Smart Gobbler: Development of Java Based Application for Scheduling, Routing and Mapping of Garbage Trucks using A Search Algorithm for Route Optimization and Geographic Information System for Mapping

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Abstract- ***The "Smart Gobbler: Development of Java-Based Application for Scheduling, Routing, and Mapping of Garbage Trucks using A Search Algorithm for Route Optimization and Geographic Information System for Mapping" project targets the Philippines' inefficient garbage collection schedules, which are aggravated by growing urbanization and increasing waste production. The primary aim of the Smart Gobbler project is to enhance waste management efficiency through the integration of real-time information and responsible disposal practices. This Java-based smart trash management system, created using Agile methodology, combines real-time data with ethical disposal procedures to transform traditional waste management. The system was built with JavaScript for the interactive user interface, Apache NetBeans as an integrated development environment, and MySQL Workbench for database management. Key features include real-time garbage truck tracking, efficient collection routes, user notifications, and thorough reporting. The system's creation required thorough planning, design, coding, and intensive testing to assure usability, functionality, and dependability. The implementation of EcoSmart significantly reduced bin overflows and illegal dumping, while increasing operational efficiency and community involvement in managing waste. User feedback suggests great satisfaction with the system's performance, implying that it has the potential for widespread use to promote environmental sustainability and improve public health.***

Indexed Terms- ***Waste management, real-time data, Java application, sustainability, urban development, environmental health, route optimization, GIS mapping.***

I. INTRODUCTION

Garbage collection schedules in the Philippines have long been a significant issue affecting communities nationwide. The country's rapid population growth and urban development have led to an increase in waste production, putting immense pressure on existing waste disposal methods. One of the primary challenges faced by waste management authorities is the lack of a reliable and consistent garbage collection timetable. The irregularity in collection schedules results in some areas experiencing sporadic collection days, leading to overflowing bins and unhygienic conditions in neighborhoods. This not only poses health risks to residents but also contributes to environmental pollution and degradation. In many places, overflowing bins and inconsistent collection schedules are made worse by the absence of effective waste management systems. The need for more efficient waste management techniques is urgent, according to Sohag and Podder (2020). Furthermore, according to Breukelman, Krikke, and Löhr (2019), there is little doubt that the Philippines and other developing nations are experiencing the symptoms of a failing urban waste management system, which calls for immediate action to address the primary causes of these problems.

In response to these challenges, the researcher has developed "Smart Gobbler: Development of Java Based Application for Scheduling, Routing and Mapping of Garbage Trucks using A Search Algorithm for Route Optimization and Geographic

Information System for Mapping." This application aims to address the complex issues associated with waste management and its broader impact on the economy and environment. Smart Gobbler is designed to optimize garbage truck routes and schedules through the use of a search algorithm for route optimization and Geographic Information System (GIS) for mapping, leveraging Java technology to transform conventional garbage disposal practices.

Smart Gobbler represents a significant advancement in the pursuit of more sustainable and effective waste management techniques. The serious negative effects of ineffective waste management on the environment and the economy cannot be overstated. Inefficient waste management poses significant financial risks to communities and governments, in addition to threatening human health and contributing to environmental pollution. By using modern technology and real-time data, Smart Gobbler seeks to revolutionize how communities manage their waste. This innovative approach provides a dynamic and adaptable waste management solution, in contrast to traditional systems that often rely on outdated equipment and manual processes. Ultimately, this benefits the economy and the environment by decreasing operating costs and resource usage while increasing the efficiency of garbage collection and disposal.

Through the integration of route optimization algorithms and GIS mapping, Smart Gobbler aims to create a cleaner, healthier, and more sustainable environment for communities nationwide. By addressing the shortcomings of current waste management practices, Smart Gobbler contributes to the overarching goal of achieving efficient and environmentally responsible waste management in the Philippines. To achieve this goal, the researcher aims to: (1) Teach the community the value of proper trash disposal methods and inspire participation in recycling and waste reduction initiatives. (2) Utilize real-time data to optimize garbage collection routes, which will decrease travel times, save fuel for waste collection vehicles, and improve overall operational effectiveness. (3) Make sure that waste collection schedules are up to date by developing a Java application that will guarantee timely pickups and reduce bin overflow occurrences. (4) Decrease the amount of trash can overflows and the presence of pests and organisms that spread disease linked to inadequate waste management, all of which contribute to the creation of a cleaner environment.

II. RELATED WORKS

This part examines recent studies in the specified field alongside comparable approaches across various disciplines.

Arebey et al., (2010). The integration of communication technologies such as GPS and GIS are utilized for developing a solid waste monitoring system aimed at enhancing response to customer inquiries, handling emergency cases, and estimating the amount of solid waste without truck driver involvement. The system includes a GIS-based map server, database server, and control station server. Tracking devices mounted on the trucks collect real-time location information via GPS. Users can view each truck's current location during the collection stage through a Java application system, enabling effective fleet management. Truck positions and trash bin data are displayed on a digital map provided by a map server. This system allows for real-time monitoring of both the waste bins and the trucks.

Idowu et al., (2012). Waste management involves the handling of solid refuse from its source of generation through storage, collection, transportation, recovery, and treatment processes to disposal. This study developed a web-based GIS waste disposal management system aimed at achieving effective waste management and creating a spatial map of waste collection locations in any local government area. The system monitors, manages, and maintains all waste collection tanks at various sites. Implementing this technology will assist Nigeria's local government waste management units in achieving a clean environment, reducing the spread of epidemics, and ensuring public safety.

Castillo and Otoma (2013). As the Philippines experiences rapid economic growth, managing solid waste has become increasingly challenging. The researchers highlight the importance of the Ecological Solid Waste Management Act of 2000 (Republic Act 9003) in shaping waste management policies. Despite

this legislation, the country faces ongoing issues such as reliance on open dumps and limited landfill sites, which threaten environmental sustainability and public health. They advocate for a collaborative approach involving government, communities, and stakeholders to improve waste segregation, transportation, treatment, and disposal. Rapid urbanization and population growth have led to a significant increase in waste generation, with urban areas producing more waste per capita than rural areas. Metro Manila generates 8,636 tons of garbage daily, with household waste comprising the majority. The primary methods of waste management in the Philippines are landfilling and the 3R (Reduce, Reuse, Recycle) approach, as incineration is prohibited.

Badve et al., (2020). EcoSmart, a waste management system, utilizes real-time data from IoT technologies to improve garbage collection. By incorporating real-time data, the system dynamically adjusts garbage collection routes, considering factors like truck and bin capacities and proximity. This approach addresses issues like overflowing bins and increased costs associated with traditional methods, thereby enhancing waste management and reducing costs.

Kalibera et al., (2009). Real-time conditions are crucial in adjusting collection schedules in garbage collection systems. By aligning data with current conditions, municipalities can optimize routes and reduce fuel consumption, promoting sustainable practices. This system streamlines operations, minimizes delays, and contributes to environmental sustainability, benefiting communities and the planet.

Pardini et al., (2019) The increasing population density in cities has led to a significant increase in waste generation, a significant challenge for large urban centers worldwide. The Internet of Things (IoT) and cloud computing offer automation possibilities for solid waste management, focusing on interaction between concessionaires and waste generators for shorter collection times, reduced costs, and citizenship promotion. This paper reviews literature and compares available solutions to identify open research issues.

Sharma, C., et al. (2022) explores research trends in smart cities, a global topic requiring scientific investigation. Extracting a corpus of 8320 articles from 2010 to 2022, the study presents a comprehensive overview of the IoT in smart cities research. The study uses topic modeling technique to formulate three research questions and answer in-depth research. The findings highlight the growing phase of smart cities and the need for further scientific investigation to understand and adapt to these trends.

Salac, Salac, and Samonte (2023). Population growth and urbanization in the Philippines have led to an increase in waste generation, straining the already overworked waste management system. This has resulted in issues such as illegal dumping, overloaded landfills, inadequate garbage collection services, and pollution of aquatic bodies. The lack of facilities and funds for waste management by municipal governments contributes to these issues. To address these issues, the researchers propose integrating truck position tracking technology into garbage collection schedules and reporting procedures. This method saves operating costs, optimizes waste collection processes, and allocates resources more effectively. Data-driven decision-making in waste management can help reduce the negative effects of uncontrolled trash production on the environment and public health. This helps to develop cleaner and sustainable methods while also improving the effectiveness of waste management operations.

Gupta et al. (2020). Waste management is a global concern, posing threats to public health and the environment. Advancements in technology, such as IoT and analytics, have improved waste collection procedures, enhancing efficiency, cost reduction, and environmental impact. The researchers found that real-time data from sensors can improve waste collection routes, leading to better resource management and operational efficiency. Gupta (2020), highlight the significance of using real time data from sensors to improve waste collection routes based on fill levels. This is in line with the goal of our EcoSmart system, which aims to adapt collection schedules dynamically using real time information leading to better resource management and operational efficiency. Additionally, their discoveries on employing analytics for maintenance of waste collection vehicles align, with our strategy to maintain the reliability and longevity of our Java application waste management system.

Johansson, B., & Kroon, L. (2006). Waste management systems in Sweden have been improved by equipping recycling containers with level sensors and wireless communication, providing real-time data to operators. This study, using analytical modeling and discrete-event simulation, found that dynamic scheduling and routing policies offer lower operating costs, shorter collection distances, and reduced labor.

Hashemi-Amiri et al., (2023). Integrated smart waste management (ISWM) is a technologically advanced approach to waste management, utilizing IoT technology to optimize operations. This study proposes a novel multi-objective model for waste collection, recycling, and recovery steps, utilizing a chance-constrained programming approach, meta-heuristic algorithms, Taguchi parameter design method, and Best Worst Method (BWM) to maximize probabilistic profit, minimize travel time, and reduce transportation costs. This approach addresses uncertainty and improves waste collection efficiency.

Although little relevant research has been conducted on this technology, this study has an advantage, particularly in terms of the approach and tools employed to develop the system. The preceding studies informed the researcher's decision to develop and implement a Java Application Smart Waste Management System to improve waste management through real-time information and responsible disposal.

III. METHODS

This research adopts a mixed-method design to explore the potential of the Smart Gobbler system in achieving its goal of optimizing waste collection, routing garbage trucks efficiently, and mapping collection areas using advanced technology. By combining qualitative and quantitative measurements, this approach aims to comprehensively understand how the Java Application Smart Gobbler system can contribute to improved waste management.

Qualitative data collection will be conducted through online surveys and virtual interviews, providing deep insights into how the system can encourage responsible waste disposal and recycling among residents, and enhance the operations of waste management authorities. During the developmental phase, a comparative analysis method will guide the design and feature selection process of the Smart Gobbler system, ensuring it aligns with the goal of providing real-time information, optimizing routes, and promoting environmentally responsible behaviors. Quantitative data will be gathered to measure the system's effectiveness in terms of reducing travel time, fuel usage, and the frequency of overflowing bins. Metrics such as collection efficiency, resource utilization, and community engagement in waste disposal practices will be analyzed to assess the impact of Smart Gobbler.

The overarching objective is to derive valuable insights that inform the development of a comprehensive framework, prioritizing the efficiency and sustainability of waste management through Smart Gobbler system.

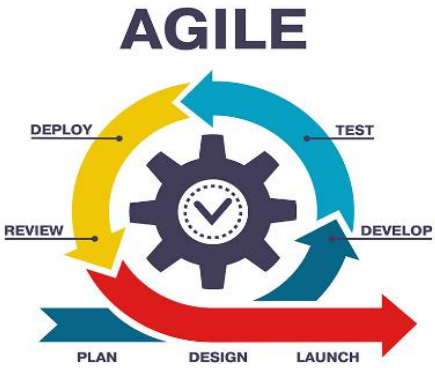


Fig. 1. Agile Methodology

The researcher used Agile methodology to bolster the system's adaptability in meeting the dynamic needs of waste management stakeholders, mitigate potential risks, and consistently deliver value throughout the development process. This approach fosters collaborative teamwork, enhances flexibility, and facilitates continual evolution, ultimately resulting in the creation of a superior software solution poised to elevate user satisfaction levels within the waste management ecosystem.

This research illustrates the effectiveness of the Agile methodology in improving waste management operations in a systematic manner. To improve garbage collection and recycling procedures, lower environmental pollution, and boost waste management

operations' effectiveness, the system in question uses a Java Application framework as its primary.

A. Planning Phase

The Planning Phase marks the inception of the Smart Gobbler project, following the Agile methodology. During this crucial stage, the team will meticulously develop a comprehensive plan for the Java Application Smart Waste Management System. An interdisciplinary team will convene for detailed planning sessions to outline the system's requirements, functionalities, and technical specifications. The primary objective of this phase is to streamline waste management practices through real-time information dissemination, encourage responsible disposal and recycling behaviors, and optimize garbage collection scheduling. Leveraging real-time data, the system aims to keep residents informed about scheduled garbage collection times, optimize waste collection routes, mitigate environmental pollution, and enhance overall operational efficiency. Addressing the specific needs and challenges of both residents and waste management authorities will be paramount to ensure the system's effectiveness and user-friendliness.

1) Project Framework: Following thorough analysis, this study has produced a project framework designed to provide valuable insights into information processes within the context of waste management decision-making. This framework encompasses the components of the Java-based Smart Gobbler application, tailored to optimize scheduling, routing, and mapping of garbage trucks. These components include: 1) Garbage Collection Scheduling and Notifications; 2) Route Optimization Engine; 3) User Feedback and Satisfaction Monitoring; 4) Message Queuing and Delivery; 5) Data Analytics and Reporting; 6) Illegal Dumping Reporting; 7 Waste Templating and Personalization; 8) Incident Reporting and Resolution.

Fig. 2. Project Framework of Java-based Smart Gobbler Application

1) Architecture of Java-based Smart Gobbler Application: The progress of the Smart Gobbler Application is presented below:

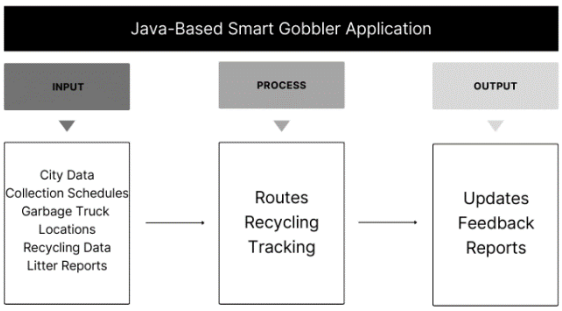


Fig. 3. Architecture of Smart Waste Management System

Input. This part relates to how the Smart Gobbler Java-based Application functions on a daily basis. It includes a wide range of statistics, such as reports on litter, recycling, garbage truck locations, collection dates, and city-specific information. Applications for managing internal data and tracking whereabouts are also regarded as essential elements. Together, these components guarantee prompt coordination and effective handling of the waste management process. To maximize system effectiveness, precise and current data on city plans, traffic patterns, and garbage production are essential.

Process. The Smart Gobbler Java-based Application processes this input data through several critical functions aimed at optimizing waste collection and recycling operations. One of the primary processes is route optimization, which involves the collection and analysis of route data to facilitate more effective and efficient coordination of garbage collection. The system uses advanced algorithms to determine the most efficient paths for garbage trucks, minimizing

travel time and fuel consumption. Recycling management is another key process, where the system organizes and manages all relevant recycling data. Tracking is a key function that provides real-time data on waste bin locations and garbage truck movements. This function is crucial for residents, as it allows them to track the location of garbage trucks and know when to put their trash outside for collection.

Output. Smart Gobbler Waste Management System includes real-time updates on the location of garbage trucks, allowing residents to know exactly when to take their trash outside for collection. Waste management trucks also submit regular updates, feedback, and detailed reports through the application. This ensures timely communication and adherence to waste management protocols, enabling authorities to address operational issues promptly and improve the efficiency of the waste management system continuously.

2) *Use Case Modeling:* To illustrate how the system functions and how the user will interact with it, the researcher employed a use case diagram in this step. Diagram 1 demonstrates how the system responds to the user as well as how the user interacts with the system. Diagram 2 illustrates how the system can meet the user's needs and how it communicates with them.

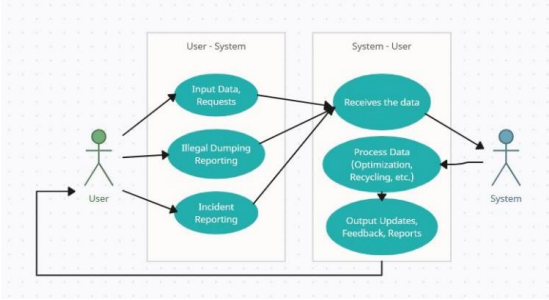


Fig. 4. Users Interaction with the System

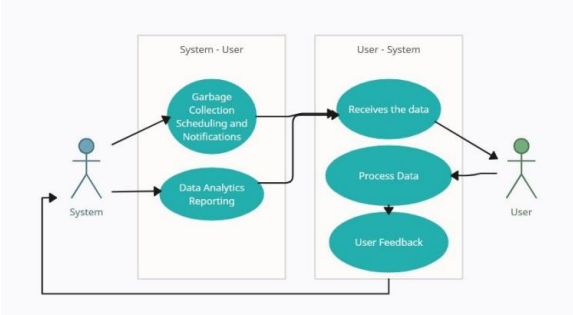


Fig. 5. System Interaction with User

B. Design Phase

In this phase, we delve into the practical implementation of our chosen solution, addressing the question of "how" we will execute our solution effectively. To develop our Smart Gobbler Java-based Application, we utilize specialized software applications designed for rapid system creation and optimal functionality.

For designing the user interface and functionality, we use Apache NetBeans, a versatile integrated development environment (IDE). Our system is an application that allows users to track the location of each garbage truck, providing real-time updates on their whereabouts. This feature enables residents to know the current location of garbage trucks. Additionally, users can view the schedule of garbage truck visits in their city, allowing them to know when to put their garbage outside, thus preventing overflowing bins.

Our system also includes an announcement section to keep users informed about system updates and important notifications. These notifications will alert users when a garbage truck has arrived in their area and provide updates on the truck's schedule. To ensure seamless communication between our system and its users, we implement a registration process for contact numbers. This step is essential to guarantee that users receive notifications from our system. Before officially launching the system, we conduct thorough testing, including a dry run period lasting several days. During this phase, the system will send test messages to registered users to confirm successful message reception.

Additionally, our system features a contact section, allowing residents to report issues such as missed garbage pickups, accidents related to waste disposal, and improper disposal practices by others. This contact section ensures that residents can easily communicate any problems, enabling us to respond promptly and maintain effective waste management services.

C. Developing Phase

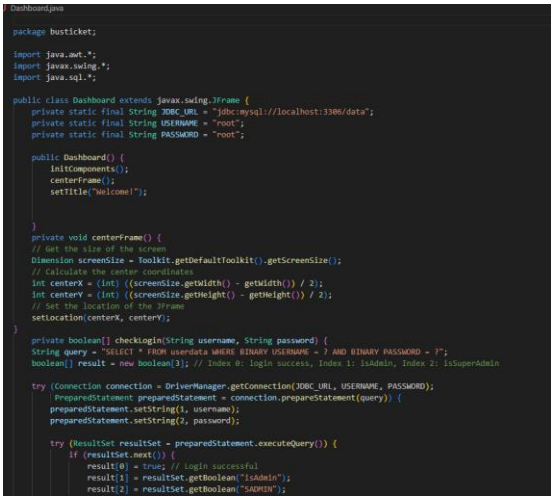
Under the agile methodology, the project moves into the Development phase, when the team carefully builds and continuously improves the key elements of

the Smart Gobbler Java-based Application. Central to this effort is the utilization of JavaScript as the primary programming language, with Apache NetBeans as our IDE.

In this stage, we use JavaScript to create an interactive user interface and functionalities. To make sure that users are able to explore and engage with the system, this includes real-time tracking maps, schedules, announcements, and contact forms. To display the current location of garbage trucks, real-time tracking is implemented using JavaScript and connected with map APIs.

We utilize JavaScript (Node.js) for back-end development, which takes care of data processing, storage, and client-server communication. In order to safely store user data, truck schedules, and tracking information, databases must be set up and maintained. MySQL Workbench is employed to handle the database management when residents register in our system. This tool allows us to design, develop, and administer our MySQL databases effectively, ensuring data integrity and facilitating smooth interactions between the system and its users.

This phase also involves the integration of third-party APIs for real-time notifications, map services, and other required functionalities. Debugging and continuous testing guarantee that all the parts work as a whole. Through systematic development and improvement of these elements, our goal is to raise the effectiveness of waste management services, which will benefit the community as a whole.


Dashboard.java

```
package busticket;

import java.awt.*;
import javax.swing.*;
import java.sql.*;

public class Dashboard extends javax.swing.JFrame {
    private static final String JDBC_URL = "jdbc:mysql://localhost:3306/data";
    private static final String USERNAME = "root";
    private static final String PASSWORD = "root";

    public Dashboard() {
        initComponents();
        centerFrame();
        setTitle("Welcome!");


    }
    private void centerFrame() {
    // Get the size of the screen
    Dimension screenSize = Toolkit.getDefaultToolkit().getScreenSize();
    // Calculate the center coordinates
    int centerX = (int) ((screenSize.getWidth() - getWidth()) / 2);
    int centerY = (int) ((screenSize.getHeight() - getHeight()) / 2);
    // Set the location of the JFrame
    setLocation(centerX, centerY);
}
    private boolean[] checkLogin(String username, String password) {
    String query = "SELECT * FROM userdata WHERE BINARY USERNAME = ? AND BINARY PASSWORD = ?";
    boolean[] result = new boolean[3]; // Index 0: login success, Index 1: isAdmin, Index 2: isSuperAdmin

    try (Connection connection = DriverManager.getConnection(JDBC_URL, USERNAME, PASSWORD);
         PreparedStatement preparedStatement = connection.prepareStatement(query)) {
        preparedStatement.setString(1, username);
        preparedStatement.setString(2, password);

        try (ResultSet resultSet = preparedStatement.executeQuery()) {
            if (resultSet.next()) {
                result[0] = true; // Login successful
                result[1] = resultSet.getBoolean("isAdmin");
                result[2] = resultSet.getBoolean("SADMIN");
```

Fig. 6. Sample Code using JavaScript

D. Testing Phase

During the testing stage, we concentrate on confirming the Smart Gobbler Java-based Application usability, functionality, and dependability. This stage makes sure the system satisfies user requirements and expectations while addressing the question of "how well" our system works under different circumstances. This will combine all the components into a dedicated testing environment, after which the usability, performance, security, and communication will be tested. We want to make sure that our Smart Gobbler Java-based Application is dependable, safe, and easy to use before we formally release it, so we're going to test it thoroughly and thoroughly. By going through this comprehensive procedure, we are able to find and fix problems and provide our users with a high-quality solution that fits their demands.

E. Deploy and Review

In our agile approach to improving waste management with the Smart Gobbler Java-based Application, the Deploy and Review phase follows each step and guarantees the smooth integration of developed functionality. In order to determine new functions' effectiveness and performance in realistic waste management settings, they must be introduced in a controlled environment during this phase. After deployment, a thorough review takes place with the aim of enhancing community well-being by means of effective waste management. Feedback from our respondents and end users enables required modifications and enhancements. Through increased waste management efficiency, this iterative review process ensures that the system will continuously improve to satisfy high standards of security, dependability, and user satisfaction, eventually promoting societal well-being.

IV. PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

In order to properly evaluate the data, the researchers will gather the data via face-to-face interviews. During the face-to-face interview, we researchers will have the opportunity to hear the suggestions and comments of the 20 Novaliches Bayan residents who are 18 years of age and older in order to ascertain what further needs to be corrected. The interviewer gives the respondents the assurance that the information

gathered for the survey will remain private. The information obtained from the interview, which the participants completed, will be used as supporting documentation when the researchers conduct their analysis.

The 20 respondents, who were divided into (5) garbage workers and (7) Novaliches Bayan residents, were asked the same questions with informed consent. With the aid of technology, all responses from the respondents were gathered, and data collection went smoothly.

Instructions: The researchers thoroughly graded the questionnaires completed by each respondent and decided to use the statistical methodologies described below:

1. Likert Scale Range - A Likert scale is a one-dimensional scale that researchers use to elicit respondents' thoughts and opinions about a variety of topics focused in the system.

Scale	Weighted Mean	Corresponding Remarks
4	3.50 - 4.00	Strongly Agree
3	2.50 - 3.49	Agree
2	1.50 - 1.49	Disagree
1	1.00 - 1.49	Strongly Disagree

2. Weighted Mean Method - Following data collection and organization, we analyzed responses obtained using a 4-point Likert scale by utilizing the weighted mean approach. With the help of this strategy, we were able to efficiently summarize the data and get understanding of the overall perspective or opinion of the respondents.
Formula:

$$\bar{x}_{\text{overall}} = \frac{\sum_{i=1}^{n} \bar{x}_i}{N}$$

Wherein:
X is the overall weighted mean.
Xi is the weighted mean for each question.
N is the total number of questions.

Garbage Workers Evaluation

Indicator	Mean	Interpretation
The system provides all necessary features for effective waste management.	3.33	Agree
The schedule information for garbage trucks is correct and reliable.	3.33	Agree
The system's features are appropriate for my waste management needs.	3.42	Agree
Over-all	3.36	Agree

Table 1: Functionality

Table 1 presents the five garbage collectors' evaluation of the system based on its functionality. The system received an overall score of 3.36, with a verbal interpretation of "agree".

Indicator	Mean	Interpretation
Notifications about the garbage truck's arrival are sent promptly.	3.33	Agree
The system operates efficiently without consuming excessive device resources.	3.42	Agree
The system handles a large number of users without performance issues.	3.50	Strongly Agree
Over-all	3.42	Agree

Table 2: Performance Efficiency

Table 2 presents the five garbage collectors' evaluation of the system based on its performance efficiency. The system received an overall score of 3.42, with a verbal interpretation of "agree".

Indicator	Mean	Interpretation
The system functions well alongside other	3.28	Agree

applications on my device.		
The system integrates well with other services (e.g., calendar apps for reminders).	3.42	Agree
Over-all	3.35	Agree

Table 3: Compatibility

Table 3 presents the five garbage collectors' evaluation of the system based on its compatibility. The system received an overall score of 3.35, with a verbal interpretation of "agree".

Indicator	Mean	Interpretation
The features of the system work as expected every time.	3.33	Agree
The system is available and functional whenever I need to use it.	3.25	Agree
When a problem occurs, the system provides clear instructions for resolving the issue.	3.33	Agree
Data is not lost even if the system crashes or fails.	3.25	Agree
Over-all	3.29	Agree

Table 4: Reliability

Table 4 presents the five garbage collectors' evaluation of the system based on its reliability. The system received an overall score of 3.50, with a verbal interpretation of "agree".

Residents Evaluation

Indicator	Mean	Interpretation
The system provides all necessary features for effective waste management.	3.58	Strongly Agree
The schedule information for garbage trucks is correct and reliable.	3.58	Strongly Agree
The system's features are appropriate for my waste management needs.	3.75	Strongly Agree
Over-all	3.64	Strongly Agree

Table 1: Functionality

Table 1 presents the five garbage collectors' evaluation of the system based on its functionality. The system received an overall score of 3.64, with a verbal interpretation of "strongly agree".

Indicator	Mean	Interpretation
Notifications about the garbage truck's arrival are sent promptly.	3.25	Agree
The system operates efficiently without consuming excessive device resources.	3.16	Agree
The system handles a large number of users without performance issues.	2.92	Agree
Over-all	3.11	Agree

Table 2: Performance Efficiency

Table 2 presents the five garbage collectors' evaluation of the system based on its performance efficiency. The system received an overall score of 3.11, with a verbal interpretation of "agree".

Indicator	Mean	Interpretation
The system functions well alongside other applications on my	3.42	Agree

device.		
The system integrates well with other services (e.g., calendar apps for reminders).	3.22	Agree
Over-all	3.32	Agree

Table 3: Compatibility

Table 3 presents the five garbage collectors' evaluation of the system based on its compatibility. The system received an overall score of 3.32, with a verbal interpretation of "agree".

Indicator	Mean	Interpretation
The features of the system work as expected every time.	3.5	Strongly Agree
The system is available and functional whenever I need to use it.	3.33	Strongly Agree
When a problem occurs, the system provides clear instructions for resolving the issue.	3.83	Strongly Agree
Data is not lost even if the system crashes or fails.	3.66	Strongly Agree
Over-all	3.58	Strongly Agree

Table 4: Reliability

Table 4 presents the five garbage collectors' evaluation of the system based on its reliability. The system received an overall score of 3.58, with a verbal interpretation of "strongly agree".

CONLCLUSION AND RECOMMENDATIONS

The "Smart Gobbler: Development of Java-Based Application for Scheduling, Routing, and Mapping of Garbage Trucks using A Search Algorithm for Route Optimization and Geographic Information System for Mapping" project has successfully revolutionized waste management by integrating advanced route optimization algorithms and GIS mapping. Implemented as a Java-based application, the project has streamlined the processes of garbage truck scheduling, routing, and real-time tracking. By leveraging advanced software applications and Agile methodology, the project has achieved high operational efficiency, ensuring timely communication and coordination within waste management operations.

The system's real-time tracking features, developed using Apache NetBeans and JavaScript, provide residents with up-to-date information on garbage truck locations and schedules. This functionality enables residents to put their trash out at the right time, thereby reducing overflowing bins and illegal dumping. MySQL Workbench handles the data inputted by residents, and the system includes an announcement section and a contact number registration process to ensure continuous updates for users. The database design, using JavaScript (Node.js) for back-end development, ensures data integrity and efficient storage of user data, truck schedules, and tracking information. The integration of third-party APIs enhances the system's functionality by providing real-time notifications and map services. Continuous testing and debugging have ensured seamless functionality.

A critical aspect of this research is its use of the a search algorithm for route optimization. This algorithm efficiently computes the shortest and most cost-effective routes for garbage trucks, minimizing travel time and fuel consumption. By doing so, it enhances the overall efficiency of waste collection operations, ensuring that garbage trucks follow the most optimal paths. The integration of Geographic Information System (GIS) technology further strengthens the system by providing precise mapping and spatial analysis capabilities. GIS helps in visualizing and managing the geographic aspects of waste collection, such as pinpointing the exact locations of bins, monitoring the coverage areas of garbage trucks, and identifying potential problem areas. This spatial awareness allows for better planning and execution of waste management strategies.

The system's scalability, maintainability, and reliability have been validated through rigorous testing, achieving a high technological readiness level. As a result, the Smart Gobbler system optimizes waste management processes and contributes to environmental sustainability and community well-being. Using a 4-point Likert scale, responses from five garbage collectors were analyzed with the weighted mean method. Their evaluations yielded scores of 3.36 for functionality, 3.42 for performance efficiency, 3.35 for compatibility, 3.50 for reliability, and 3.58 for usability, with verbal interpretations of "agree" and "strongly agree," indicating a positive overall reception of the system.

It is recommended that other cities and municipalities adopt the Smart Gobbler system to improve their waste management practices. Customizing the system to fit local waste management processes will be crucial for successful implementation. Additionally, further studies should be conducted to evaluate the social and economic impact of the Smart Gobbler system on local government units and communities. These studies will provide valuable insights into the system's benefits and identify areas for further improvement.

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