SMART WASTE MANAGEMENT SYSTEM

ANGELLA TAMANDANI NAMKUMBA

REG. NO: 19311055003

PPN:2023MHPPR055002

GUIDE

MS. ETHEL CHIKHOSWE

Project Report

Submitted In partial fulfillment of the requirements for the Degree of

BACHELOR OF ENGINEERING IN COMPUTER SCIENCE

JULY, 2024

DMI-ST. JOHN THE BAPTIST UNIVERSITY MANGOCHI

MALAWI

PROFORMA FOR APPROVAL OF PROJECT PROPOSAL

Proposed Project Team:

S.No.	Reg. No.	Name of the student	Semester	Branch
1	19311055003	ANGELLA NAMKUMBA	X	BE

Title of the Project:	SMART WASTE MANAGEMENT SYSTEM
Subject Area:	ANDROID APPLICATION
Name of the Guide:	MS ETHEL CHIKHOSWE
Designation:	LECTURER-II
Address with Phone No.: DMI – St. John The Baptist University, P.O.BOX 406, Mangochi, Malawi (+265 994771255)	
Office:	DMI – St. John The Baptist University, P.O.BOX 406, Mangochi, Malawi
Residence:	DMI-St. John the Baptist University, Mangochi, Malawi
No. of projects & students currently working under the Guide:	10

Signature of the Student **Signature of the Guide with seal**

Date.....

N.B.: Please do not forget to enclose the synopsis of the project and the Bio-data of the Guide. In case the complete and signed Bio-Data of the Guide is not enclosed, the proposal will not be entertained**.**

For Office Use only:

SYNOPSIS	APPROVED	✓	NOT APPROVED	
GUIDE	APPROVED	✓	NOT APPROVED	

Comments / Suggestions for reformulation of the Project.

Date..... **Signature of the HOD**

BIO-DATA OF THE PROPOSED GUIDE FOR PROJECT WORK

1.PERSONALINFORMATION

NAME (in block letters)	: MS. ETHEL CHIKHOSWE
Date of Birth & Age	: 27/08/1999 & 24
Sex	: FEMALE
Academic Qualification	: BSc(cs), MBA
Official Address	: DMI – St. John the Baptist University, Mangochi, Malawi, :P. O BOX 406 Mangochi, Malawi.
Phone No. and Fax.	: 0991287287
Residential Address	: DMI – St. John the Baptist University, Mangochi, Malawi
Phone No., and e-mail id	: 0994771255 & chisochikhoswe@gmail.com

2. DETAILS OF EMPLOYMENT

Designation	: Lecturer-II
Field of Specialization	: NETWORKING, IoT, ARDUINO
Teaching Experience (in years)	:03
Industrial Experience (in years)	:01

Particulars of contribution / experience in the field of specialization: Published two articles

No. of Projects guided: 27

I **ETHEL CHIKHOSWE** DO HEREBY ACCEPT TO GUIDE **MS ANGELLA NAMKUMBA**, A STUDENT OF THE **BACHELOR OF ENGINEERING IN COMPUTER SCIENCE** PROGRAM OF THE **DMI-ST JOHN THE BAPTIST UNIVERSITY, MANGOCHI, MALAWI.**

CERTIFICATE OF THE GUIDE

This is to certify that the project work entitled, **SMART WASTE MANAGEMENT SSYSTEM** is a bonafide work of **MS. ANGELLA NAMKUMBA**, Registration No**. 19311055003** in partial fulfillment for the award of the ddegree **of BACHELOR OF ENGINEERING IN COMPUTER SCIENCE OF DMI ST. JOHN THE BAPTIST UNIVERSITY, MANGOCHI, MALAWI** under my guidance. This thesis work is original one and not submitted earlier for the award of any degree elsewhere.

Student's Signature:	
Signature of the Guide:	

DECLARATION BY THE CANDIDATE

I, **MS. ANGELLA NAMKUMBA** hereby declare that this project report **BIN MANAGEMENT SYSSTEM** submitted to **DMI-ST. JOHN THE BAPTIST UNIVERSITY, MANGOCHI, MALAWI** in the partial fulfillment of requirements for the award of the degree of **BACHELOR OF ENGINEERING IN COMPUTER SCIENCE** is a record of the original work done by me under the supervision of **MS. ETHEL CHIKHOSWE.**

Register No.:	19311055003
Date:	04-07-2024
Signature:	

DMI-ST. JOHN THE BAPTIST UNIVERSITY

MANGOCHI - MALAWI

BONAFIDE CERTIFICATE

Register No: 19311055003

Certified that this is a bonafide record of work done in Project **SMART WASTE MANAGEMENT S SYSTEM** by Ms. **ANGELLA NAMKUMBA** of **the BACHELOR OF ENGINEERING** course in **COMPUTER SCIENCE** at **DMI ST JOHN THE BAPTIST UNIVERSITY MANGOCHI, MALAWI.**

During the academic year: 2019-2024

INTERNAL EXAMINER **EXTERNAL EXAMINER**

ABSTRACT

As cities strive to create liveable environments for their residents, the implementation of an eco-friendly, efficient, and effective garbage management system has become a critical solution. The conventional smart waste management system, relying on regular waste trucks making predefined rounds, often falls short in covering every area of the city and inefficiently utilizes government resources (Ayysamy A, 2020). To address these challenges, this paper proposes a comprehensive system that leverages mobile technology to revolutionize garbage management. Administrators play a pivotal role in this system, utilizing a bin management application to perform tasks such as bin management, driver coordination, user complaint handling, and driver work report analysis. The objective is to provide a cost-effective solution that enables the government to optimize available resources and enhance the efficiency of garbage management, thereby addressing the overwhelming daily volume of waste while ensuring convenience for citizens in garbage disposal. The proposed system encompasses a driver application that offers predictive and guided routes for garbage trucks, empowering drivers to efficiently navigate collection routes. Drivers interact with the system by updating the status of their work, and the collected data is securely stored for analysis and further optimization. In addition, an Android application is developed to cater to both the workforce and citizens. This application allows users to create complaints related to garbage issues and provides real-time information on the availability of smart bins. By integrating mobile, an ultrasonic sensor and GSM (Global System for Mobile); a message will be sent to the authorized individual when the content in the bin reaches to the maximum. This proposed solution aims to improve operational efficiency, optimize resource allocation, and enhance citizen convenience. It offers a comprehensive and sustainable approach to garbage management, enabling cities to tackle the mounting waste challenges while fostering a cleaner and healthier environment for all residents.

Keywords: *Solid Waste Management, Ultrasonic Sensor, Automated Waste Management, Level Indicator***,** *Global System for Mobile, Geolocation Features, Android Application, Mobile Integration.*

ACKNOWLEDGEMENT

First and foremost, I am grateful to the **ALMIGHTY GOD** for the strength, ability and above all, grace that He has showered upon me throughout this project.

I stand indebted in gratitude to our beloved **FOUNDER/CHANCELLOR OF DMI & MMI REV. FR. DR. J.E. ARUL RAJ** for all the facilities provided at our institution.

I would like to thank **DR. T.X.A ANNATH** the President University Council, DMI group of Institutions, Malawi, **DR. IGNATIUS A. HERMAN,** the Director of Education DMI group of Institution, Malawi, **REV. FR SUNDAR** the Secretary to University Council, for providing me an opportunity to do this successfully.

I further proudly express my esteemed gratitude to **DR. JERIN LENO** the Vice Chancellor, **DR BENNEDICT MALUNGA** the Principal**, REV.FR.SAHAYA RUBIN** vice Principal (Admin), for their encouragement by assistance and guidance towards completion of this project.

I would like to thank the **DMI - ST. JOHN THE BAPTST UNIVERSITY, MANGOCHI, MALAWI**, for providing an opportunity to do the project work as part of our curriculum.

I sincerely thank **DR. LUHANGA** (the HOD, School of Computer Science and Information Technology) for his valuable support; reviews critique among other things. I extend my gratitude to **MS. ETHEL CHIKHOSWE** (my guide for the project for the support, critique and all contributions to the project. I thank all my friends and family for creating a good working environment and of course, all my lecturers for broadening my academic knowledge and understanding.

Lastly, I would like to thank my parent's **MR & MRS NAMKUMBA**, for their relentless loving, moral and financial support they rendered all the way until project completion. Without them, my project was void.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER I
INTRODUCTION

1.1 INTRODUCTION

The Smart Waste Management Android Application is a system designed to revolutionize the way waste bins are managed in the modern world (B, 2019). With features such as user login, admin login, driver management, the application aims to streamline waste management processes, enhance efficiency, and promote environmental sustainability. The Smart Waste Management Android Application provides a user-friendly interface for seamless management and tracking of bins, drivers, and trash levels. It caters to three main user roles: users, administrators, and drivers. The users have roles in the system and hence registered users can log in to the application using their credentials and they can provide feedback and report any issues related to the bins or the waste management process. Then the Admin can also log in to perform their specific task, authorized administrators can log in to the application with elevated privileges. Some of the roles for the admin include; adding new bins to the system, updating bin information (such as location and capacity), and monitor the overall status of bins. Furthermore, Administrators can assign drivers to specific bins, manage driver schedules, and track their activities.

The Smart Waste Management Android Application offers several advantages to users, administrators, and drivers. Users benefit from the convenience of finding available bins nearby and providing feedback to improve waste management services. Administrators can optimize bin management, track driver activities, and make informed decisions based on real-time data. Drivers can efficiently collect waste based on assigned bins and optimized routes, reducing time and fuel consumption.

Overall, the Smart Waste Management Android Application contributes to effective waste management, reduces environmental impact, and promotes sustainability by leveraging technology (R Fujdak P, 2016). It enhances user experience, optimizes operations, and empowers stakeholders to actively participate in building a cleaner and greener future.

1.2 OBJECTIVES

The concept of a Smart Waste Management System is an innovative approach aimed at addressing numerous issues that contribute to pollution and diseases within society. Timely and efficient garbage management is essential to prevent irregularities that could have adverse effects on the environment.

The Smart Waste Management System aligns particularly well with the concept of smart cities. The primary objectives of our proposed system include:

- Monitoring and effectively managing the disposal of garbage.
- Implementing intelligent technologies for an efficient garbage management system.
- Minimizing the need for human intervention.
- Reducing human time and effort required for waste management.
- Promoting a healthier environment free from waste-related problems.

CHAPTER II
SYSTEM STUDY

2.1 INTRODUCTION

Cities grapple with inefficient waste collection, overflowing bins, and environmental concerns, pushing the current system to its limits. This analysis proposes a smart waste management system (SWMS) equipped with sensors and a central intelligence platform. By monitoring bin levels, optimizing routes, and engaging residents, SWMS aims to revolutionize waste collection, minimize environmental impact, and create a more sustainable future for our cities. This system delves into the feasibility, viability, and impact of SWMS, paving the way for a transformative approach to waste management.

2.2 LITERATURE REVIEW

S.NO	AUTHOR	YEAR	TITLE	DESCRIPTION
1	Lawal Ahmad, Kabiru Ibrahim Jahun,	2020	SMART GARBAGE BIN MONITORING WITH SMS FEED BACK	An automatic waste bin was designed and built around gear system
2	Soumya Pillai	2022	SMART GARBAGE SEGREGATION AND MONITORING SYSTEM	An automated system in which sensors identifies waste over a table and categorise it in dry and wet until its full, the sends an SMS
3	Kishore N, Naveen Kumar T	2019	GSM. AUTOMATED TRASH COLLECTOR	An automated trash collector that only comes to the user location but also alerts the concerned authority via

			WITH SMS	
4	M.R Mustafa, Ku Nurul Fazira Ku Azir	2017	SMART BIN	An automated system that uses ultra sonic sensor as input and ARM microcontroller
5	Norfadzlia Mohd Yusof	2018	SMART BIN FOR SMART WASTE	An automated system that comprises of solar power waste bin control with SMS
6	Libeum John	2020	SOLID MANAGEMENT SYSTEM	An automated system that uses WSN and a sensor node.
7	Kaula Lungat	2010	SMART WASTE MANAGEMENT SYSTEM	An automated system that uses ultrasonic sensor via IOT technology
8	M, Abdulah	2019	SMART GARBAGE MONITORING SYSTEM	An automated system that uses level and Arduino as a microcontroller.
9	Mark Gerald, O, Giged, T Battung	2020	E-RECYCLE BIN	An automated system designed to support system for sustainable garbage collection route planning.
10	O.Rybnytska, F. Burstein	2009	OPTIMISATION OF WASTE MANAGEMENT SYSTEM	Developed system for sustainable garbage planning.
11	K Deka, K Goswami	2016	IOT-BASES MONITORING AND SMART PLANNING	Development system that monitors and manages Waste
12	P. Harbabu, S, R Kassa, J	2019	IMPLEMENTATION OF AN SMART WASTE MANAGEMENT SYSTEM	The study developed a mobile application associated with smart trash bin, interfaced with a GSM modem.

13	Mahajan S. A. Kokane	2017	SMART WASTE MANAGEMENT USING IOT	The study presented an IOT model for Realtime monitoring system for the garbage level.
14	S. Kanta, S Jash	2020	INTERNET OF THINGS MONITORING SYSTEM	This paper used IOT technology sensor such as wireless sensor network
15	S. Idwan S, J, A. Zubeda	2010	SMART SOLUTIONS FOR SMART CITIES SYSTEM	They developed system that finds optimized path and resources optimization for solid waste.

Table 2.2: Literature Review

2.2.1 GAP ANALYSIS

The comprehensive evaluation of a smart waste management system involves several key areas, by conducting a comprehensive gap analysis in these areas, researchers and developers can gain insights into where improvements are needed, helping to guide the future development and research efforts in the field of smart waste management.

- **Integration of User Feedback**

Ensure the existing system effectively incorporates feedback from drivers, administrators, and public users for continuous improvement, fostering a user-centric approach.

- **Optimization of GSM and GPS Technologies**

Assess the efficiency of GSM and GPS modems, identifying and addressing gaps in signal strength, accuracy, and data transmission to enhance tracking capabilities.

- **User Interface and Experience**

Evaluate the user interface for drivers, administrators, and public users, pinpointing usability issues and gaps in user training or support to create an intuitive and user-friendly design.

- **Data Security and Privacy**

Examine the system's adherence to data security and privacy standards, identifying gaps in protecting sensitive information and proposing strategies for improvement.

- **Scalability and Adaptability**

Analyse the system's scalability and adaptability, identifying gaps in handling increased data volume or incorporating new features to ensure flexibility and future-proofing.

- **Cost-Efficiency and Sustainability**

Assess the cost-effectiveness of the system, identifying areas for improvement and exploring gaps in environmental and financial sustainability for a balanced solution.

- **Community Engagement**

Evaluate community engagement in waste management practices, identifying gaps in awareness, participation, or collaboration to develop inclusive and community-driven waste management solutions.

- **Regulatory Compliance:**

Assess the system's compliance with waste management regulations and standards, identifying gaps and proposing measures to ensure full legal compliance.

2.3 PROBLEM DEFINITION

Currently most cities were using trucks and people to empty the bins. These bins are unnecessary emptied by the waste collection trucks. The cities lack the infrastructure, resources and capacity to manage the rising quantities of waste being generated. Furthermore, inadequate waste management is leading to the accumulation of waste causing services environmental and social consequences including: a heightened flood risk and threats public health from water –borne and vector borne diseases.

In addition, the regular open burning of waste is causing local air pollution accelerated climate change, and further public health concerns related to respiratory diseases, it increases the maintenance cost of the waste collection and disposal system. On the other hand, some of the waste bins are overfilled and spilled in the surroundings.

2.4 EXISTING SYSTEM

The existing waste management system is manual and reactive, relying on cleaning staff to monitor and empty bins as they fill up.

2.4 FEASIBILITY STUDY

Every morning, employees make their way to their workstations, but there is a significant lack of available garbage bins for all those individuals. In the bustling streets of urban cities, countless people pass by the same location within a minute. One apparent solution to this issue would be for the cleaning staff to remain near the garbage bins daily until they become full, allowing them to clean them promptly. However, this approach is not a practical or effective solution.

There are several noteworthy negative consequences associated with constantly full garbage bins. One of the primary effects is that the surrounding area starts emitting an unpleasant odour, creating an overall unpleasant environment. As a result, people begin placing their trash on the sides of the garbage bins (Kaushal R, 2020).

2.5 PROPOSED SYSTEM

In this new proposed system some problems will be addressed with the help of the sensor systems since the level of trash in the dustbins will be detected and communicated to the authorized control room through GSM. The Ultrasonic sensor will work by using ultrasonic sound waves in detecting the level of trash while GSM will function for communication purpose to send message to the high officials when the dust bin is not cleaned.

The geographical location of each bin will be tracked using GPS technology, allowing for precise monitoring and management of bin locations. Additionally, making it user-friendly and efficient.

Advantages

- Real-time information on the fill level of the dustbins.
- Optimized deployment of dustbins based on actual needs.
- Cost reduction and resource optimization.
- Improved environmental quality.
- Reduction in unpleasant odours.
- Cleaner cities.
- Intelligent management of services within the city.
- Effective utilization of dustbins

2.6 SYSTEM OBJECTIVES

The concept of a Smart Waste Management System is an innovative approach aimed at addressing numerous issues that contribute to pollution and diseases within society. Timely and efficient garbage management is essential to prevent irregularities that could have adverse effects on the environment.

The objectives of the bin tracking system are as follows;

- To address the inefficiency in waste collection and disposal methods, particularly the unnecessary use of trucks and manual labuor.
- To develop a waste management system that can handle the increasing waste generation in the country.
- To mitigate the environmental and social consequences of inadequate waste management, including flood risks, water and vector-borne diseases, air pollution, climate change, and respiratory diseases.
- To reduce the maintenance cost associated with waste collection and disposal.
- To prevent overfilled waste bins and the spillage of waste in the surroundings.

2.7 SYSTEM SPECIFICATIONS

The specifications required to run this software via web based and Android application are:

2.7.1 SOFTWARE SPECIFICATIONS

- Arduino
- Java
- Android studio
- Fire base

2.7.2 HARDWARE SPECIFICATIONS

- Arduino board
- Ultrasonic Sensor (HC-SR04)
- GPS Modem
- Power Supply

CHAPTER III

SYSTEM DESIGN

3.1 INTRODUCTION

The overall structure of the system can be effectively visualized through diagrams, providing a clear representation of the front-end and back-end processes required for the successful completion and operation of the project. These diagrams serve as a concise visual depiction, showcasing both the internal and external aspects of the project and presenting a series of quick scenes that illustrate its overall design.

3.2 SYSTEM ARCHITECTURE

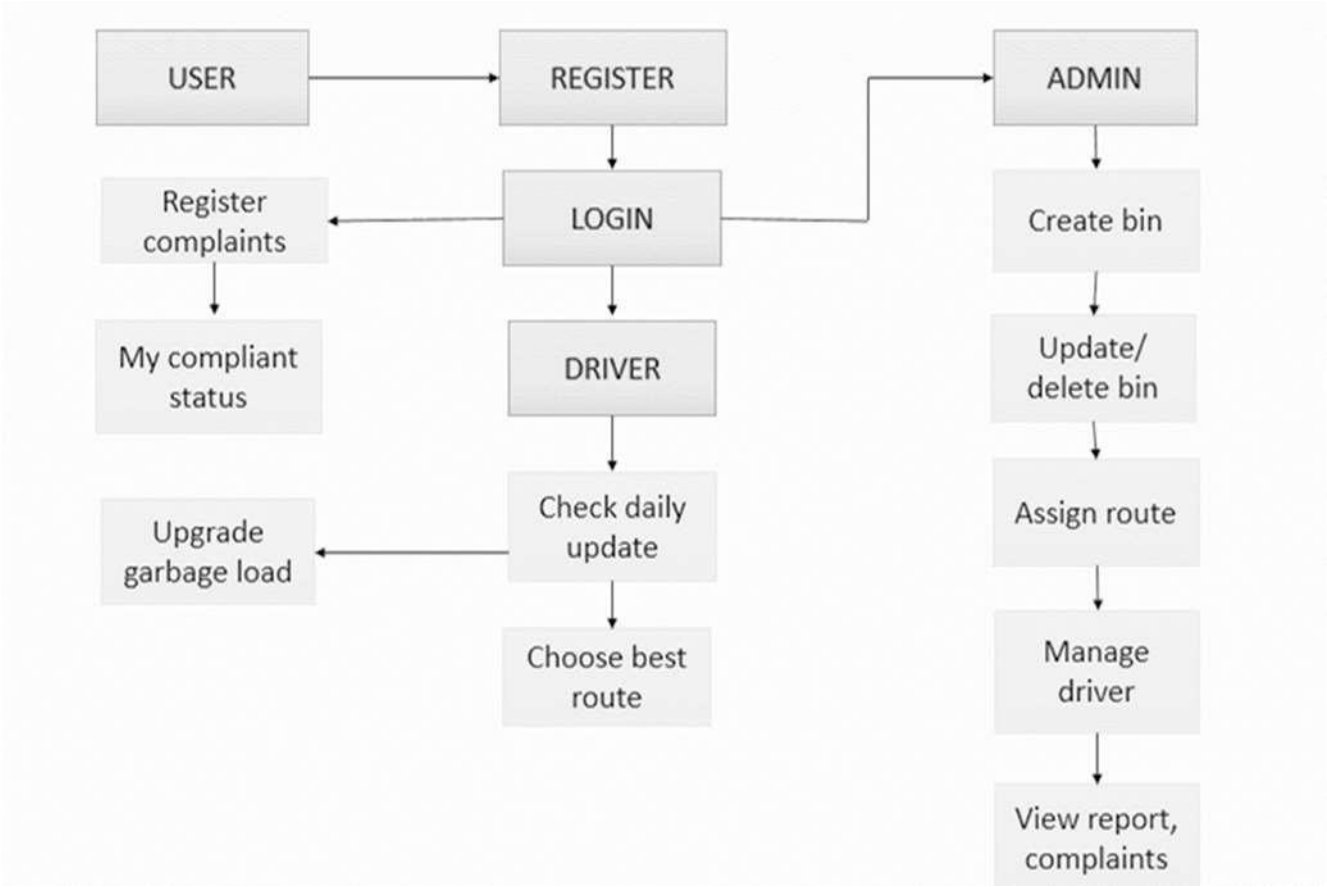

Figure 3.2. System Architecture

3.3 USE CASE DIAGRAM

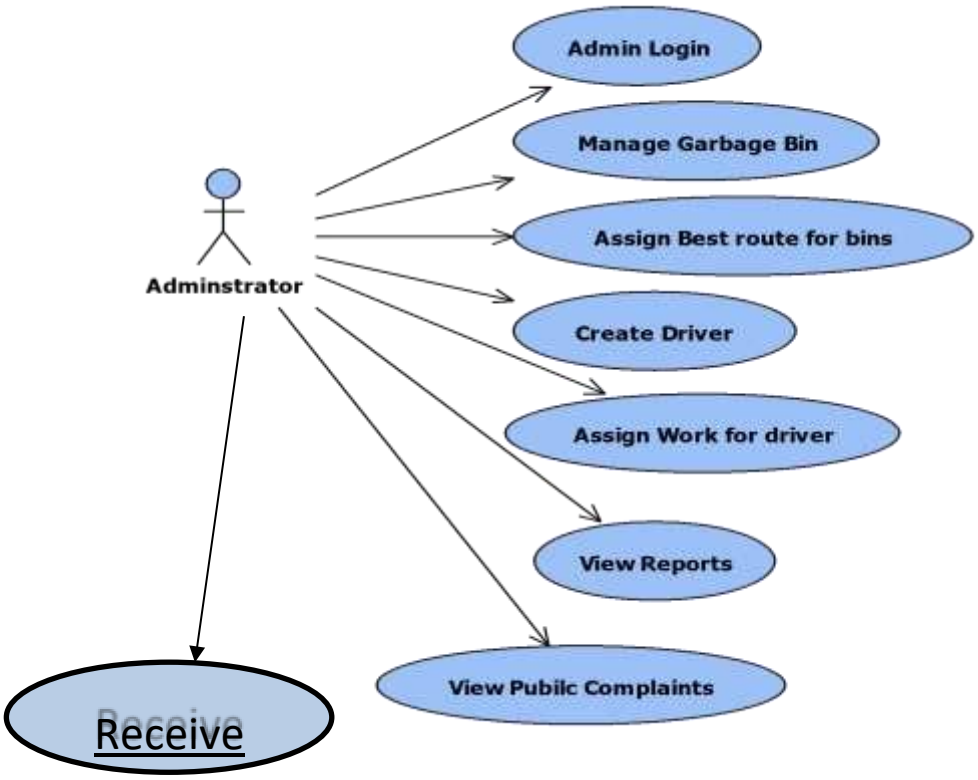

Figure 3.3.1 Use Case diagram for Admin

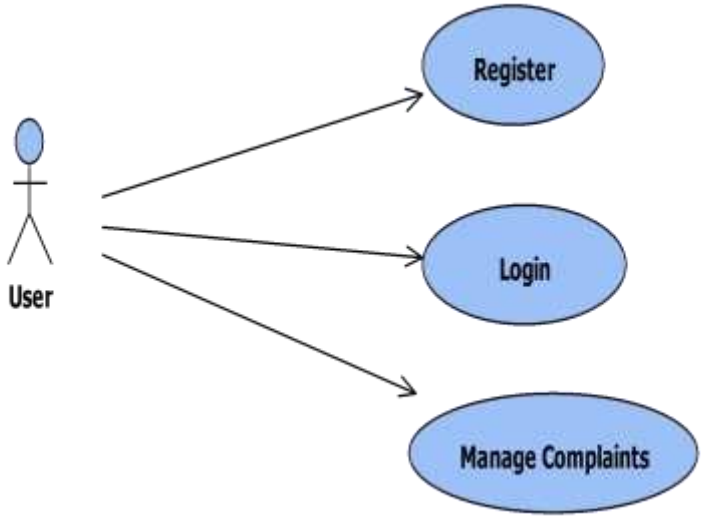

Figure 3.3.2. Use Case diagram for a User

.

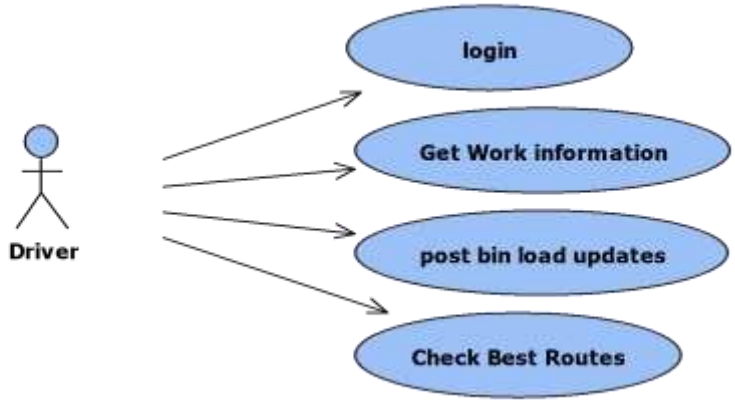

Figure 3.3.3. Use Case diagram for driver.

3.4 DATA FLOW DIAGRAM

LEVEL 0

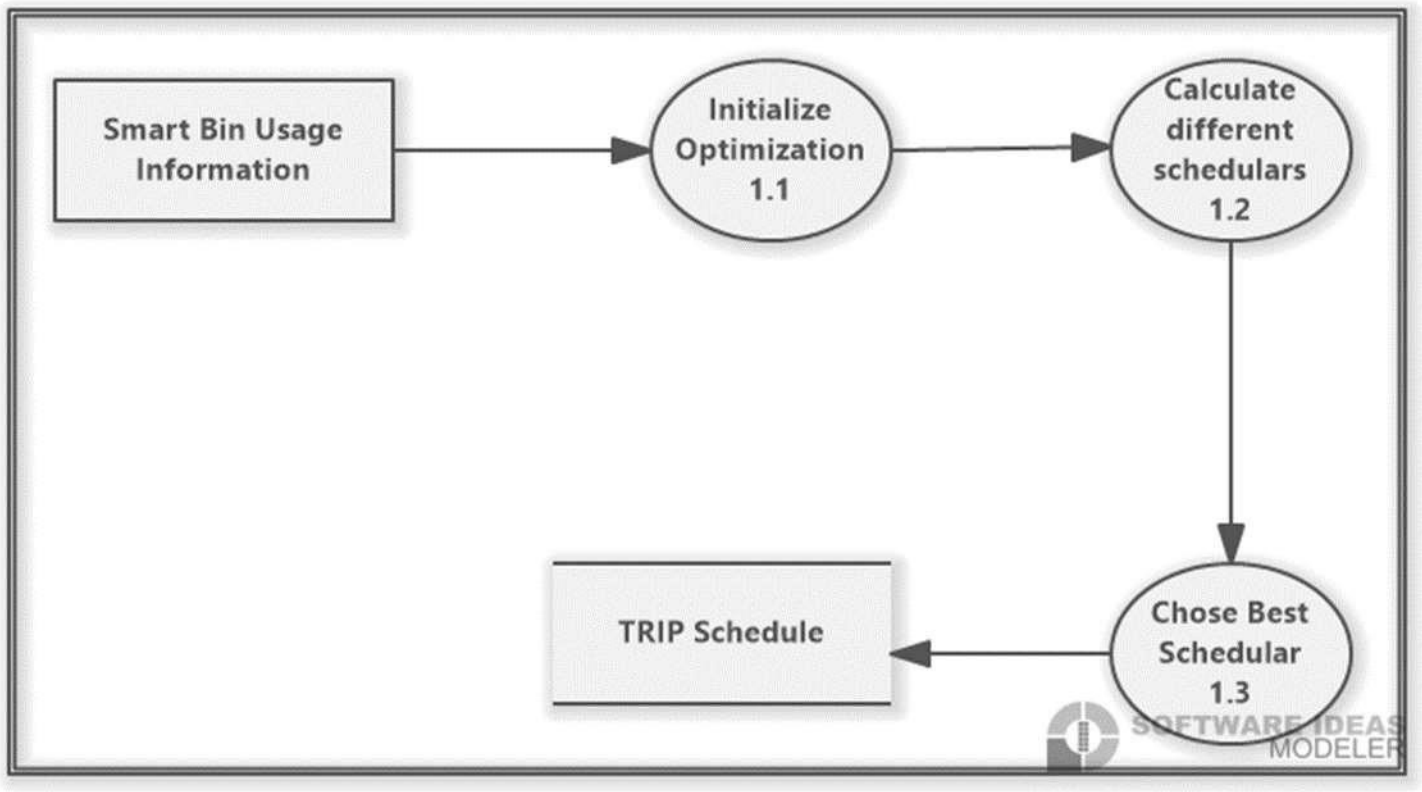

Figure 3.4 level 0 Data flow for Android Application

LEVEL1

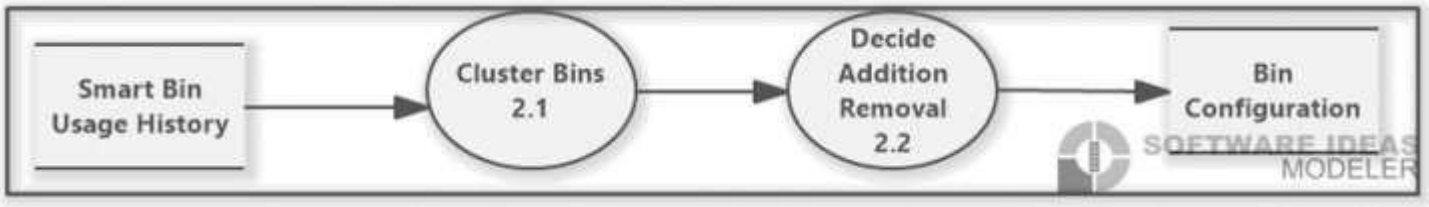

Figure 3.4.2 level 1 data flow

LEVEL 2

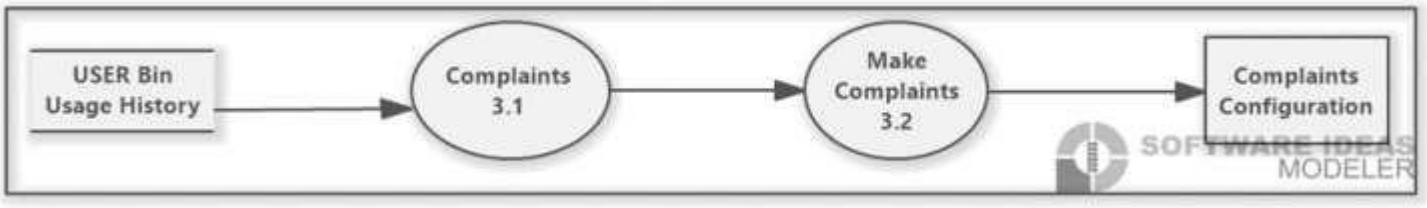

Figure 3.4.3 level 2 data flow

3.5 CLASS DIAGRAM

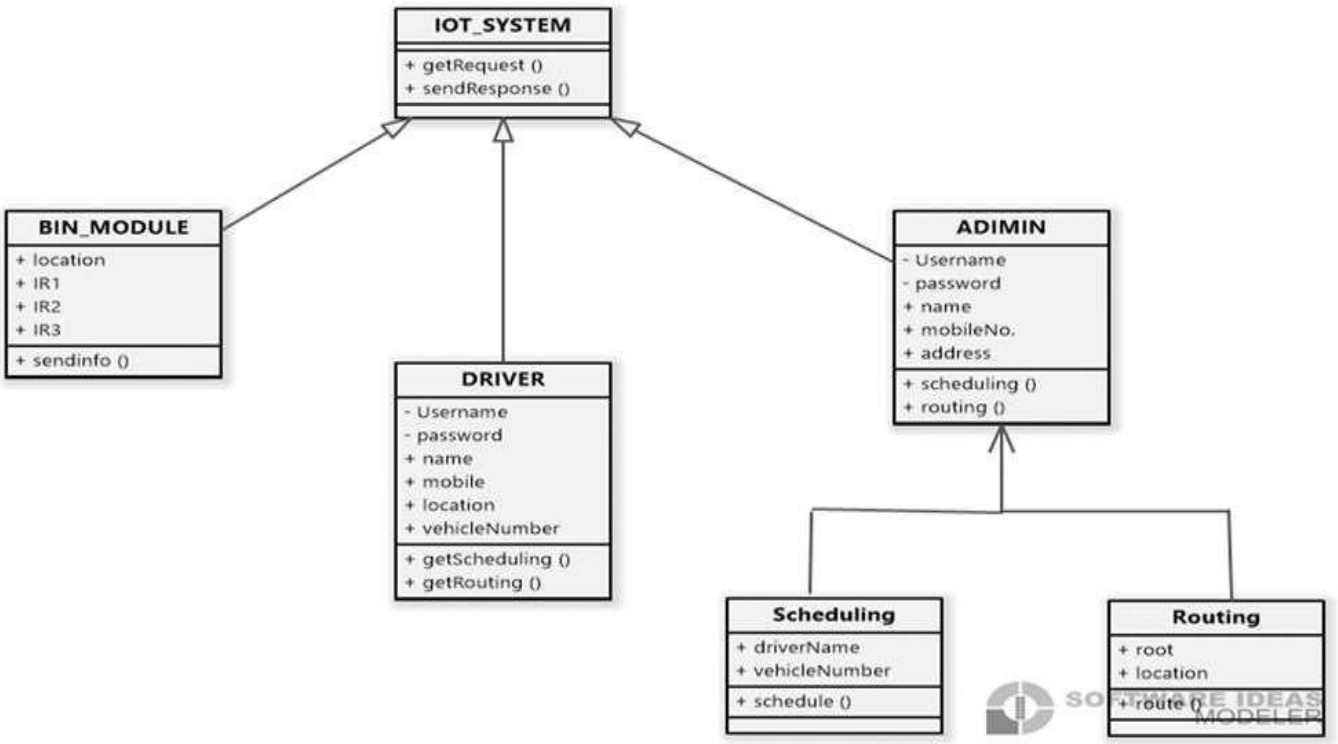

Figure 3.5: Class Diagram

3.6 SEQUENTIAL DIAGRAM

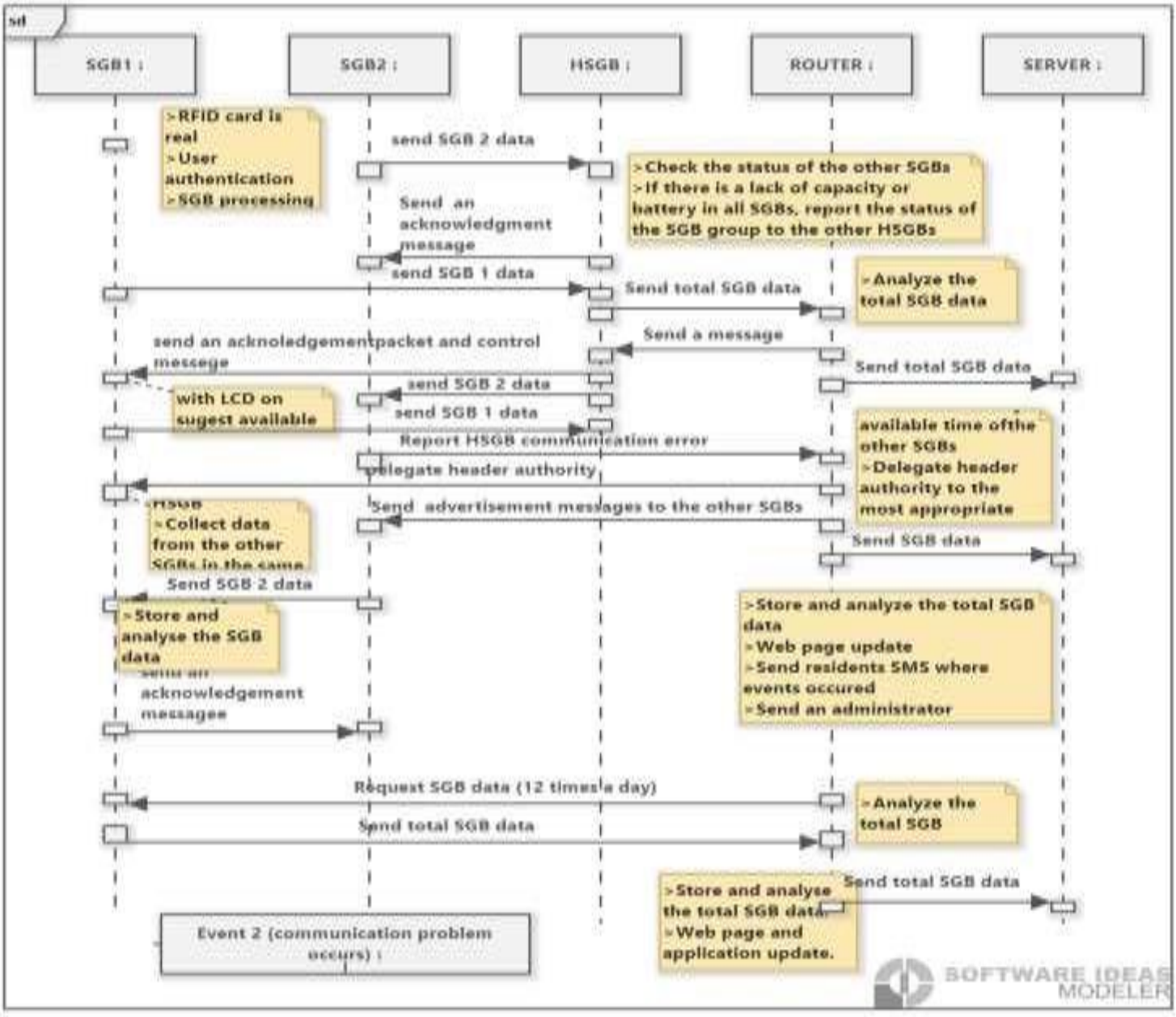

Figure 3.6: Ssequential diagram

3.7 ACTIVITY DIAGRAM

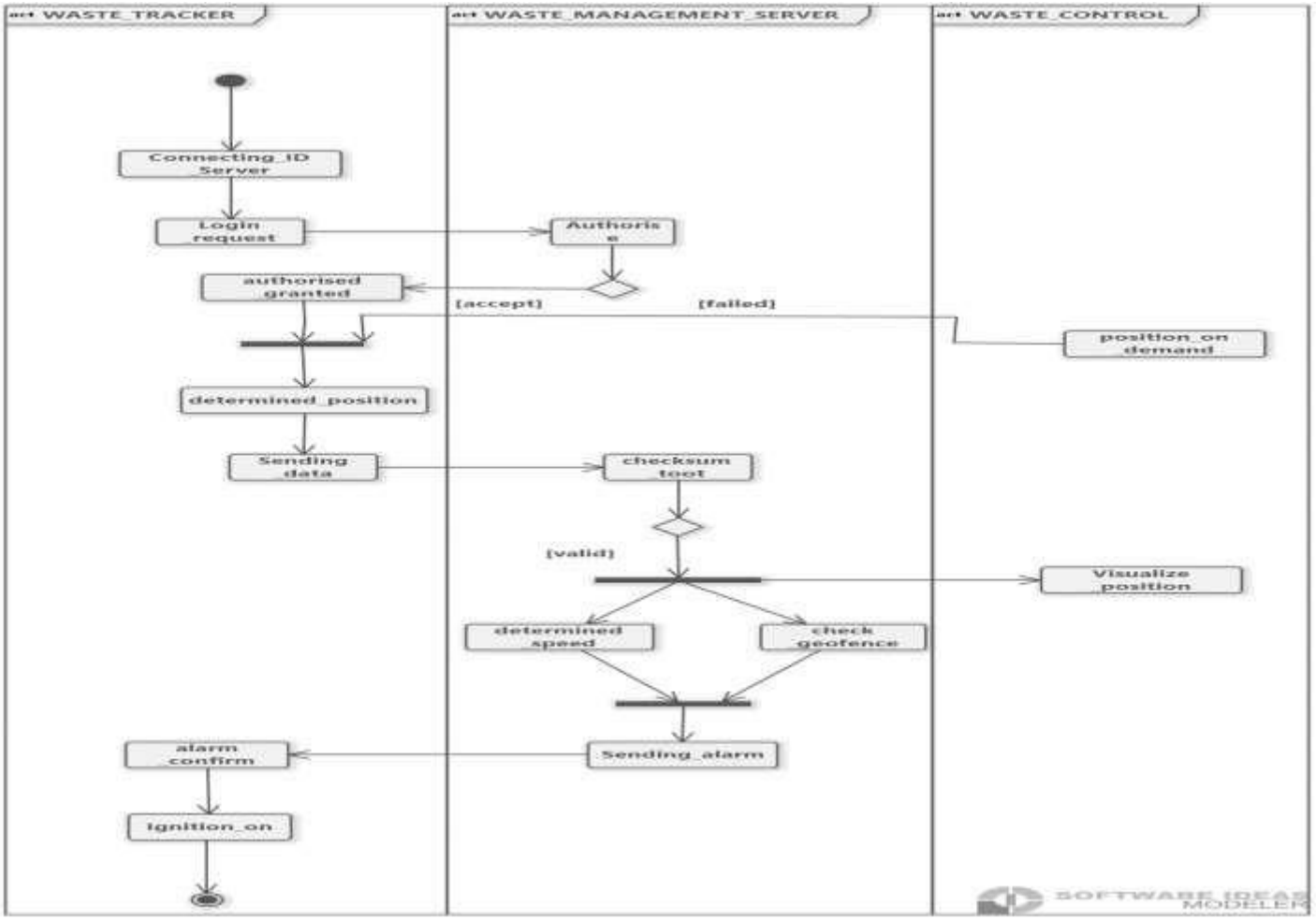

Figure 3.7 Activity diagram

3.8 INPUT DESIGN

The input design of the smart waste management system involves the user interface elements and methods through which users, administrators, and drivers interact with the application. Below is a code for input system.

```
import android.os.Bundle;
import android. view.View;
import android.widget.Button;
```

```
import
android.widget.EditText;
import android.widget.Toast;
public class MainActivity
extends AppCompatActivity {
private EditText
binNumberEditText; private
Button trackBinButton;
@Override protected void onCreate(Bundle savedInstanceState) {
super.onCreate(savedInstanceState);
setContentView(R.layout.activity_main); binNumberEditText =
findViewById(R.id.binNumberEditText); trackBinButton =
findViewById(R.id.trackBinButton);
trackBinButton.setOnClickListener(new View.OnClickListener()
{
@Override public void
onClick(View v) {
String binNumber = binNumberEditText.getText().toString();
// Perform validation on the bin number
if (isValidBinNumber(binNumber)) {
sssssssss
// TODO: Implement logic to track the bin
// Display a success message
```

```
Toast.makeText(MainActivity.this, "Bin tracked: " + binNumber,

Toast.LENGTH_SHORT).show();



} else {

// Display an error message
Toast.makeText(MainActivity.this, "Invalid bin number", Toast.LENGTH_SHORT).show();

}

}

}); } private boolean isValidBinNumber(String

binNumber) {

// TODO: Implement bin number validation logic

// For example, check if the bin number is in the correct format or if it exists in the database

// Return true if the bin number is valid, false otherwise return

binNumber.matches("[A-Z]{2}\\d");

}
```

CHAPTER IV
SYSTEM DEVELOPMENT

4.1 INTRODUCTION

System development involves a process of solution production with help of system related software's. Apart from gathering smart, knowledgeable and field experienced colleagues, for development completion, the software development process also needs systematically and practical technique to successfully complete a project. A software's life cycle is the series of identifiable stages the software product undergoes during its usage (Sujatha, 2018).

4.2 MODULE DESCRIPTION

This is an era of information technology where automation of each and every activity is gaining importance tech-wise. These modules work together to provide a comprehensive bin Management system for an Android application.

1. AUTHENTICATION MODULE

The Authentication Module ensures secure access to the application modules.

- Login

The primary function of this module function is the login page for the administrator, drivers and general public. All other modules are accessible after logging in. This module records for the admin, general public and driver username and password.

- Register

The public is required to register by providing their basic details in order to access the services provided by the application. Once registered, the public can log in to the application to avail the services when needed.

2. USER COMPLAINT MODULE

The User Complaints module acts as a vital feedback loop in the Smart Waste Management System, empowering residents to voice concerns when drivers miss scheduled waste collection. This streamlined module provides a direct channel for reporting missed pickups, allowing administrators to quickly

address residents' issues, optimize route planning, and maintain service quality. It ultimately fosters trust and transparency between users and the waste management system, ensuring seamless waste collection and satisfied residents.

3. GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM) MODULE

The Global System for Mobile Communication (GSM) module acts as the crucial nerve centre for prompt waste collection, bridging the gap between overflowing bins and efficient resolution. Leveraging ultrasonic sensors to detect fill levels, this module triggers automatic alerts when bins reach critical capacity. These alerts are then seamlessly directed to designated officials or bin collectors via SMS or data connectivity, ensuring swift, targeted action, and preventing overflowing hazards. The GSM module effectively streamlines communication, minimizing response times, and optimizing waste collection routes, ultimately leading to cleaner streets and happier residents.

4. BIN GEOLOCATION FEATURE MODULE

The Geolocation Feature module transforms waste collection from a logistical dance into a choreographed symphony. Imagine bin collectors no longer playing 'Where's Waldo' with overflowing bins, but instead, armed with a map illuminated by real-time bin locations. This module overlays bin fill levels onto a digital map, guiding drivers with laser precision to the bins that need them most. No more wasted detours, no more overflowing frustration - just optimized routes, efficient waste collection, and cleaner streets for everyone. This is the power of relocated bins: waste management transformed, one pin on a map at a time.

5. BIN MANAGEMENT SYSTEM MODULE

The Smart Bin Management module serves as the central nervous system of your waste management symphony. It takes the raw data from drivers, admins, and users and orchestrates an efficient, dynamic collection ballet.

The admin acts as the central control hub, managing waste bins, driver’s routes, and users’ complaints. The driver focuses on executing the waste collection tasks by following assigned routes and updating the admin.

4.3 METHODOLOGY

Waterfall Method

The Waterfall methodology, often likened to a cascading waterfall, takes a step-by-step approach to software development. Let's explore its stages through the lens of building a smart waste management system (SWMS):

1. Requirements Gathering and Analysis:

- Gather insights: Interview waste management personnel, city officials, and residents to understand their needs and expectations for the SWMS.
- Prioritize needs: Analyse the gathered information and prioritize features based on impact, feasibility, and urgency.
- Document requirements: Craft a clear and concise requirements specification document outlining functionalities, user roles, and technical specifications.

2. System Design:

- Conceptual design: Define the overall architecture of the system, including hardware (bins, sensors, network), software components (data collection, analysis, visualization), and communication protocols.
- Technical design: Translate the conceptual design into detailed technical specifications for each component, including algorithms, data structures, and programming languages.
- User interface design: Design intuitive and user-friendly interfaces for residents, administrators, and drivers to interact with the system.

3. Implementation:

- Coding: Developers build the various software components based on the technical design, ensuring code quality and adherence to coding standards.
- Hardware integration: Set up and configure the physical components like sensors, communication modules, and waste bins.
- Unit testing: Each component is rigorously tested to ensure it functions as intended.

4. Integration and Testing:

- System integration: Combine all developed components and test their seamless interaction within the entire system.
- Functional testing: Verify that the system meets all functional requirements documented in the specification.
- Non-functional testing: Assess the system's performance, security, and usability from different user perspectives.

5. Deployment and Maintenance:

- Release and installation: Deploy the system to its intended environment, whether cloud-based or on-premises.
- Training and support: Provide user training and technical support to ensure smooth adoption and address any issues that may arise.
- Maintenance and updates: Monitor system performance, fix bugs, and implement new features and updates as needed.

4.5 ALGORITHM

Below is an outline of the algorithm and techniques for the Smart Waste Management Android System.

1. Optimized Route Planning Algorithm:

   This algorithm determines the most efficient routes for waste collection. The algorithms that can be applied to minimize travel distance and time are genetic algorithms, ant colony optimization and Dijkstras algorithm.

2. Dynamic Bin Creation Algorithm

   This algorithm determines optimal locations for new waste bins based on usage patterns. Clustering algorithms like K-Means can help identify areas with high waste generation, aiding with strategic bin replacement.

3. User Authentication Algorithms.

   This algorithm ensures user authentication for public users. The hash-based algorithms like bcrypt for password storage and verification, ensuring data security.

4. Real-Time Data Processing Algorithm.

This algorithm handles real-time data from sensors, drivers and users. Stream processing algorithms like apache kafta can manage and process real-time data efficiency.

These algorithms form the foundation for the functionality and features of the Smart Waste Management. The implementation details may vary depending on the specific technologies and frameworks used for development. (S kandawala, 2019)

CHAPTER V
SYSTEM TESTING

5.1 INTRODUCTION

This chapter describes the levels of system testing soon after its development during the course of implementing for use. Every system must be tested before presenting, advertising or marketing. Testing gives room for error checking and identification, professionalism and implementation detection for project perfection. Self-testing, client, user, customer and student testing is therefore important.

5.2 SYSTEM TESTING

System testing is a crucial phase in the software development life cycle that aims to verify and validate the functionality, reliability, and performance of a software system.

In the case of a smart waste management system, system testing would involve testing the entire system to ensure it meets the requirements and functions correctly.

5.2.1 UNIT TESTING

TEST CASE	PURPOSE	PROCEDURE	EXPECTED RESULTS (Pass or Fail)	ACTUAL RESULTS (Pass or Fail)
User authentication 1. Admin	The admin login function should return a success response or grant access to the admin dashboard.	Pass valid admin credentials (username and password) to the admin login function.	Pass	Pass
User authentication 2. User Registration	The user registration function should	Provide valid user registration details (name, email,	Pass	Pass

	successfully create a new user account.	password) to the user registration function.		
Mobile phone	To test if the application can function	Single click.	Pass	Pass
Logout	To test if user can successfully logout of the website	Mouse navigation	Pass	Pass

Table 5.1 Unit Testing Results

The code below verifies unit testing for the system.

```
<?xml version="1.0" encoding="UTF-8"?>
<phpunit bootstrap = "vendor/autoload.php"
         backupGlobals               = "false"
         backupStaticAttributes      = "false"
         colors                      = "true"
         convertErrorsToExceptions   = "true"
         convertNoticesToExceptions  = "true"
         convertWarningsToExceptions = "true"
         processIsolation            = "false"
         stopOnFailure               = "false"
         syntaxCheck                 = "false">

  <testsuites>
    <testsuite name="Smart Bin">
      <directory>assets</directory>
      <directory>.idea</directory>
    </testsuite>
  </testsuites>

  <filter>
    <whitelist>
      <directory suffix=".php">assets/vendor/</directory>
    </whitelist>
  </filter>

  <php>
    <env name="APP_ENV" value="testing"/>
  </php>

</phpunit>
```

5.2.2 INTEGRATION TESTING

The integration testing aspects for the driver, admin, and user roles in the system, is ensuring smooth interaction and functionality across all interfaces.

ROLE	TEST CASE ID	DESCRIPTION	EXPECTED OUTCOME	PASS/FAIL
Driver	TC-Driver 01	Verify that the driver can login with valid credentials	Driver successfully log in and access their dashboard	PASS
Driver	TC-Driver 02	Ensures seamless integration between driver and interface	Driver can navigate through the system	PASS
Admin	TC-Admin 01	Verify access to driver registration after logging in as admin	Admin can access and use the driver registration feature	PASS
Admin	TC-Admin 02	Verify access to user complaints	Admin can access user complaints and give feedback.	PASS
User	TC-User 01	Verify access to the smart waste management system features	User can access system features	PASS
User	TC-User 02	Validates user experience in accessing and interacting the systems features	Users experience a smooth interaction with the system features	PASS

Table 5.2 integration testing

5.2.3 VALIDATION TESTING

A validation testing compares the speed of the project, the adaptability, as well as dependability qualities of the project under testing phase against the thought set or assumed by the users to be useful and effective.

FIELD	REQUIREMENT
Username (Admin/User	Required: Enter a string
Password (Admin/User)	Required: Enter integer

Table 5.3 Validation Testing (Valid Input)

Null Data Test Case

Field	Test Data	Error Message
Username (Admin/User)	Null	Enter username
Password (Admin/User)	Null	Enter password
Student login as Admin	Null	Invalid Login
Admin login as User	Null	Invalid Login

Table 5.4 Validation Testing (Invalid Input)

5.2.4 USER ACCEPTANCE TESTING

User Acceptance Testing (UAT) in the system ensures that the application meets specified requirements and fulfils user needs. Quality Aassurance teams execute predefined test cases and scenarios to validate the system's functionality. This process involves real-world testing by end-users to ensure usability and effectiveness. It confirms that the system aligns with user expectations, ensuring seamless interaction and satisfaction with the Smart Waste Management System. The two examples of predefined test cases for User Acceptance Testing **(Manicipal, 2017)**.

TEST TYPE	CASE ID	DESCRIPTION	EXPECTED OUTCOME	PASS/FAIL
User Interface Testing	UAT-UI-01	Verify that the interface is intuitive and easy to navigate for both users.	Successfully login as an admin and main dash board displays relevant statics	PASS
Alerts and Notifications Testing	UAT-AN-01	Validate that the system generates timely alerts and notifications for bin overflow.	System recognizes bin at predefined fill level and triggers an alert.	PASS

Table 5.5 User Acceptance Testing

CHAPTER VI

SYSTEM IMPLEMENTATION

6.1 USER TRAINING AND DOCUMENTATION

The implementation of the Smart Waste Management System involves creating separate interfaces for administrators, users, and drivers, each catering to their specific roles and responsibilities. This ensures smooth operations and efficient waste management.

The system incorporates GSM and ultrasonic sensors to detect when waste bins are full. When a bin reaches its capacity, an SMS notification is sent to the admin, enabling timely waste collection. Additionally, a geolocation feature allows drivers to visualize the locations of waste bins, optimizing their routes for collection.

Comprehensive diagrams support the implementation process, providing a clear and visual understanding of the workflow. The system's design emphasizes seamless integration and user-friendly interfaces, facilitating effective waste management.

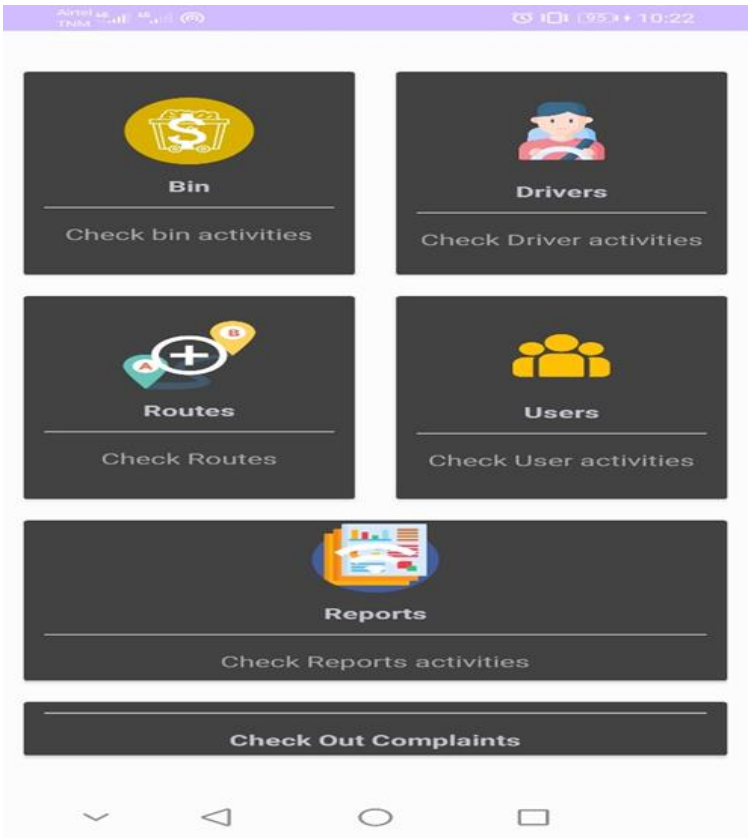

Figure 6.1. Showing Admin dashboard

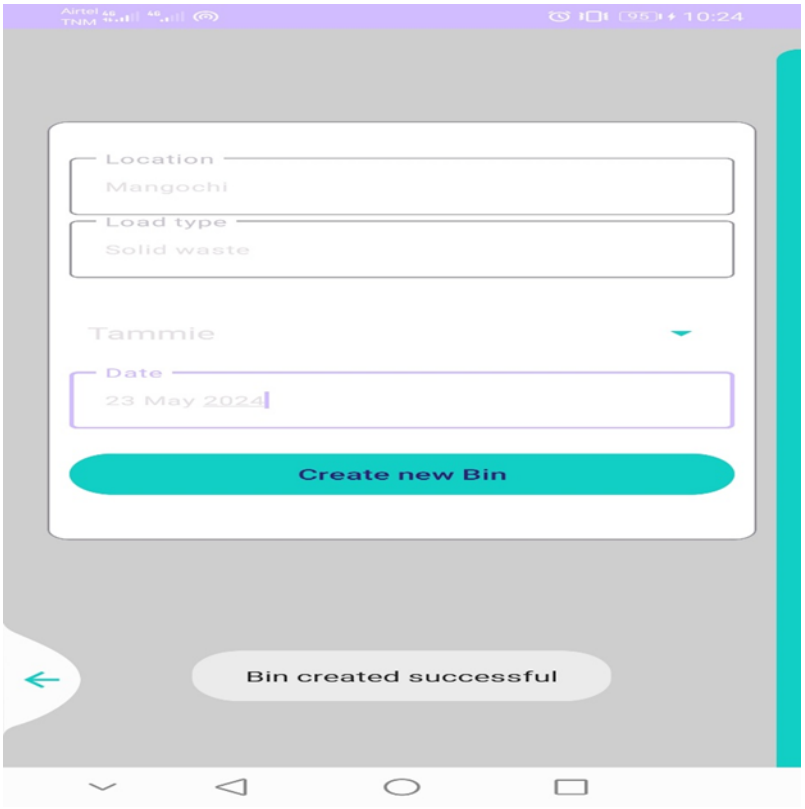

Figure 6.2. Showing successful result of creating a bin

Figure 6.3. Shows Admin creating Driver.

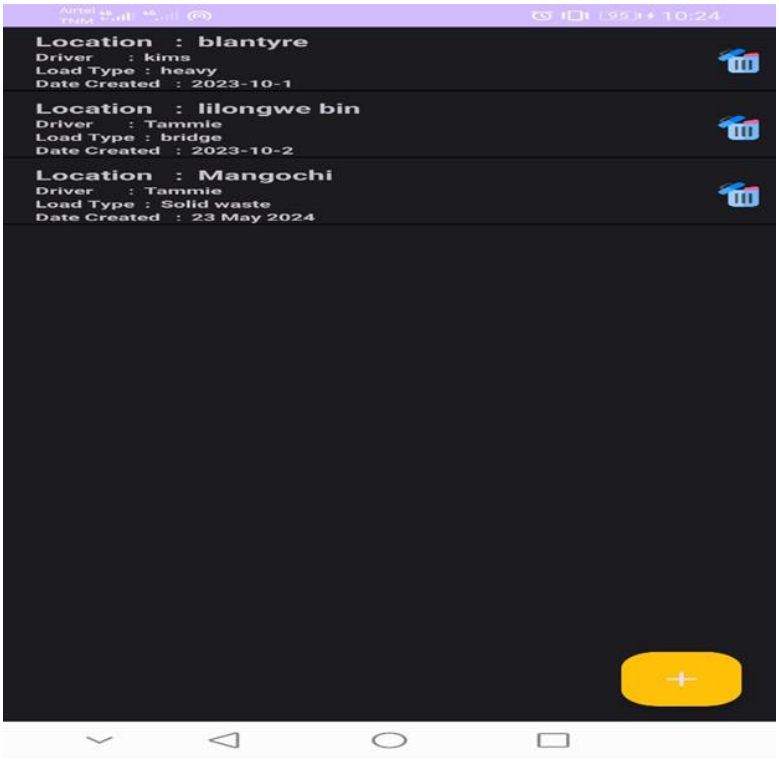

Figure 6.4. Shows the drivers which are created.

USERS DETAILED DIAGRAMS

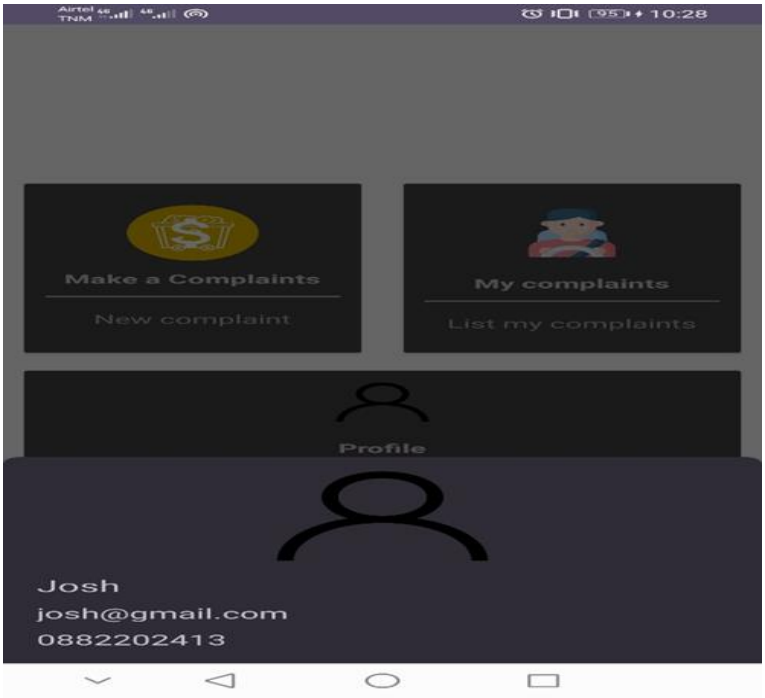

Figure 6.7. Showing User Dashboard.

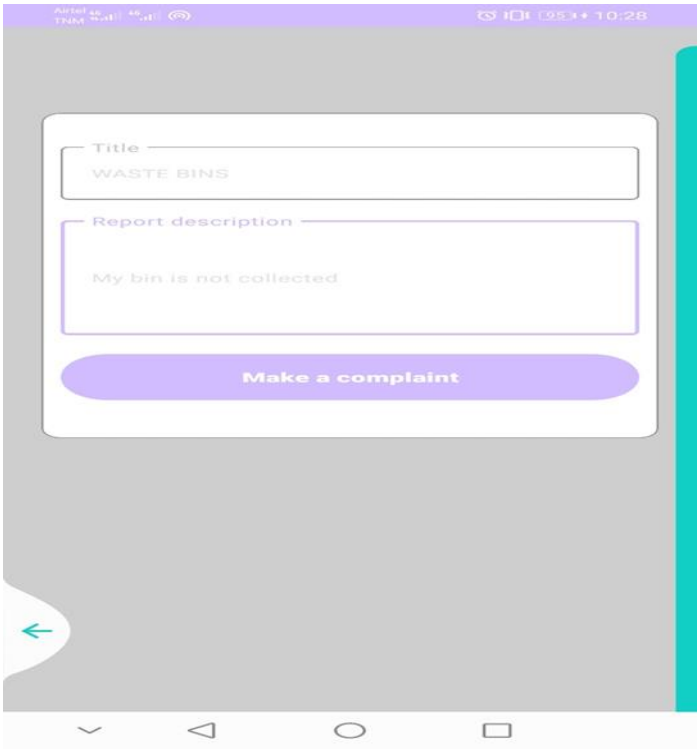

Figure 6.5. Shows User lodge complaint.

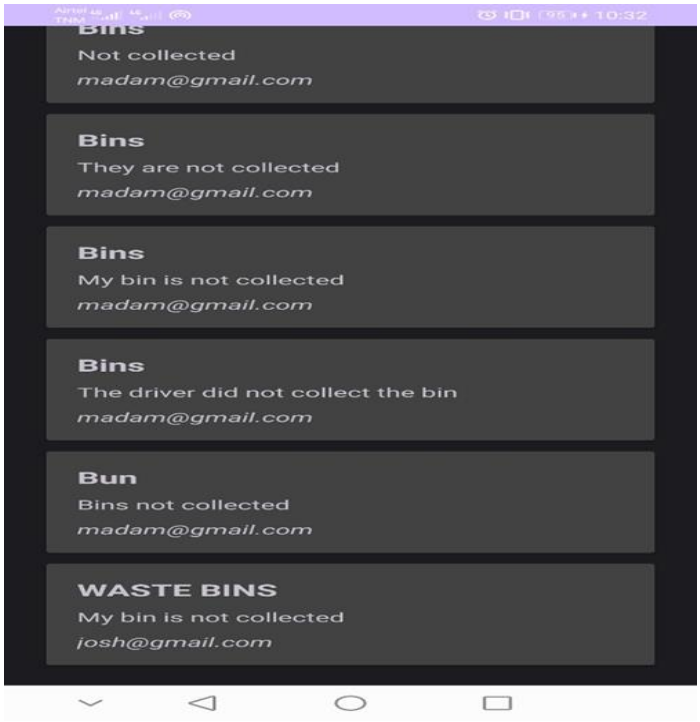

Figure 6.6 Shows the complaint history.

Figure 6.7 Shows the Font end of the system.

At this point, the project is running as anticipated and giving the desired output. Errors concerning mobile application have been dealt with, debugging, compiling and error correction. The system has thus been designed and implemented successfully.

CHAPTER VII

PROBLEMS FACED AND SOLUTIONS

7.1 PROBLEMS FACED

The project posed challenges, particularly in terms of sourcing materials for the hardware implementation. The materials were hard to find and expensive, adding complexity to the project. Hence, other problems included navigating alternative solutions due to material scarcity and devising cost-effective strategies to meet project requirements without compromising quality. Android Studio is an application that requires frequent Gradle updates and the downloading of various libraries and dependencies. Consequently, this caused significant issues when running the application.

1. CODE EXECUTION

During the execution of the code in the Smart Waste Management System, various challenges were encountered. I often find myself grappling with hardware compatibility issues, which can lead to malfunctions or incorrect readings from sensors and other devices. Additionally, errors in data processing compromised the accuracy and integrity of the waste management information. Connectivity problems with networks sometimes disrupt communication between system components, impacting the ability to monitor operations in real-time and send out timely notifications. Security vulnerabilities are also a concern, as they may expose our system to cyber threats. Furthermore, poorly optimized code struggled to handle large volumes of data or concurrent user interactions, leading to performance issues. Inadequate error handling and recovery mechanisms posed a risk of system failures or data loss during unexpected events. Lastly, integration issues may arise, hindering seamless data exchange with external systems or databases. To address these challenges, we conduct thorough testing, debugging, and continuous monitoring to ensure the smooth operation and optimal performance of our Smart Waste Management System.

2. ERROR DEBUGGING

Encountering challenges arose while identifying errors during the debugging process, with some errors not being explicitly defined by the script or debugger. It proves to be arduous to detect errors within the back-end tool and offer corresponding solutions.

7.2 SOLUTIONS

Some of the practically used solutions that helped throughout to project completion are:

- Staying updated with the latest versions of Gradle and libraries. Perform regular updates and maintenance to keep the development environment in sync with the necessary dependencies. Additionally, ensure that you have a reliable internet connection to minimize any potential interruptions during the downloading process.
- Evaluating the feasibility and potential risks of the proposed ideas before implementation. Seek feedback and input from experienced individuals or subject matter experts to enhance the chances of success. Consider prototyping or conducting small-scale tests to validate the effectiveness of the ideas before committing to full-scale implementation (Ayysamy A, 2020).
- Practicing proper code documentation, adhere to coding best practices, and conduct regular code reviews. Utilize debugging tools and techniques to identify and resolve errors promptly. Consider implementing robust error handling mechanisms to minimize the impact of unexpected errors and ensure the stability and reliability of the database.
- Utilizing debugging tools and techniques provided by the development environment or specialized debugging software. Analyze error logs and messages to identify patterns or commonalities. Experiment with different troubleshooting methods, such as step-by-step code execution or isolating specific sections of code for testing. In cases where errors are not explicitly defined by the script or debugger, seek support from online developer communities, forums, or documentation specific to the back-end tool being used.

CHAPTER VIII

CONCLUSION AND SUGGESTIONS

8.1 CONCLUSION

We have successfully created a Smart Waste Management System that is both cost-effective and efficient. Implementation of smart garbage management systems like this holds immense potential for significantly improving our overall well-being and reducing harmful toxins in our daily lives.

Furthermore, this system has the capability to reduce fuel consumption of garbage trucks by optimizing collection routes based on the presence of a substantial number of cans in specific geographic locations. This targeted approach ensures that collection takes place only when there is a significant amount of waste to be collected in a particular area.

Due to its minimal funding requirements, this system can be readily adopted by countries that are not keen on investing heavily in their waste management departments. It offers a cost-effective solution that can be easily implemented worldwide.

8.2 SUGGESTION

The implementation is focused solely on a single bin, but by integrating multiple bins, each with its own unique ID, it becomes possible to monitor them by creating a separate database for each bin, which can be managed using SQL technology. The inclusion of smart bins in the integration enables smarter, more efficient, and less wasteful waste collection processes.

CHAPTER IX
SUGGESTION FOR PROJECT EXTENSION

In the future, this article proposes the integration of IoT solutions to develop a system that enables the municipal council to effectively address the garbage problem in a smart city. This system facilitates interaction among various stakeholders, including citizens, the workforce, and administrators.

There are several potential areas for future improvements. However, due to the focus on maintaining a low-cost approach for this project, certain enhancements are currently limited. One such area involves the identification of different types of garbage directly from the bin, eliminating the need for manual segregation by humans. If successfully implemented, a single large bin could replace the requirement for four separate bins for different types of garbage, as the bin itself would automatically segment the waste.

Another potential area for improvement is the communication infrastructure. Rather than each bin individually connecting to an access point to communicate with the server, the bins could establish communication with each other and connect to an access point through a central hub. This approach has the potential to reduce network costs and enhance overall network efficiency.

REFERENCES

1. Ayyasamy, A., Muthukumar, S., & Arputharaj, K. (2020). *A Smart Waste Management System for Efficient Waste Collection.* In 2020 International Conference on Innovations in Green Energy and Healthcare Technologies (IGEHT).
2. "Colombo Vehicle Statistics (2015)." Indi.ca. [Online]. Available: http://indi.ca/2015/10/*colombo-vehicle-statistics*-2015/. [Accessed: 09- Jan-2017]
3. Council, Colombo Municipal. "Colombo Municipal Council." *Garbage Collection.* [Online]. Available: http://colombo.mc.gov.lk/garbagecollection.php/. [Accessed: 04-Jan-2017]
4. Kaushal, R., Kumar, P., & Pandit, A. K. (2020). *Smart Bin: An Innovative System for Solid Waste Monitoring and Management.* In 2020 IEEE Region 10 Symposium (TENSYMP).
5. "Population and Housing." *Population and Housing.* [Online]. Available: http://www.statistics.gov.lk/page.asp?page=Population%20and%20Hous ing/. [Accessed: 09-Jan-2017]
6. Kokate, V. B., Shinde, J. V., & Chavan, S. S. (2019). *Smart Waste Management System for Smart Cities.* In 2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU).
7. S. Lokuliyana, J. A. D. C. A. Jayakody, L. Rupasinghe, and S. Kandawala, "*IGOE IoT framework for waste collection optimization,*" 2017 6th National Conference on Technology and Management (NCTM), Malabe, 2017, pp. 12-16.
8. R. Fujdiak, P. Masek, P. Mlynek, J. Misurec and E. Olshannikova, "*Using genetic algorithm for advanced municipal waste collection in Smart City,*" 2016 10th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP), Prague, 2016, pp. 1- 6.
9. Sujatha, S., Ramya, S., Divya, M., Dharani, R., & Prathyusha, R. (2018). *Smart Waste Management System using IoT.* In 2018 International Conference on Smart City and Emerging Technology (ICSCET).
10. T. Anagnostopoulos, A. Zaslavsky, A. Medvedev, S. Khoruzhnikov, *"Top-k Query based Dynamic Scheduling for IoT-enabled Smart City Waste Collection,"* In Proc. of 41 the 16th IEEE International Conference on Mobile Data Management (MDM 2015), Pittsburgh, US.

APPENDIXES

COPYRIGHT LETTER

I **MS. ANGELLA NAMKUMBA.** hereby declare that this project report **SMART WASTE MANAGEMENT SYSTEM** submitted to **DMI-ST. JOHN THE BAPTIST UNIVERSITY**, in the partial fulfillment of requirements for the award of the degree of **ENGINEERING** in **COMPUTER SCIENCE** is a record of the original work done by me under the supervision of **MS ETHEL CHIKHOSWE**

I certify that this project thesis was indeed done and written by me and contains no material that has been accepted for the award of any other degree in any other university, to the best of my knowledge and belief and contains no material previously published or written by another person, except where due reference has been made in the text. Therefore, no part of this documentation may be reproduced in any form without prior written permission by me, except in the case of brief quotations and certain non-commercial uses. I give consent to this copy of thesis to be deposited in the university library being made available for viewing and referencing.

Yours faithfully **Signature of the Examination office**

MISS. ANGELLA NAMKUMBA.