

# **SMART WASTE MANAGEMENT SYSTEM**

Submitted in partial fulfillment of the requirements for the award of  
Bachelor of Engineering degree in Computer Science and Engineering

by

Ashitha (38110052)



**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**

**SCHOOL OF COMPUTING**

**SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC**

**JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

**MARCH – 2020**



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**Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119**

**[www.sathyabama.ac.in](http://www.sathyabama.ac.in)**



## **DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**

### **BONAFIDE CERTIFICATE**

This is to certify that this  
Project Report is the bonafide  
work of Ashitha (38110052).  
who carried out the project  
entitled “**SMART WASTE  
MANAGEMENT SYSTEM**”  
under the supervision from  
November 2019 to April 2020.

Internal Guide

**Dr.J.Jabez M.E., Ph.D.,**

Head of the Department

---

**Submitted for Viva voce Examination held on\_\_\_\_\_**

**Internal Examiner**

**External Examiner**

## **DECLARATION**

I **AMBATI DEEPIKA** hereby declare that the Project Report entitled “**SMART WASTE MANAGEMENT SYSTEM**” done by me under the guidance of **DR. R. AROUL CANESSANE, M.E., Ph.D.**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY**.

**DATE:**

**PLACE:**

**SIGNATURE OF THE CANDIDATE**

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## **ABSTRACT**

A smart waste bin when combined with an efficient routing algorithm and a good central management helps to create a very well organised, effective dynamic waste management system. This project introduces an innovative way of using out a smart integrated sensing system that will help to automate the waste management process that includes the collection. Major problem in the system is to plan the pickup the bins that are ready. In this project, a heuristic algorithm is developed to solve this capacitated arc routing problem (CARP) considering multiple trips for the available vehicles, capacity of the vehicle, capacity of the bins to be collected and crew's working time. The objective function of the proposed model aims to minimize total traversed distance and total usage cost of vehicles. This information can be linked with municipality web server for immediate action. The waste bins are tracked by a unique number which represents its location. This proposed model gives all information related to physical condition of a particular bin and can easily reach the corresponding authority. The whole information is interconnected with a server-based web-information system at the host server. Also a central management helps the admin to authorize the drivers the routes and all other admin capabilities. The best route proposed by this system once approved by the admin will be sent to the assigned drivers for pickup.

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## LIST OF ABBREVIATIONS

|      |                                     |
|------|-------------------------------------|
| CARP | Capacitated Arc Routing Problem     |
| CVRP | Capacitated Vehicle Routing Problem |
| TSP  | Travelling Salesman Problem         |
| UI   | User Interface                      |



# **CHAPTER 1**

## **INTRODUCTION**

Internet of Things (IoT) has taken priority in research among the technical communities due to the advances and popularity in sensing, propulsion, exchange of information and control. IoT is a broad domain providing many services, such as smart waste collection system for making a city smart, healthcare observation, transportation facility, logistics department to find vehicles or packages, etc.

IoT comprises very large number of devices interconnected to the internet. IoT is an integrated system comprising different physical entities such as various components, transportation system, constructions and other things—fixed with electronics, software, detectors, and network connectivity that make them capable to gather the information and exchange data. It allows to operate remotely through network framework, generating new opening for more direct incorporation of the physical world into computer-based systems, and enhances perfection, accurateness and financial benefits. With IoT, the technology (sensors and actuators) has become sophisticated to create smart and intelligent systems. Every object is separately identified is capable to work within the existing internet architecture. It is estimated that by 2020 nearly 50 billion components will be integrated into IoT.

Constant rise in population has lead to difficulty in maintaining the cleanliness of public areas and has also made garbage management to degrade staggeringly. This leads towards an unhygienic environment and is responsible for various types of disease in the locality. To eliminate the healthcare issues and improve the cleanliness, an 'IoT-based garbage management system' is proposed in this paper. Internet of Things (IoT) has brought a chance to build a smarter and a healthy city.

IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS) and the Internet. The concept may also be referred to as the Internet of Everything. The internet of things (IoT) is the internetworking of physical devices, vehicles, buildings and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. A thing, in the Internet of Things, can be

a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low -- or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network.



**FIG 1.1 SMART CITY**

IoT makes our live easier as the objects are having brain (sensors help in making decisions) and communicate using wireless networks for helping us make better choices. Currently, popularity of smart city development has made researchers to work along with engineers, urban developers and architects to improve efficiency of municipal services. This efficiency of the system depends on quality of life, maintenance, economy and sustainability. Using Waste Management system one can reduce the amount of available waste. It is very useful for future use. .

To make the city smarter, the waste management is an important aspect. The sensors are placed on the thrash bins (dustbins) that are placed on the common public places. When the waste attains the defined level of the sensor, a specific signal goes to microcontroller. The controller then gives indication by sending notification to

authorities about the status of the bin for further action. For mobile application GSM technology is used for the same notification purpose. In this project, a smart waste collection system is presented which provides intelligence to trashcans using an IoT paradigm, embedded with sensors, that can interpret, gather, and send waste bin volume data and sense various stinky gases over the internet. These data are sent to server and after processing the corresponding information is transmitted to municipality and persons responsible for waste collection of the city through app notification. The responsible person can check the status of bin by accessing site at any time.

The advantages of this system, in comparison to a conventional waste collection approaches are economic and efficiency factors. As the condition of all waste bins is known to the authority they can collect waste according to the heuristic routing algorithm (to optimize the direction and schemes of waste collection logistic) so that minimum fuel and vehicles are required to collect the waste.

### **1.1 MOTIVATION OF THE PROJECT**

According to the Central Public Health and Environmental Engineering Organization (CPHEEO), the waste creation in India is around 1.3 pounds per individual per day. This statistic means that India could be generating as much as 27 million more tons of waste than the US per year because of large population. Government of India has been trying for years to get a way out to handle the country's ever-growing amount of trash . This project proposes a smart and efficient way to collect the thrash. Nowadays, generating different types of solid wastes and manifestation of their associated social, economic and environmental inconsistencies create numerous complications for urban service management in regard to the collection, transportation, processing and disposal of such wastes. An optimal planning in collecting, management, and disposal of urban waste are mandatory requirements if we need improvement in city health and do the same in acost effective way.

In general all routing problems related to the urban wastes collection series of predefined edges is existed with positive or zero demand and the objective is to find the best tours covering all required edges (edges with positive demand)-Capacitated

Arc Routing Problem (CARP). Since this project deals with the routing that is similar to the problem is a complicated version of the classic CARP, it would be an NP-hard problem. Hence, this project gave an opportunity to study various TSP algorithms to come up with a constructive heuristic algorithm to solve the problem.

## **1.2 ORGANIZATION OF THE REPORT**

This report is organized as follows: Chapter 2 gives a brief of description of the related work and the literature survey done for this work. Chapter 3 analyses the system. The design of the system is described in Chapter 4. The system implementation is detailed in Chapter 5 and the results and are Output of the system is explained and highlighted in Chapter 6. Finally, conclusions are given Chapter 7 along with future scope.

Appendix 1 contain the sample code and screenshots. Final part of this report contains the “Reference” containing the list of paper that were referred for the project. This statistic means that India could be generating as much as 27 million more tons of waste than the US per year because of large population. Government of India has been trying for years to get a way out to handle the country’s ever-growing amount of trash. This project proposes a smart and efficient way to collect the trash. Nowadays, generating different types of solid wastes and manifestation of their associated social, economic and environmental inconsistencies create numerous complications for urban service management in regard to the collection, transportation, processing and disposal of such wastes. In general all routing problems related to the urban wastes collection a series of predefined edges is existed “A robust periodic capacitated arc routing problem for urban waste collection considering drivers and crew’s working time” [5] which is one of the major decisions in organizations such as municipalities in the context of the urban waste collection. This model aims to minimize total traversed distance and total usage cost of vehicles over a planning period. To solve the problem, an improved hybrid simulated annealing algorithm (SA) is developed based on a heuristic algorithm. It has been proved that the performance of the proposed algorithm is acceptable in comparison with the exact solution method. This also provided some applicable results according to the model of the integrated problem by considering working times, planning horizon and uncertainty

of demand in order to cover the gaps in the literature and create a managerial tool to be helpful in decision making processes.

Aksan Surya Wijaya, Zahir Zainuddin and Muhammad Niswar proposed a system "Design a Smart Waste Bin for Smart Waste Management" [1] aims to understand the Smart Waste Collection Routing Problem and the algorithm developed here considers the use of real-time information on the bins' fill-level to define dynamic routes. Genetic Algorithm is used to solve the travelling salesman problem for waste collection. Ultrasonic sensor which is placed on the top of bin collects the data and transmit to server side through GSM/GPRS shield. At sever end all information is stored on to database. Based on database plan for optimized path using genetic algorithm. The information collected by sensors is sent over the internet to a server where it is stored and processed. This information is then used for monitoring the waste bins using a web page and notifications is sent to the admin once the bin reaches the maximum level or weight or CO<sub>2</sub> level. The essential characteristics of this scheme are that it is planned to learn from experience and to make conclusion not only on the daily waste level status but also forecast future state, availability of vehicle near the site and other affecting factors. The information collected by sensors is sent over the internet to a server where it is stored and processed. This information is then used for monitoring the waste bins using a web page and notifications is sent to the admin once the bin reaches the maximum level or weight or CO<sub>2</sub> level

## **CHAPTER 2**

### **LITERATURE SURVEY**

#### **2.1 RELATED WORK**

A few smart bin methods and approaches for routing the garbage pickup have been summarized here.

Debajyoti Misra, Gautam Das, Triankur Chakraborty, Debaprasad Das has proposed “An IoT-based waste management system monitored by cloud” [2] that predicts the chance of overflow of the waste bin before it occurs so the environment is maintained clean from stink. Ultrasonic-level sensors take to sense the level of waste in a waste bin. The proposed system can sense the waste level and intensity of bio-gas generated in the municipal area. The information collected by sensors is sent over the internet to a server where it is stored and processed. This information is then used for monitoring the waste bins and decision to pick up the bin is made. The essential characteristics of this scheme are that it is planned to learn from experience and to make conclusion not only on the daily waste level status but also forecast future state. This helped to understand the efficient collection process which saves money, manpower and time.

Labib S M proposed Volunteer GIS (VGIS) Based Waste Management [7] that provides a common platform for citizens’ active participation in waste management, and also help bridge the gap between citizens and local government, thus would open opportunities for active e-governance. Geo-location of Dhaka city is studied, and the areas are divided into several wards based in city corporations numbers and the wards are differentiated based on their jurisdiction areas. The boundary of each words are collected as GIS shapefile from Dhaka city corporation office, later on these are converted in JSON format for overlaying with the Google map interfaces. Based on the report from an volunteer the admin and update the collection schedule. A full functional interactive Geoweb, for the volunteers who want to contribute in the waste management system provides real time data about waste related problems. Allow people to get general waste management related information like collection schedule.

ErfanBabaeTirkolaee, Iraj Mahdavi , Mir Mehdi SeyyedEsfahanifocuses on the optimal scheduling and routing of vehicles in periodic capacitated arc routing problems in their work “A robust periodic capacitated arc routing problem for urban waste collection considering drivers and crew’s working time” [5] which is one of the major decisions in organizations such as municipalities in the context of the urban waste collection. This model aims to minimize total traversed distance and total usage cost of vehicles over a planning period. To solve the problem, an improved hybrid simulated annealing algorithm (SA) is developed based on a heuristic algorithm. It has been proved that the performance of the proposed algorithm is acceptable in comparison with the exact solution method. This also provided some applicable results according to the model of the integrated problem by considering working times, planning horizon and uncertainty of demand in order to cover the gaps in the literature and create a managerial tool to be helpful in decision making processes.

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Töania Rodrigues Pereira Ramos , Carolina Soares de Moraes , Ana Paula Barbosa-Povoa propose “IoT based Waste Management: An Application to Smart City” [16] that the smart waste-bin system can be adapted into general waste-bin and it consists of the sensing units, a Bluetooth and GSM Module for data transmission, and a mobile application and web-based monitoring for interfacing and communication with the waste department for waste management.

Maya Chavan, T.R. Pattanshetti discussed in their “Survey on Municipal Waste Collection Management in Smart City” [10] that The waste collection and garbage-

truck allocation problem could be solved by traditional mathematical linear methods show insufficient efficiency in some more difficult cases of waste collection. The large amount of variables was the reason for large computation time. The recent research works use mostly the heuristic solutions and methods dealing with the municipal waste collection as with a Travelling Salesman Problem (TSP). Their survey introduces various on how to approach the waste collection algorithm.

Jose M. Gutierrez, Michael Jensen, Morten Henriksen and Tahir Riaz have proposed "Smart Waste Collection System Based on Location Intelligence[6] that details on Shortest Path Spanning Tree (SPST) and Genetic Algorithm (GA) approaches for routing algorithm for the collection process. The SPST is used for calculating the minimum distance between points and GA to minimize the driving distance for visiting the selected cans and returning to the headquarters.

## **2.2 INFERENCE OF THE LITERATURE SURVEY**

After the study, it is understood that the smart bins monitoring is very efficient as it does not pickup the bins that are not yet full and saves time and energy. Also the system becomes effective only when an efficient routing algorithm is implemented. It was found that most of the smart bin implementations used the periodic capacitated arc routing method for collection which doesn't use the maximum efficiency of the smart bins and the maximum capacity of the vehicles. Hence there is a need for most optimised routing and pickup methods that will reduce the overall cost and the distance travelled.

## **CHAPTER 3**

### **SYSTEM ANALYSIS**

#### **3.1 PROBLEM DEFINITION**

IoT based Internet of Things (IoT) and their applications have been gaining importance in Smart City solutions. To cope with high density of population, service automation for smart waste management system is needed. This project should propose a model to continuously monitor the waste bin and report to the authority. The model should also propose a route that is very cost effective to collect all the bins that are ready to be picked up.

#### **3.2 PROPOSED SOLUTION**

The intelligent sensor-based waste bin would estimate the level, weight of waste in it, presence of CO<sub>2</sub> need to be detected and notifications need to be sent to the central management for appropriate action. The concept proposed uses ultrasonic-level sensor takes to sense the level of waste in a waste bin, a load sensor to sense the weight of the thrash and a gas sensor to sense the level of alcohol(CO<sub>2</sub>) in the air. The information collected by sensors is sent over the internet to a server where it is stored and processed. This information is then used for monitoring the waste bins using a web page and notifications is sent to the admin once the bin reaches the maximum level or weight or CO<sub>2</sub> level. The essential characteristics of this scheme are that it is planned to learn from experience and to make conclusion not only on the daily waste level status but also forecast future state, availability of vehicle near the site and other affecting factors. The chance of getting a waste bin filled up is analysed depending on past data and the overflow of the waste bin is predicted before it occurs. For all the bins that are ready to picked up, a heuristic algorithm is used for efficient routing of the garbage pickup trucks. The route could be accepted or rejected by the admin. The webpage will tell the status of the bin at all times and will have all information about the vehicles available for pickup. A waste container is a container for temporarily storing waste, and is usually made out of metal or plastic. A special sonic transducer is used for the ultrasonic proximity sensors, which allows for alternate transmission and reception of sound waves.

### **3.3 OBJECTIVES**

- To develop a web application to monitor the levels and status of bin and to view the available vehicles for pickup
- To develop a technique that can efficiently create route for pickup and view the route proposed and store all the related statistics

### **3.4 FUNCTIONAL REQUIREMENTS**

- The smart bin should sense the level, weight and the ethanol presence effectively.
- System should notify the application if either the level or weight or ethanol gas reaches its limit
- System should propose an efficient route for the bins that have crossed the threshold and marked as filled
- System should be able to view the route and monitor all the bins
- System view all the information about the vehicles.

### **3.5 HARDWARE REQUIREMENTS**

- Operating System- Windows
- Processor- Intel core i3. 3.60GHz
- RAM- 4 GB or more
- System type- 32 or 64 bit Operating System

### **3.6 SOFTWARE REQUIREMENTS**

#### ***3.6.1 Application Programming Interfaces***

- XAMPP

XAMPP is a free and open-source cross-platform web server solution stack packaged developed by Apache Friends, consisting mainly of the Apache HTTP Server, MariaDB database, and interpreters for scripts written in the PHP and Perl programming languages. Since most actual web server

deployments use the same components as XAMPP, it makes transitioning from a local test server to a live server possible.

- MYSQL

MySQL is (as of March 2014) the world's second most widely used open-source relational database management system (RDBMS). The MySQL development project have made its source code available under the terms of the GNU General Public License, as well as under a variety of proprietary agreements. MySQL is a popular choice of database for use in web applications, and is a central component of the widely used LAMP open source web application software stack (and other 'AMP' stacks). LAMP is an acronym for "Linux, Apache, MySQL, and Perl/PHP/Python." Free-software-open source projects that require a full-featured database management system often use MySQL.

## **CHAPTER 4**

### **SYSTEM DESIGN**

#### **4.1 PURPOSE**

This system design chapter aims in knowing the logical view of architecture design, sequence diagram, data flow diagram, user interface design of the software that are used in performing the operations such as transferring the data to server, design of web page to view the bin status and the admin controls regarding the system.

#### **4.2 SCOPE**

The scope of this design chapter is to describe the overall features of the system by defining the requirements and establishing the high-level view of the system. During architectural design, the various web pages and their interconnections are identified and designed. The major software components are identified and decomposed into processing modules and conceptual data structures and the interconnections between the modules are identified. The modules are identified in the proposed system the main features of the system such as the hardware design including the bin, the data send/receive design and later webpage that uses the data for the user to perform all operations related to the waste management process.

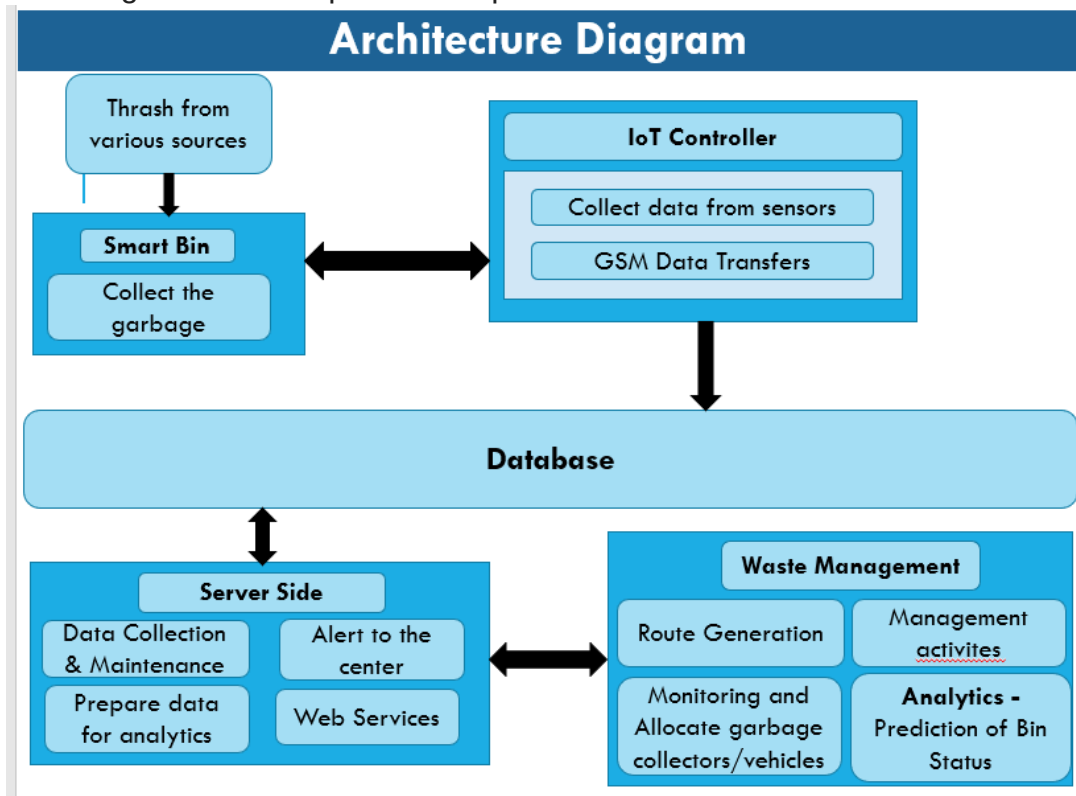
#### **4.3 MODULES**

To make the implementation of this waste management system more efficient and easy manageable with respect to testing, integration and better code is under maintenance it is broke down into controllable modules. This proposed system contains the three main modules and are referred in the architecture diagram *Fig:4.1 : Architecture Diagram* below.

- Bin with sensors to support the smart system
- IoT Board – to transfer data from the bin to the server
- Web page to view/monitor bin status, route generation and perform all admin actions

## 4.4 USE CASES

A use case diagram at its simplest is a representation of a user's interaction with the



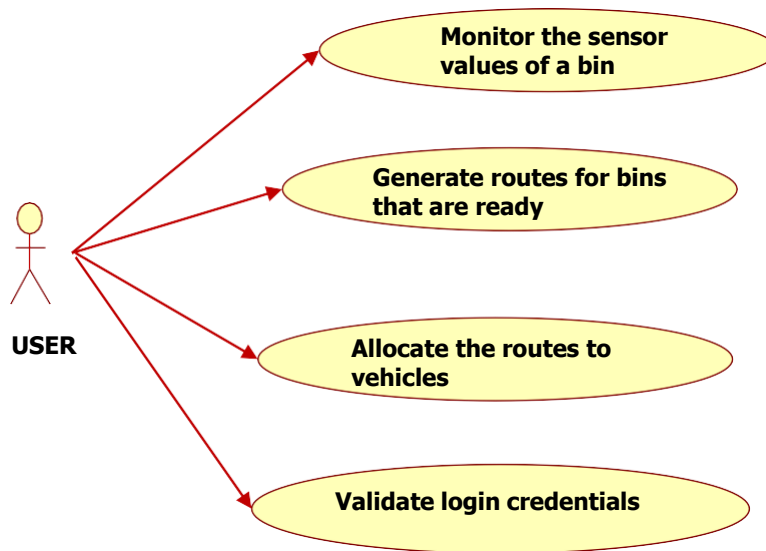
**Fig:4.1 : Architecture Diagram**

the system that shows the relationship between the user and the different use cases in which the user is involved. A use case diagram can identify the different types of users of a system and the different use cases and will often be accompanied by other types of diagrams as well.

### 4.4.1 Webpage-UserModule

In the webpage-user module the actor is the user and this module allows the user to monitor the bin, vehicle status and generate the routes. Following is the UML diagram is the same. To make the implementation of this waste management system more efficient and easy manageable with respect to testing, integration and better code is under maintenance it is broke down into controllable modules. The metro cities and major economic hubs generate the maximum volume of waste, but a survey of 20 smaller cities selected to be developed as smart cities show that most are struggling to manage waste. This information is then used for monitoring the waste bins using a

web page and notifications is sent to the admin once the bin reaches the maximum level.



**Fig: 4.2 : UML For Webpage-User Module**

**Table 4.1 : Webpage-User Module UML Description**

| Use Case      | Description                                                                                                                                               |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Actor         | User                                                                                                                                                      |
| Pre-Condition | Database connection should be established.                                                                                                                |
| Main Scenario | Waste bin's level, weight and CO2 level is monitored. Bins that are ready are used to generate the pickup route(s). Admin approves/disapproves the routes |

|                       |                                                                                                                       |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| <b>Post Condition</b> | Generated routes can be viewed. Bin and vehicle status can be monitored. Routes generated for a day can be monitored. |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------|

## 4.5 GRAPHICAL USER INTERFACE

A user interface that helps the user monitor the bin status and auto generate the efficient route for all the bins that are ready is created using php. The use case explained in Fig: 4.2 : UML For Webpage-User **Module** is performed using this GUI. The web page first authenticates the login credentials and allows the admin to perform the following.

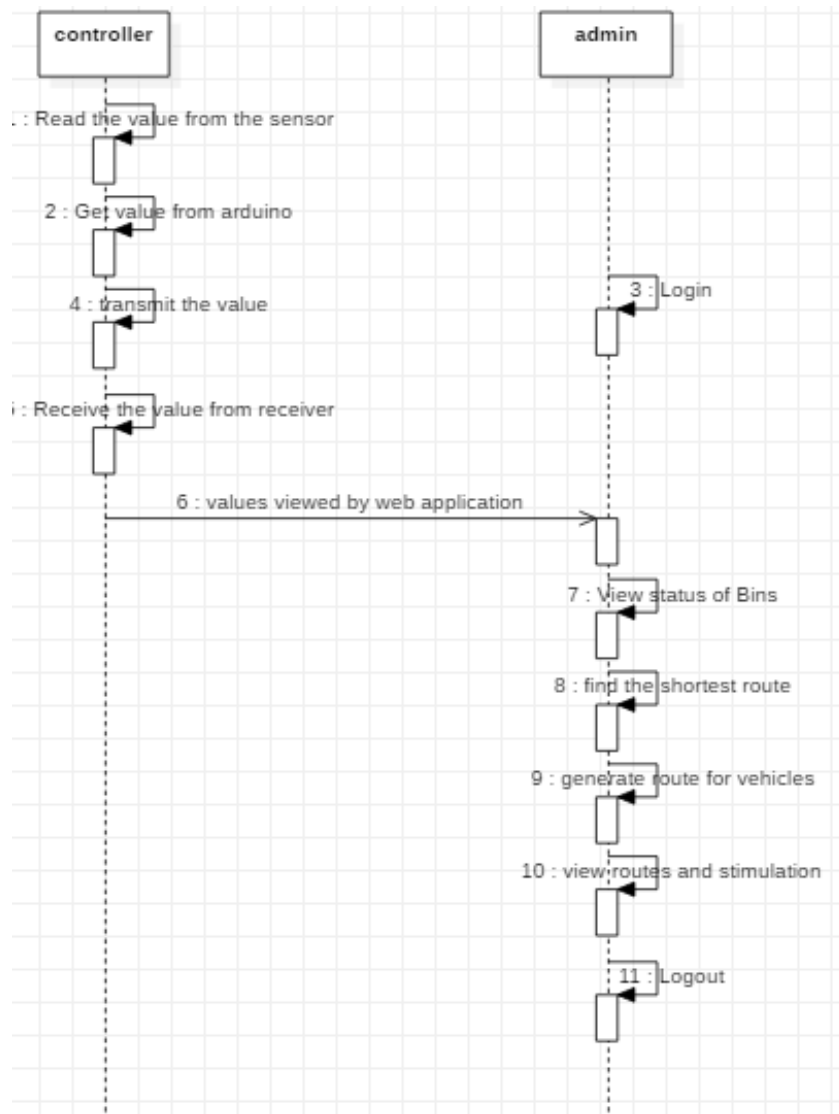
- Allows to add/edit a bin at a location.
- Allows to add/edit a vehicle at a location.
- Should be able to view the status (level, weight and CO<sub>2</sub> level) of all the bins.
- Generate route for all the bins that are full.
- Accept or reject the routes generated.
- View the route generated.

### Sequence Diagram for the Web Application

The sequence diagram for the Web Application is mentioned in the below Fig: 4.3 :Sequence Diagram For Web Application that explains the sequence of actions that happens in the web application.

The metro cities and major economic hubs generate the maximum volume of waste, but a survey of 20 smaller cities selected to be developed as smart cities show that most are struggling to manage waste. So, there should be an improvement in the waste management techniques. Early garbage removal trucks were simply open bodied dump trucks pulled by a team of horses. They became motorized in the early part of the 20th century and the first close body trucks to eliminate odours with a dumping lever mechanism were introduced in the 1920s in Britain. If the garbage level in the bin is crossing the first threshold level,

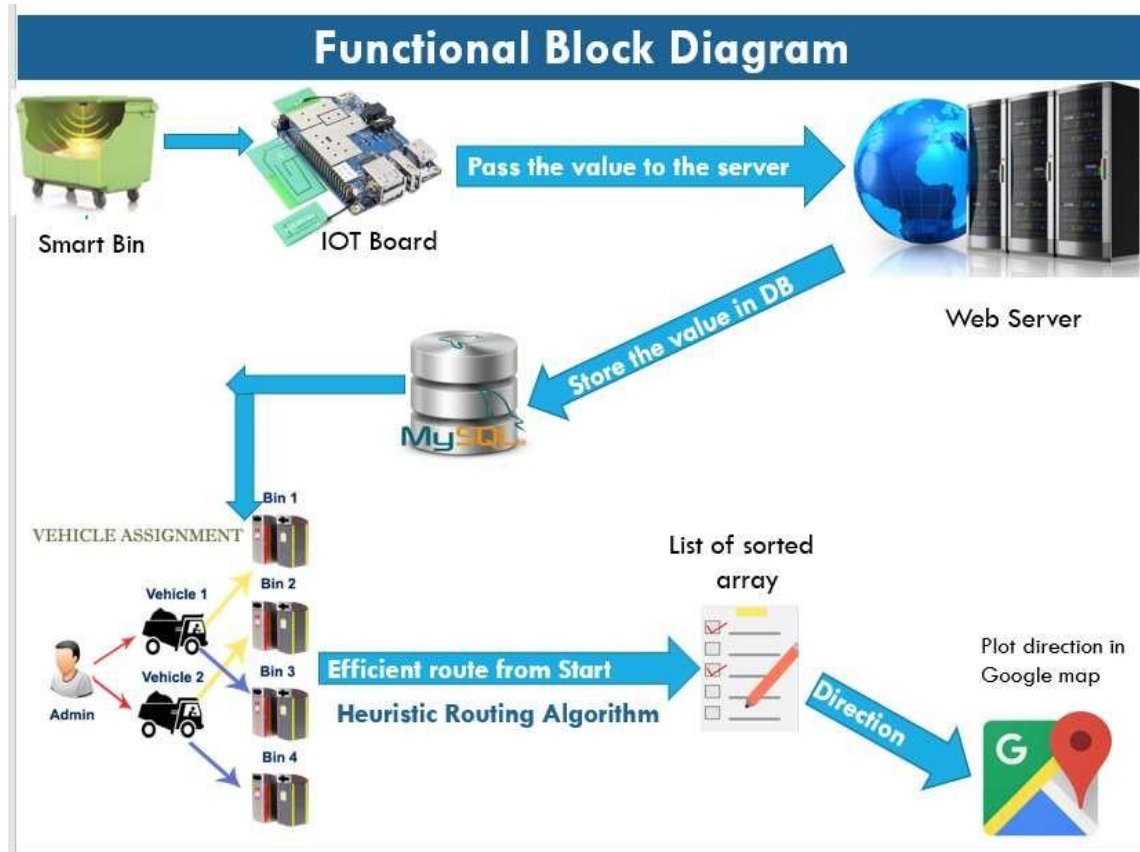
then the first warning message is generated and sent to the municipality. Besides, the green LEDs will be turned ON in order to alert all the residents at every floor. Next, if the garbage level in the bin is crossing the second threshold level, then the second warning message is generated and sent to the municipality. In this case, all the residents will be alerted when the red LEDs are turned ON.



**Fig: 4.3 :Sequence Diagram For Web Application**

## Functional Block Diagram

The overall functional flow of the system is depicted in the following Fig:4.4 : Functional Block Diagram.



**Fig:4.4 : Functional Block Diagram**

The main component of this waste management system is to make the trash bin integrated with three sensors namely the load sensor to sense the weight of the trash, ultrasonic sensor to sense the level of the trash put into the bin, a gas sensor to sense the alcohol level in the bin. This sensor-based waste bin would estimate the level, weight of waste in it, presence of CO<sub>2</sub> and send these data to server through IoT Board using GSM. These data notifications need to be sent to the central management for appropriate action. The information collected by sensors is sent over the internet to a server where it is stored in MySQL database and later processed by the web application. This information is then used for monitoring the waste bins using a web page and notifications is sent to the admin once the bin reaches the maximum

level or weight or CO<sub>2</sub> level. All the bins are continuously monitored. All the bins are marked as FULL when either their level raises more than the admin defined threshold or when the weight reaches admin defined max threshold or the alcohol (CO<sub>2</sub>) level in the atmosphere raise more than the admin defined threshold. The bins that have the status FULL are considered as the bins that has to be picked up. The location of the bins are available by the GPS unit of the bin. Using these locations an effective route is generated using the heuristic routing algorithm. The algorithm is explained in detail implementation chapter. The generated routes can be assigned to the vehicles by the admin. The webpage will give the admin the option to view the routes. The following section the document will explain the implementation in detail.



**Fig: 4.5 : Arduino Uno**

The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button. This contains all the required support needed for microcontroller.

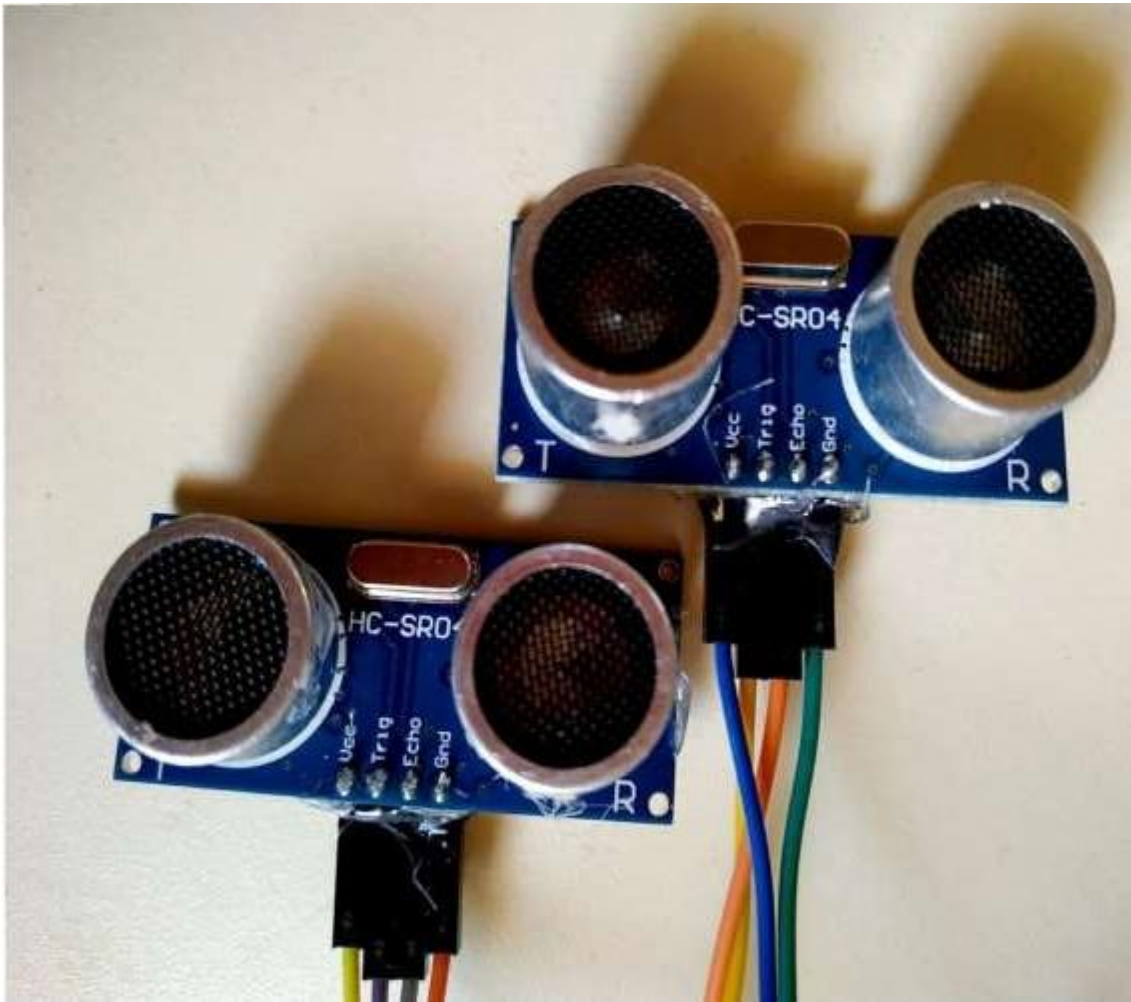
Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. It can be used in any application where you need to connect a device to your local network or internet.



**Fig:4.6: Wifi Serial IOT**

The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. This module comes with AT commands firmware which allows you to get functionality like arduinowifi shield, however you can load different firmwares to make your own applicaiton on the modules' memory and processor. Its a very economic module and has a huge and growing community support.

This module has onboard 80Mhz low power 32 bit processor which can be used for custom firmwares. This also means that you can host small webpages without any external controller. For more details see : NODEMCU . The ESP8266 supports APSD for VoIP applications and Bluetooth co-existance interfaces, it



**Fig: 4.7: Ultrasonic Sensor**

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity.

Ultrasonic sensors can be used for many applications, including precise detection of objects and contactless monitoring of fill levels. ... They generate high frequency sound waves and evaluate the echo which is received back by the sensor. The web application mainly eases the monitoring of the bins along with some admin functionalities. This is done by placing the Arduino board with sensors at the waste bin, which transmits the sensor data to the server through IoT Board-GSM. The web application mainly eases the monitoring of the bins along with some admin functionalities. The architecture diagram of the application is mentioned in Fig:5.1 : Application Architecture. The bin details can be edited by the administrator if needed.

This module has onboard 80Mhz low power 32 bit processor which can be used for custom firmwares. This also means that you can host small webpages without any external controller. For more details see : NODEMCU . The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

ESP8266 is transforming the world with its low cost and high features which makes it an ideal module for Internet Of Things (IOT). It can be used in any application where you need to connect a device to your local network or internet. The metro cities and major economic hubs generate the maximum volume of waste, but a survey of 20 smaller cities selected to be developed as smart cities show that most are struggling to manage waste. So, there should be an improvement in the waste management techniques. Early garbage removal trucks were simply open bodied dump trucks pulled by a team of horses. They became motorized in the early part of the 20th century and the first close body trucks to eliminate odours with a dumping lever mechanism were introduced in the 1920s in Britain. If the garbage level in the bin is crossing the first threshold level, then the first warning message is generated and sent to the municipality. contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

ESP8266 is transforming the world with its low cost and high features which makes it an ideal module for Internet Of Things (IOT). It can be used in any application where you need to connect a device to your local network or internet. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity.

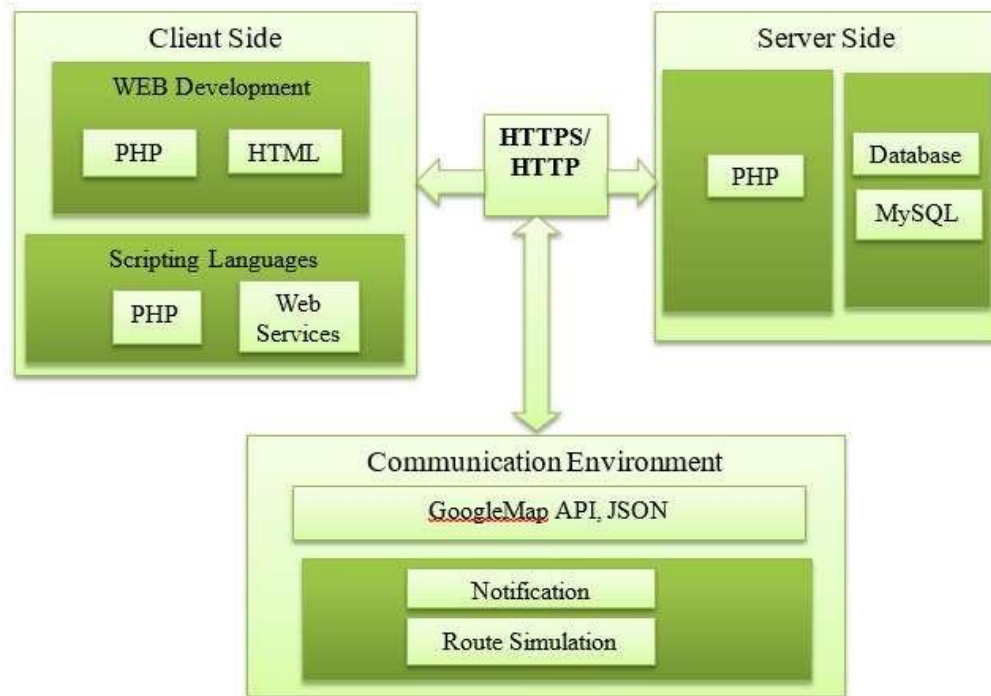
## **CHAPTER 5**

### **SYSTEM IMPLEMENTATION**

#### **5.1 WEB BASED WASTE MANAGEMENT APPLICATION**

The project enables the organizations to meet their needs of smart garbage management system. This system allows the user to know the fill level of each garbage bin in a locality or city at all time, to give a cost effective and time saving route to the truck drivers. This system would be able to automate the solid waste monitoring process and management of the overall collection process using IOT (Internet of Things). The system consist of main subsystems namely Smart Trash System(STS) and Smart Monitoring and ControllingHut(SMCH).In the system, whenever the waste bin gets filled or weight reaches maximum threshold or alcohol level reaches above the threshold a notification is sent to the web application. This is done by placing the Arduino board with sensors at the waste bin, which transmits the sensor data to the server though IoT Board-GSM.

The web application mainly eases the monitoring of the bins along with someadmin functionalities. The architecture diagram of the application is mentioned in Fig:5.1 : Application Architecture. With the web application, the administrator will be view all dustbins. The admin will be able to register/add new dustbin in a location by dragging the location in the map. The latitude and longitude of the dragged location will be retrieved to locate the bin. The bin details can be edited by the administrator if needed. The administrator will be able to add new vehicle details like capacity, name, starting point etc. The web portal will provide functionality to manage the system and the dustbin information.The dustbin sensor data can monitored continuously. It will also give notifications when a bin becomes FULL. , if the garbage level in the bin is crossing the second threshold level, then the second warning message is generated and sent to the municipality. In this case, all the residents will be alerted when the red LEDs are turned ON. The accepted routes can be viewed in the simulation window.The routes generated can then be approved or dismissed by the admin.



**Fig:5.1 : Application Architecture**

The bins that are ready to be picked up are used to generate the pickup routes and trips using the heuristic algorithm as explained in section 5.1.1 below. The routes generated can then be approved or dismissed by the admin. The accepted routes can be viewed in the simulation window.

### **5.1.1 Heuristic Routing Algorithm**

This section explains on algorithm used for generating the route or the bins that are ready to pick up. The problem is to determine the optimal number of vehicles, the optimal tour for each vehicle including possible multiple trips which minimizes the usage cost of vehicles and the traversing cost of all traversed edges in all time periods of planning. In this problem, the vehicles are in the depot, firstly. They begin their tour to service the required edges through collecting wastes and then, return to the depot after filling their capacity. The capacity constraint of vehicles and their maximum available times result in determining the number of required vehicles. The step by step algorithm is explained in **Error! Reference source not found.**

The Routing approach performs, in an integrated way, the choice of the bins to be visited each day and the best sequence to collect them while guaranteeing the maximum profit. This maximum overflowing threshold represents a maximum usage of the bins' capacity. In this model, the number of vehicles to be used is a decision variable and forcing the model to allocate to the operation the least possible number of vehicles. Considering an operational decision level, the routes to be performed at day are decided in the morning of day, after receiving the real-time information on the bins' fill-level, as shown in **Error! Reference source not found..** The model is run every morning, defining the sequence of bins to be visited for each day, considering the ones that are worth to be collected given its fill-level and the transportation cost incurred to collect them. The step by step algorithm is explained in **Error! Reference source not found..**

## 5.2 PROBLEM ASSUMPTIONS

The algorithm has some limitations and assumptions that are detailed below.

- The objective function, in addition to the minimization of traversing cost of the edges, is to minimize the number of required vehicles to meet the total demand.
- Only one depot is considered in the problem.
- The starting point for all the vehicles is restricted to one point
- The depot and starting point are assumed to be the same location
- The vehicles are homogenous, and the graph network is asymmetric.
- Each vehicle begins the tour from the starting point and returns to the depot.
- Each type of vehicle has a unique average speed and waste loading/unloading time on each edge.
- Vehicle usage cost is the cost paying to the driver and fuel cost for each vehicle.
- Each vehicle has a maximum duration of service denoting the working time of its driver and crew.
- Each vehicle may have multiple trips.

Due to the high degree of the problem complexity and also, considering uncertainty in the constraints of the proposed model, solving the problem by the exact method is only possible in small size problems. Therefore, in this section, a heuristic

algorithm developed to solve the problem approximately. The heuristic algorithm is implemented to generate solutions sorted based of the shortest distance to service the bins. The traversing cost between two required bins is the shortest path between them which has been determined by Distance Matrix lat long algorithm (Google APIKey -Dijkstra algorithm).The best solution or any other solutions can be chose by the admin and assigned to a particular vehicle.

### 5.3 MATHEMATICAL IMPLEMENTATION

In this section, the mathematical model of the proposed problem is presented. For this purpose, sets, parameters, and variables are defined firstly. The goal of the algorithm is to achieve the min Cost as low as possible.

#### 5.3.1 Sets

V: Set of the nodes in the graph network

K: Set of the vehicles

E: Set of all the edges defined in the network

T: Set of trips

#### 5.3.2 Parameters

$d_{ij}$ : Traversing distance of the edge  $(i,j) \in E$

$cv_k$ : Usage cost of kth vehicle

$W_k$ : Capacity of kth vehicle in each trip

#### 5.3.3 Decision variables

$x_{ijk}^t$  : 1 if edge  $(i,j) \in E$  is traversed by  $t^{\text{th}}$  trip of vehicle k in trip t, otherwise 0.

$u_{kt}$ : 1 if vehicle k is used in trip t, otherwise 0.

$$\text{MinCost} = \sum_{(i,j) \in E} \sum_{k \in K} \sum_{t \in T} x_{ijk}^t d_{ij} + \sum_{k \in K, t \in T} cv_k u_{kt}$$

Step 1: Select all the bins that are ready to be collected. Each bin will be a node.

Step 2: Chose the demand parameter (future work). For now, shortest distance will be the only parameter for consideration.

Step 3: Calculate the number of trips based on the to be picked up bin capacity. If the bin has capacity 'c' while a truck has capacity 'C', then the truck can load waste form maximum  $C / c$  bins.

Step 4: Admin chooses the vehicle for allocation of trips. Based on the allocation we will now have the total number of routes to be generated

Step 5: Choose the first trip

Step 6: Sort the available bins as per shortest distance from the starting point of the vehicle. This is to make sure that the minCost is as low as possible

Step 7: Choose the bin with shortest edge and add it to the trip. Remove the bin from the available bins and move the vehicle's starting point to the selected bin's location

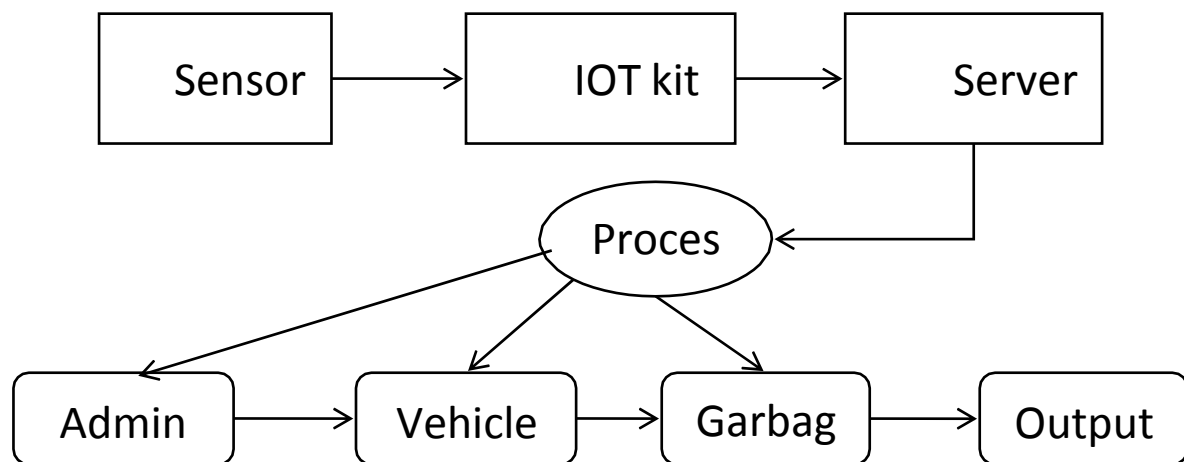
Step 8: Repeat steps 4,5 until the vehicle capacity ( $W_k$ ) is reached or if there are no more bins

Step 9: Display the route generated for the vehicle for the admin to approve

Step 10: If there are any more bins to be served, select the next available vehicle or add a new trip to the already selected vehicle and repeat steps 4 to 8 until no more bins are there to be served.

When the Heuristic algorithm ends, the best solution will be suggested for the admin to choose and confirm the routes for the vehicles.

#### 5.4 SYSTEM ARCHITECTURE



**Fig: 5.2 : Flow Design**

Using the sensors the data is collected from the garbage bins. From sensors the data is sent to IOT kit where it contains the wifi serial . notifications are sent to the

vehicles to collect the garbage available in a particular location. Periodically the process will be continued and the amount of waste can be reduced by informing the users.

The Routing approach performs, in an integrated way, the choice of the bins to be visited each day and the best sequence to collect them while guaranteeing the maximum profit. This maximum overflowing threshold represents a maximum usage of the bins' capacity. In this model, the number of vehicles to be used is a decision variable and forcing the model to allocate to the operation the least possible number of vehicles. Considering an operational decision level, the routes to be performed at day are decided in the morning of day, after receiving the real-time information on the bins' fill-level, as shown in **Error! Reference source not found.** The model is run every morning, defining the sequence of bins to be visited for each day, considering the ones that are worth to be collected given its fill-level and the transportation cost incurred to collect them. The step by step algorithm is explained in **Error! Reference source not found.**

In this problem, the vehicles are in the depot, firstly. They begin their tour to service the required edges through collecting wastes and then, return to the depot after filling their capacity. The capacity constraint of vehicles and their maximum available times result in determining the number of required vehicles. The step by step algorithm is explained in **Error! Reference source not found.** Due to the high degree of the problem complexity and also, considering uncertainty in the constraints of the proposed model, solving the problem by the exact method is only possible in small size problems. Therefore, in this section, a heuristic algorithm developed to solve the problem approximately.

## CHAPTER 6

### RESULT AND ANALYSIS

#### 6.1 WEB APPLICATION PHASE

Everyday the bins that have the status FULL are filtered and are displayed in the route planner. The route planner will suggest the number of trips needed to pickup all the bins based on the capacity of the registered bins. This output for the number of routes and number of vehicles needed is shown in Fig:6.1 : Route Planner UI

The screenshot displays the 'Route Planner' interface within a 'Waste Management' system. It features a sidebar with navigation options: Dashboard, Bin Info, Vehicle Info, and Route Planner (highlighted). The main content area is titled 'Route Planner' and contains a 'Filled Bin Details' section with a 'REFRESH' button. Below this is a table of 8 bins, all with a 'Full' status. The table columns are #, Bin ID, User Name, Capacity, Curr. Level, Location, and Status. Below the table, it indicates 'Showing 1 to 8 of 8 entries' with 'Previous' and 'Next' navigation links. The bottom section shows the calculated results: 'Number of Trips Need : 2 (Ready for the Trip)' and 'List of Vehicles Available'. A table below this lists two vehicles (Veh\_001 and Veh\_002) and their assigned trips (Trip 1 and Trip 2), each with a 'View Details' button.

| # | Bin ID   | User Name   | Capacity          | Curr. Level   | Location | Status |
|---|----------|-------------|-------------------|---------------|----------|--------|
| 1 | TBM_003  | Test User 3 | W_10 Kg - H_25 Cm | 10kg - 25Cm   | View     | Full   |
| 2 | TBM_004  | Test User 4 | W_10 Kg - H_25 Cm | 10kg - 25Cm   | View     | Full   |
| 3 | TBM_007  | Test User 7 | W_10 Kg - H_25 Cm | 10kg - 25Cm   | View     | Full   |
| 4 | TBM_008  | Test User 8 | W_10 Kg - H_25 Cm | 10kg - 25Cm   | View     | Full   |
| 5 | TBM_009  | Test User 9 | W_10 Kg - H_25 Cm | 10kg - 25Cm   | View     | Full   |
| 6 | TBM_01   | Test User 1 | W_10 Kg - H_25 Cm | 10kg - 25Cm   | View     | Full   |
| 7 | LIVE_001 | LIVE BIN    | W_10 Kg - H_25 Cm | 100kg - 100Cm | View     | Full   |
| 8 | EAR_001  | Test User 1 | W_10 Kg - H_25 Cm | 10kg - 25Cm   | View     | Full   |

Showing 1 to 8 of 8 entries

Number of Trips Need : 2  
(Ready for the Trip)

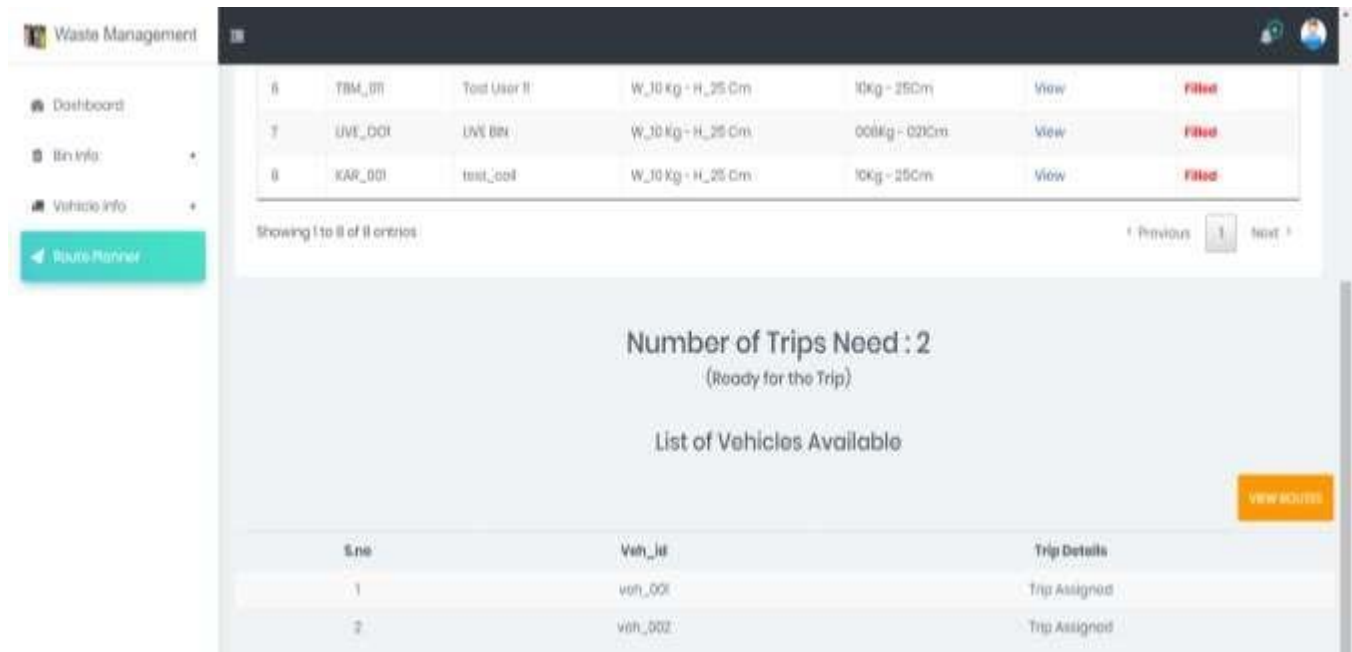
List of Vehicles Available

| S.No | Veh_Id  | Trip Details |
|------|---------|--------------|
| 1    | veh_001 | Trip 1       |
| 2    | veh_002 | Trip 2       |

**Fig:6.1 : Route Planner UI**

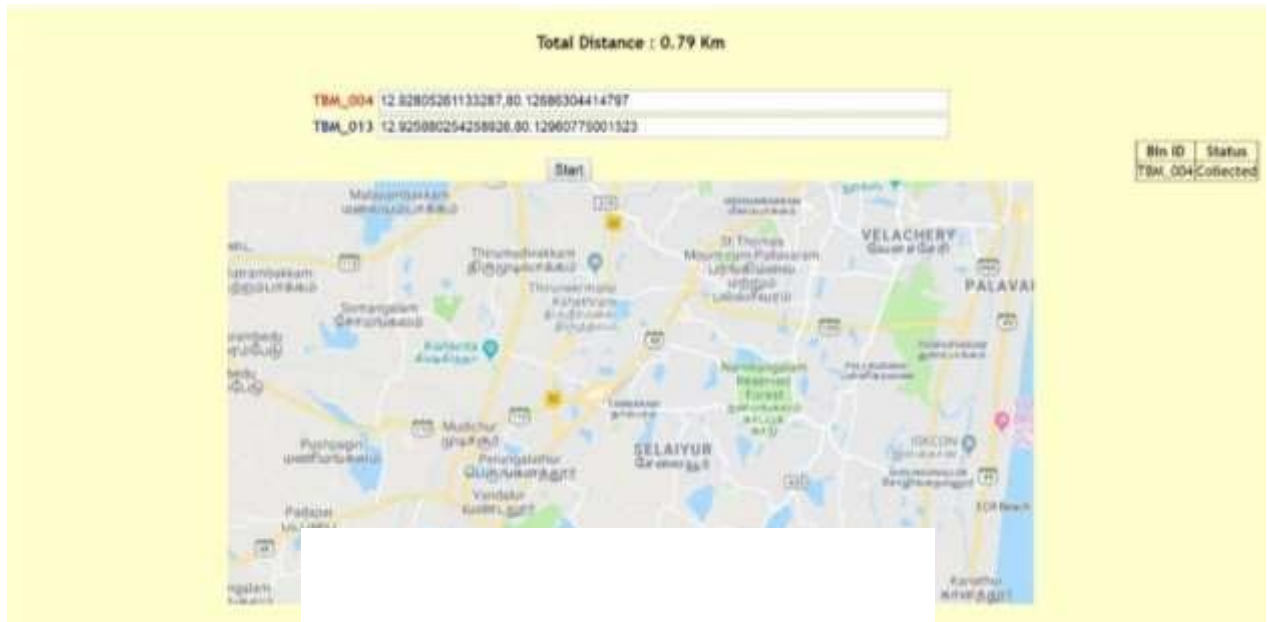
Once the trips are assigned to the vehicles the shortest route will be generated and the routes for trips are assigned to the vehicles can be viewed through

simulation. After the assignment the output screen will look like Fig: 6.2 :Route Planner UI After Trip Assigned.

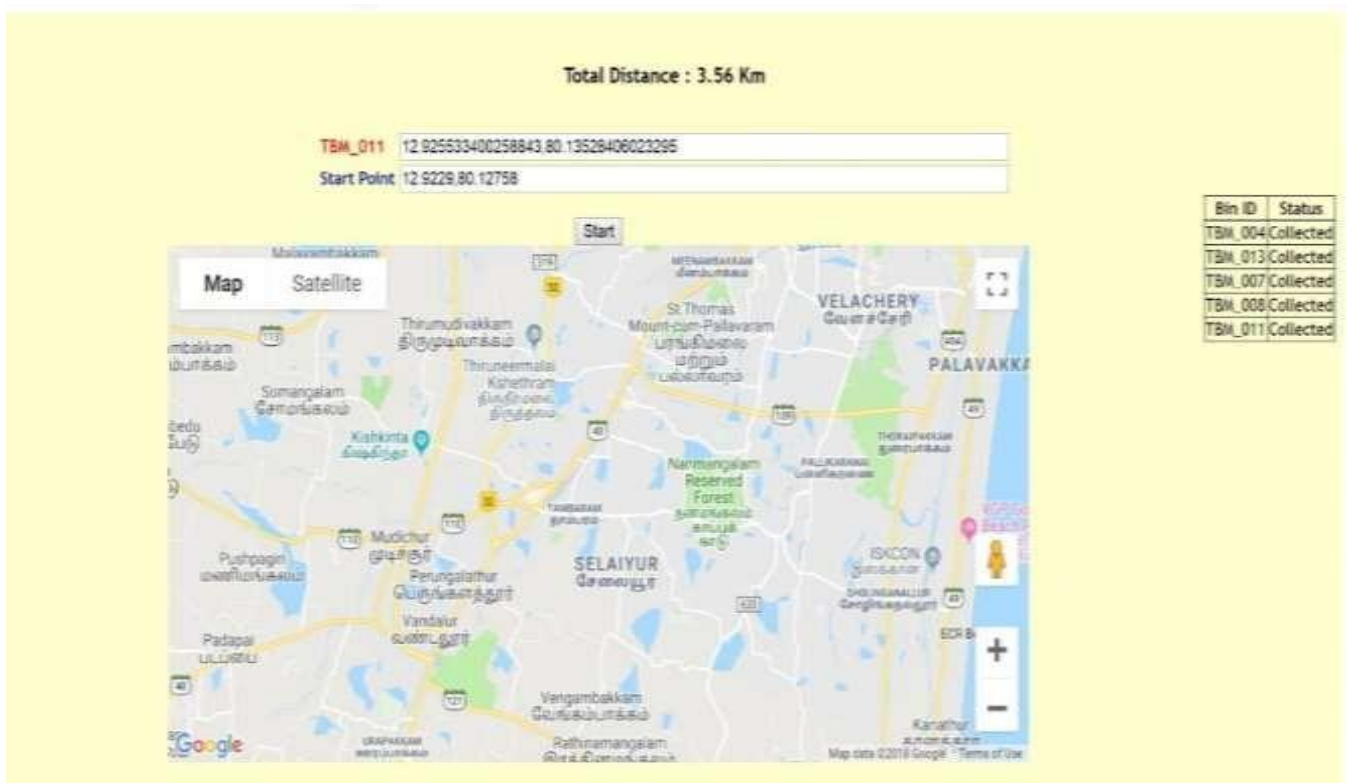


**Fig: 6.2 :Route Planner UI After Trip Assigned**

Once the trips are assigned to the vehicles generated routes can be viewed through simulation. The simulation shows the actual route that will be taken by the garbage truck driver and simulates the bin collected status as it reaches every bin. The vehicles are sent to the respective places and the garbage will be collected based on the time lapse which we have set in our data base. The route planner will suggest the number of trips needed to pickup all the bins based on the capacity of the registered bins. The simulation shows the actual route that will be taken by the garbage truck driver and simulates the bin collected status. After the assignment the output screen will look like Fig 6.2. Due to the high degree of the problem complexity and also, considering uncertainty in the constraints of the proposed model, solving the problem by the exact method is only possible in small size problems. Therefore, in this section, a heuristic algorithm developed to solve the problem approximately.



**Fig:6.3 :Simulation Of Generated Route 1**



**Fig: 6.4 : Simulation Of Generated Route 2**

## **CHAPTER 7**

### **CONCLUSION AND FUTURE WORK**

#### **7.1 CONCLUSION**

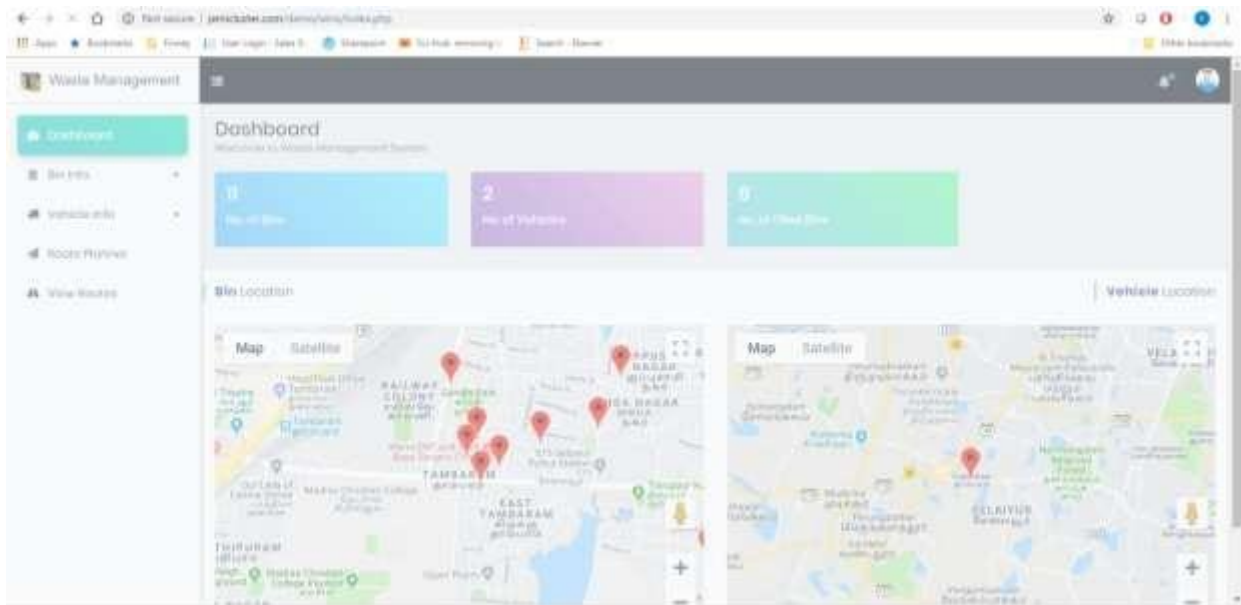
This project work presents an smartgarbage collection system for a smart city. The model is based on an Internet of Things sensing trashcan which measures the waste level and presence of bad smell gases and sends this information to a server for storage and processing over the internet. These data help to create an efficient collection process which saves money, manpower and time. The efficiency and economic feasibility of the system are represented in detail. It reduces chance overflow, as data are uploaded four times a day and municipal authority is aware of dustbin's physical condition. As the bad smell starts to generate, information reaches to responsible authority so that they can take necessary action. The optimal scheduling and routing of vehicles using the heuristic algorithm optimizes the total cost in planning and scheduling of vehicles by reducing the number of required vehicles and determining the optimal routes. The objective of maintain a clean and healthier city is thus achieved.

#### **7.2 FUTURE WORK**

As an extension to this project work, predictive analysis can be used on how quick the bin will fill and plan the routing for the bin pickup accordingly so that more efficiency in fuel and time is achieved. This will help to use the vehicle capacity in max. Also a mobile application can be developed for the drivers to update the bin status after pickup and also help them with easy navigation. In addition to this using special cameras so that the type of waste can also be recognized, and appropriate decisions can be made.

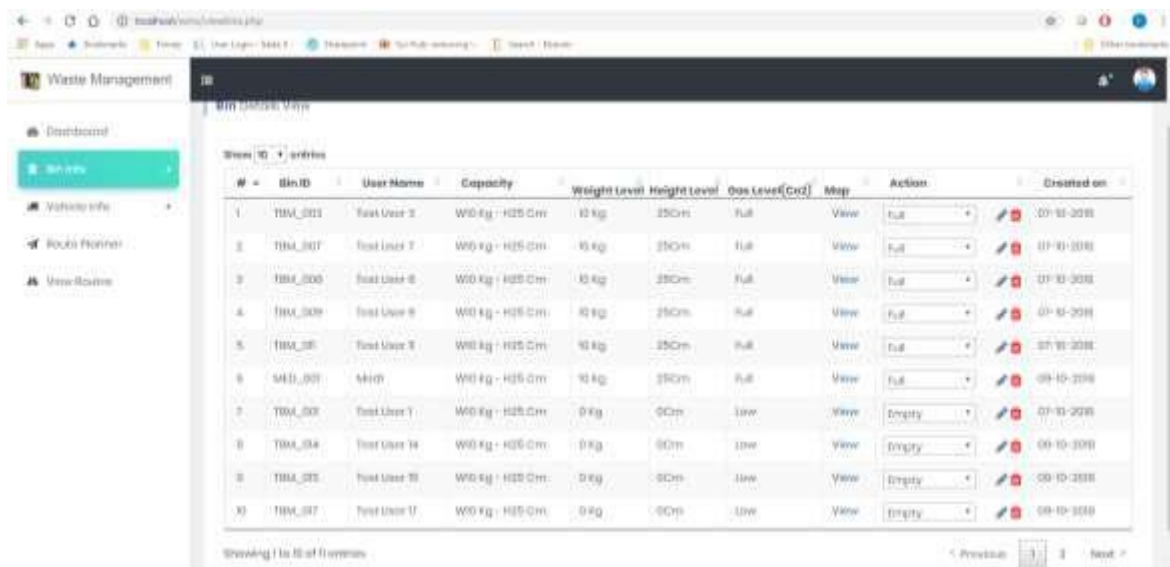
The optimal scheduling and routing of vehicles using the heuristic algorithm optimizes the total cost in planning and scheduling of vehicles by reducing the number of required vehicles and determining the optimal routes. The objective of maintain a clean and healthier city is thus achieved.

## SCREENSHOTS



**Fig:7.1 :Main Dashboard**

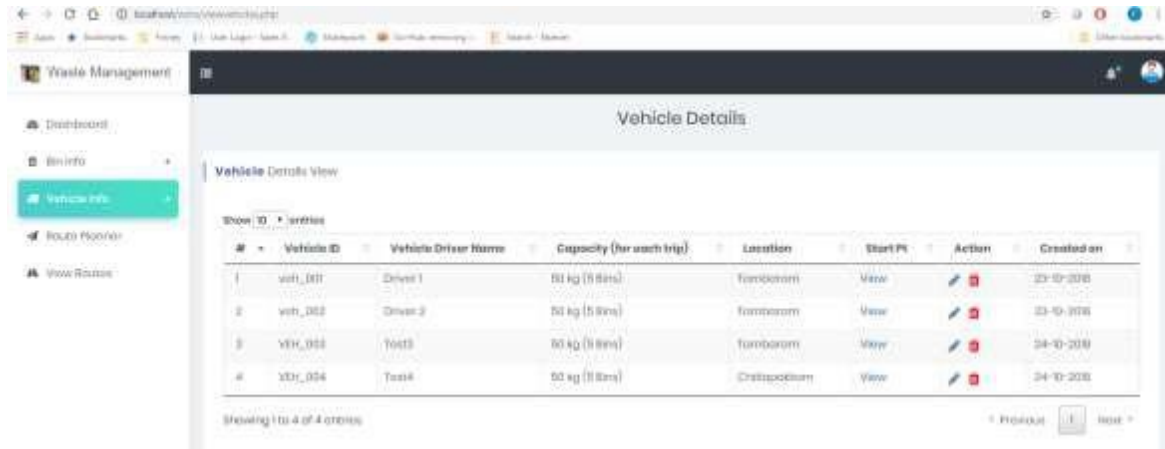
Fig:7.1 :Main Dashboard shows the main dashboard of the web application.



**Fig: 7.2 :View Bin UI**

All the bins and the vehicles can be viewed in the web application for admin usage. These screen shots are shown in Fig: 7.2 :View Bin UI and Fig:7.3 :View Vehicle UI. View.

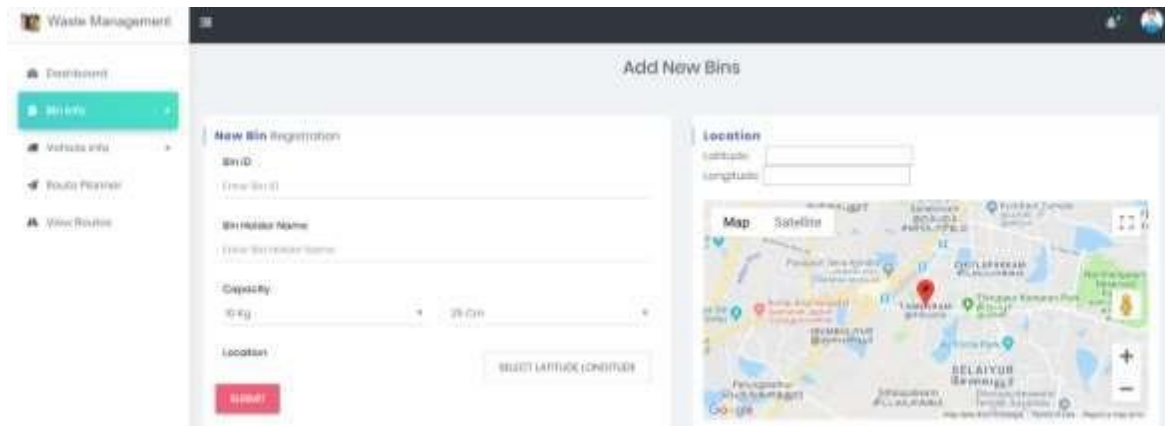
All the bins and the vehicles can be viewed in the web application for admin usage. These screen shots are shown in *Fig: 7.2 :View Bin UI* and *Fig:7.3 :View Vehicle UI*.



| # | Vehicle ID | Vehicle Driver Name | Capacity (for each trip) | Location   | Start Pt | Action                                                                                                                                                                  | Created on |
|---|------------|---------------------|--------------------------|------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 1 | veh_001    | Driver 1            | 50 kg (5 Bins)           | Tomborom   | View     |   | 23-10-2018 |
| 2 | veh_002    | Driver 2            | 50 kg (5 Bins)           | Tomborom   | View     |   | 23-10-2018 |
| 3 | VEH_003    | Tosik               | 50 kg (5 Bins)           | Tomborom   | View     |   | 24-10-2018 |
| 4 | VEH_004    | Tosik               | 50 kg (5 Bins)           | Chitsoodum | View     |   | 24-10-2018 |

**Fig:7.3 :View Vehicle UI**

New bin and new vehicles can be added through UI shown in the following Fig: 7.4 : Add New Bin UI and Fig: 7.5 :Add new Vehicle UI.



**Fig: 7.4 : Add New Bin UI**

The optimal scheduling and routing of vehicles using the heuristic algorithm optimizes the total cost in planning and scheduling of vehicles by reducing the number of required vehicles and determining the optimal routes. The objective of maintain a clean and healthier city is thus achieved. Server page contains all the available data

collected for each time gap. It is actually developed by us using PHP and various web technologies.

The screenshot shows a web application for 'Waste Management'. On the left is a sidebar menu with options: 'Dashboard', 'Bin info', 'Vehicle info' (highlighted in green), 'Route Planner', and 'View Routes'. The main content area is titled 'Add New Vehicle'. It features a 'New Vehicle Registration' form with the following fields: 'Vehicle ID' (with a hint 'Enter vehicle ID'), 'Vehicle Driver Name' (with a hint 'Enter driver name'), 'Capacity' (with a hint 'Enter capacity'), and 'Location' (with a hint 'Select Start Point' and a dropdown arrow). A red 'Submit' button is at the bottom of the form.

**Fig: 7.5 :Add new Vehicle UI**

The screenshot shows a web browser displaying a 'Server Page' with a table of waste bin data. The table has four columns: 'sno', 'Dustbin 1', 'Dustbin 2', and 'Date'. It displays 10 rows of data, all with 'EMPTY' status for both dustbins. The background shows a street scene with a waste collection vehicle.

| sno | Dustbin 1 | Dustbin 2 | Date                |
|-----|-----------|-----------|---------------------|
| 1   | EMPTY     | FULL      | 2020-02-21 10:40:37 |
| 2   | EMPTY     | EMPTY     | 2020-02-21 10:36:43 |
| 3   | EMPTY     | EMPTY     | 2020-02-21 10:36:41 |
| 4   | EMPTY     | EMPTY     | 2020-02-21 10:36:39 |
| 5   | EMPTY     | EMPTY     | 2020-02-21 10:36:28 |
| 6   | EMPTY     | EMPTY     | 2020-02-21 10:36:26 |
| 7   | EMPTY     | EMPTY     | 2020-02-21 10:36:24 |
| 8   | EMPTY     | EMPTY     | 2020-02-21 10:36:22 |
| 9   | EMPTY     | EMPTY     | 2020-02-21 10:36:21 |
| 10  | EMPTY     | EMPTY     | 2020-02-21 10:35:36 |

Showing 1 to 10 of 64 entries

**Fig: 7.6 : Server Page**

Server page contains all the available data collected for each time gap. It is actually developed by us using PHP and various web technologies.

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## APPENDIX

### SAMPLE CODE

#### View.php

```
<?php
session_start();
ini_set('error_reporting', E_ALL & ~E_NOTICE & ~E_STRICT & ~E_DEPRECATED);
$name=$_SESSION["username"];
if($name == "guest"){
error_reporting(E_ALL && E_PARSE);
if(isset($_POST['submit_button']))
{
mysqli_query($connection, 'TRUNCATE TABLE iiot5');
header("Location:view.php");
exit();
}
?>
<!DOCTYPE html>
<html>
<head><meta http-equiv="Content-Type" content="text/html; charset=utf-8">
<style>
.container-fluid{
margin-top:40px;
}
a:hover{
background-color:#c4bebe;
}
a:active {
background-color:red;
}
```

```

input[type="submit"]
{
body
{
background-image:url('maxresdefault.jpg');
background-repeat: no-repeat;
}
div#myTable_wrapper {
width: 75%;
margin-left: 100px;
margin-top: 20px;
}label {
color: white;
}
.dataTables_wrapper .dataTables_length, .dataTables_wrapper .dataTables_filter,
.dataTables_wrapper .dataTables_info, .dataTables_wrapper
.dataTables_processing, .dataTables_wrapper .dataTables_paginate {
color: #fefefe !important;
}
</style>
<script src="https://ajax.googleapis.com/ajax/libs/jquery/3.2.1/jquery.min.js"></script>
<script type="text/javascript"
src="https://cdn.datatables.net/1.10.16/js/jquery.dataTables.min.js"></script>
<link rel="stylesheet" type="text/css"
href="https://cdn.datatables.net/1.10.16/css/jquery.dataTables.min.css">
<link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0-
alpha.6/css/bootstrap.min.css" integrity="sha384-
rwoIResjU2yc3z8GV/NPeZWAv56rSmLldC3R/AZzGRnGxQQKnKkoFVhFQhNUwEyJ
" crossorigin="anonymous">
<script src="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0-
alpha.6/js/bootstrap.min.js" integrity="sha384

```

```

vBWWzlZJ8ea9aCX4pEW3rVHjgt7zpkNpZk+02D9phzyeVKE+jo0ieGizqPLForn"
crossorigin="anonymous"></script>
<script>$(document).ready(function(){
    $('#myTable').DataTable();
});</script>
</head>
<body>
<div class="container-fluid">
<div class="row">
<div class="col-md-5">
</div>
<div class="col-md-4">
</div>
<div class="col-md-3">
<a href="chart.php" style="text-decoration: none;padding:10px;"><font
color="black">View Analysis</font></a>
<a href="logout.php" style="text-decoration: none;padding:10px;"><font
color="black">Logout</font></a></div>
</div>
<div>
<h3 style="text-align:center;color:white;">Air Quality Management System</h3>
<table id="myTable">
<thead>
<tr><th>Sno</th><th>Sensor 1</th><th>Sensor 2</th><th>Date</th></tr></thead>
<?php
$i=0;
$das=mysqli_query($connection,"select * from iiot5 order by snodesc");
while($ff=mysqli_fetch_assoc($das))
{
    $i++;
    ?>

```

## Result.php

```
<?php
error_reporting(E_ALL && E_PARSE);
$val1=$_REQUEST['a'];
$val2=$_REQUEST['b'];
date_default_timezone_set('Asia/Kolkata');
$date=date("Y-m-d h:i:s");
$das=mysqli_query($connection,"insert into iiot5(dataa,datab,date)
values('$val1','$val2','$date')");
?>
```

## FINAL CODE

```
const int trigPin = 4;
const int echoPin = 5;
const int trigPin2 = 2;
const int echoPin2 = 3;
#include <LiquidCrystal.h>
LiquidCrystal lcd(13, 12, 11, 10, 9, 8);
long duration;
int distance;
long duration1;
int distance1;
long duration2;
int distance2;
void setup()
{
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);
  Serial.begin(9600);
  lcd.begin(16, 2);
  lcd.setCursor(0, 0);
  lcd.print("D:");
}
void loop()
{
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
```

```

digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance= duration/58.82;
int height=distance;
digitalWrite(trigPin2, LOW);
delayMicroseconds(2);
digitalWrite(trigPin2, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin2, LOW);
duration2 = pulseIn(echoPin2, HIGH);
distance2= duration2/58.82;
int height2=distance2;
lcd.setCursor(0, 0);
lcd.print("D:");
lcd.setCursor(2, 0);
lcd.print((height/100));
lcd.print((height%100)/10);
lcd.print((height%10));
if(height<20)
{
lcd.setCursor(6
, 0);
lcd.print("F");
Serial.print("*");
Serial.print("H:FULL,");
}
if(height>20)
{
lcd.setCursor(6, 0);
lcd.print("E");
Serial.print("*");
Serial.print("H:EMPTY,");
}
lcd.setCursor(0, 1);
lcd.print("D2:");
lcd.setCursor(3, 1);
lcd.print((height2/100));
lcd.print((height2%100)/10);
lcd.print((height2%10));
if(height2<20)
{
lcd.setCursor(7, 1);
lcd.print("F");
Serial.print("H2:FULL,");}

```