PROJECT REPORT

TEAM ID:PNT2022TMID37949

PROJECT NAME : Smart waste management system for metropolitan cities

1. INTRODUCTION:

1.1 Project Overview:

The solid waste is increasing in urban and rural areas as the population is increasing and waste management has become a global concern. In implementing the smart cities the great challenge is how to manage waste with low cost and high performance. Waste has a negative impact on the quality of society which smart cities aim to improve. The process of collecting wastes, separating it, and transporting the containers daily and quickly to avoid any prospect of a spread of diseases is a complex process. The Internet and its applications have become an integral part of today's human lifestyle. It has become an essential tool in every aspect. Due to the tremendous demand and necessity, researchers went beyond connecting just computers into the web. With the help of IOT, garbage in the cities can be collected on monitoring the bin level, to prevent overflow of the garbage which negatively impacts the environment and to avoid or postpone garbage collection schedules in case of low garbage levels.

1.2 Purpose:

We amalgamate technology along with waste management in order to effectively create a safe and a hygienic environment. 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. This makes it possible to plan more efficient routes for the trash collectors who empty the bins, but also

lowers the chance of any bin being full for over a week. A good level of coordination exists between the garbage collectors and the information supplied via technology. This makes them well aware of the existing garbage level and instigate them whenever the bins reach the threshold level. They are sent with alert messages so that they can collect the garbage on time without littering the surrounding area. The fill patterns of specific containers can be identified by historical data and managed accordingly in the long term. Thus, smart waste management provides us with the most optimal way of managing the waste in an efficient manner using
technology.

2.LITERATURE SURVEY:

2.1 Existing problem:

Waste management has become an alarming challenge in local towns and cities across the world. Often the local area bins are overflowing and the municipalities are not aware of it. This affects the residents of that particular area in numerous ways starting from bad odour to unhygienic and unsafe surroundings. Poor waste management - ranging from non-existing collection systems to ineffective disposal -causes air pollution, water and soil contamination. Open and unsanitary areas contribute to contain viruses and bacteria (i.e., salmonella and e-coli), which are a risk to human health. Toxic components such as Persistent Organic Pollutants (POPs) pose particularly significant risks to human health and the environment as they accumulate through the food chain. Animals eating contaminated plants have higher doses of contaminants than if they were directly exposed. Precipitation or surface water seeping through waste will absorb hazardous components from landfills, agricultural areas, feedlots, etc. and carry them into surface and groundwater. Contaminated groundwater also poses a great health risk, as it is often used for drinking, bathing and recreation, as well as in agricultural and industrial activities. Landfills and waste transfer stations can attract various pests (insects, rodents, gulls, etc.) that look for food from waste. These pests can spread diseases through.

LITERATURE SURVEY:

A number of researches and reviews have been done over the past few decades on the topic of 'SMART WASTE MANAGEMENT FOR METROPOLITAN CITIES'. A few notable of them are given below.

PAPER 1

AUTHORS: Mohammad Aazam, Marc St-Hilaire, Chung-Horng Lung, Ioannis Lambadaris
YEAR: 2016

DESCRIPTION:

Mohammad Aazam et al proposed Cloud SWAM, in which each bin is equipped with sensors to notify its waste level. Different bins for each category of waste, namely: organic, plastic/paper/bottle, and metal. In this way, each type of waste is already separated and through the status, it is known how much of waste is collected and of what type. The availability of data stored in the cloud can be useful for different entities and stakeholders in different ways. Analysis and planning can start from as soon as waste starts gathering and up to when recycling and import/export related matters are conducted. The system Cloud SWAM provides Timely waste collection. Timely and efficient way of collecting waste leads to better health, hygiene, and disposal. The system provides the shortest path to the location of waste bins. So the collectors can plan a better and fuel efficient route.

PAPER 2

AUTHORS: Dr. N. Sathish Kumar, B.Vijayalakshmi, R. Jenifer Prarthana, A .Shankar

DESCRIPTION:

Designed a smart dustbin in which the dustbin gets blocked when it reaches a threshold value. The ultrasonic sensor measures the waste volume.The microcontroller reads the data from the sensor and

alerts the server. For the verification process RFID tag (ID card of the cleaner) interrupts the RFID reader, the ultrasonic sensor checks the status of the dustbin and sends it to the web server. An android application is used to view the alerts and status at the server end.

PAPER 3

AUTHORS: Belal Chowdhury and Morshed U. Chowdhury

DESCRIPTION:

Designed a five layer architecture for RFID and sensor based waste management systems. The layers are named as physical layer, middleware layer, process layer, data access layer and user interface layer. The physical layer consists of the actual RFID hardware components and it includes RFID waste tag, reader and antennas. Middleware layer is act as the interface between the RFID reader, load cell sensor and waste management service providers (i.e., waste collectors, and municipalities) IT system. The important element of RFID and load cell sensor systems is the middleware layer , which is viewed as the central nervous system from the waste management system perspective. This layer enables waste management service provider's (e.g., waste collector) a quick connectivity with RFID readers and load cell sensors and also the layer lowers the volume of information that waste management system applications need to process, by grouping and filtering raw RFID and load cell data from readers and sensors respectively. An application- level interface is provided by a middleware layer for managing RFID readers, and load cell sensors for processing large volumes of waste data for their application.

PAPER 4

AUTHORS: Mohd Helmy Abd Wahab, Aeslina Abdul Kadir, Mohd Razali Tomari and Mohamad Hairol Jabbar

YEAR: **2014**

DESCRIPTION:

Proposed a Smart Recycle Bin that caters for recycling glass, paper, aluminium can and plastic products. It automatically

evaluates the value of the wastes thrown accordingly and provides a 3R card. The recycle system enables collection of points for performing a disposal activity into designated recycle bins. Such a system encourages recycling activities by allowing the points to be redeemable for products or services. The system records the data related to the disposal activities, disposed material, identification of the user and points collected by the user. The user has to touch his card to the specified RFID reader at the recycle bin. Recycle bin doors open and the user puts waste one by one. A microcontroller processes information about his user ID and number of wastes and sends it to a database server. The database server calculates the user points and updates it. The system provides user login to an online system to check his total points.

PAPER 5

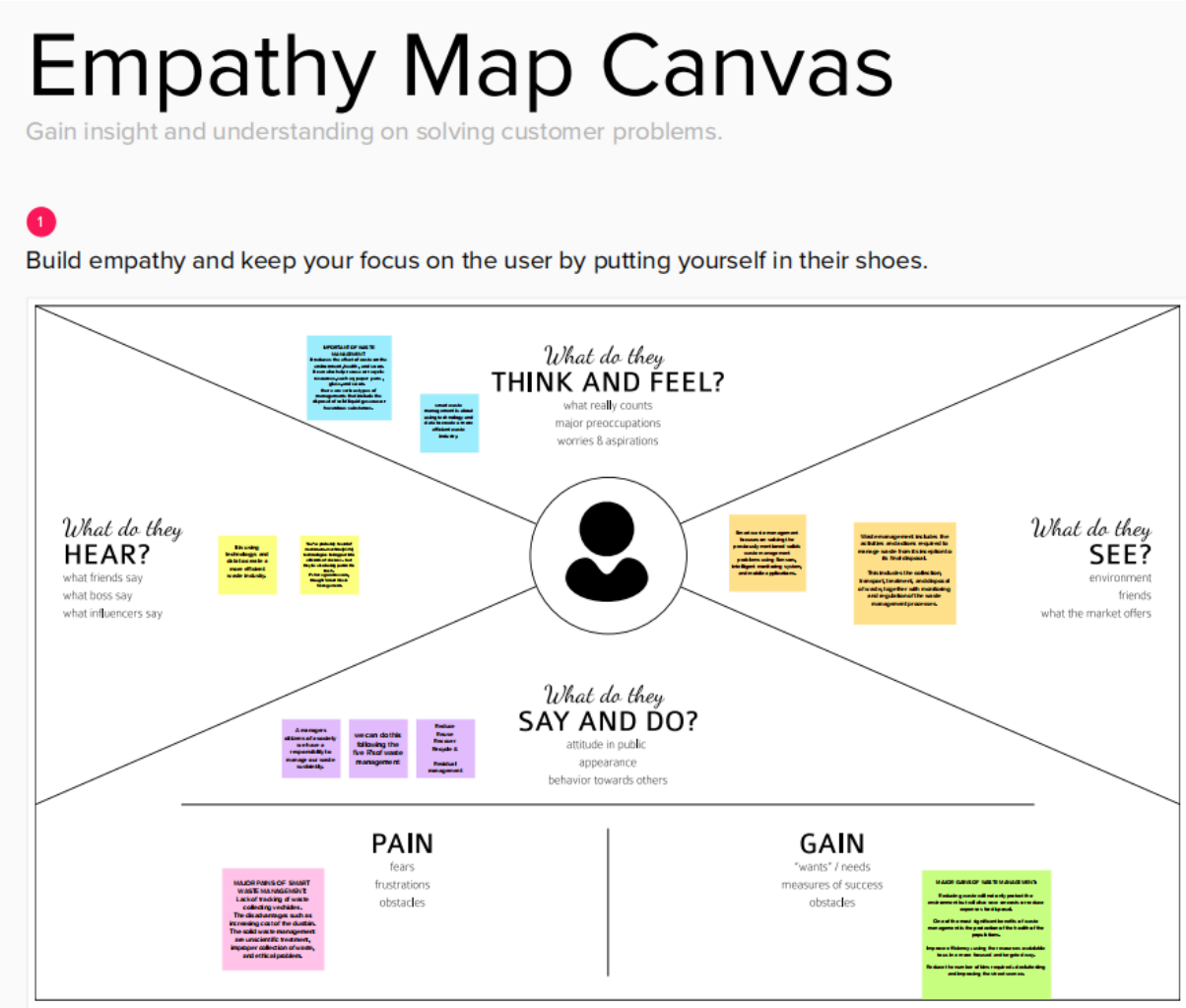
AUTHORS: Fachmin F olianto, Yong Sheng Low and Wai Leong Yeow
YEAR: 2015

DESCRIPTION:

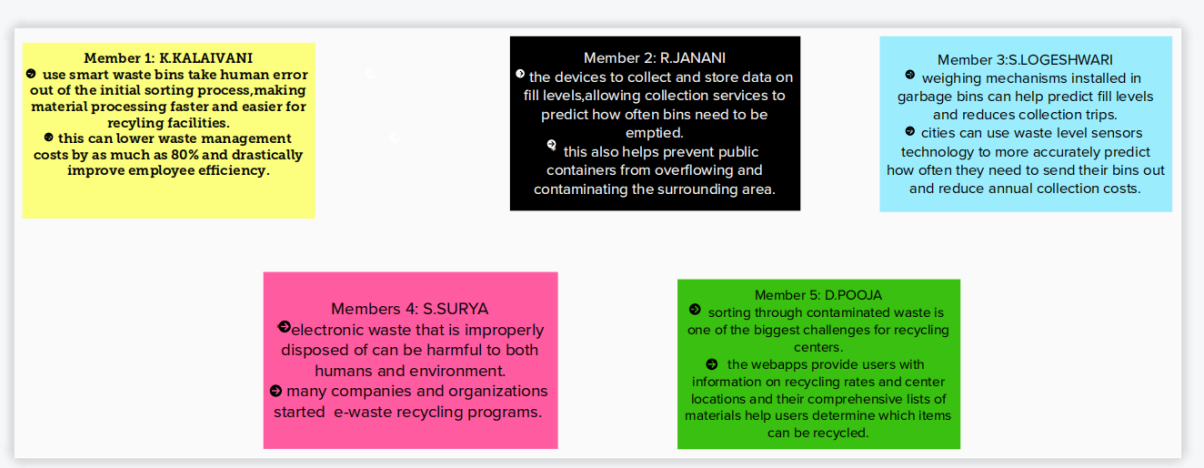
Proposed Smart bin system has 3 –tier architecture. The ultrasonic sensor installed in every Smartbin senses bin fullness and reports readings and sensor statuses. The sensor reading is transmitted to the gateway nod which is installed in every sensor cluster. It forwards the information to the backend server. The analytics module in the back end server analyzes data collected by the bin sub system. The analytics module processes fullness readings, compares against predefined rules, and generates events upon exceeding threshold. The bin sub-system sends information to the workstation and it shows meaningful information to users through a graphical user interface.

2.3 Problem Statement Definition:

3.IDEATION & PROPOSED SOLUTION:



3.2 Ideation & Brainstorming:



3.3 Proposed Solution:

S.NO.	Parameter	Description
1.	Problem Statement (Problem to be solved)	To avoid hazards due to overflow of garbage in roads
2.	Idea / Solution description	Indication of garbage bin overflow over GPS.
3.	Novelty / Uniqueness	Continuously tracking and altering
4.	Social Impact / Customer Satisfaction	Public awareness and proper knowledge of waste management, health effects, environmental problems that are related to waste management is very important for successful execution of any waste management related practices.
5.	Business Model (Revenue Model)	Waste management generates revenue through the provision of various waste management and disposal services and recycling solutions to residential, commercial, industrial and municipal clients.
6.	Scalability of the Solution	Recycling of waste , separating biodegradable and non- biodegradable waste before dumping them .

3.4 Problem Solution fit:

WHO IS YOUR CUSTOMER ? PUBLIC / MUNICIPALITY OFFICE	**EXPLORE LIMITATION TO BUY/USE YOUR PRODUCT OR SERVICE:** **To avoid the hazard / putrid / diseaster agents.**	**HOW ARE YOU GOING TO BE DIFFERENT THAN COMPETITION:** The garbage is collected and it will be **bio-degradable and non bio-degradable substance.** The bio-degradable structure are reusable or recycled and it will be used venoplastic in a organic farming.
FOCUS ON FREQUENT , COSTLY OR URGENT PROBLEM TO SOLVE: A very important phase of the development of smart cities is waste management and this is often overlooked in the development of smart cities. " **Smart Waste Management "** smart cities are leveraging the internet of things **(IoT)** to create an efficient system to save cities human resources , money and save the environment.	**UNDERSTAND THE CAUSE OF THE PROBLEM:** Overflowing waste causes **air pollution and respiratory diseases.**one of the out comes of overflowing garbage is air pollution ,which causes various respiratory diseases and other adverse health effects as contaminnants are absorbed from lungs into other parts of the body.	**TAP INTO ,RESEMBLE OR SUPPORT EXISTING BEHAVIOUR:** Exploring the 3 rs of waste management **Reduce , Reuse , Recycle.** in order to keep the material out of the landfill as possible , it's important for each of us to do our part .one of the 3 ways of Rs to put that plan into action is in the waste management.
DISIGN TRIGGERS COSTLY THAT FIT REAL LIFE, SPARK ASSOCIATION, MAKE IT FAMILIAR: **E**mpathic-design techniques cant's replace market research ;rather, they contribute to the flow of ideas that need further testing. Photographs show spatial arrangements and details that may go unnoticed in the field. **Step One: OBSERVATION.** **Step. Two: Capturing Data.** **Step three: Reflection and Analysis.** **Step four: Brainstorming for solution.** **Step five: Developing prototypes of possible solutions.**	**YOUR "DOWN TO EARTH" SOLUTION GUESS:** **Promoting door-to-door collection of waste by subsiding waste collection by ULBs.** **Project ,planning and implementation of waste-to-compost (WTC)plant criticised.** **The union government asked to open WTC plants in all states in the country in a big way.**	**BE WHERE YOUR CUSTOMER ARE** **PUBLICS / HOSPITALS / MARKETS / STREETS / APPARTMENT / INDUSTRIES / WASTE AREAS etc....**
ADD EMOTIONS FOR STRONGER MESSAGE: **Struggling to cure from the diseases and not normal life style.** **Mentally affected more than physically by the causes.**		

4.REQUIREMENT ANALYSIS:

FUNCTIONAL REQUIREMENT:

FR NO.	FUNCTIONAL REQUIREMENT(Epic)	SUB REQUIREMENT (Sub-task)
1.	Real time monitoring bins	*The Dashboard displays real-time data on fill-levels of bins monitored by smart sensors. In addition to the % of fill-level, based on the historical data, the tool predicts when the bin will become full, one of the functionalities that are not included even in the best waste management software. *Sensors recognize picks and can check when the bin was last collected. With real-time data and predictions, we can eliminate the overflowing bins.
2.	Adjust bin distribution	*Ensure the most optimal distribution of bins. Identify areas with either dense or sparse bin distribution. * Make sure all trash types are represented within a stand.
3.	Eliminate inefficient picks	*Eliminate the collection of half-empty bins. The sensors recognize picks. * The report shows how full the bin was when picked. You immediately see any inefficient picks below 80% full.
4.	Plan waste collection routes	*The tool semi-automates waste collection route planning. *Based on current bin fill-levels and predictions of reaching full capacity, we are ready to respond and schedule waste collection.

NON-FUNCTIONAL REQUIREMENT:

NFR NO.	NON-FUNCTIONAL REQUIREMENT	DESCRIPTION
1.	Availability	*By developing & deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter.
2.	Scalability	*Using smart waste bins reduce the number of bins inside town , cities coz we able to monitor the garbage 24/7 more cost effect and scalability when we moves to smarter
3.	Reliability	*Smart waste management is also about creating better working conditions for waste collectors and drivers. *Instead of driving the same collection routes and servicing empty bins, waste collectors will spend their time more efficiently, taking care of bins that need servicing.
4.	Security	*Use a reusable bottles. *Use reusable grocery bags.

5.PROJECT DESIGN

5.1 Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically.

It shows how data enters and leaves the system, what changes the information, and where data is stored. A smart waste management platform uses analytic to translate the data gather in your bins into actionable insights to help you improve your waste services.

You can receive data on metric such as:

• The first test conducted is the situation where the garbage bin is empty or its garbage level is very low

• Then, the bin is filled with more garbage until its level has surpassed the first threshold value, which is set to 80% then the first warning SMS is being sent, as depicted

• The first notification SMS sent by the system, once the waste reaches the level of 85% full

• The second notification SMS sent by the system, indicating that bin is at least 95% full and the garbage needs to be collected immediately

• Locations prone to overflow

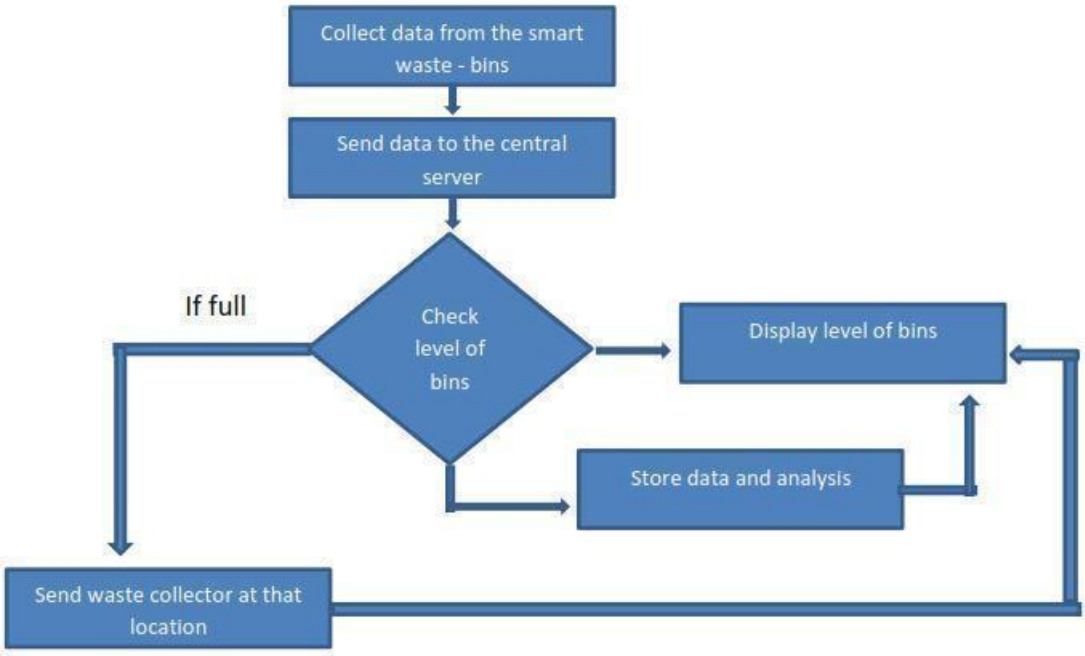
• The number of bins needed to avoid overflowing waste

• The number of collection services that could be saved

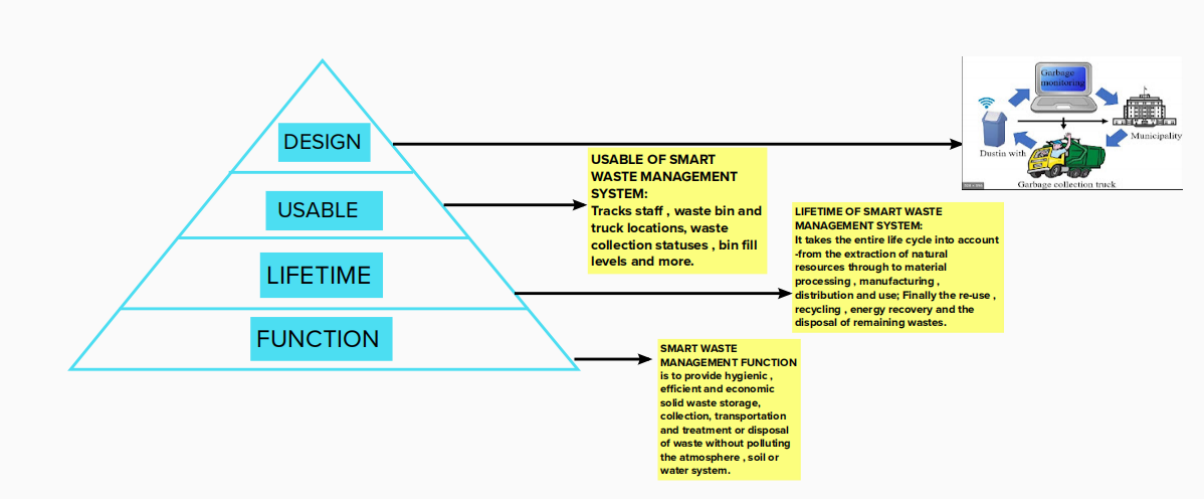
• The amount of fuel that could be saved

• The driving distance that could be saved

Data flow diagram:



5.2 Solution Architecture:



Design:

- 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.

Software and system required:

- Python IDLE
- 4GB processor and OS-Windows/Linux/MAC

Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	Web Portal	HTML,CSS,NodeRed, Javascript.o r on
2.	Application Logic-1	To calculate the distance of dreck and show the real time level in web portal , information getting via ultra sonic sensor and the alert message activate with python script to web portal.	Ultrasonic sensor/ Python.
3.	Application Logic-2	To calculate the weight of the garbage and show the real time weight in web portal, this info getting via load cell and the alert message activate with python to web portal.	Load cell/Python.
4.	Application Logic-3	Getting location of the Garbage.	GSM / GPS.
5.	Cloud Database.	Database Service on Cloud	IBM DB2, IBM Cloudant etc.
6.	File Storage	File storage requirements	Github,Local file system.
7.	External API-1.	Firebase is a set of hosting services for any type of	Firebase.

		application. It offers NoSQL and real-time hosting of databases, content, social authentication, and notifications, or services, such as a real-time communication server.	
8.	Ultrasonic Sensor.	To throw alert message when garbage is getting full.	Distance Recognition Model.
9.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration:localhost Cloud Server Configuration:localhost,Firebase.	Localhost,Web portal.

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	NodeRed,Python,IBM Simulator.	IoT
2.	Security Implementations	Raspberry Pi is connected to the internet and for example used to broadcast live data, further security measures are recommended and use the UFW(uncomplicated Firewall).	IoT
3.	Scalable Architecture	Raspberry pi:Specifications Soc: rspi ZERO W CPU: 32-bit computer with a 1 GHz ARMv6 RAM: 512MB Networking: Wi-Fi Bluetooth: Bluetooth 5.0, Bluetooth Low Energy (BLE). Storage: MicroSD GPIO: 40-pin GPIO header, populated	IoT

S.No	Characteristics	Description	Technology
		Ports: micro HDMI 2.0, 3.5mm analogue audio-video jack, 2x USB 2.0, 2x USB 3.0, Ethernet Dimensions: 88mm x 58mm x 19.5mm, 46g	
4.	Availability	These smart bins use sensors like ultrasonic and load cell to send alert message about the trash level recognition technology, and artificial intelligence, enabling them to automatically sort and categorize recycling litter into one of its smaller bin.	IoT.
5.	Performance	Number of request:RPI manages to execute 129-139 read requests per second. Use of Cache:512mb Use of CDN's:Real time	IoT/Web portal.

PROJECT PLANNING & SCHEDULING:

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	Literature survey on the selected project & gathering information by referring the, technical papers,research publications etc.	28 SEPTEMBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements	24 SEPTEMBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	25 SEPTEMBER 2022
Proposed Solution	Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc.	23 SEPTEMBER 2022
Problem Solution Fit	Prepare problem - solution fit document.	30 SEPTEMBER 2022
Solution Architecture	Prepare solution architecture document.	28 SEPTEMBER 2022

Customer Journey	Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit).	05 OCTOBER 2022
Functional Requirement	Prepare the functional requirement document.	11 OCTOBER 2022
Data Flow Diagrams	Draw the data flow diagrams and submit for review.	12 OCTOBER 2022
Technology Architecture	Prepare the technology architecture diagram.	13 OCTOBER 2022
Prepare Milestone & Activity List	Prepare the milestones & activity list of the project.	21 OCTOBER 2022
Project Development - Delivery of Sprint-1, 2, 3 & 4	Develop & submit the developed code by testing it.	IN PROGRESS

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	The User (garbage collector) can register for the application using the respective credentials provided to them	10	High	Kalaivani Janani Logeshwari Surya Pooja
Sprint-1	Designing	USN-2	Designing a circuit with sensors and Arduino interface	10	Medium	Kalaivani Janani Logeshwari Surya Pooja
Sprint-2	Login	USN-3	As an administrator, register in IBM Cloud	10	Medium	Kalaivani Janani Logeshwari Surya Pooja
Sprint-2	Code development	USN-4	Develop a code to send a message when bin overflows using Ultrasonic Sensor	10	High	Kalaivani Janani Logeshwari Surya Pooja
Sprint-3	Sensor	USN-5	Detect the level of garbage using sensor and store it in server for specific interval of time	20	High	Kalaivani Janani Logeshwari Surya Pooja
Sprint-4	Communication Medium	USN-6	Garbage Collector receives the message from authority and goes to collect the garbage.	10	High	Kalaivani Janani Logeshwari Surya Pooja
Sprint-4	Communication Medium	USN-7	Once the garbage is collected the particular person should intimate the completion of task.	10	Medium	Kalaivani Janani Logeshwari Surya Pooja

Project Tracker, Velocity & Burndown Chart:

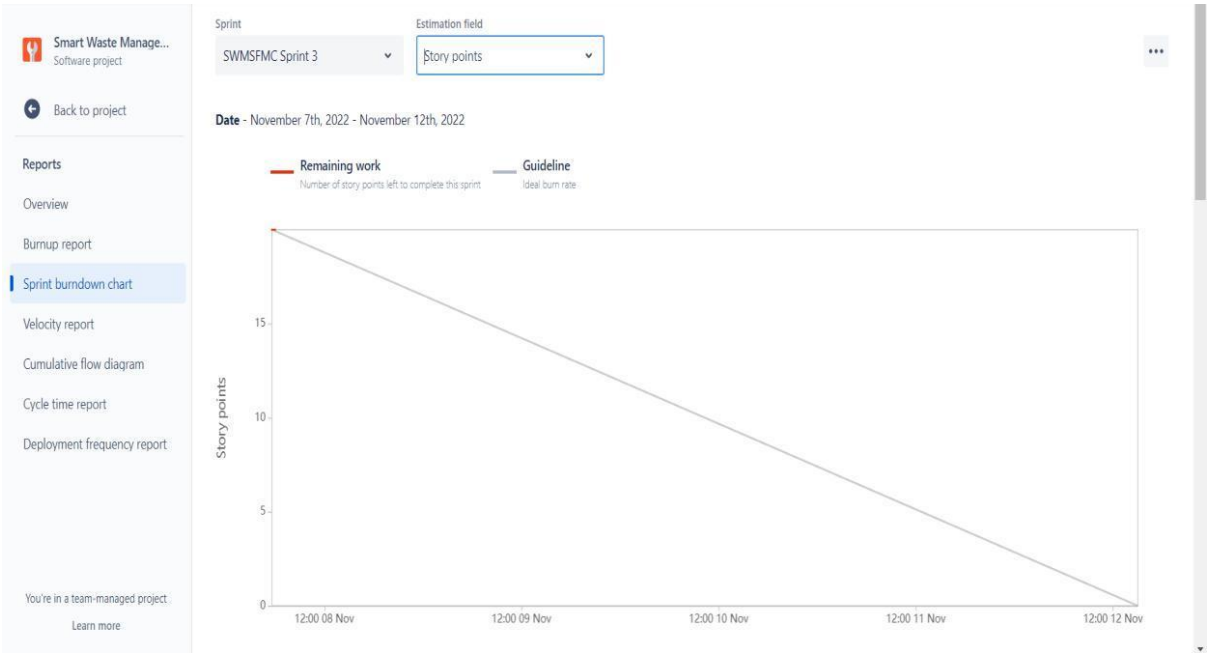
Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022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

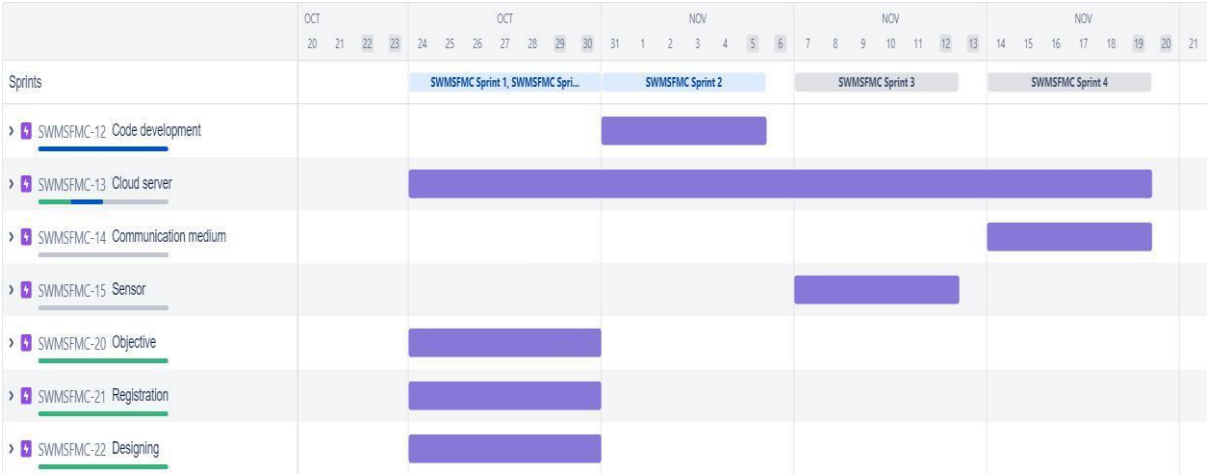
Velocity:

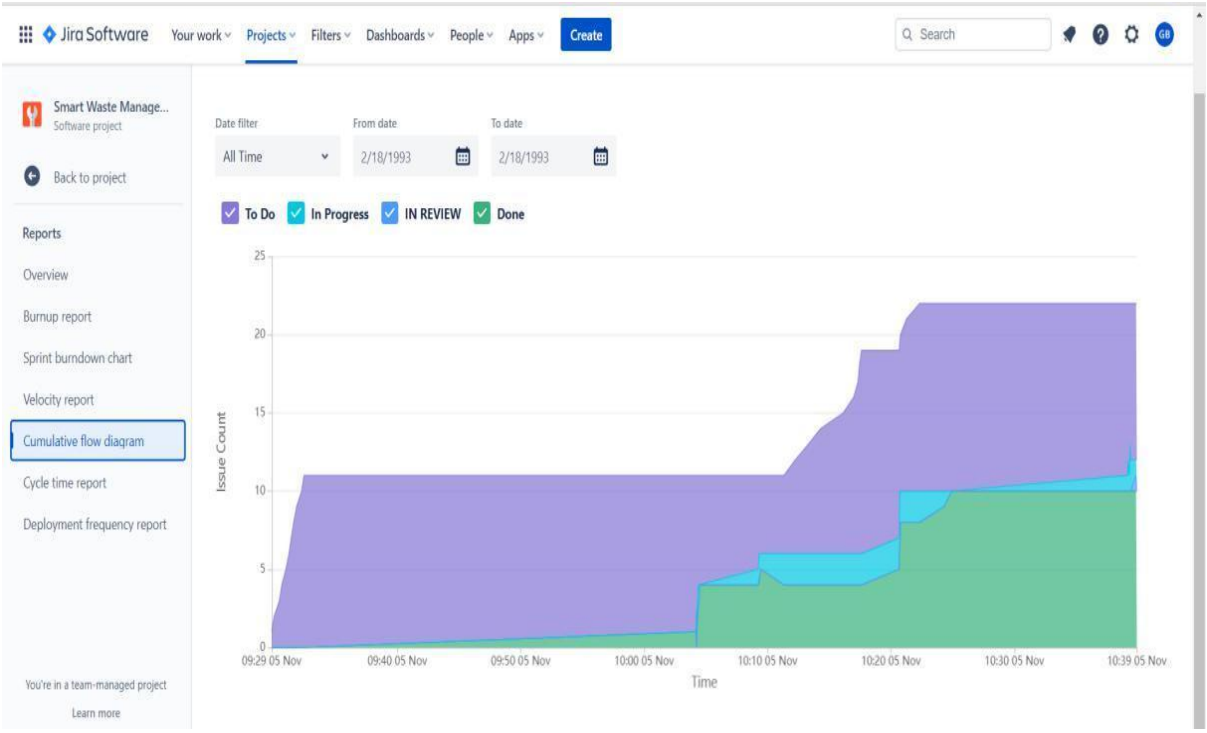
Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

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

6.3 Reports from JIRA

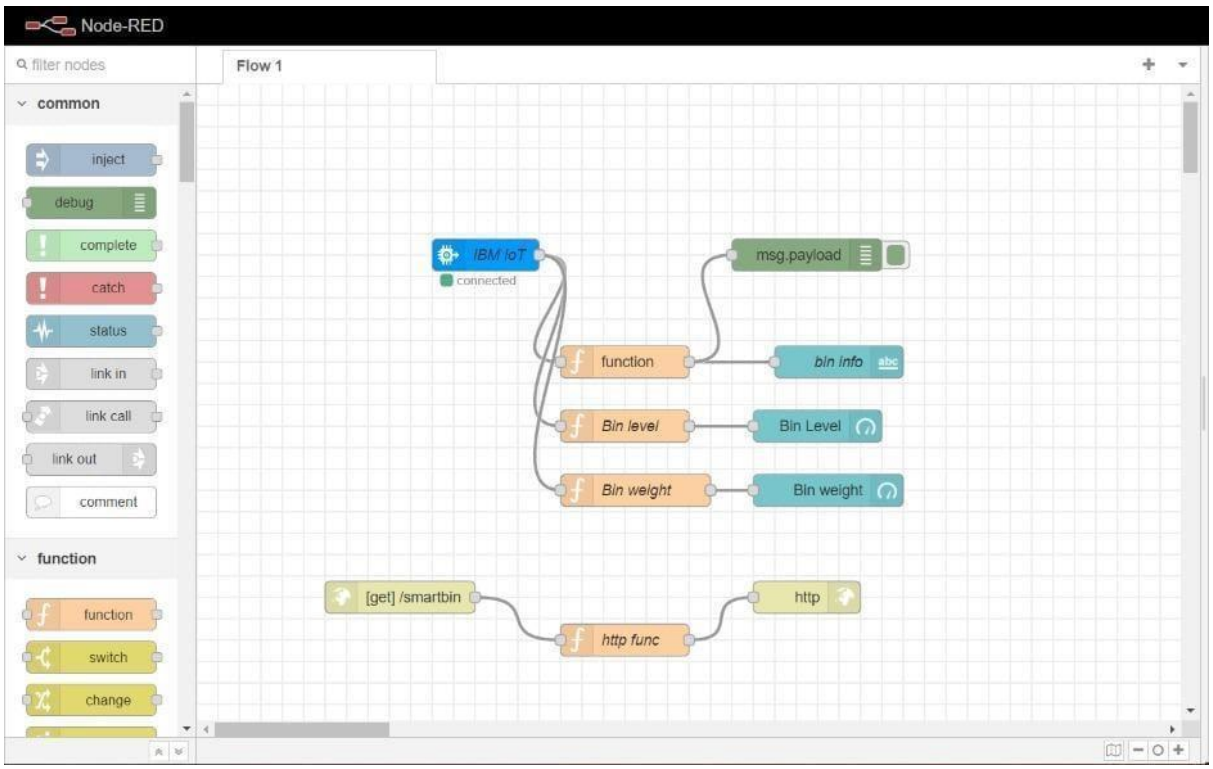




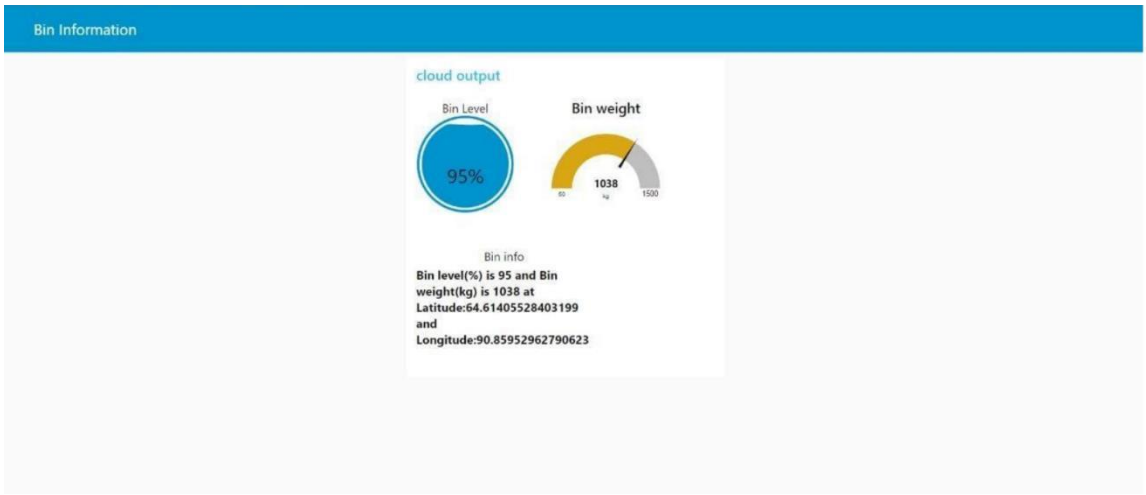

Jira Software
Your work
Projects
Filters
Dashboards
People
Apps
Create
Search
Smart Waste Manage...
Software project
Back to project
Reports
Overview
Burnup report
Sprint burndown chart
Velocity report
Cumulative flow diagram
Cycle time report
Deployment frequency report
You're in a team-managed project
Learn more
Date filter
All Time
From date
2/18/1993
To date
2/18/1993
To Do
In Progress
IN REVIEW
Done
Issue Count
25
20
15
10
5
0
09:29 05 Nov
09:40 05 Nov
09:50 05 Nov
10:00 05 Nov
10:10 05 Nov
10:20 05 Nov
10:30 05 Nov
10:39 05 Nov
Time

7. CODING & SOLUTIONING (Explain the features added in the project along with code)

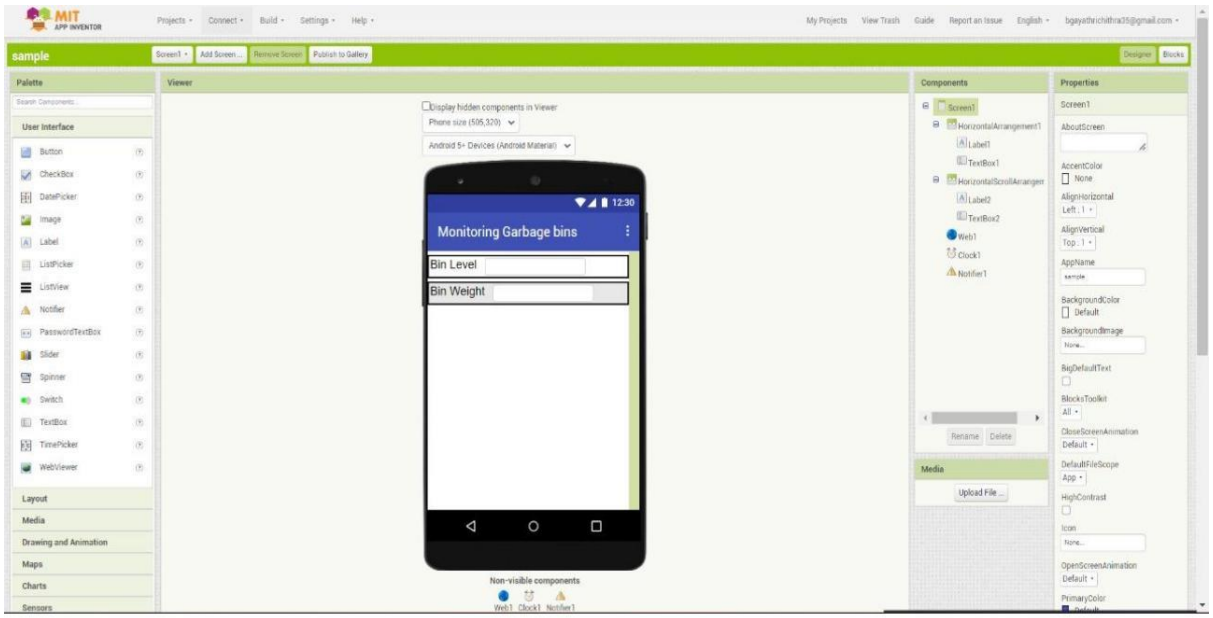
7.1 Feature 1 - Node Red:

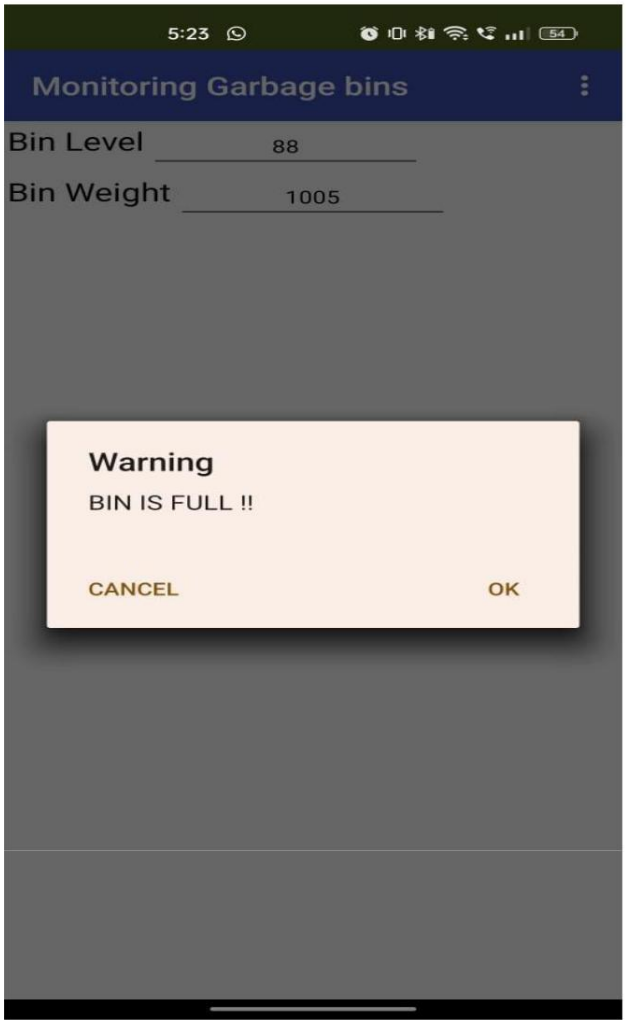


7.2 Feature 2- Web UI Displaying bin details

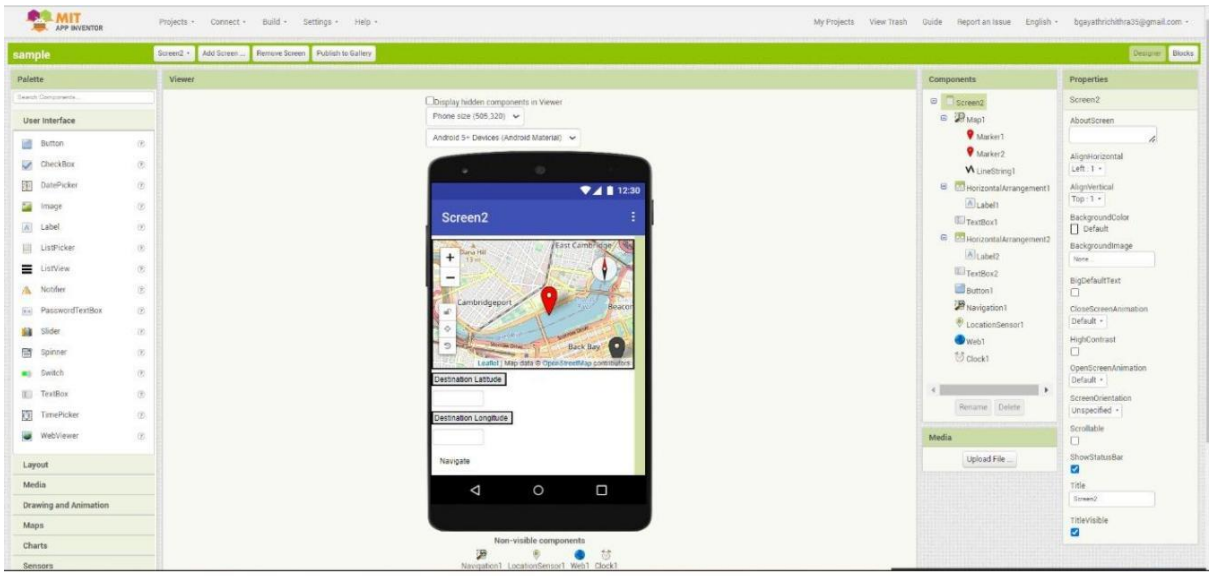


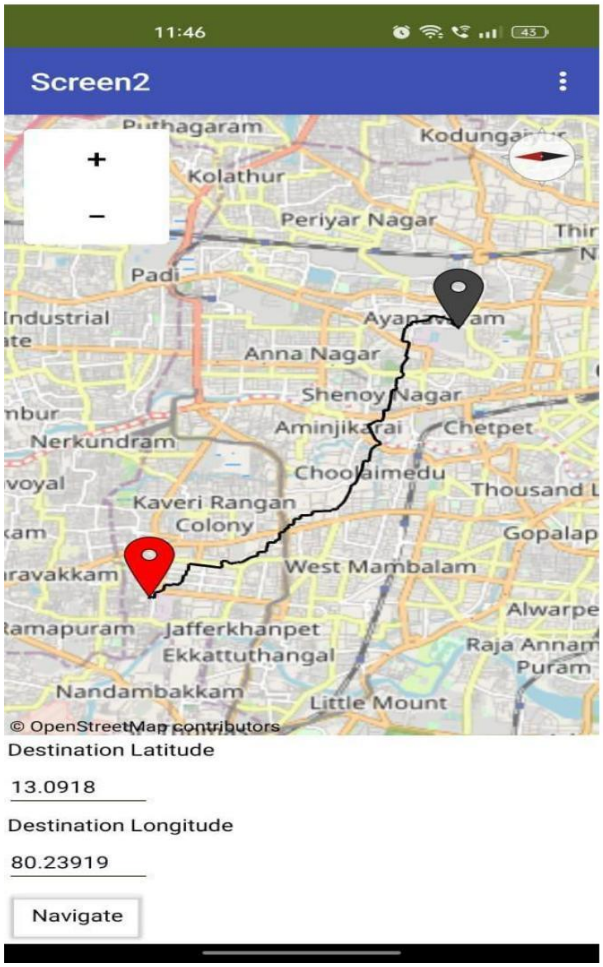
7.3 Feature 3-Live update





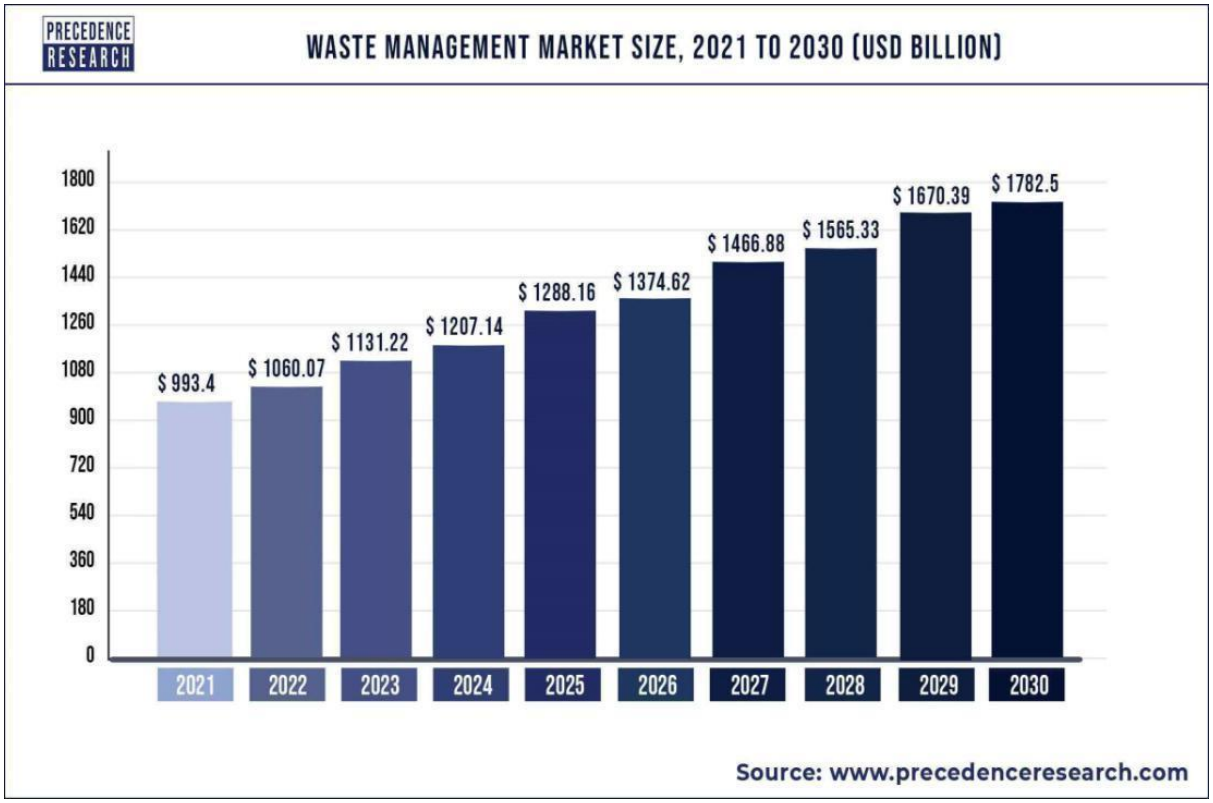
7.4 Feature 4 - Location Tracker





8.RESULTS :

8.1 Performance Metrics:



9. ADVANTAGES & DISADVANTAGES

ADVANTAGES:

1.Reduction in Collection Cost

2.No Missed Pickups

3.Reduced Overflows

4.Waste Generation Analysis

5.CO_2 Emission Reduction

DISADVANTAGES:

System requires a greater number of waste bins for separate waste collection as per population in the city. This results in high initial cost due to expensive smart dustbins compare to other methods. Sensor nodes used in the dustbins have limited memory size.

10.CONCLUSION

A Smart Waste Management system that is more effective than the one in use now is achievable by using sensors to monitor the filling of bins. Our conception of a "smart waste management system" focuses on monitoring waste management, offering intelligent technology for waste systems, eliminating human intervention, minimizing human time and effort, and producing a healthy and trash-free environment. The suggested approach can be implemented in smart cities where residents have busy schedules that provide little time for garbage management. If desired, the bins might be put into place in a metropolis where a sizable container would be able to hold enough solid trash for a single unit. The price might be high.

11.FUTURE SCOPE

There are several future works and improvements for the proposed system, including the following:

1.Change the system of user authentication and atomic lock of bins, which would aid in protecting the bin from damage or theft.

2.The concept of green points would encourage the involvement of residents or end users, making the idea successful and aiding in the achievement of collaborative waste management efforts, thus fulfilling the idea of Swachh Bharath.

3.Having case study or data analytics on the type and times waste is collected on different days or seasons, making bin filling predictable and removing the reliance on electronic components, and fixing the coordinates.

4.Improving the Server's and Android's graphical interfaces.

12. APPENDIX

SOURCE CODE

```python
#Installing necessary libraries
import wiotp.sdk.device
import time
import random
import requests
import math

#Configuration details for connecting python script to IBM Watson IOT Platform
myConfig = {
"identity": {
"orgId": "mldk59",
"typeId": "pythoncode",
"deviceId":"252525"
},
"auth": {
"token": "QZqODYo6U*Q6b+IpuC"
} }

def myCommandCallback(cmd):
```

```python
def myCommandCallback(cmd):
    print("Message received from IBM IoT Platform: %s" % cmd.data['command'])
    m=cmd.data['command']

#Connecting the client to ibm watson iot platform
client = wiotp.sdk.device.DeviceClient(config=myConfig,logHandlers=None)
client.connect()


#Generate Random values for latitude, longitude in a circular distribution from the current location and
#alert the garbage collector to go to the particular location where the bin level and bin weight exceeds the thresho

while True:

    res = requests.get('https://ipinfo.io/')
    data = res.json()
    loc = data['loc'].split(',')
    theta = random.uniform(0,2*math.pi)
    area = (0.05**2)*math.pi
    radius = math.sqrt(random.uniform(0,area/math.pi))
    latitude,longitude = [float(loc[0])+radius*math.cos(theta), float(loc[1])+radius*math.sin(theta)]
```

```python
    binlevel=random.randint(10,100)
    binweight = random.randint(50,1500)

    if binweight>=1000 and binlevel>80:
        myData={'latitude':latitude, 'longitude':longitude,'binlevel':binlevel,
                'binweight':binweight}
        client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0,
        onPublish=None)
        ##print("Published data Successfully: %s", myData)
        print("BIN IS FULL..TIME TO EMPTY IT!!!!\n",myData)
        client.commandCallback = myCommandCallback
        time.sleep(2)
        #break

    else :
        print("BIN IS IN NORMAL LEVEL...")
        time.sleep(2)
```

GitHub Link:

https://github.com/IBM-EPBL/IBM-Project-54971-1663229866