Total Test Case	Succe ssful	Failed	Success Rate (%)
Collector	78	76	2	97%
Customer	48	48	0	100%
Total	126	124	2	98%

The table presents the test results, showing the counts of passed and failed test cases for each user role, with an overall Task Success Rate (TSR) of 98% across 126 test scenarios. This outcome shows that the majority of the system's features worked properly during testing. For the Collector role, two scenarios failed across 78 tests, resulting in a 97% success rate, whereas the Customer role achieved a perfect 100% success rate. This 98% success rate aligns with the study by Muin & Yaqin (2025), which achieved a success rate of 97.87%. In their study, of 47 test cases executed, 46 were declared valid (successful) and 1 was declared invalid (failed) in the email input validation, leading to the conclusion that the system functioned well in accordance with the specified requirements [20]. The failed scenarios in the Collector role will be further reviewed to identify potential causes and ensure they do not affect the main system's functionality. Overall, these results show that the system can support its core functions during alpha testing.

This study provides practical implications by supporting the implementation of a digital platform for scrap metal pickup services, particularly in facilitating interaction between customers and collectors. From an academic perspective, this research can serve as a reference for developing mobile-based location-tracking systems for service-oriented applications, especially in the context of local waste management and recycling systems.

CONCLUSION

This study successfully designed and developed an Android-based application for scrap metal pickup services in Manado City using the Prototype method. The system uses Firebase for backend tasks and the Google Maps API to track locations in real time, enabling customers and collectors to interact with each other.

Based on system testing using Black-Box Testing with the Equivalence Partitioning technique through Alpha Testing, the application successfully ran most of its main functionalities, including authentication, pickup request submission, collector selection, real-time tracking, and transaction processing. From a total of 126 test cases, 124 test cases were successful, and 2 test cases failed, resulting in a Task Success Rate (TSR) of 98%.

However, several limitations were identified, particularly in input validation and system performance influenced by network conditions and GPS delays. In addition, testing was conducted on a limited scale, so further testing is required to evaluate system performance in a broader usage environment.

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