SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

TEAM ID:PNT2022TMID05379

PROJECT REPORT

1. INTRODUCTION

1.1 Project Overview

IoT is bringing revolution to almost every aspect of our lives by changing how we do things. Theuse of Smart IoT devices is on the rise with all the industries heavily investing in IoT. The main aimsof investing in IoT are to improve operations efficiency, improve product quality, and reduce the costs ofproduction.

1.2 Purpose

Smart waste management is about using technology and data to create a more efficient waste industry. Based on IoT (Internet of Things) technology, smart waste management aims to optimize resource allocation, reduce running costs, and increase the sustainability of waste services

2. LITERATURE SURVEY

Abstract

In today's world, one of the major environmental problems is the collection management and disposal of the garbage. The main theme of the work is to develop a Smart intelligent garbage alert system for a proper waste management. This paper proposes a Garbage level detection in bins. Getting the weight of the garbage in the bin. Alerts the authorized person to empty the bin whenever the bins are full. Garbage level of the bins can be monitored through a web App. We can view the location of every bin in the web application by sending GPS location from the device.

Literature Survey

[1] Authors have considered two garbage bins, for waste Segregation, and sensors are attached to bins for garbage Data collection to avoid Overfilling. Overfilling of the bins is prevented using Sensors, but no Mechanism for waste Collection is proposed

[2] The proposed system uses Ultrasonic sensors to collect Real-time garbage level which takes the garbage Readings every time the lid of the bin is opened and Closed. Ease of the users is taken into Consideration. But there is no mechanism to assign routes to trucks for the collection Process.

[3] This paper focuses on the Real time garbage level and the level of toxicity present in it and uses the air quality Sensor CCS811 for measuring the toxicity level. The routes are generated Using Dijkstras algorithm. The system rewards the Points in virtual wallets Based on waste Disposed to encourage People to keep the city Clean, but the algorithm Used for routing is not explained in detail.

[4] The system uses real-time Garbage data and calculates the shortest path using Google API. The capacity of the Truck is not considered while generating shortest routes.

[5] Waste collection problem is a set-covering and vehicle routing problem (VRP) involving inter-arrival time constraints, bi-level optimization formula to model the split delivery VRP with several trips to decide the shortest path.

Developed an ACO algorithm for route improvisation. It lacked service for vehicles of a particular category to traverse small streets or bridges that have weight constraint.

[6] Waste collection routing Problem is included in a Mixed-integer nonlinear Programming model after which garbage is unloaded to find out the optimal route for all the garbage trucks. Aimed to avoid the combined collection of Waste which differed in Quality. Instead, it focused on the Collection of Homogeneous trash cans Owing to the same Quality of waste for higher rate of recovery and lower rate of Disposal.

[7] The primary components of IoT are accompanied with Intelligent Transportation Systems and surveillance Systems which enhance Quality of Service in waste Collection. It has proposed an advanced Decision Support System model. Covered an important Aspect of waste Collection which is Access to areas which are not feasible to visit.

[8] The paper discussed Different variations of Vehicle Routing Problem (VRP) and mainly focuses on the variation of VRP which is used for reduction of fuel the generation of Routes focuses on the Distance and fuel Consumption. The Vehicle capacities are not considered.

Reference

- **[1]** P. Chowdhury, R. Sen, D. Ray, P. Roy and S. Sarkar, Garbage Monitoring and Disposal System for Smart City Using Iot, 2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT), Bangalore, India, 2018, pp. 455-460, doi:10.1109/ICGCIoT.2018.8753060.
- **[2]** S. Lokuliyana, A. Jayakody, G. S. B. Dabarera, R. K. R. Ranaweera, P. G. D. M. Perera and P. A. D. V. R. Panangala, Location Based Garbage Management System with IoT for Smart City, 2018 13th International Conference on Computer Science & Education (ICCSE), Colombo, 2018, pp. 1-5, doi:10.1109/ICCSE.2018.8468682.
- **[3]** Mirchandani, S., Wadhwa, S., Wadhwa, P., & Joseph, R. (2017). IoT enabled dustbins. 2017 International Conference on Big Data, IoT and Data Science (BID). doi:10.1109/bid.2017.8336576.
- **[4]** Chaudhari, S. S., & Bhole, V. Y. (2018). Solid Waste Collection as a Service using IoT -Solution for Smart Cities. 2018 International Conference on Smart City and Emerging Technology (ICSCET). Doi:10.1109/icscet.2018.8537326.
- **[5]** Huang, Shan-Huen & Lin, Pei-Chun. (2015). Vehicle routing—Scheduling for municipal waste collection system under the Keep Trash Off the Ground policy. Omega. 55. 10.1016/j.omega.2015.02.004.

- **[6]** Fooladi, Somayeh, Hamed Fazlollahtabar, and Iraj Mahdavi. Waste Collection vehicle routing problem considering similarity pattern of Trashcan and garbage unloading. (2015).
- **[7]** Medvedev, Alexey & Fedchenkov, Petr & Zaslavsky, Arkady & Anagnostopoulos, Theodoros & Khoruzhnikov, Sergey. (2015). Waste Management as an IoT-Enabled Service in Smart Cities.

  10.1007/978-3-319-23126-6_10.

- **[8]** Y. Peng and X. Wang, Research on a Vehicle Routing Schedule to Reduce Fuel Consumption, 2009 International Conference on Me

2.3 Problem Statement Definition

A big challenge in the urban cities is solid waste management. The garbage collecting authority in traditional waste management system doesn't know about the level of garbage in dustbin, if the dust bins gets full by garbage then it gets overflowed as well as spelled out from the dustbin leading to unhygienic condition in cities. People throw garbage on that dustbin which is already overflowed. Sometimes due to unclean garbage bins bad smell arises also toxic and unhygienic gases are produced which is way to support to the air pollution and to some harmful diseases which are easily spreadable. It is very bad look of the city. Use of traditional system result in inefficient and time and money spending system.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy map Canvas

An empathy map is a collaborative tool teams can use to gain a deeper insight into their customers. Much like a user persona, an empathy map can represent a group of users, such as a customer segment. The empathy map was originally created by Dave Gray and has gained much popularity within the agile community.

EMPATHY MAP

THINKS

1.Sometimes collection routes are not efficient, since some containers are empty.
2.Balance between collection circuits are different.
3.Want to complete the collection circuit the fastest way possible.
4.Some containers and vehicles stops are not possible.

SAYS

1.Some items are not being separated properly.
2.Spend too much time in traffic,delaying collection time frames.
3.There are several containers that are difficult to access.
4.There should be a better way to communicate with the command centre.

DOES

1.Empties waste containers manually or mechanically.
2.Check the on-board vechicle computer.
3.House-to-House waste collection.
4.Reports incidents found during the collection process.
5.Follow specific collection routes.

FEELS

1.Pride for contributing to the reduction of waste.
2.Empowered when given new tools to work.
3.Anxious and stressed by social pressure.
4.Frustrated with some citizens that don't take waste collection seriously.
5.Over-whelmed with the amount of work and working schedule.

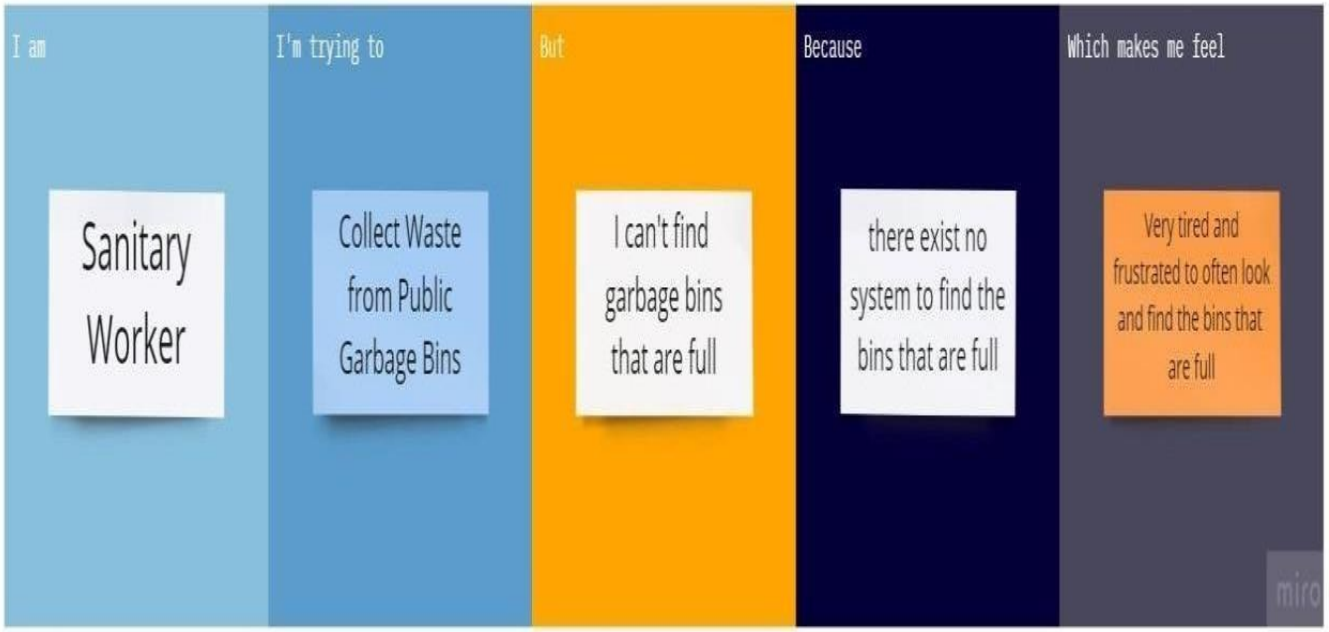
PAINS

1.People not understanding the importance of segregating waste.
2.Not knowing what containers are empty or full.
3.WCS system routes are time consuming.

GAINS

1.More efficient collection routes.
2.Help reduce waste and pollution.
3.More balanced work and personal life.

3.2 Ideation & Brainstorming



3.3.Proposed Solution

Project team shall fill the following information in proposed solution template.

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	This project deals with the problem of waste management in smart cities, where the garbage collection system is not optimized. This project enables the organizations to meet their needs of smart garbage management systems. This system allows the authorised person to know the fill level of each garbage bin in a locality or city at all times, to give a cost-effective and time-saving route to the truck drivers.
2.	Idea / Solution description	The key research objectives are as follows: • The proposed system would be able to automate the solid waste monitoring process and management of the overall collection process using IOT (Internet of Things). • The Proposed system consists of main subsystems namely Smart Trash System(STS) and Smart Monitoring and Controlling Hut(SMCH). • In the proposed system, whenever the waste the circuit at the waste bin, which transmits it to the receiver at the desired place in the area or spot. • In the proposed system, the received signal indicates the waste bin status at the monitoring and controlling system.
3.	Novelty / Uniqueness	We are going to establish SWM in our college but the real hard thing is that janitor (cleaner) don't know to operate these thing practically so here our team planned to build a wrist band to them, that indicate via light blinking when the dustbin fill and this is Uniqueness we made here beside from project constrain.

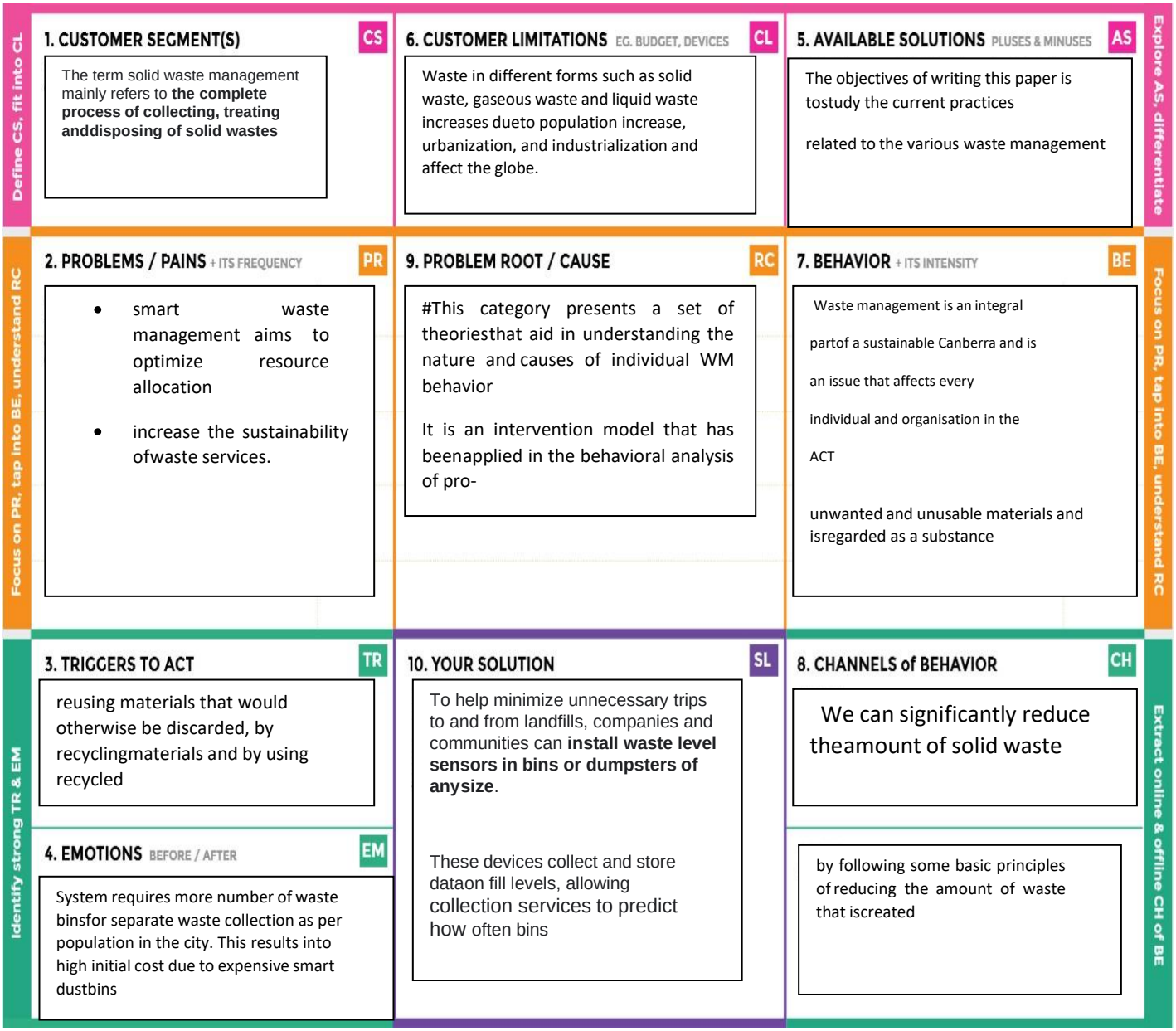
4.	Social Impact / Customer Satisfaction	From the public perception as worst impacts of present solid waste disposal practices are seen direct social impacts such as neighbourhood of landfills to communities, breeding of pests and loss in property values
5.	Business Model (Revenue Model)	Waste Management organises its operations into two reportable business segments: Solid Waste, comprising the Company's waste collection, transfer, recycling and resource recovery, and disposal services, which are operated and managed locally by the Company's various subsidiaries, which focus on distinct geographic areas; and Corporate and Other, comprising the Company's other activities, including its development and operation of landfill gas-to-energy facilities in the INDIA, and its recycling brokerage services, as well as various corporate functions.
6.	Scalability of the Solution	In this regard, smart city design has been increasingly studied and discussed around the world to solve this problem. Following this approach, this paper presented an efficient IoT-based and real-time waste management model for improving the living environment in cities, focused on a citizen perspective. The proposed system uses sensor and communication technologies where waste data is collected from the smart bin, in real-time, and then transmitted to an online platform where citizens can access and check the availability of the compartments scattered around a city.

3.4 Problem Statement

An inefficient waste management may create serious environmental impacts like infectious diseases, land and water pollution, and climate changes. In this design smart waste management is used for proper disposal and efficient collection of waste by using a Web application.

- Garbage level detection in bins.
- Getting the weight of the garbage in the bin.
- Alerts the authorized person to empty the bin whenever the bins are full.
- Garbage level of the bins can be monitored through a web App.
- We can view the location of every bin in the web application by sending GPS location from the device.

3.5 Problem Solution Fit



4. REQUIREMENT ANALYSIS

4.1 Functional Requirements:

Taking sensor reading from the Sensor Circuit • Pushing the data to a MySQL database. Retrieving information from database for Calculation garbage bin which fulfils the condition for garbage collection.

Example: Collect garbage from bins whose level is over 80% of bin. Following are the functional requirements of the proposed solution:

FR-1	Fitting IoT device in the trashcans.	The IoT device need to be fixed in the dustbin with water proof safety. The IoT device consists Ultrasonic sensor, IR sensor, Weight sensor. To send data to the cloud GSM/GPRS is used.
FR-2	Connecting to the cloud.	The device should configure to connect to the cloud. The data of sensors need to be received and processed.
FR-3	Predictions for bin fulness.	In this system, a 24×7 monitoring system is designed for monitoring dumpsters, A smart and organized system is designed for selective clearing the ultrasonic sensor is used for measuring the level of waste in the dustbin, DC motor powered platform is used for segregating wet and dry waste, IR sensor and moisture sensor is used for separating wet and dry waste. If either of the containers is full then an alert message is sent from the dustbin to employees and the cloud. In turn, employees can clear the corresponding dumpster.
FR-4	Real-time waste monitoring	Trash and recycling containers can be outfitted or produced with low-cost sensors that monitor everything from the amount and types of material in a container to temperature, odour and location of the bin.
FR-5	Do not miss a pick	For periodically picked bins, we provide Pick evaluation. The tool records picks (sensor) and compares them to the schedule. Authorized person can immediately identify any missed, or off-schedule picks.
FR-6	Routes to the dumpsters	Based on current bin fill-levels and predictions of reaching full capacity, you are ready to respond and schedule waste collection.

		driver can compare planned vs. executed routes to identify any inconsistencies.

4.2 Non-functional Requirements:

The project requires a user interface for monitoring and manually intervening (if required) in the efficient and timely collection of garbage from the selected Garbage bins.

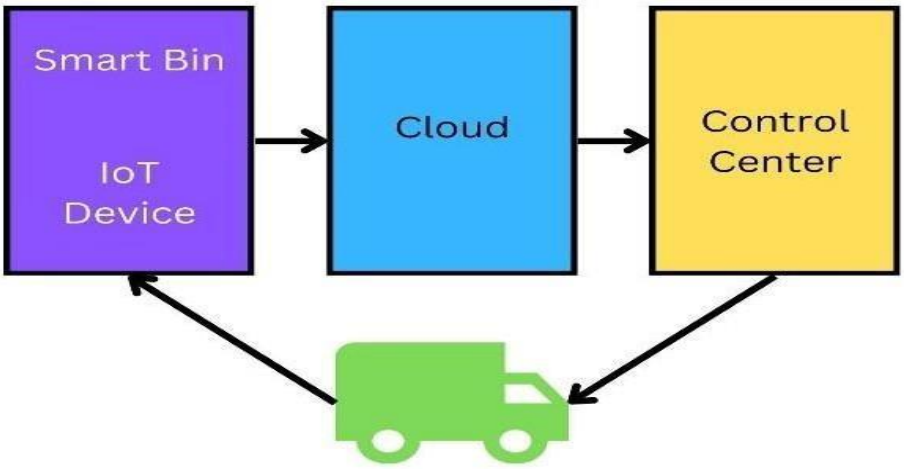
Following are the non-functional requirements of the proposed solution.

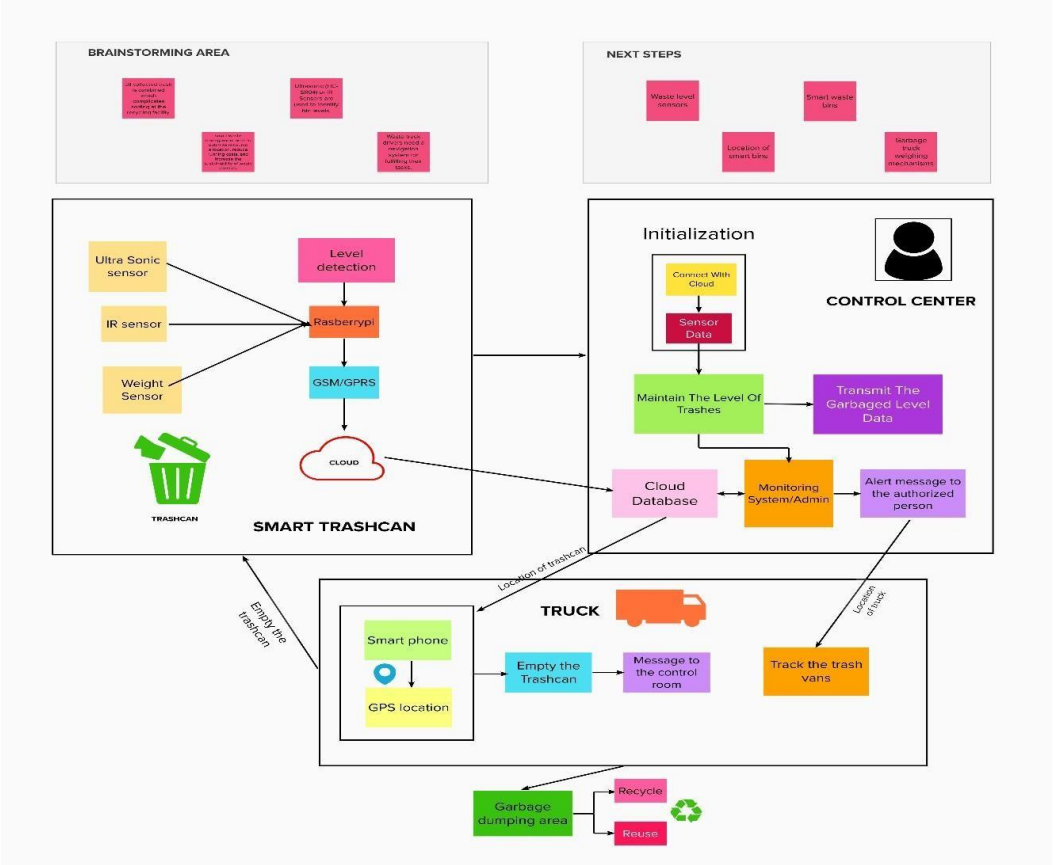
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	IoT solutions for waste management problems offer municipalities data intelligence and real-time insights. In that regard, the fill patterns of specific containers can be identified by historical data and managed accordingly in the long term. In addition to hardware solutions, mobile applications are used to overcome the challenges in the regular waste management system, such as keeping track of the drivers while they are operating on the field.
NFR-2	**Security**	Building and deploying IoT-based smart waste management in cities can be a complex, time-consuming and resource-intensive process. Many municipal IT departments will not have the resources or in-house skills to support such a project internally.
NFR-3	**Reliability**	One of the difficult operational problems of municipal and local authorities are facing is the collection of municipal solid waste. In recent years, due to environmental concerns and number of costs, most of the municipalities have been forced for assessing their solid waste management and examining their cost- effectiveness and environmental impact, forexample, designing the collection of routes. During the past 15 years

NFR-4	**Performance**	An integrated Arduino program is developed to synchronize the identification system, automated lid system, micro-controller, display system, and communication system. An ultrasonic sensor is attached to the front side of the garbage bin. The transmitter of the ultrasonic sensor emits an ultrasonic sound that is beyond the human ear listening range, and the receiver receives the reflected sound waves by the solid objects.
NFR-5	**Availability**	Another purpose of this project is to make the proposed waste management system as cheap as possible. A cost in BDT is presented in the following Table 3 needs for the construction of the proposed smart bin.
NFR-6	**Scalability**	The city diverts about 80% of its waste from landfills and hopes to go "zero waste" by the end of 2020. Besides strict regulations and high waste management fees for end consumers and businesses.

5. PROJECT DESIGN

5.1 Data Flow Diagrams





Simplified Diagram The IoT device is fitted in the trashcans.

- The sensors in the device senses the garbagelevel.
- The GSM/GPRS will send the information aboutthe garbage level to the cloud.
- The admin in the control center notifies theauthorized person to collect the garbage.
- The truck driver will be notified the route to thefilled dumpsters.
- The trashes are loaded to the truck.
- The more number of bins needed in highpopulated area.
- The overflowing of trashcans can be avoided.
- No missed pickups of trashcans.
- New smart dustbins can be install by justconnecting the IoT device to the cloud.

User Stories:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Admin	Login	USN-1	As an admin, I can monitor every dustbinand its garbage levels.	I can monitor the system.	High	Sprint-4
		USN-2	As an admin, I will inform the authorized person to empty the trashcan.	I can inform authorized person.	Medium	Sprint-2
		USN-3	As an admin, I can notice the trash levelof every dustbin.	I can notice the trashlevel.	Low	Sprint-2
Admin 2	Login	USN-4	As a Co-Admin, I can send alert message to the truck drivers.	I can alert truck driver.	High	Sprint-1
Trash Van Driver	Login	USN-5	As a trash van driver, I will follow theroute to the dustbin.	I can reach the filled trashcans.	High	Sprint-2
Garbage Collector		USN-6	As a waste collector, I will collect all the trash from the dumpsters and load it to thetruck.	I can empty the trashcans.	Medium	Sprint-2
Municipalofficer	Login	USN-7	As a municipality officer, I can supervisethe process and ensure the cleanliness ofcity.	I can manage all these process going good.	High	Sprint-1
Trashcan Monitor	Register	USN-8	As a trashcan monitor, I can initialize newtrashcans.	I can register new smart trashcans.	Medium	Sprint-3
		USN-9	As a trashcan monitor, I can check the quality of IoT device's quality.	I can check the IoT device.	Medium	Sprint-3

5.2 Solution & Technical Architecture:

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Its goals are to:

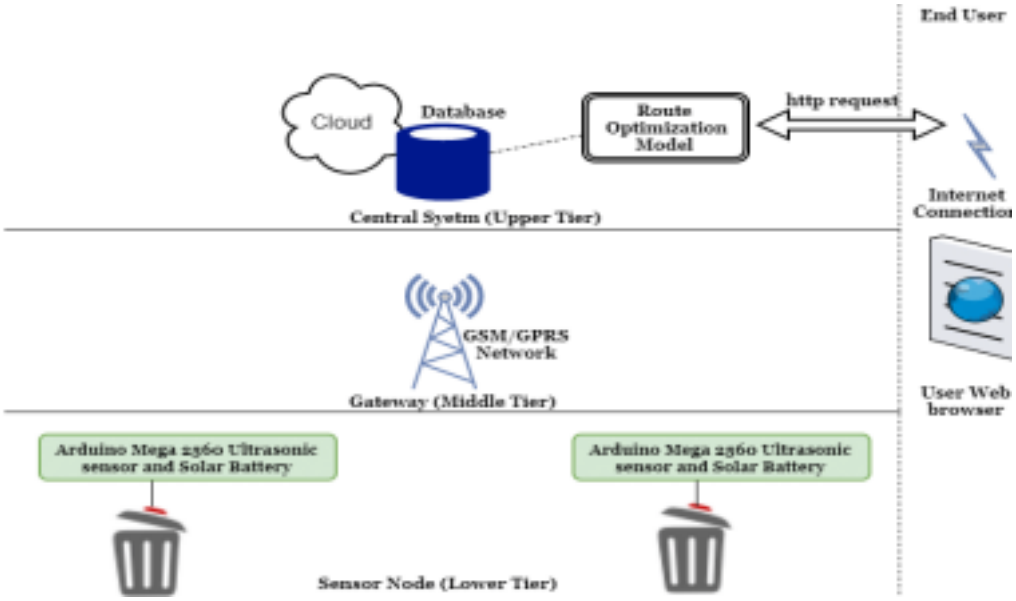
• Discover the finest technological solution to address current company issues..

• Describe the software's design, features, functionality, and other elements to the project's stakeholders..

• Specify the features, stages of development, and requirements for the solution.

• Offer guidelines for how the solution is created, managed, and delivered.

Example - Solution Architecture Diagram



Technical Architecture:

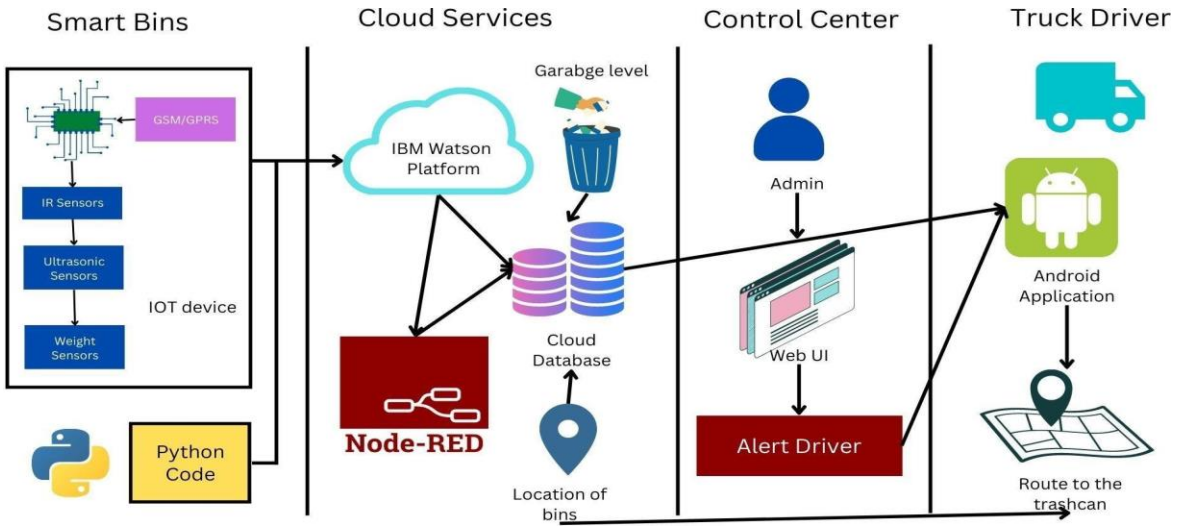


Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	Arduino Uno	The Arduino Uno is an open-source microcontrollerboard based on the Microchip ATmega328P microcontroller.	Arduino programming itself is donein **C++.**
2.	Application Logic-1	Logic for IR sensor data.	C++/Python
3.	Application Logic-2	Logic for Ultrasonic sensor data.	C++/Python
4.	Application Logic-3	Logic for a Weight sensor data	C++/Python
5.	GPRS/GSM	The Arduino GSM shield allows an Arduino boardto connect to the internet, send and receive SMS, and make voice calls using the GSM library.	C++/Python
6.	Cloud Sever	Application deployment on Local System / Cloud	IBM Watson IoT Platform, Node Red
7.	Cloud Database	Database Service on Cloud	IBM Watson IoT platform, Cloudant DB
8.	User Interface	How user interacts with application to alert thetruck driver.	HTML, CSS, JavaScript , Python etc.
9.	External API-1	Purpose of External API used in the application tolocate the trashcans.	Google Maps Geolocation API

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Microcontroller	Arduino Uno is used to make the IoT device	C++/Python
2.	Security	Encryption/Decryption used for security purpose	GSM/GPRS,Python
3.	Scalable Architecture	New features can be added.	Node Red
4.	Availability	Web application can be accessed from anywhere	IBM Watson IoT Platform, HTML, CSS, JavaScript
5.	Performance	All truck drivers can access the application at sametime.	Cloudant DB, IBM Watson IoTPlatform

5.3 User Stories

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Login	USN-1	As a Administrator, I need to give user id and passcode for ever workers over there in municipality	10	High	Vidhya
Sprint-1	Login	USN-2	As a Co-Admin, I'll control the waste level by monitoring them vai real time web portal. Oncethe filling happens, I'll notify trash truck with location of bin with bin ID	10	High	Vidhya
Sprint-2	Dashboard	USN-3	As a Truck Driver, I'll follow Co-Admin's Instruction to reach the filling bin in short rootsand save time	20	Low	Vigneswari
Sprint-3	Dashboard	USN-4	As a Local Garbage Collector, I'II gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills	20	Medium	Vaishnavi
Sprint-4	Dashboard	USN-5	As a Municipality officer, I'll make sure everything is	20	High	Thilaga Dharshini

			proceeding as planned and without any problems			

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

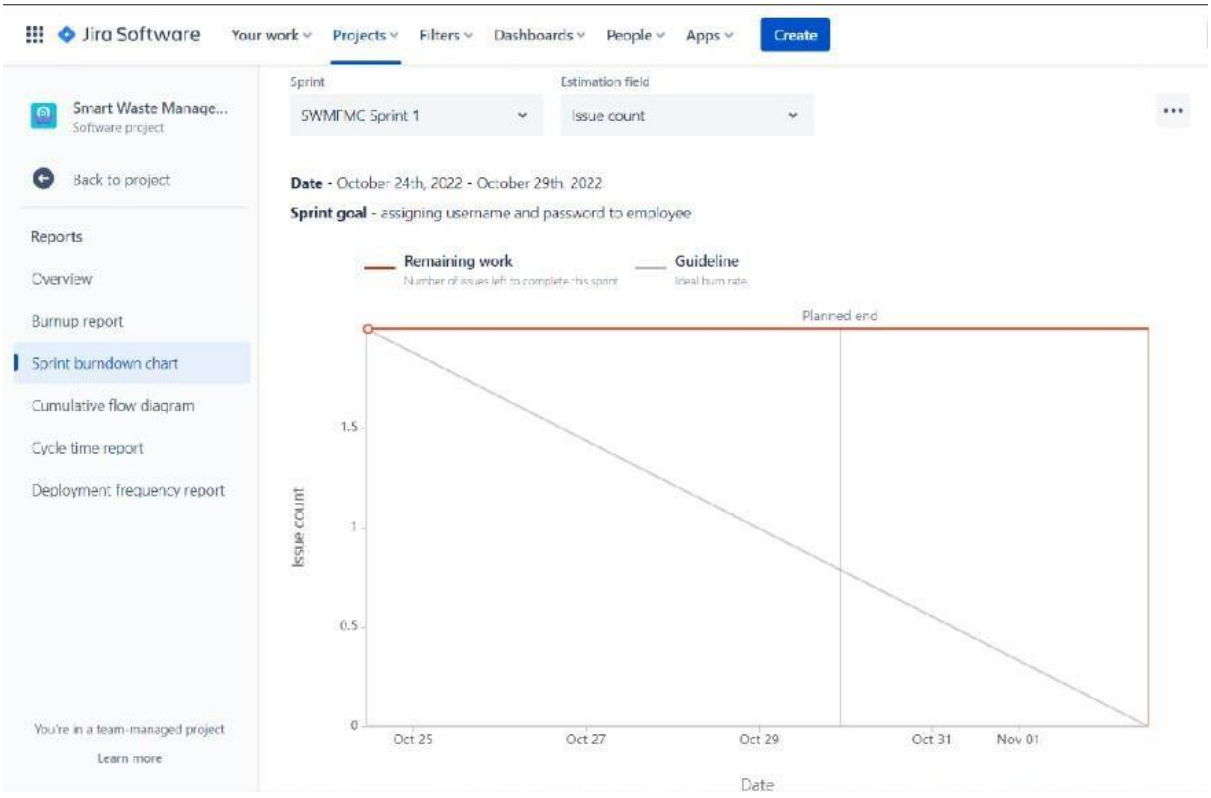
Velocity:

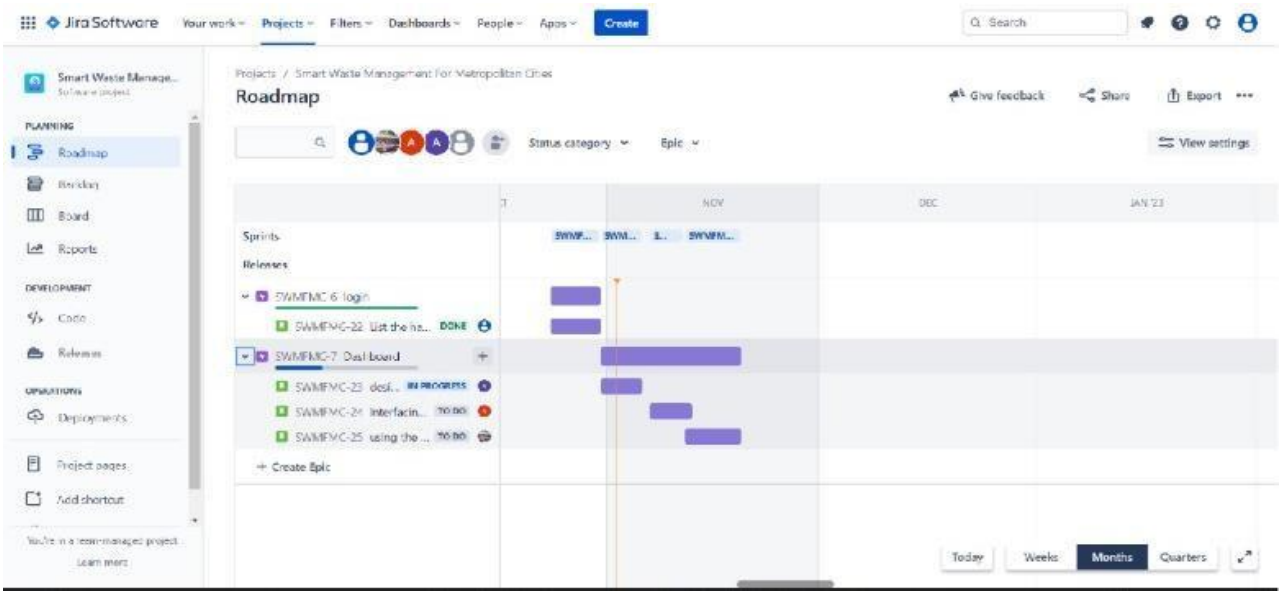
Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's

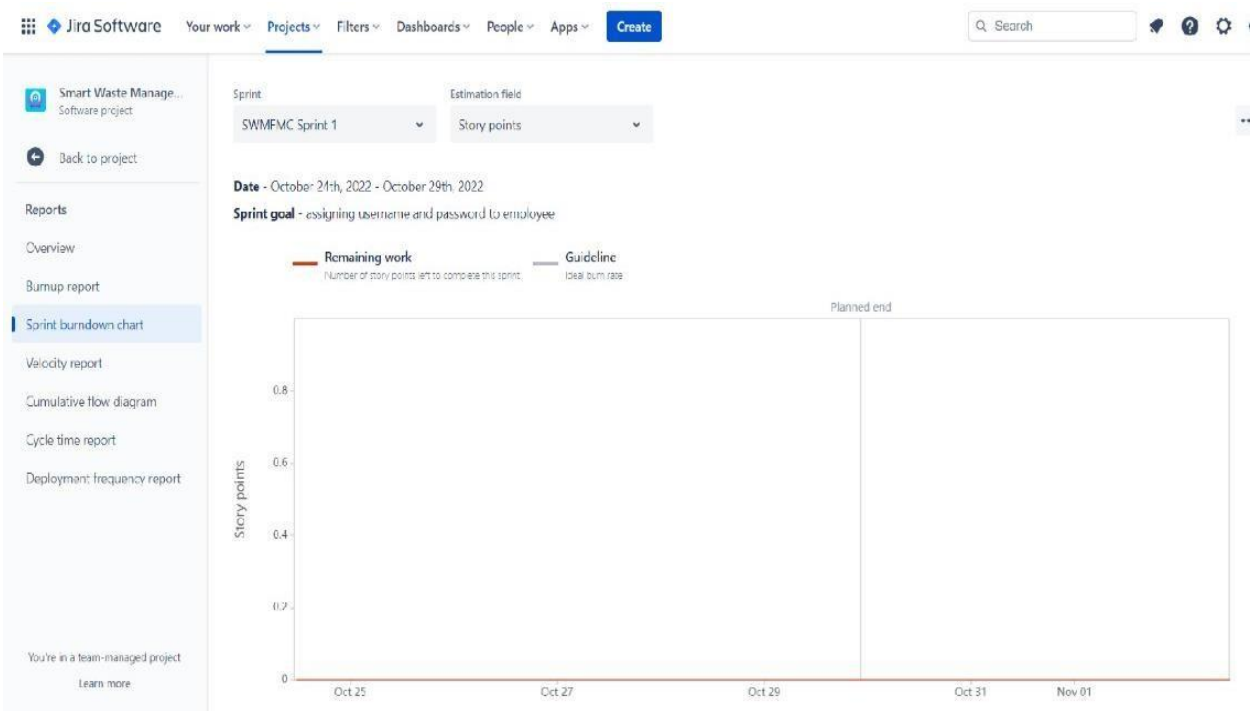
calculate the team's average velocity (AV) per iteration unit (story points per day)

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

6.2.Reports from JIRA

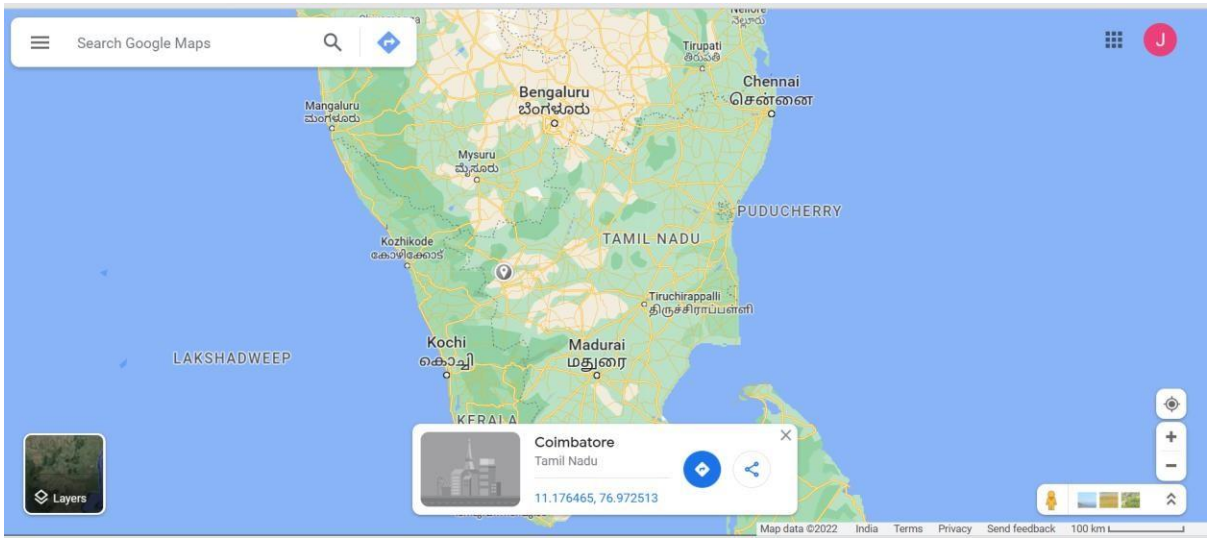






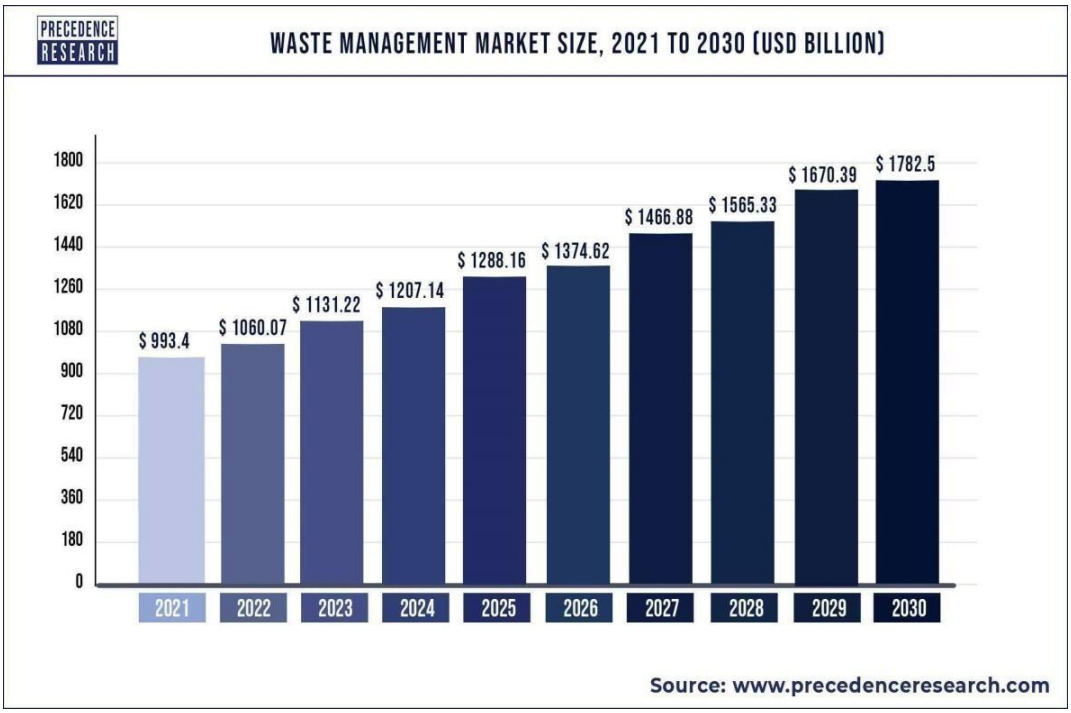
7.CODING & SOLUTIONING

7.1Feature



8.RESULTS

8.1Performance Metrics



9.ADVANTAGES & DISADVANTAGES

Advantages

- No Missed Pickups.
- Reduced Overflows.
- Waste Generation Analysis.
- CO2 Emission Reduction.
- Reduction in Collection Cost.

Disadvantages

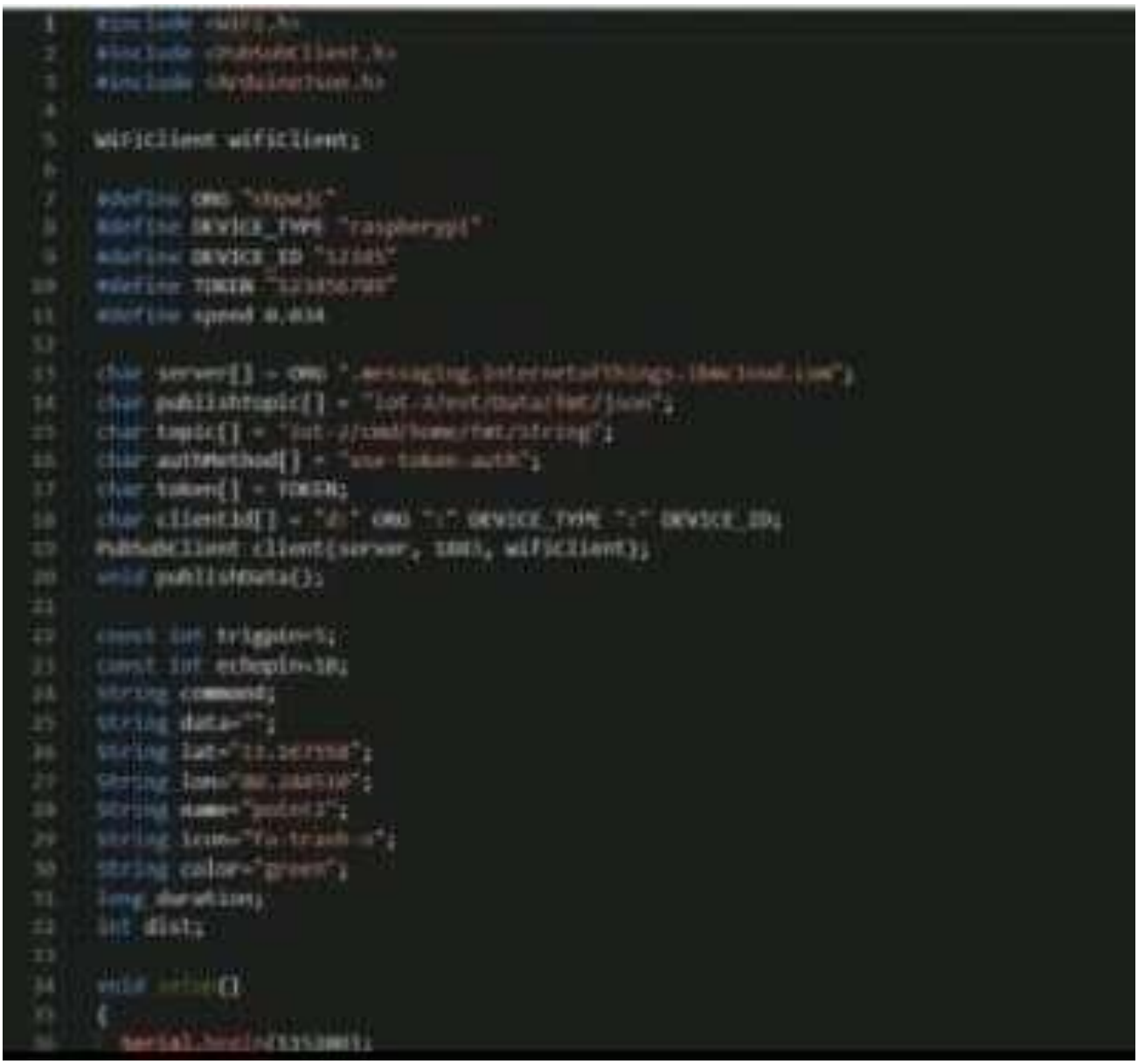
- Setting up the sensor
- Non-optimized truck routes
- Non-uniform waste distribution of waste in bins

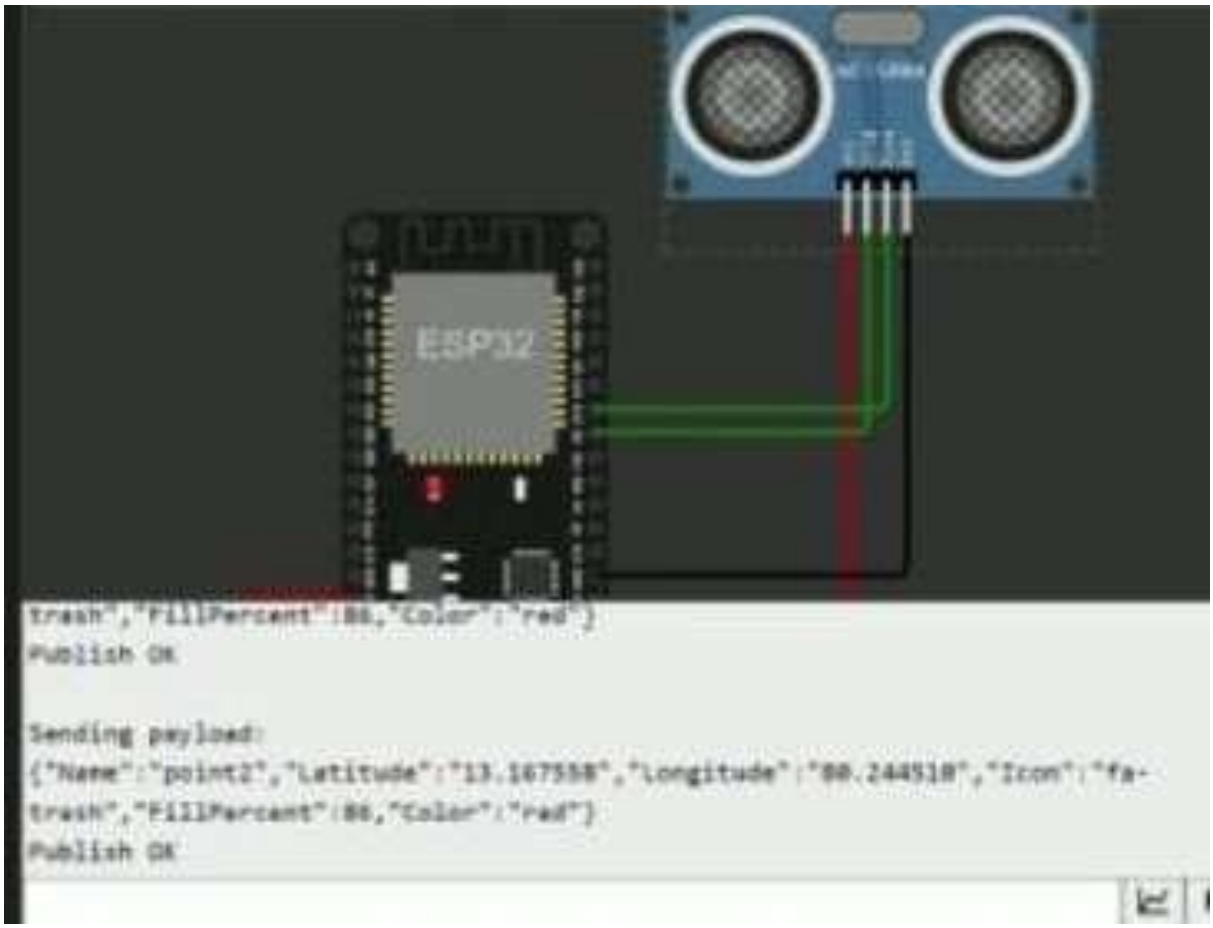
10. CONCLUSION

This proposed system, integrates different sensing and communication technologies to monitor real time bin information. This system is good enough to carry out practically as it helps to collect the garbage from the garbage bins on time before the garbage overflows from that bin which can possess threat to the health of the people leaving in nearby area. This project can avoid such situations of overflowed dustbin and the message can be sent directly to the cleaning vehicle instead of the contractor's office (Authority). In Smart system design main is Development of web portal and applications for city administration, municipal staff and public.

11. FUTURE SCOPE

Total of approximately 143,449 MT of municipal waste is generated daily. However, only 35,062 tons of waste is treated. A report from MNRE says that **waste generation is expected to reach 300 million tons annually by the year 2047**. There are four tiers to waste management to reduce its environmental impact: pollution prevention and source reduction; reuse or redistribution of unwanted, surplus materials; treatment, reclamation, and recycling of materials within the waste; and disposal through incineration, treatment, or land burial.

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