PROJECT REPORT

Date	24 November 2022
Project Name	Smart Waste Management System for Metropolitan Cities
TEAM ID	PNT2022TMID15126

1. **INTRODUCTION**
    1. **Project Overview**

        In this project, a system is introduced to manage waste in big cities effectively without having to monitor the parts 24×7 manually. Here the problem of unorganized and non-systematic waste collection is solved by designing an embedded IoT system that will monitor each dumpster individually for the amount of waste deposited. Here an automated system is provided for segregating wet and dry waste. A mechanical setup can be used for separating the wet and dry waste into separate containers here sensors can be used for separating wet and dry. For detecting the presence of any waste wet or dry can be detected using an IR sensor in the next step for detecting wet waste a moister sensor can be used. In this process, if only IR is detected motor will rotate in the direction of the dry waste container if both the sensor detects the waste then it will go to the wet container. Both these containers are embedded with ultrasonic sensors at the top, the ultrasonic sensor is used for measuring distance. This makes it possible to measure the amount of waste in the containers if one of the containers is full then an alert message will be sent to the corresponding person.

    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 w ho 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**
    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 odor 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-col), which are a risk to human health. monition of drinking water and can cause infection and transmit diseases. 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.

2. **References**

[1] Hashish no, M., et al. A Smart waste management for Health Awareness. in 2019 5111 International Conference on Information Management (ICIM). 2019.

[2] H. 91eau, Global Waste management and IOT. 2017.

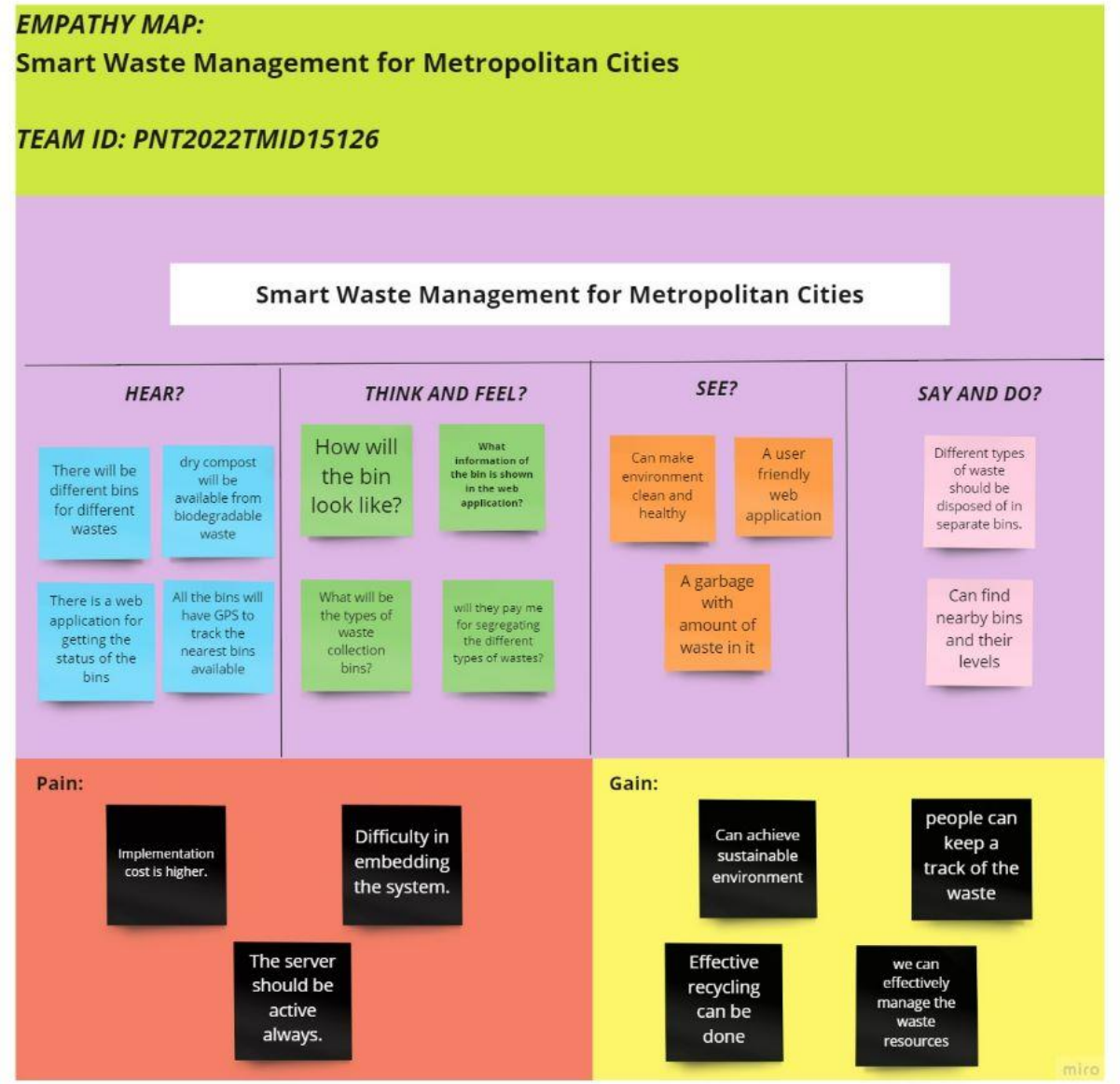
[3] Michel Lange, V., et al., Planning and production of waste management 2018.

3. **Problem Statement Definition**

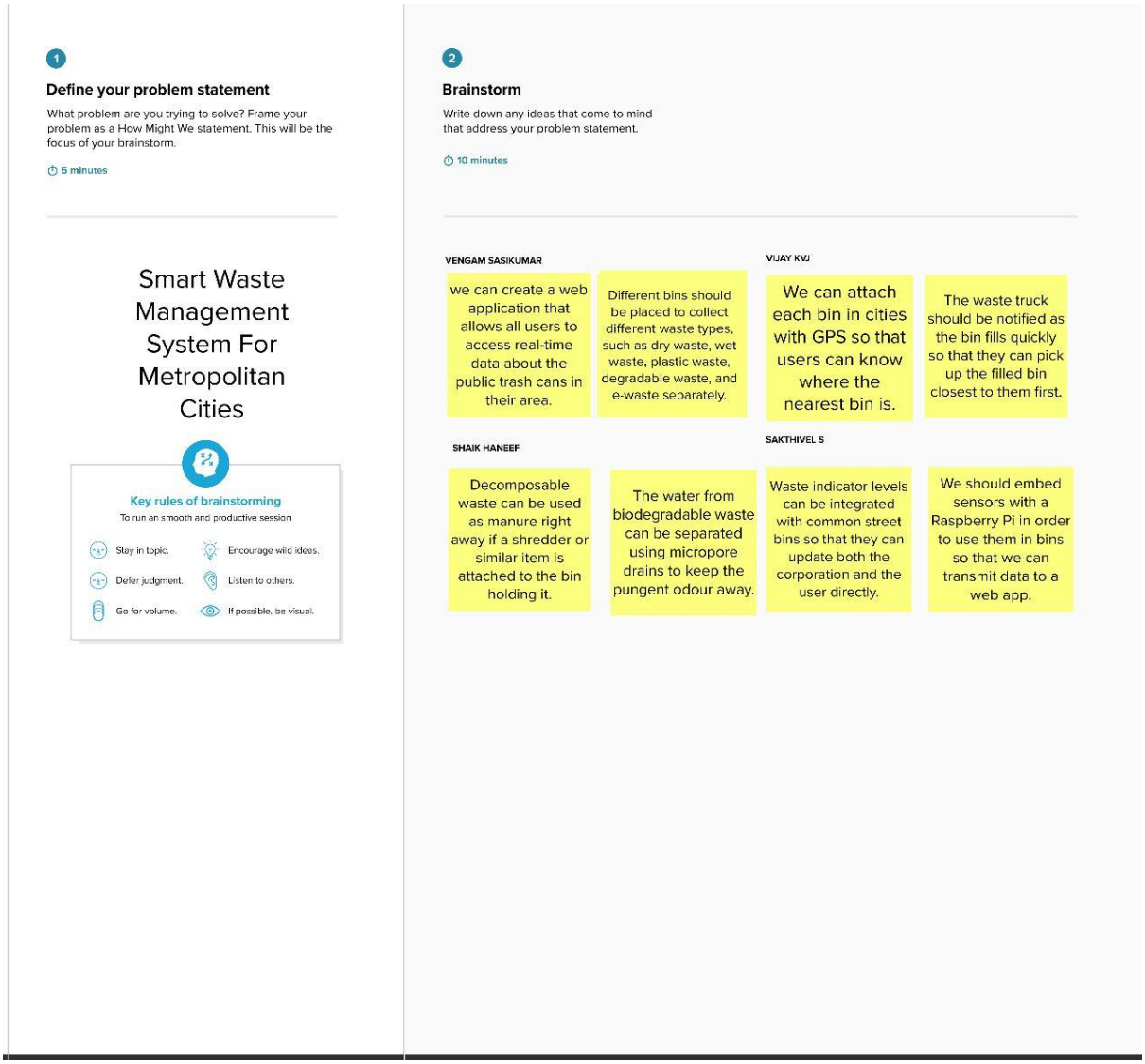
Problem Statement (PS)	**I am (Customer)**	**I'm trying to**	**But**	**Because**	**Which makes me feel**
PS-1	Municipal	Get notified	Don't	There is no	Frustrated
	corporation	when the	have the	tool available	
	authority	trash cans	facilities	to determine	
		are full and	at the	the level of	
		be made	moment	bins.	
		aware of			
		where the full			
		cans			
		are located.			
PS-2	Individual working for a private limitedcorporation	Get rid of the example of asurplus of waste	The trash cans arealways	I occupy a metropolitan city which isinvariably	Worried
			filled	crowded	

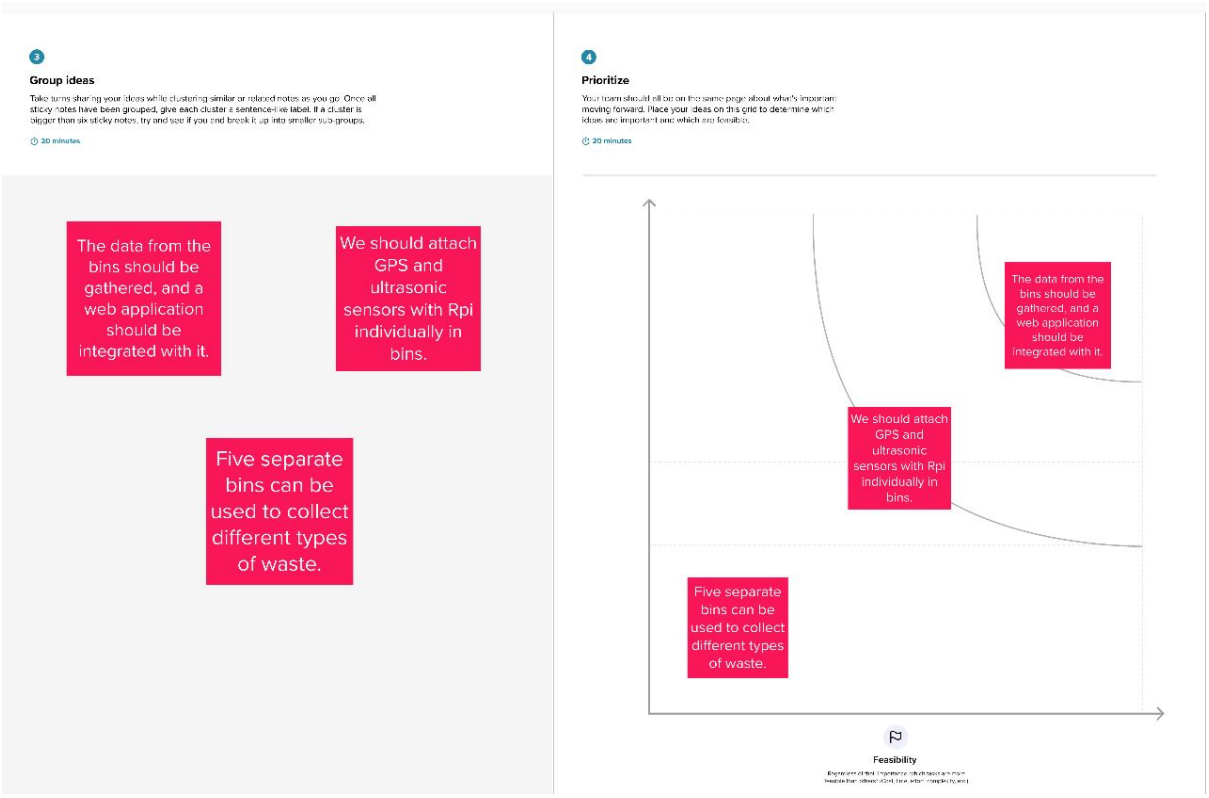
3. IDEATION & PROPOSED SOLUTION

1. Empathy Map Canvas



2. **Ideation & Brainstorming**



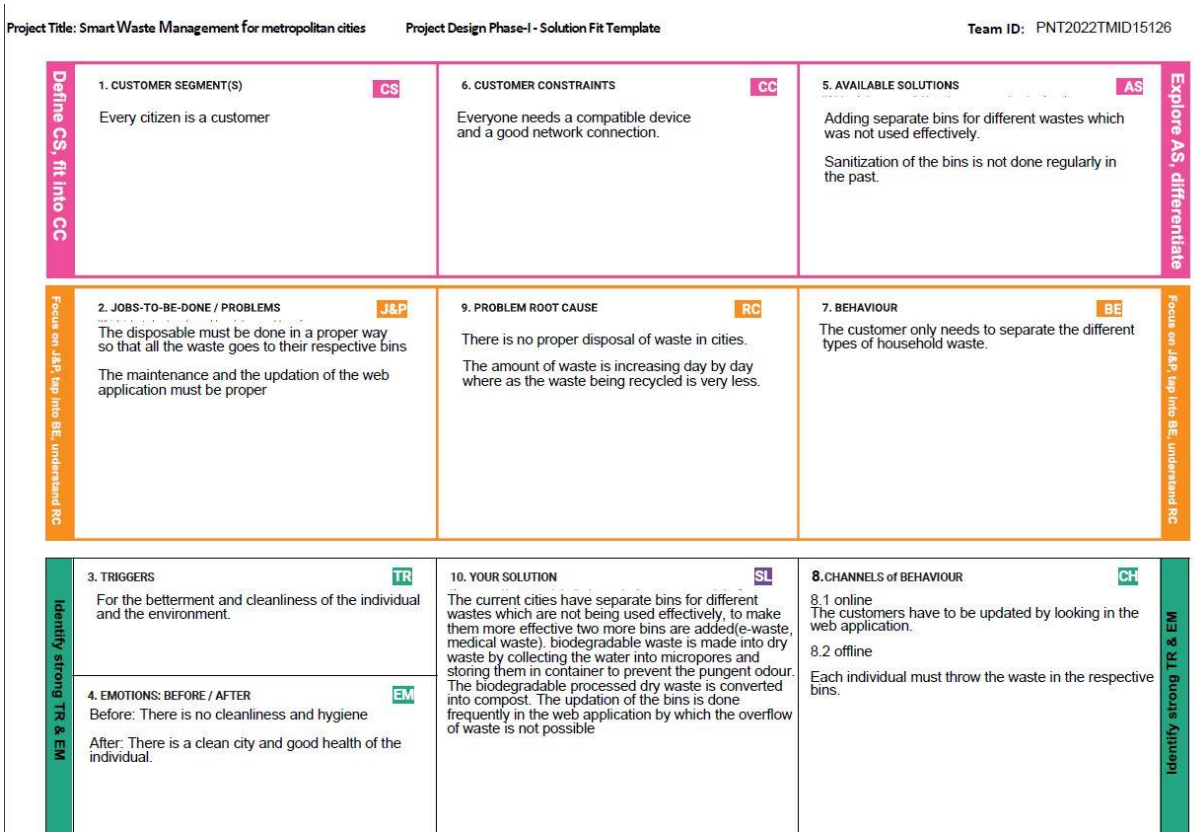


3. Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to besolved)	The amount of waste generated will be disposed properly and it will be easy for the corporation toclear the bins that is filled first. Apart form this, people can directly track the status of the bins through a web application and can easily locate the bin nearest to them to dispose any waste.
2.	Idea / Solution description	With the Web application both the users(people)and the corporation can track every bin and the status of the bin and it makes the disposal easier.
3.	Novelty / Uniqueness	The water from biodegradable waste can be separated using micro pore drains to keep thepungent odor away.
4.	Social Impact/ Customer Satisfaction	Reduces the overflow of waste in the bins byalerting to the trash collecting trucks therebykeeping the public space hygiene.

5.	Business Model (Revenue Model)	The e-waste, plastics and biodegradable waste arecollected in separate bins. E-waste can contain some useful metals which can recycled and reused. Plastics can be recycled and reused. Biodegradable waste can be turned into fertilizers.
6.	Scalability of the Solution	The above proposed solution is much more effective than the previously used and existingwaste management, especially in metro politan cities.

4. Problem Solution fit



4. REQUIREMENT ANALYSIS

1. Functional requirement

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story/ Sub-Task)
FR -1	Visit the web applicationthrough any browser	Registration through Mobile NumberRegistration through Gmai l

FR -2	Customers are asked to dispose the different types of waste in the respective bins	For example: E-waste, Organic waste, Plastics should bethrown away only in the bins maintained separately for them.
FR -3	For any complaints, the user needs to visit the query promp t box in the web application.	The user needs to use the raise any query prompt boxto raise any complaint.

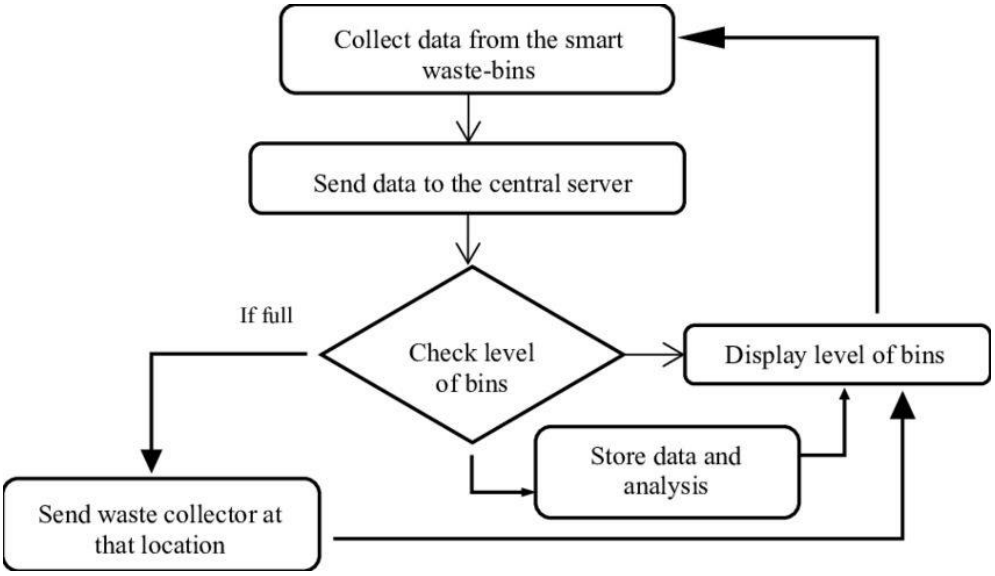
2. **Non-Functional requirements**

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

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	TheWeb Application is easy to use,and the users can track real time updates.
NFR-2	**Security**	The user information will be secured as the accounts are verified with Gmail.
NFR-3	**Reliability**	Operates in a real time manner resulting in less manpower.
NFR-4	**Performance**	Accurate information will be provided, thusincreasing the efficiency. This will decrease the total expenditure associatedwith the garbage collection.
NFR-5	**Availability**	The smart waste bins can be used everywhere andthus the intended authority can collect the waste whenever the bins are fully dumped with garbage
NFR-6	**Scalability**	As the smart bins have sensors and integrated with the web application, the waste can be managed efficiently and avoids unwanted dumping of waste.

5. **PROJECT DESIGN**
    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.

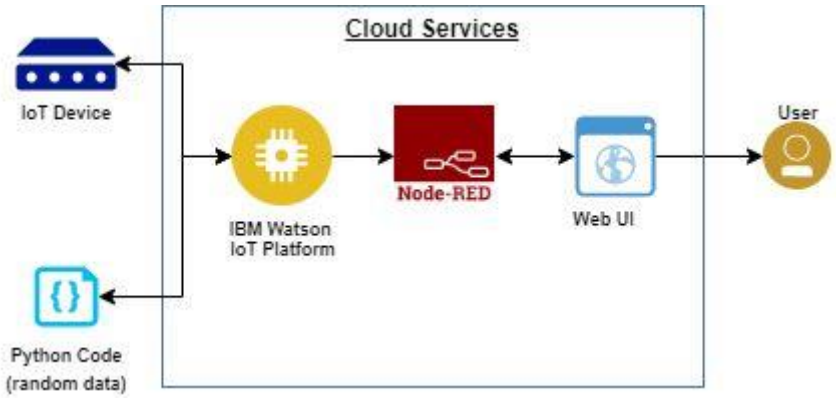


It shows how data enters and leaves the system, what changes the information, and where data is stored.
A smart waste management platform uses analytic to translate the data gather in your bins into actionable insights to help you improve your waste services.You can receive data on metric such as:

i. The first test conducted is the situation where the garbage bin is empty or itsgarbage level is very low.
ii. Then, the bin is filled with more garbage until its level has surpassed the firstthreshold value, which is set to 80% then the first warning SMS is being sent, as depicted.
iii. The first notification SMS sent by the system, once the waste reaches the level of85% full.
iv. The second notification SMS sent by the system, indicating that bin is at least95% full and the garbage needs to be collected immediately.
v. Locations prone to overflow.
vi. The number of bins needed to avoid overflowing waste.
vii. The number of collection services that could be saved.
viii. The amount of fuel that could be saved.
ix. The driving distance that could be saved.

2.Solution & Technical Architecture

SOLUTION ARCHITECTURE



TECHNOLOGY ARCHITECTURE

DESIGN:

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

Software and system required:

1. Python IDLE.
2. 4GB processor and OS-Windows/Linux/MAC.

Table-1: Components & Technologies:

S.no	Component	Description	Technology
1.	User Interface	Mobile Application	HTML, CSS,JavaScript.
2.	Application Logic	Logic for a process in the application	Java
3.	Database	Data Type,Configurations etc.	MySQL
4.	Cloud Database	Database Service on Cloud	IBM Cloud
5.	File Storage	File storage requirements	Local File system and IBMcloud

6.	Infrastructure (Server / Cloud)	Application Deployment onCloud Local Server Configuration	Local and Cloud Foundry

Table-2: Application Characteristic:

S. no	Characteristics	Description	Technology
1.	Open-Source Frameworks	GitHub	Internet hosting service
2.	Security Implementations	Application security: Firewall: Cisco	Network automation
3.	Scalable Architecture	It provides the room for expansionmore database of smart bins addedadditionally can be updated.	Cloud storage
4.	Availability	As the system control is connected to web server it isavailable 24*7 and can be accessed whenever needed.	Server
5.	Performance	Performance is high it uses5mb caches	Wireless Sensor Network

3. **User Stories**

6. **PROJECT PLANNING & SCHEDULING**
   1. **Sprint Planning & Estimation**

TITLE	**DESCRIPTION**	**RELEASE DATE**

Literature Survey andInformation Gathering	Surveying on the topic of selected project & gatheringinformation by referring the,technical papers , research publications etc.	23 SEPTEMBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvasto capture the user pains & gains on particular issue.	25 SEPTEMBER 2022
Ideation	Jot down the ideas by organizing the brainstorming session and prioritize the top 3ideas based on the feasibility & importance.	27 SEPTEMBER 2022
Proposed Solution	Prepare your proposed solution of the project which includes thenovelty, feasibility of idea, business model,social impact, scalability of solution, etc.	28 SEPTEMBER 2022
Problem Solution Fit	Prepare problem - solutionfit document.	28 SEPTEMBER 2022
Solution Architecture	Prepare solution architecture document.	30 SEPTEMBER 2022
Customer Journey Map	Prepare the customer journeymaps to understand the user interactions & experiences with theapplication (entry to exit)	17 OCTOBER 2022
Functional Requirement	Prepare the functional requirement for the project.	17 OCTOBER 2022
Data FlowDiagrams	Draw the data flow diagrams to understand the flow of execution of the project.	18 OCTOBER 2022
Technology Architecture	Prepare the technology architecture diagram.	18 OCTOBER 2022
Milestone &Activity List	Prepare the milestones &activity list of the project.	29 OCTOBER 2022

Delivery of Sprints	Submit the coding developmentof the project and submit in sprints. Sprint -1 Sprint -2 Sprint -3 Sprint -4	30 October 2022 5 November 2022 11 November 2022 17 November 2022

2. **Sprint Delivery Schedule**

Product Backlog, Sprint Schedule,and Estimation

Use the below template to create product backlog and sprint schedule

Sprint	**Functional Requirement (Epic)**	**User StoryNumer**	**User Story / Task**	**Story Points**	**Priority**	**Team Members**
Sprint-1	IoT device	USN-1	[illegible]	2	High	Vijay, Sasikumar
Sprint-1	Simulation	USN-2	Simulating and testing it using Test Board	1	Low	Vijay, Sasikumar
Sprint-2	Interfacing	USN-1	Interfacing IBM Watson and Python IDLE	2	High	Sakthivel, Haneef
Sprint-3	Node-RED	USN-1	Creating Node-RED service and interfacing the IoT device	2	High	Haneef, Sasikumar
Sprint-4	Dashboard	USN-1	Monitoring the Dashboard	1	Medium	Vijay, Sakthivel

Project Tracker, Velocity & Burndown Chart: (4 Marks)

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	18	06 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	15	14 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	18	20 Nov 2022

3. **Reports from JIRA**

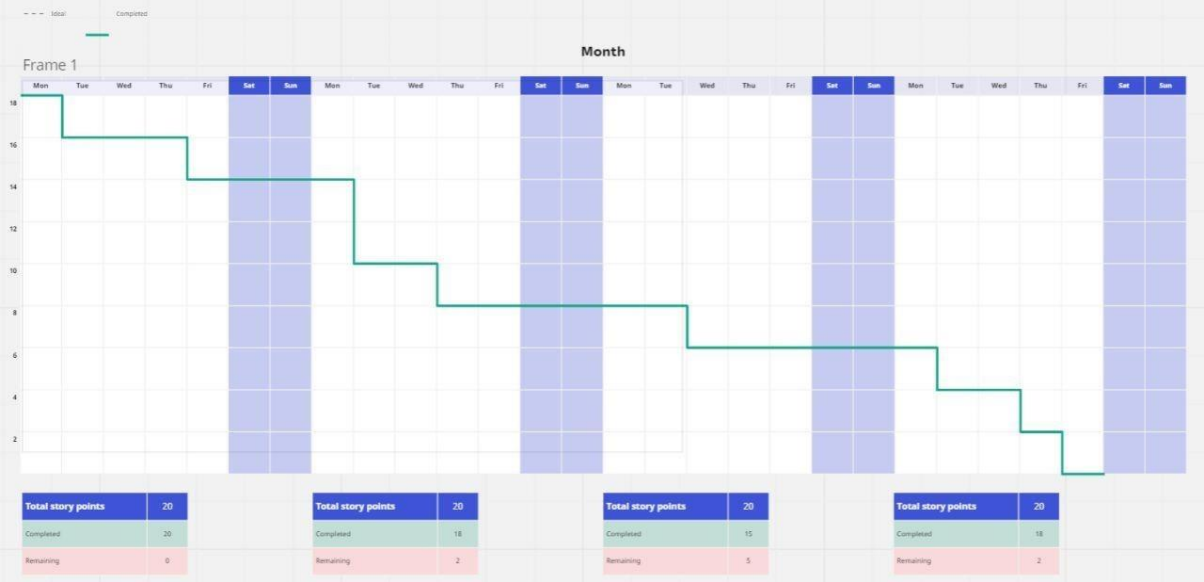
Velocity:

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)

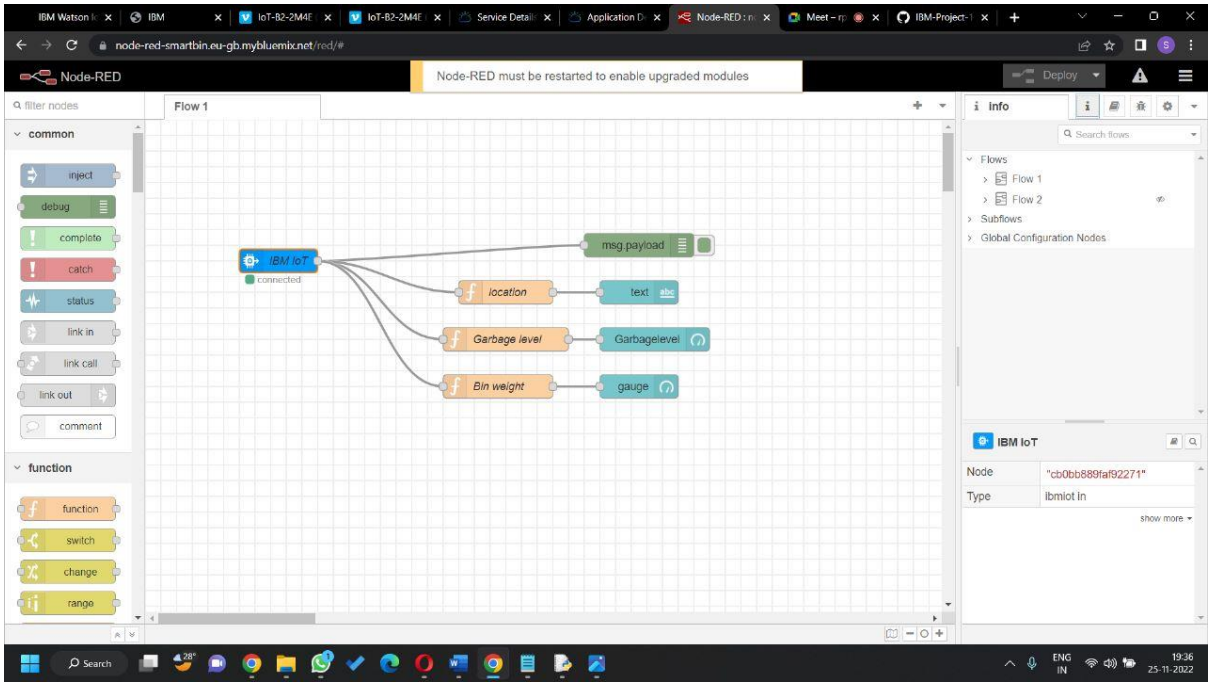
$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

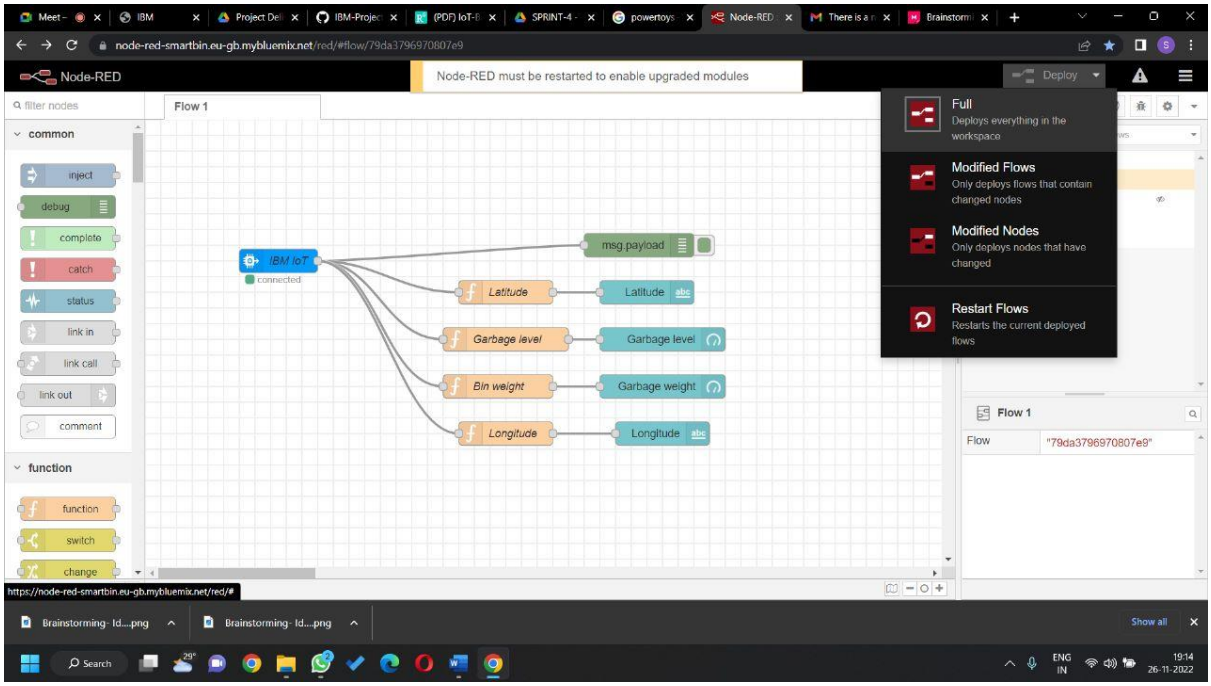
Burndown Chart:

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies suchas Scrum. However, burn down charts can be applied to any project containing measurable progress over time.

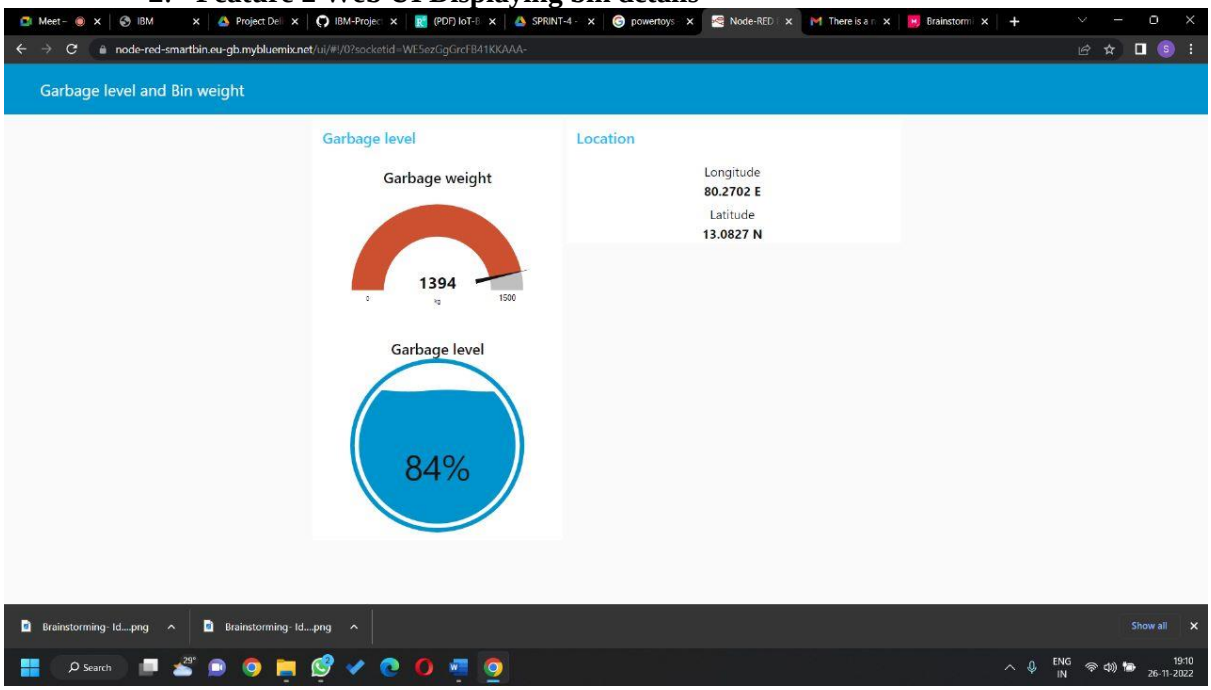


7. **CODING & SOLUTIONING (Explain the features added in the project along with code)**
    1. **Feature 1 NODE RED**



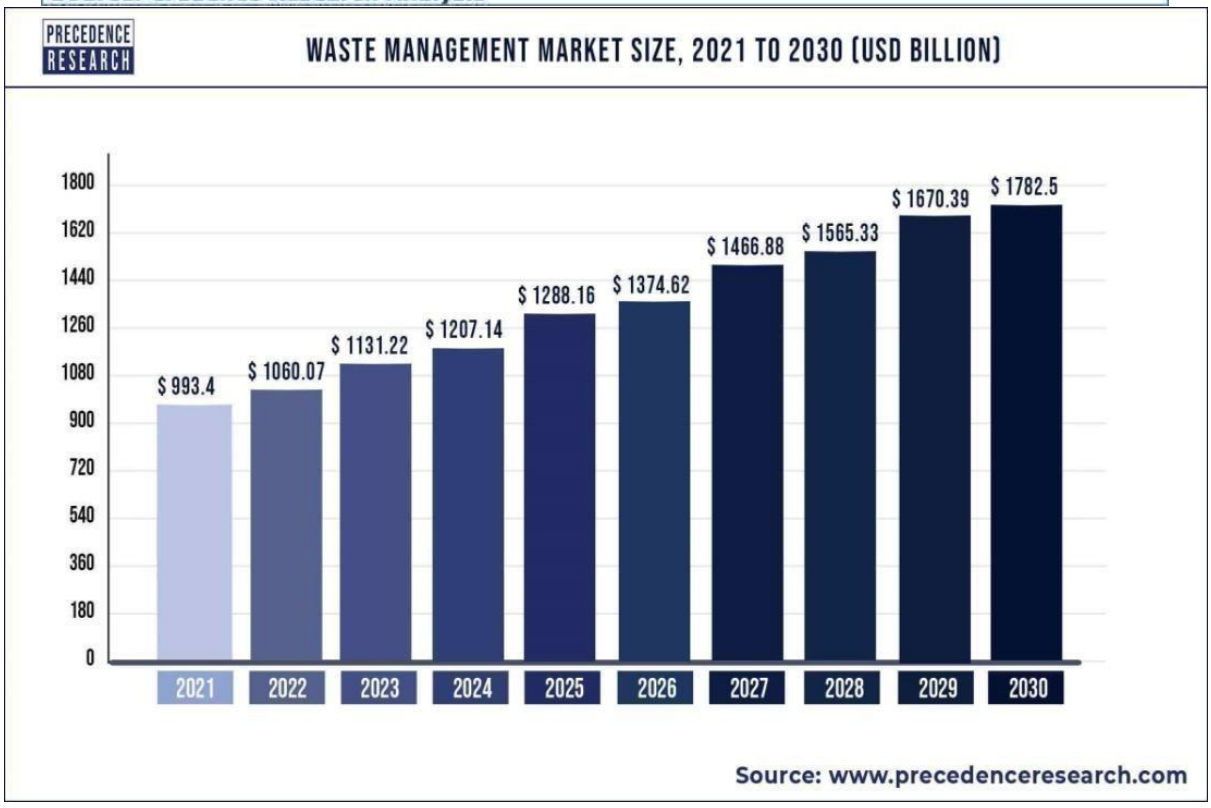


2. **Feature 2 Web UI Displaying bin details**



8.RESULTS

1. **Performance Metrics**



9. **ADVANTAGES & DISADVANTAGES**

Advantages:

➡It saves time and money by using smart waste collection bins and systems equipped with fill level sensors. As smart transport vehicles go only to the

filled containers or bins. It reduces infrastructure, operating and maintenance costs by up to 30%.

➡It decreases traffic flow and consecutively noise due to less air pollution as result of less waste collection vehicles on the roads. This has become possible due to two way communication between smart dustbins and service operators.

➡It keeps our surroundings clean and green and free from bad odor of wastes, emphasizes on healthy environment and keep cities more beautiful.

➡It further reduces manpower requirements to handle the garbage collection process.

➡Applying smart waste management process to the city optimizes management, resources and costs which makes it a "smart city".

➡It helps administration to generate extra revenue by advertisements on smart devices.

Disadvantages:

➡System requires a greater number of waste bins for separate waste collection as per population in the city. This results into high initial cost due to expensive smart dustbins compare to other methods.

➡Sensor nodes used in the dustbins have limited memory size.

➡Wireless technologies used in the system such as zigbee and wifi have shorter range and lower data speed. In RFID based systems, RFID tags are affected by surrounding metal objects (if any).

➡It reduces man power requirements which results into increase in unemployment for unskilled people.

➡The training has to be provided to the people involved in the smart waste management system.

10. **CONCLUSION**

We have implemented real time waste management system by using smart dustbin to check the fill level of smart dustbin whether the dustbins are full or not. In this system the information of all smart dustbins can be accessed from anywhere and anytime by the Concern person and he can take decision accordingly. By implementing this proposed system, the cost reduction, resource Optimization effective use of Smart dustbins can be done.

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 thebin 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 Bharat.

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 fix ing the coordinates.

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

12. **APPENDIX**

Source Code :

```
#Project: Smart Waste Management System for Metropolitan cities
#Team ID: PNT2022TMID15126
#Installing necessary libraries
import wiotp.sdk.device
import time
import random
import requests
import math
#Configuration details for connecting python script to IBM Watson
   IOTPlatform
myConfig = {
"identity": {
"orgId": "6p7adf",
"typeId": "Smart_Bin",
"deviceId":"NT15126"
},
"auth": {
"token": "Yo7cQU?Z3S9v964o5x"
} }
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 binlevel and bin weight exceeds the threshold
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)]
 binlevel=random.randint(10,100)
 binweight = random.randint(50,1500)

 if binweight>=1000 and binlevel>80:
   myData={'latitude':latitude,
   'longitude':longitude,'binlevel':binlevel,'binweight':binweigh
   t}
   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(4)

 #break

 else :
    print("BIN IS IN NORMAL LEVEL...")
    time.sleep(2)
 #Disconnect the client connection
client.disconnect()
```

GitHub
Video link