Nigerian Journal of Engineering Science and Technology Research, Vol. 12, No. 1, 2026(22-36)

DEVELOPMENT OF AN ONLINE HOUSEHOLD WASTE MANAGEMENT SYSTEM (CASE STUDY KANO CITY, NIGERIA)

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ABSTRACT

In large cities such as Kano in Nigeria, urban waste management faces significant challenges, including inefficiencies in waste pickup scheduling, lack of transparency, limited user engagement, lack of real-time tracking, and poor operational efficiency. To address the afore mentioned challenges, this paper proposes an online household waste management system developed using PHP Laravel, Filament, Vue.js, and MySQL guided by Agile software development methodology. The system successfully integrates waste pickup scheduling, company bidding, secure payment processing, and real-time updates into a user-friendly platform. Usability testing was carried out to ensure that all components function as expected. Total of 50 anonymous users participated in the usability testing. The overall average responses reveal that 27% of the responses are strongly agree and 35% of the responses are agree, thus suggesting that about 62% of the respondents are highly satisfied with the overall usability of the proposed household waste management system. This result shows adequate user satisfaction across all major functionalities of the system. Overall, 31% of the responses are neutral, indicating that a noticeable number of users chose Neutral across the questions. Only a small number of users, overall, 7% and 1% selected Disagree or Strongly Disagree respectively. This system demonstrates that digital technology can significantly improve urban waste management, promoting efficiency, sustainability, and user satisfaction. In the near future, mobile application version of the system could be developed for wider accessibility on mobile devices.

Keywords: Household waste, Online system, Urban planning, Environmental pollution

1 INTRODUCTION

Waste management is a crucial component of urban planning and public health, particularly in rapidly growing cities, such as Kano in Nigeria. Effective waste management ensures cleanliness, reduces environmental pollution, and mitigates health risks associated with improper waste disposal [1]. However, in many cities, current waste management practices are largely informal and characterized by inefficiencies, including inconsistent pickup schedules, lack of real-time tracking, and inadequate communication between waste collectors and residents [2]. Residents in these urban areas often dispose of their waste independently or rely on irregular services provided by municipal or private waste collectors. This approach leads to several challenges, such as missed pickups, uncollected waste accumulating in public spaces, and a general lack of accountability [2]. The absence of a structured, technology-driven system results in significant operational gaps, negatively impacting the overall effectiveness of waste management in these cities. Globally, digital solutions have been implemented to address similar challenges in waste management. For example, smart waste management systems in cities like Seoul and Singapore utilize technologies such as IoT sensors and data analytics to optimize waste collection routes, monitor bin levels, and improve service delivery [3]. These systems have proven to enhance efficiency, reduce costs, and improve the overall user experience. In contrast, the waste management system in Kano, Northern Nigeria, is overwhelmed by significant inefficiencies and a lack of standardization, resulting in inconsistent service delivery, environmental pollution, and public health risks. Residents often face irregular waste pickups, insufficient communication from waste collection services, and a general lack of accountability, leading to dissatisfaction and improper waste disposal practices such as burning or indiscriminate dumping. These issues are exacerbated by the absence of an online system that allows residents to schedule pickups, and track service status on the quality of service. This gap presents an opportunity for developing an online waste management system that can automate and streamline the waste collection process, ensuring timely pickups, enhanced communication, and improved service quality [4]. This paper proposes an online waste management system which aims to address the aforementioned issues by providing a platform for residents to request waste pickups, and track their status in real-time. By leveraging Laravel and Filament for the backend, the proposed system offers an intuitive user interface, robust data management capabilities, and seamless integration with existing waste collection services. This solution not only improves the efficiency of waste management but also promotes a cleaner and healthier urban environment.

2 REVIEW OF RELATED WORK

In this section we review existing literature relevant to the development of the Online Waste Management System. It focuses on key areas such as smart waste management solutions, and user interaction with waste management technologies. [5] proposed a blockchain-based waste tracking system aimed at improving transparency and accountability in waste management processes. The system records waste generation, transportation, and recycling activities on a decentralized ledger, ensuring tamper-proof data storage and supporting circular economy initiatives. [6] proposed an AI-driven smart waste collection optimization system designed for urban environments. The system integrates machine learning algorithms with IoT-enabled waste bins to predict fill levels and dynamically optimize collection routes based on traffic and demand patterns. The system improves operational efficiency and reduces fuel consumption during waste collection. [7] developed the Re Use Link system, designed to foster sustainable urbanism through solid waste reuse. The system integrates behavioral, logistic, and digital aspects to connect municipal authorities, residents, and other stakeholders involved in waste management. It also includes time management and object mapping for waste identification. [8] developed a cloud-based smart waste management platform aimed at improving coordination between households, waste collectors, and municipal authorities. The system uses cloud infrastructure to enable real-time data sharing, request submission, and service tracking, supporting scalable and centralized waste management operations in smart cities. [2] developed an e-Waste Management System aimed at addressing challenges related to e-waste disposal and recycling in India. This web application, built using Java, enables users to submit e-waste collection requests, track the status of their requests, and allow administrators to manage these requests effectively. [3] proposed an innovative solution called iSmartWMS for smart city waste management. The system automates waste monitoring and management through IoT sensors, providing real-time communication and alerts for waste collection needs. The system was simulated on a local machine network. [8] developed an Intelligent Waste Management System using deep learning and IoT. The system focuses on classifying waste in real-time using Convolutional Neural Networks (CNN), while IoT sensors monitor waste levels and weights. The key functionalities include classifying waste into digestible and indigestible categories, as well as real-time monitoring of waste levels using ultrasonic and load sensors. [4] introduced a web-based geographic interface system to support municipal solid waste management in England. The system uses Python, Django, QGIS, Leaflet, and D3 for data processing and geographic visualization. It provides interactive querying of waste data and visualizes the geographic distribution of waste, helping decision-makers assess waste valorization opportunities. [9] introduced a Smart Waste Management Solution designed for citizen engagement. Developed with Arduino hardware and a hybrid mobile application using Ionic, the system enables real-time monitoring of waste levels, provides web and mobile access for citizens to check bin status, and optimizes waste collection routes. [10] developed a Smart Waste Management System in Kathmandu using the MEAN stack (MongoDB, Express.js, Angular, Node.js) and Arduino for hardware integration. The system allows local authorities to manage waste collection schedules, track bin locations via GPS, and improve collection efficiency.

3 METHODOLOGY

This section outlines the methodology employed in the development of the Online Waste Management System (for Kano, Nigeria). It details the analysis of the existing system, the requirement elicitation process, and the proposed system workflow. The section provides a comprehensive overview of the steps taken to ensure that the developed system meets the needs of its users and addresses the shortcomings of the current waste management processes in Kano.

3.1 Research Workflow

The research workflow outlines the structured approach taken to develop the Online Waste Management System, from the initial concept through to project closure. Figure 1 below shows the overview of the various stages involved:

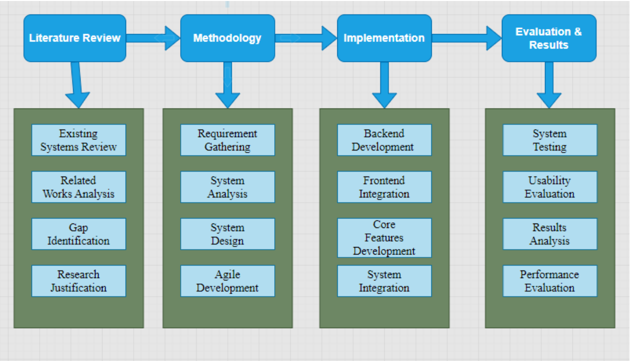

Figure 1. Research workflow

The workflow of this research follows a structured approach that begins with the identification of challenges in Kano's current waste management system and the definition of the objectives of the proposed Online Waste Management System. At this stage, the scope of the system is clearly outlined, including the target users such as households and waste collectors, as well as the expected outcomes. Key stakeholders, including waste management companies and residents, are also identified, and their roles within the system are defined. Following this, a comprehensive literature review is conducted to analyze existing waste management solutions, particularly those implemented in similar urban environments. Previous studies on waste collection efficiency, real-time tracking, and user satisfaction are examined to provide a strong foundation for the research. This stage also highlights the limitations of the current waste management practices in Kano and identifies the specific gaps that the proposed system aims to address. The methodology phase adopts the Agile development model due to its flexibility and suitability for handling evolving system requirements. During this phase, a detailed analysis of user needs and system specifications is carried out using techniques such as surveys, interviews, and direct observations. Additionally, system models including Use Case diagrams and architectural designs are developed to clearly illustrate system interactions and functionalities. In the implementation phase, the system is developed using Laravel and Laravel Filament for the backend, following best practices to ensure scalability and maintainability. The frontend is integrated seamlessly with backend functionalities to enable smooth interaction across system components. Core features such as waste pickup request submission, bidding mechanisms for service providers, real-time tracking of service status, and notification systems are implemented to meet the identified requirements. The testing phase involves evaluating individual components of the system, including user authentication, request processing, and tracking functionalities, to ensure they operate correctly. Integration testing is also performed to verify that all components work together effectively, providing a seamless user experience. Any identified issues or bugs are addressed to enhance the reliability and robustness of the system. Finally, the project closure phase involves evaluating the overall performance of the system against the initial objectives and success criteria.

3.2 Chosen System Development Methodology

The development of the proposed Online Household Waste Management System was guided by a structured approach using the **Agile Scrum Model** of the System Development Life Cycle [11]. This is depicted diagrammatically in figure 2 below. The Agile Scrum model was selected for its iterative and flexible nature, which allows for continuous improvements and adaptations based on user feedback and evolving requirements. The development process for the Online Household Waste Management System followed these key phases, repeated across multiple sprints:

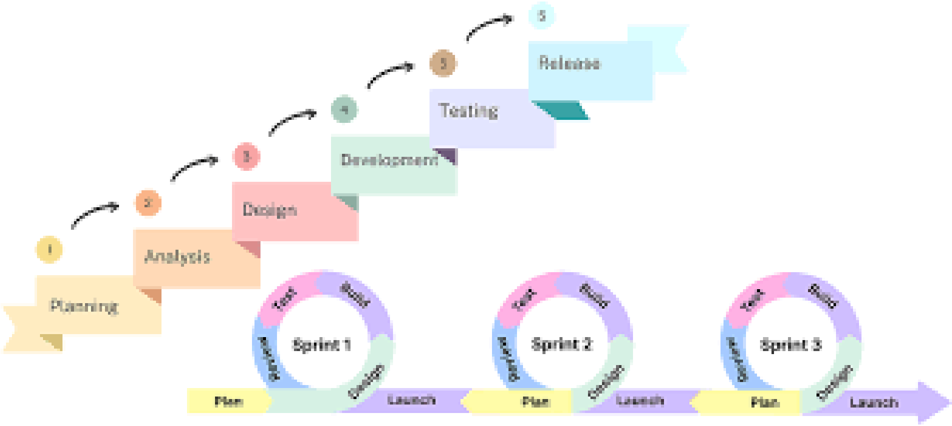

Figure 2. Development phase of the proposed system based on Agile Scrum SDLC

3.2.1 *Planning and Requirements Gathering*

At the beginning of each sprint, detailed requirements for the system's next features were gathered through user interviews, surveys, and analysis of the current waste management processes in Kano. The requirements were documented in user stories and backlog items, which served as the foundation for the sprint planning sessions.

3.2.2 *System Analysis*

The requirements collected during the phase are analyzed in order to remove ambiguities and ensure consistency and completeness. This leads us to the definition system requirement specification (SRS) which serves as input to the design phase

3.2.3 *System Design*

Based on the prioritized backlog items, the system architecture and design were updated or refined for each sprint. This phase included creating design documents and wireframes to guide the development of new functionalities while ensuring compatibility with the existing system.

3.2.4 *Development*

The system was developed incrementally according to the design specifications for each sprint. Each sprint focused on building specific features, such as waste pickup request forms, real-time tracking, and notification systems. New components were integrated into the existing system during this phase, enhancing the overall functionality and ensuring continuous delivery.

3.2.5 *Testing*

After each sprint, the developed features underwent rigorous testing to identify and resolve any issues. Testing included unit testing, integration testing, and system testing to ensure that all new components worked seamlessly with the existing system and met the required standards.

3.2.6 *Review and Feedback*

At the end of each sprint, a review session was conducted where the completed work was demonstrated to stakeholders. Feedback was collected and discussed, which informed the planning of the next sprint. This phase ensured that the system was continuously aligned with user needs and expectations, allowing for adjustments to be made based on real-time feedback.

3.2.7 Release and Launch

Once the sprint's features were successfully tested and reviewed, a release is produced and launched, making the new functionalities available to users. The launching phase involved updating the live environment and ensuring that users could access and utilize the new features without disruption.

3.3 Analysis of Existing and Proposed System

This section analyzes the current household waste management system in Kano, Nigeria, and the enhancements proposed by the Online Waste Management System. The focus is on identifying the inefficiencies of the existing system and demonstrating how the new system will address these issues.

3.4 Description of Existing System

In Kano, Nigeria, the current waste management system is predominantly manual, involving multiple stakeholders such as households, waste collectors, or municipal authorities. The system lacks a unified platform for managing waste collection requests, leading to delays, missed pickups, and poor communication between stakeholders. Households typically rely on direct contact with local waste collectors, often leading to inconsistent service and unclear scheduling. There is no real-time tracking mechanism, resulting in a lack of transparency and accountability. Moreover, the absence of a centralized system means that waste management representatives struggle to monitor performance, track service efficiency, and respond promptly to issues. This manual process contributes to an inefficient and often frustrating experience for both the residents and the waste management personnel.

3.4.1 Requirement Elicitation

This phase involves direct communication with stakeholders and end-users to understand their requirements, expectations, and constraints. For the Online Waste Management System in Kano, Nigeria, a combination of questionnaires, interviews, and observations was employed to ensure a thorough understanding of user needs and system requirements [12]. Methods Used for Requirement Elicitation: **Surveys:** Both hard copy and online questionnaires were distributed to residents of Kano to collect data on their current waste management experiences and expectations from a new system. The online survey was facilitated through Google Forms, allowing for broader outreach and convenience. This method ensured a diverse range of responses, reflecting the needs of different demographic groups, including households, waste management representatives, and waste collectors.

3.4.2 Interviews

In-depth interviews were conducted with various stakeholders, including household users, waste collectors, and municipal waste management officials. Household users shared their challenges with the current waste collection process, such as inconsistent pickups. Waste collectors provided insights into the operational difficulties they face, including unclear schedules and inefficient communication. Municipal officials discussed the challenges in monitoring and managing waste collection services effectively.

3.4.3 Observations

The existing waste management process was observed in different neighborhoods of Kano, particularly during peak collection times. These observations provided real-time insights into the practical challenges faced by both residents and waste collectors, such as delays, miscommunication, and the absence of a tracking system. Observing the process firsthand helped identify critical pain points that might not be fully captured through surveys and interviews alone.

3.4.4 Requirement Definition

The requirement definition phase outlines the detailed functional and non-functional requirements derived from the elicitation process [13]. This ensures that the system meets stakeholder needs and provides a clear direction for the design and development of the online waste management system. **Functional Requirements: Household User (End-User):** Create and manage account using email. Submit service requests with detailed requirements, Track request status and view assigned company details, select a company to assign the request. Make secure payments for completed services, View service history and payment record. **Waste Management Company:** Manage company profile and service availability. Submit bids for service requests, including costs and expected completion times. Update work status (start, in progress, completed). Provide completion details and photos. Access payment history and earnings reports. **Admin:** Access secure admin dashboard. View deposits and transaction history. Process commissions and company payouts. Resolve disputes between users and companies. Generate system reports and analytics. Manage user accounts and permission. Furthermore, figure 3 presents the functional requirements as a use case diagram showing the key actors and roles played by each actor [14].

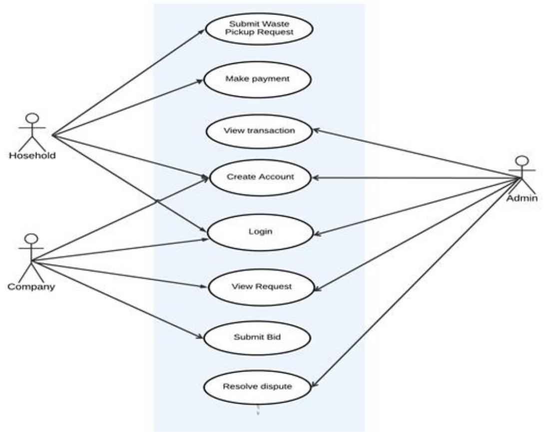

Figure 3. Use case diagram showing primary actors and their associated roles

Non-Functional Requirements: Usability: The system must have an intuitive and easy-to-use interface for all user roles, ensuring quick navigation and seamless access to key features such as waste pickup requests, tracking, and task management. **Performance:** The platform should provide real-time updates and quickly process data, even under high user loads. The system should perform efficiently under varying network conditions. **Scalability:** The system should be designed to handle an increasing number of users, waste collection requests, and additional features without performance degradation. The backend infrastructure should support future expansion. **Security:** The platform must prioritize data security, ensuring that user information is kept confidential. Measures such as encryption and secure authentication must be implemented to prevent unauthorized access. **Reliability:** The system should be highly reliable, with minimal downtime. It should include error handling, backup processes, and quick recovery mechanisms to ensure continuous operation. **Compatibility:** The platform should be compatible with a wide range of devices and screen sizes, including desktop computers, tablets, and smartphones. It should work seamlessly across various browsers and operating systems. **Maintainability:** The system should be easy to maintain, with a well-documented codebase and straightforward deployment processes. Updates and bug fixes should be efficiently applied without affecting user experience. **Responsiveness:** The system should be responsive, ensuring that users can interact with it on various devices and resolutions. The user interface should adjust accordingly for optimal display on both desktop and mobile devices.

3.5 System Design

This section provides an overview of the design considerations and methodologies used to develop the platform, ensuring a robust, user-friendly, and secure system. The design process prioritizes scalability, maintainability, and optimal performance.

3.5.1 Activity Diagram

The activity diagram visualizes the workflows of different actors, illustrating their interactions with the system and the decisions involved [15]. It outlines the processes for Households submitting and tracking requests, Companies managing assigned tasks, and Admins handling and validating service requests. This structured representation ensures a clear understanding of system behavior and user interactions. Figures 4, 5 and 6 below show the activity diagram of the system.

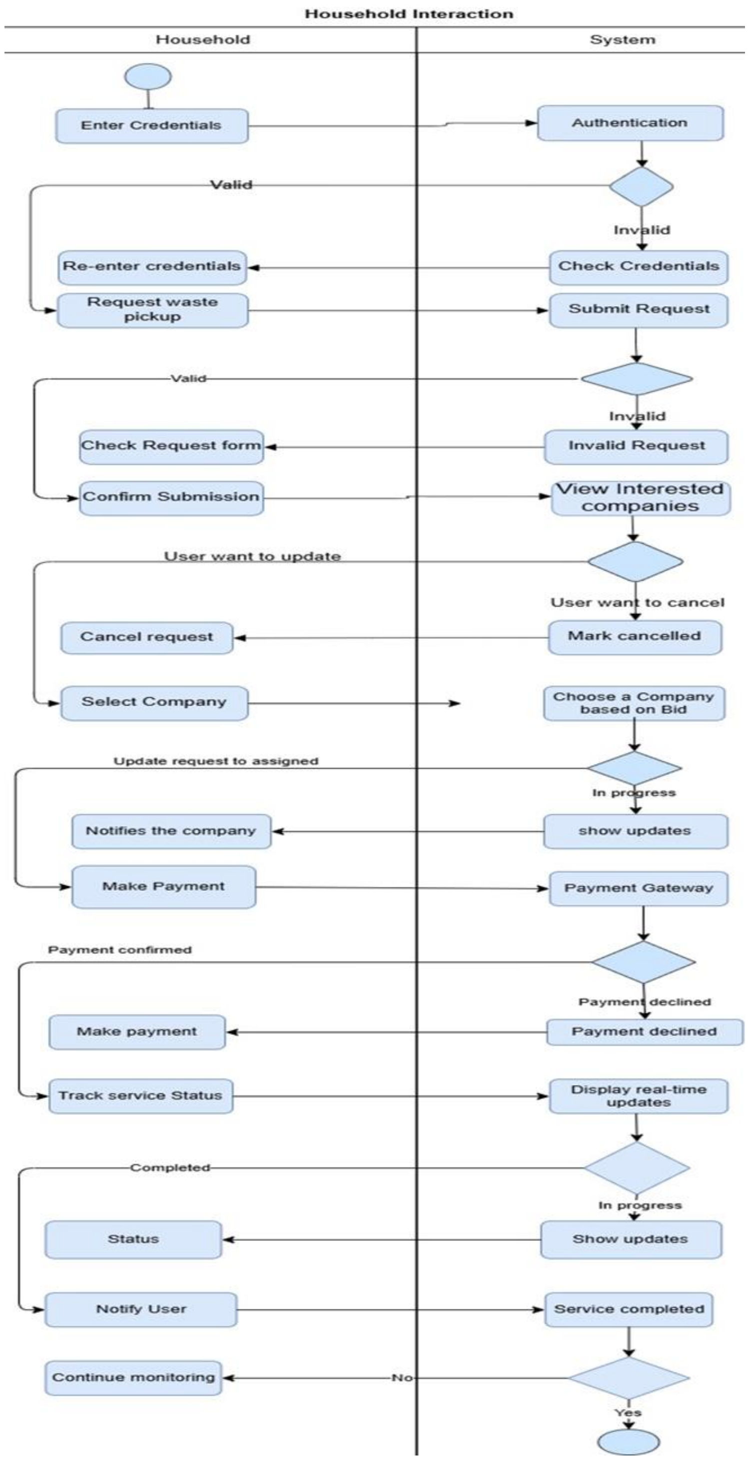

Figure 4. Activity diagram for household interaction

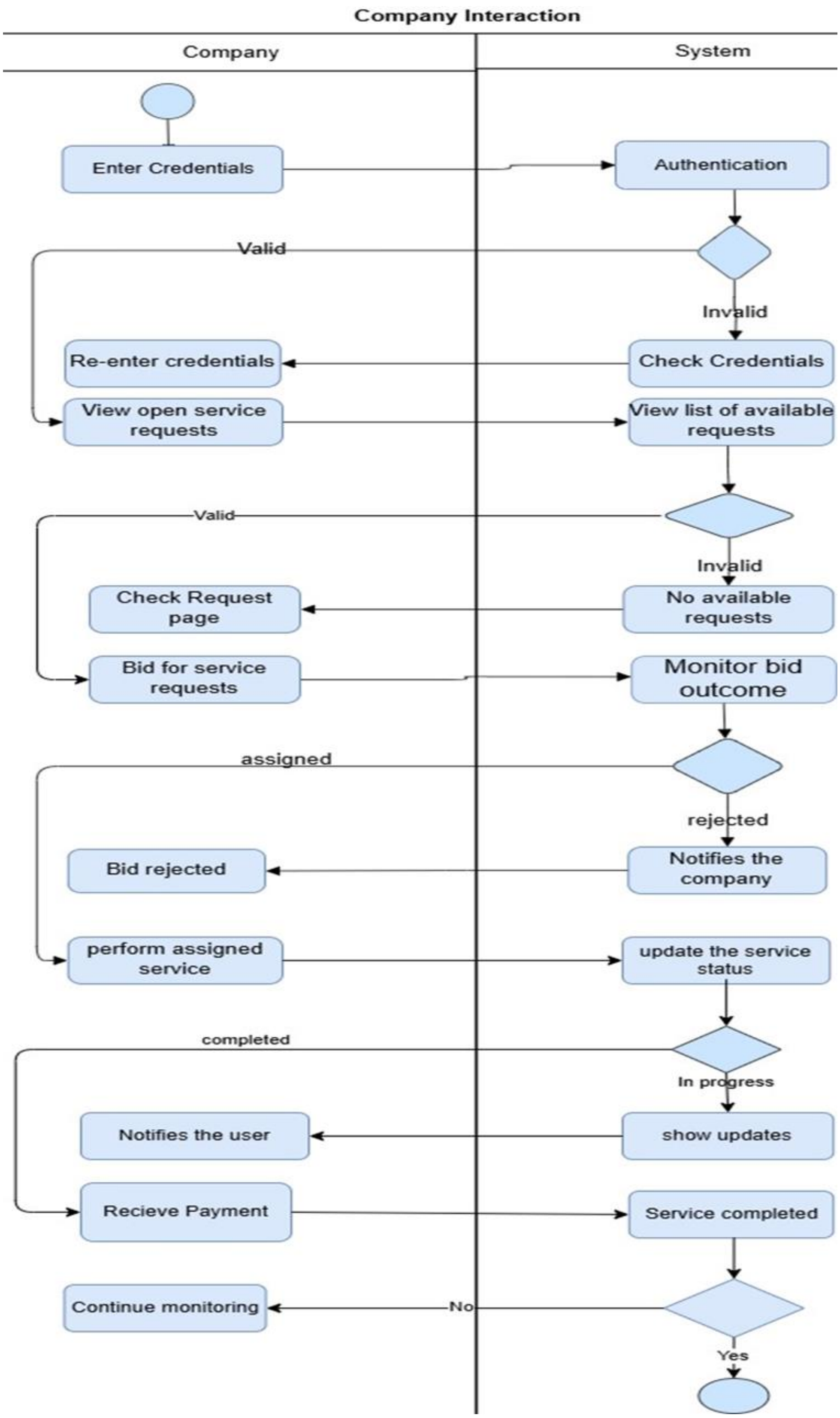

Figure 5. Activity diagram for Company interaction

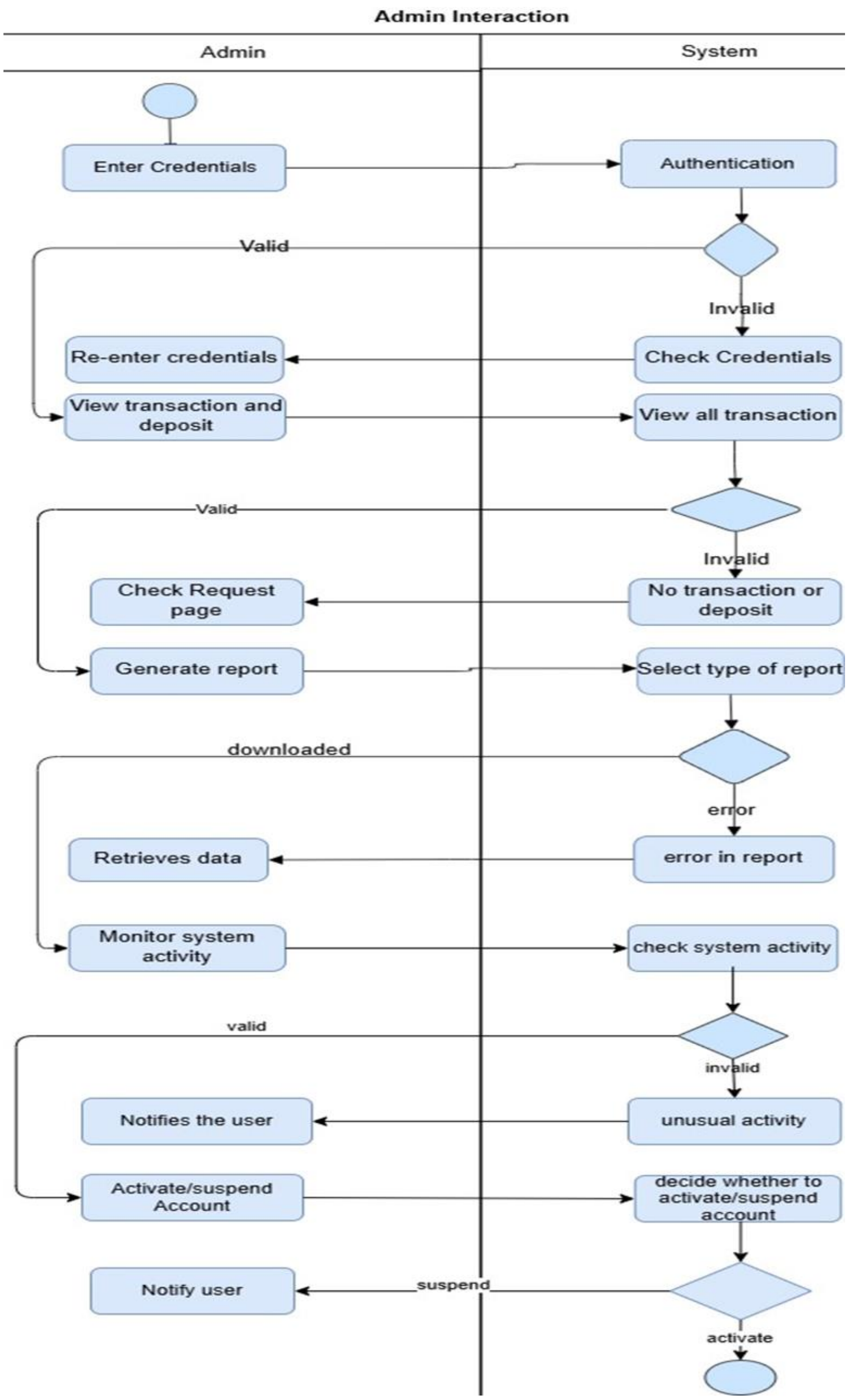

Figure 6. Activity diagram for admin interaction

3.5.2 Class Diagram

The class diagram offers a detailed representation of the system's architecture, showcasing its core classes, their attributes, methods, and interrelationships [15]. It serves as a foundational blueprint, defining the interactions between components and ensuring the system's structure supports its operational needs. The diagram clarifies data flow and interactions, providing insight into how different components collaborate to achieve the system's objectives. Figure 7 shows the class diagram.

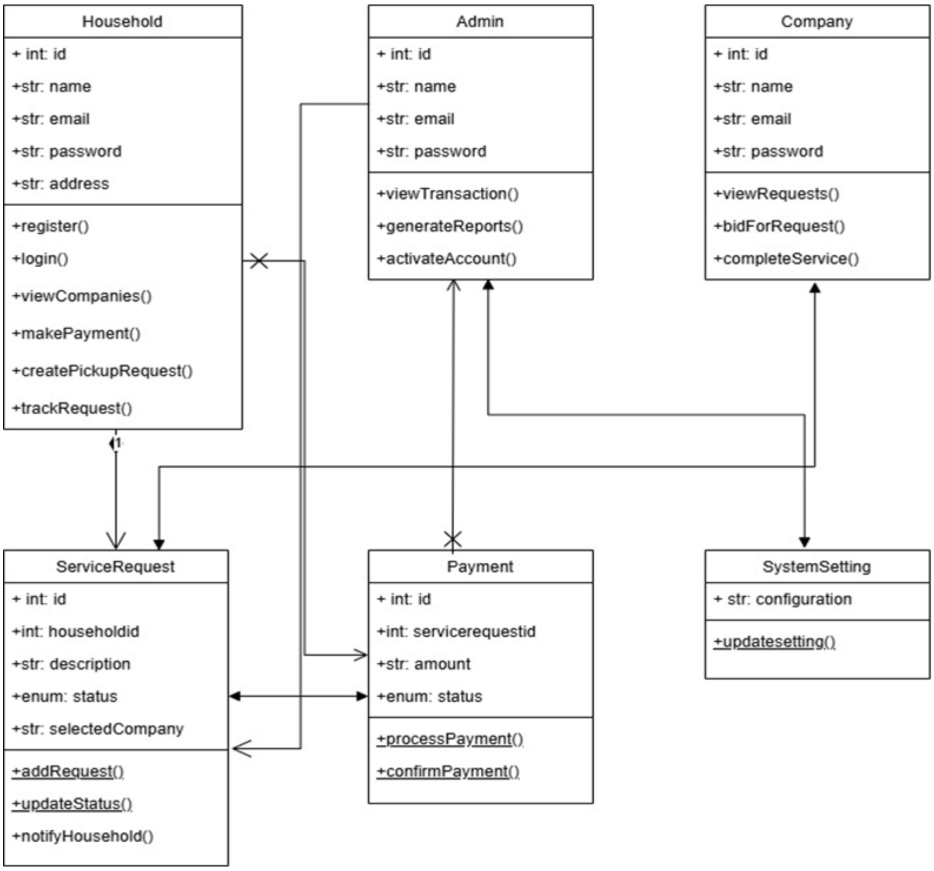

Figure 7. class diagram

3.5.3 Entity Relationship (ER) Diagram

The Entity Relationship (ER) Diagram serves as a visual representation of the database structure, outlining the entities and the relationships between them [16]. It defines the entities with their attributes and illustrates how these entities are connected to ensure a coherent and structured data model. Figure 8 below presents the ER diagram for the proposed system which shows the entities and their attributes, along with the relationships that connect them.

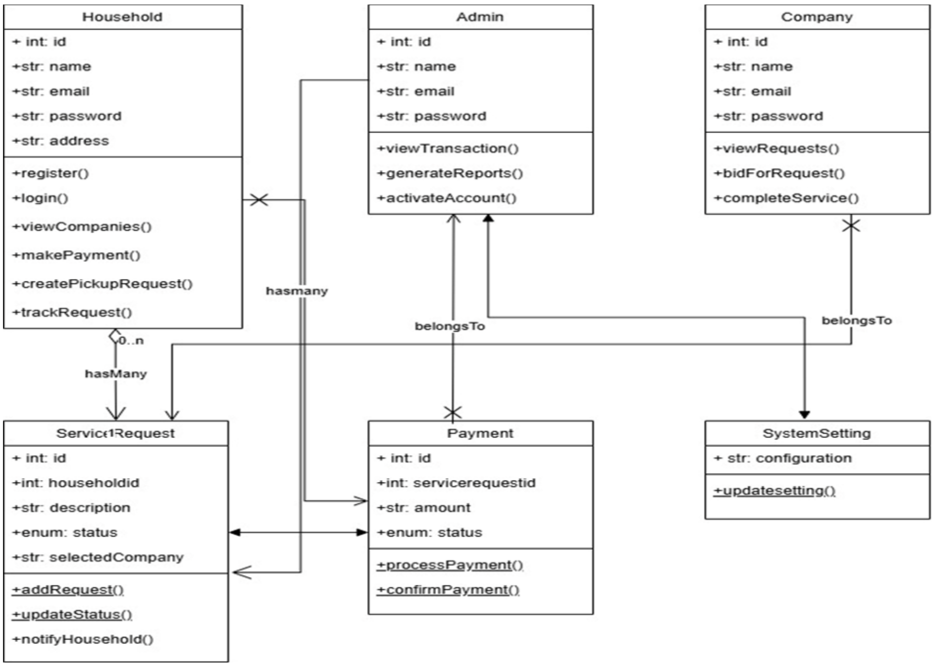

Figure 8. Entity relationship diagram

4 SYSTEM IMPLEMENTATIONS

This section details the process of implementing the system, highlighting the tools, technologies, and methodologies used to bring the system to life. Additionally, this section offers a description of the system's operation through sample interfaces, illustrating how users interact with the platform.

4.1 Implementation Tools

The implementation of the system utilizes a range of tools and technologies to ensure efficient development, scalability, maintainability and ability to streamline the development process, ensuring high performance and reliability of the final application. The tools used are listed in table 1 below.

Table 1. Implementation tools

Aspect/ Category	Software/ Tools used	Description/ purpose
Programming Language	PHP 8.1[17]	Primary programming language used for developing the backend logic of the system
Framework	Laravel [18]	PHP framework used for building robust and scalable backend functionality.
Admin Panel Framework	Filament [19]	Lightweight admin panel framework for managing the system's backend operations.
Database	MySQL [20]	Relational database used for storing user data, service requests, bids, payments, and system configurations.
Frontend Design	HTML/CSS [21]	For designing the layout and ensuring a responsive, user-friendly front-end experience.
Development Environment	Visual Studio Code [22]	Primary IDE used for coding, with extensions for PHP, Laravel, and database management.
Version Control	Git [23]	Version control system for managing codebase changes and enabling effective team collaboration.
Testing Tools	PHPUnit [24]	Testing framework for validating the functionality of PHP code.
Versioning Database	Laravel [18]	Tool for managing database schema changes and ensuring consistency during development and deployment.

4.2 Description of System Operation (Using Sample Interfaces)

The operation for the Waste Management System is designed to provide intuitive interfaces that guide users (Households, Companies, and Admins) through their respective functionalities. Below in figure 9-11 is a description of the major dashboard showing available features for the three key stakeholders.

4.2.1 Household Dashboard

A screenshot of the household dashboard which enable households to request waste management services, make payments, and track service progress is shown in Figure 9.

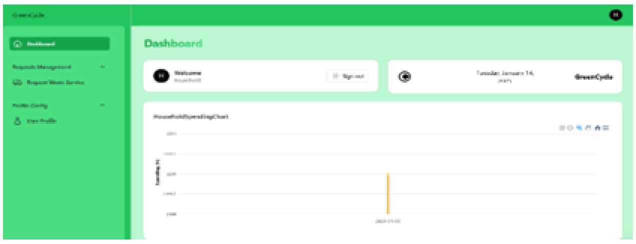

Figure 9. Household Dashboard

4.2.2 Company Dashboard

A screenshot of Company dashboard which enables companies to view and manage assigned service requests is shown in figure 10. In addition, the company can view summary of completed services, earnings, and pending payments.

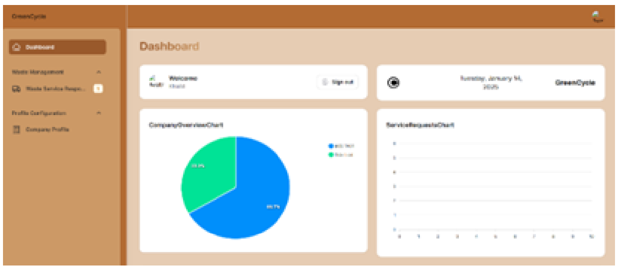

Figure 10. Company Dashboard

4.2.3 Admin Dashboard

A screenshot of the admin dashboard which enables the admin to manage service requests, validate payments, and assign companies to request submitted by household is shown below shown in figure 11. In addition, the admin dashboard also displays the overview of system activity (e.g., number of system users, service requests overview chart, company availability status).

Figure 11. Admin Dashboard

5 SYSTEM TESTING AND RESULTS

The proposed system was tested using four different methodologies, namely unit testing, integration testing, system testing, and usability testing. The results of usability testing carried out by 50 anonymous users was presented in this section. Usability testing assesses the system's ease of use and overall user experience. Feedback is gathered using a questionnaire designed for users. Participants' feedback is analyzed to identify areas of improvement for a better user experience. The result of the usability testing questionnaire is summarized in Table 2 below. In addition, the user responses are visualized using bar charts presented in Figures 12-19.

Table 2. Results of usability testing

S/N	Questions	Frequency & Percentage										Total Number of responses
		Strongly Agree (1)		Agree (2)		Neutral (3)		Disagree (4)		Strongly disagree (5)		
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	
1	The process of submitting a waste pickup request is clear and straightforward	17	34	15	30	12	24	6	12	0	0	50
2	The bidding system for waste pickup requests is intuitive and easy to understand	10	20.4	15	30.6	18	36.7	4	8.2	2	4.1	49
3	There are no confusing or unclear steps when using the system	17	37	11	23.9	15	32.6	3	6.5	0	0	46
4	Registration and login processes are easy to complete	16	32.7	17	34.7	13	26.5	2	4.1	1	2	49
5	The website design and layout are visually appealing and well-structured	10	20	20	40	18	36	1	2	1	2	50
6	**The real-time tracking feature is helpful in monitoring the status of waste pickup requests**	12	26	24	48	10	20	2	4	1	2	50
7	Page loading speed is fast when navigating between different sections of the system	10	20	19	38	17	34	4	8	0	0	50
8	**Overall, I am satisfied with my experience using the system**	11	22.4	16	32.7	17	34.7	5	10.2	0	0	49
	Average usability assessment	**13**	**27**	**17**	**35**	**15**	**31**	**3**	**7**	**1**	**1**	**49**

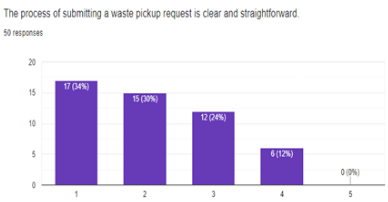

Figure 12. Result of Question 1

Figure 13. Result of Question 2

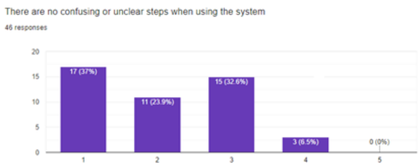

Figure14. Result of Question 3

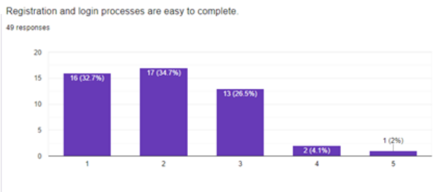

Figure 15. Result of Question 4

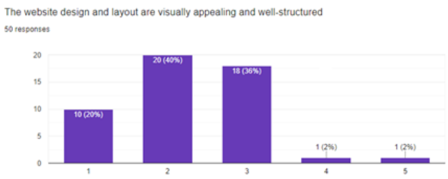

Figure 16. Result of Question 5

Figure 17. Result of Question 6

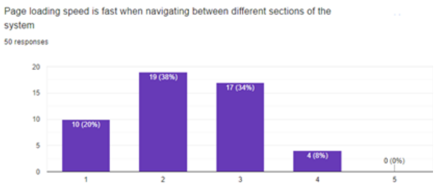

Figure 18. Result of Question 7

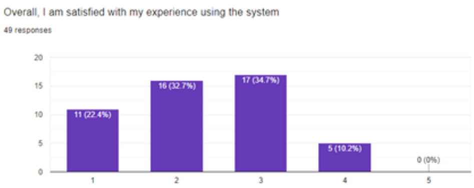

Figure 19. Result of Question 8

5.1 Discussion

Usability testing was carried out using 50 anonymous users who conducted thorough testing and filled the usability testing questionnaire. The result of the usability testing questionnaire is given in Table 2, and visualized using bar charts in Figure 12 to Figure 19. The usability testing experiment was carried across eight different aspects according to the questions in the table. For the first question, 34% of the responses are strongly agree and 30% of the responses are agree, thus suggesting that about 64% of the respondents found the process of submitting a waste pickup request clear and straightforward. About 24% are respondents are indifferent, whereas only 12% of the respondents are not satisfied. For the second question, 20% of the responses are strongly agree and 30.6% of the responses are agree, thus, suggesting that about 51% of the respondents found the bidding system for waste pickup requests intuitive and easy to understand. About 36.7% of the respondents are indifferent, whereas only 12% are not satisfied. For the third question, 37% of the responses are strongly agree and 23.9% of the responses are agree, thus, suggesting that about 61% of the respondents found that there are no confusing or unclear steps when using the system. About 32.6% of the respondents are neutral, and only about 7% are not satisfied. For the fourth question, 32.7% of the responses are strongly agree and 34.7% of the responses are agree, thus, suggesting that about 67% of the respondents found the registration and login processes easy to complete. About 26.5% of the respondents are neutral, and only 6% are not satisfied. For the fifth question, 20% of the responses are strongly agree and 40% of the responses are agree, thus, suggesting that about 60% of the respondents found the website design and layout visually appealing and well-structured. About 36% of the respondents are neutral, and only 4% are not satisfied. For the sixth question, 26% of the responses are strongly agree and 48% of the responses are agree, thus, suggesting that about 72% of the respondents found the real-time tracking feature helpful in monitoring the status of waste pickup requests. About 20% of the respondents are neutral, and only 6% are not satisfied. For the seventh question, 20% of the responses are strongly agree and 38% of the responses are agree, thus, suggesting that about 58% of the respondents found the page loading speed fast when navigating between different sections of the system. About 34% of the respondents are neutral, and only 8% are not satisfied. For the eighth question, 22.4% of the responses are strongly agree, 32.7% of the responses are agree, thus, suggesting that about 55% of the respondents found the experience of using the system to be satisfactory. About 34.7% of the respondents are neutral, and only 10% are not satisfied. The overall average responses indicated in blue at the bottom of the table reveals that 27% of the responses are strongly agree and 35% of the responses are agree, thus suggesting that about 62% of the responses are highly satisfied with the overall usability of the proposed household waste management system. For this group of users, the software functionalities and mode of operation are very satisfactory. It is observed that overall, 31% of the responses are neutral, indicating that a noticeable number of users chose Neutral across the questions. This usually means the system worked, but didn't really stand out for them either positively or negatively. In simple terms, it's "okay and usable," but not yet very impressive or intuitive for everyone. Only a small number of users, overall, 7% and 1% selected Disagree or Strongly Disagree respectively. This is a good sign that serious usability problems are limited and not widespread. In summary, the system is generally usable and well accepted, but the percentage of neutral responses shows there's still room to make the experience clearer, smoother, and more engaging so users feel more confident and satisfied while using it.

6 CONCLUSIONS

The paper focused on developing an online waste management system aimed at addressing the inefficiencies in current waste collection practices, such as poor scheduling and the lack of real-time tracking. The problem statement emphasized the need for a digital solution to streamline waste collection, improve service delivery, and enhance user experience. To address this problem, a structured methodology was employed, beginning with a thorough analysis of user and system requirements, followed by the design and development of the system. This process involved creating architectural and database designs, implementing key functionalities, and conducting comprehensive usability testing to ensure the system met all requirements and provided a reliable, user-friendly experience. Key functionalities of the developed system include user registration and authentication, waste pickup requests, company bidding for waste collection, real-time tracking of service requests, secure payment processing, and reporting and analytics. These features collectively provide an efficient and scalable solution for managing household waste, benefiting both users and waste management companies. To further expand and enhance the functionality of the waste management system, the following areas are recommended for future work. First, implement a feature allowing users to rate their service and provide feedback. This would give valuable insights into service quality, enable continuous improvement, and help companies address user concerns more effectively. Second, develop a mobile application version of the system for users to schedule pickups, track the status of their waste collection, and receive real-time notifications. This would increase user engagement and make the system more accessible. Third, create reporting and analytics tools that help waste management companies analyze waste collection data, optimize routes, and predict demand. This would improve operational efficiency and reduce costs.

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