Project Report

Team ID	PNT2022TMID05290
Project Name	SMART WASTE MANAGEMENT FOR METROPOLITAN CITIES

1.Introduction

1.1 Project Overview

In most of the developing countries, due to the increasing population and industrialization, the indiscriminate disposal of solid waste poses serious threat to healthy living of the citizens. According to researches, in addition to the waste disposal, treatment it is equally important to ensure effective waste management. The efficiency is measured in terms of required amount of time and energy. In order to meet this effectiveness, we have developed a IoT based Smart Waste Management system for Metropolitan cities. Since the maximum resources can be exploited for developing this system on a large-scale urban center's i.e., Metropolitan cities are taken into consideration. This project concentrates on developing an integrated system that ensures proper, collection, transportation and recycling of household waste on an urban scale

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 usingtechnology 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, butalso lowers the chance of any bin being full 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. 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. Thus, smart waste management provides us with the most optimal way of managing the waste in an efficient manner using technology.

2. LII'ERAI'URE SURVEY:

2.1 Existing píoblem:

Waste collection, disposal and management has become a socially disturbing issue in towns and metropolitan cities due to increasing population. wastes are being dumped regularly at a large scale. The local dumpsters are overflowing causing rotting of garbage, releasing poisonous gases and bad odour. This makes the surroundings unsafe and unhygienic. Most of the time, the municipality is unaware of the location of overflowing garbages. The ineffective disposal pollutes soil, water and air. The drinking water is contaminated by the open dumpsters near water bodies . Animals eating these garbage get infected with gut-related disorder. The land is also contaminated by the overflowing garbage hosting bacteria, viruses spreading air-borne, water-borne diseases which risks human health. The garbage collectors and truck drivers lack resources to know the location of the overflowing dumpsters thus causing ineffective collection and disposal of garbage

2.2 References:

S.NO	Title of the Author	Author Name	Year of Publication	Remarks	Output
1.	IOT based smart waste bin monitoring and municipal solid was te management sys tem for smart cities	Muhammed Irfan, Abdullah Saeed, Al Wadie , Adam	4 June 2020	Environmental Pollution. Improper collector and disposal mechanism	Collect the waste effectively. Detection of fire in waste material. Wirelessly connected with the central hub of transmit the info about the bins filling level with existing collection. Avoid the overflow of bins.
2.	A novel strategy for waste prediction using machine Learning algorithm with IOT based intelligent waste management system	G.Uganya, D.Rajalaksh mi, Arun Radhakrishn an Ramya, Yuvaraja teeka, -raman	10 Feb 2022	Low-cost Method High Accuracy Complicated method Because of using machine learning algorithm	Automatic method, predicting the possibility of waste things. The waste capacity, gas level, metal level monitored continuously Using IOT based dustbins . Tested by random forest algorithm gives the accuracy of 92.15% and give time consumptions of 0.2 ms.

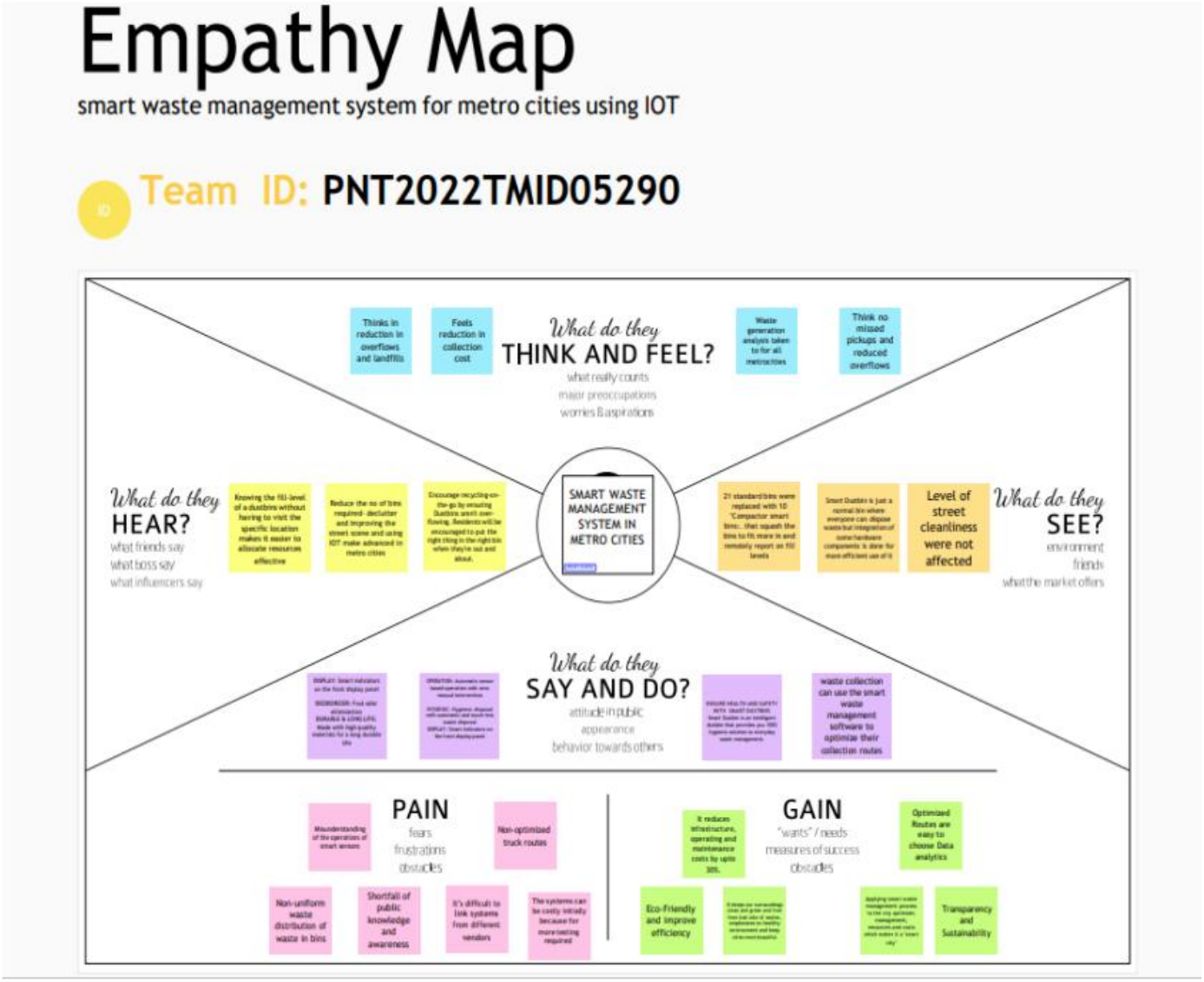
3.	System waste management	Arafat ali khan Farhana shetu Saimum bari Lawshik shikder	7 Jan 2021	Good enough to prevent the garbage overflow and ensures the partial is perfect waste management and monitoring sys tem	Microcontroller, sensor, GSM are used in the system. This proposed system would have an automated waste level detection process and also a smart monitoring and overall management process.
4.	IOT based solar powered smart waste management system with real time monitoring an advancement for smart city planning	Md.humaun Kabir,sujit roy, Md.tofail ahmed, Mahmudul alam	21 Oct 2020	project costs complicated but this can be sui table for any kind of cities or town and ensures proper collection and disposal of garbage	It enables real time monitoring of solar powered several smart bins located in different point in the city which are connected to control system through long angle (LDRA) Communication device and also supervises the waste collection and disposal time using automated
5.	Real time smart garbage bin mechanism for solid was te manageme nt in smart ci ties	Dominic Abuga N.S.Ragava	23 Oct 2021	Fuzzy logic is applied Hence real time decision making avoid real time moni toring	This mechanism proposed accesses real time information of any smart garbage bin deployed across the city and helps to resolve the problem of waste overflow from garbage bins and keeps cities clean.

2.3 Problem Statement Definition:

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	A Civilian	Dump wastes regularly provided the dust bin is not overflowing	Dust bins placed locally is overfilled with garbage which might get contaminated with bacteria and viruses	Lack of regular maintenance and disposal of the waste as the collector is unaware of the location of the overflowing dustbins	Worried that people of my locality might get infected.
PS-2	Garbage collector (Sanitary worker)	Get alerted when the garbage bins are filled to avoid late pickups and overflowing of the garbage bins.	Currently unaware of the location of overflowing garbage bins.	No proper resource to notify us about the location of the dustbins as soon as they get filled.	Helpless that I can't perform my work effectively.

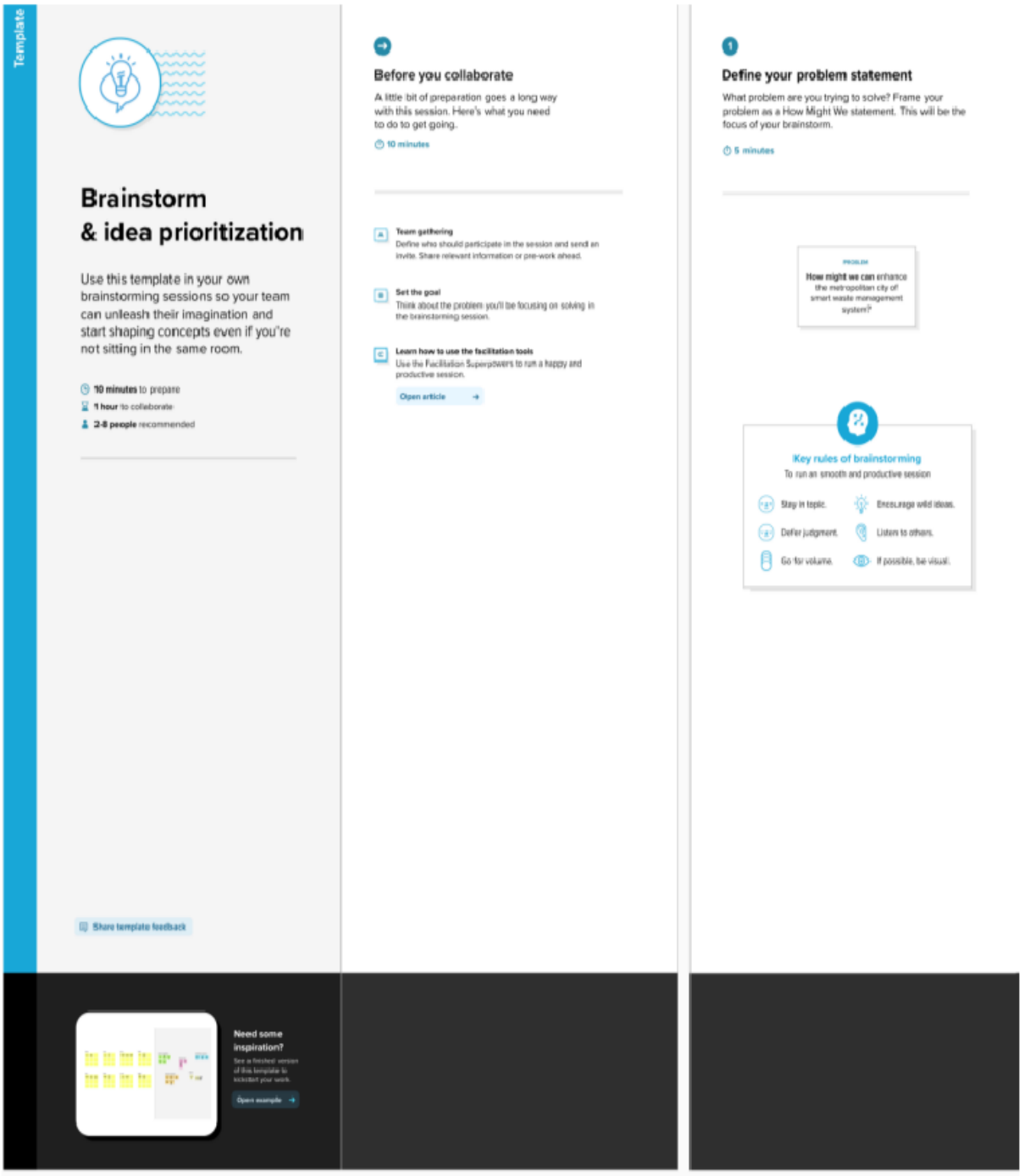
3. IDEAI'ION & PROPOSED SOLUI'ION

3.1 Empathy Map Canvas

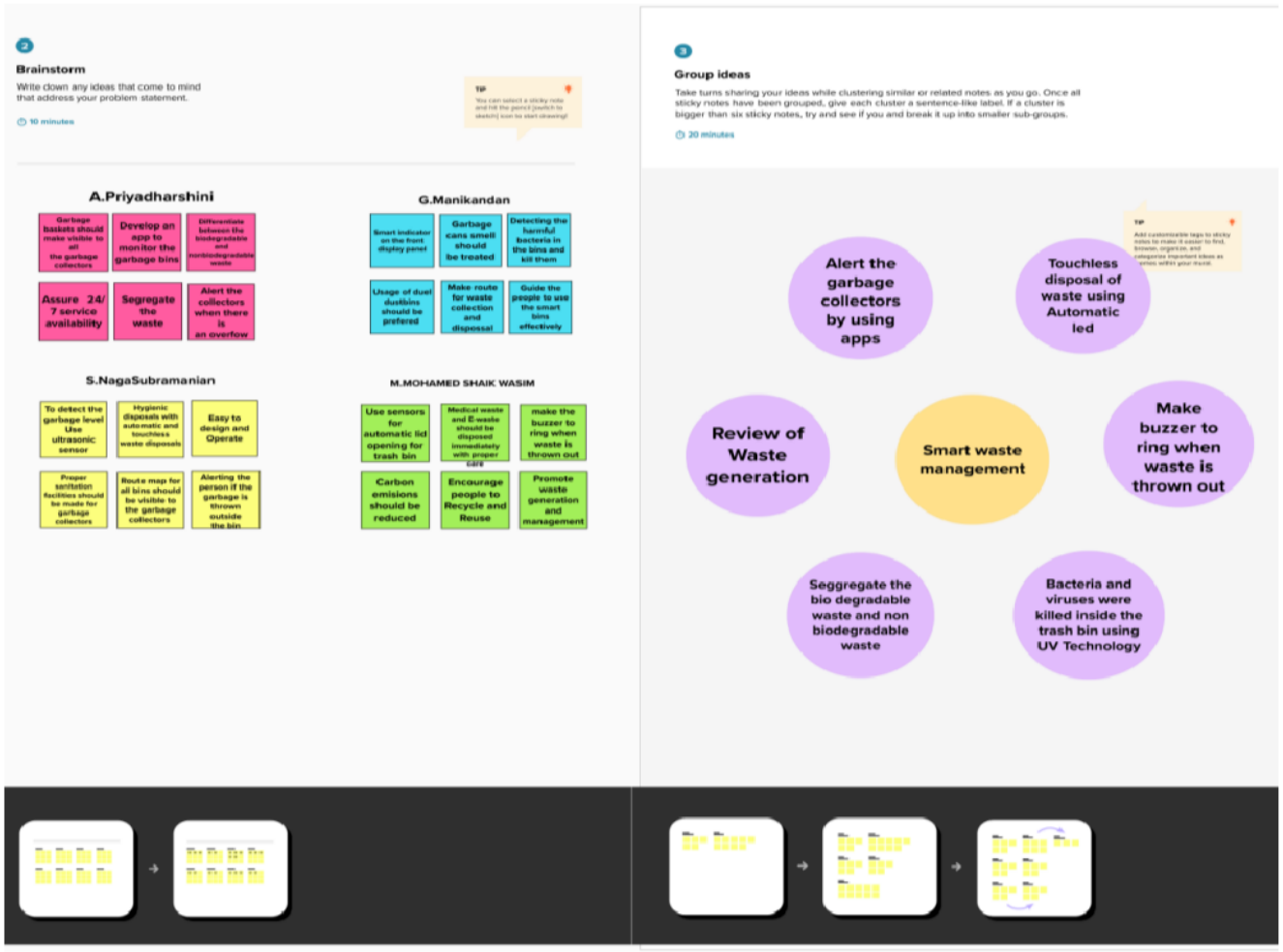


3.2 Ideation & Bíainstoíming

Step-1: Team Gathering, Collaboration and Select the Problem Statement



Step-2: Brainstorm, Idea Listing and Grouping

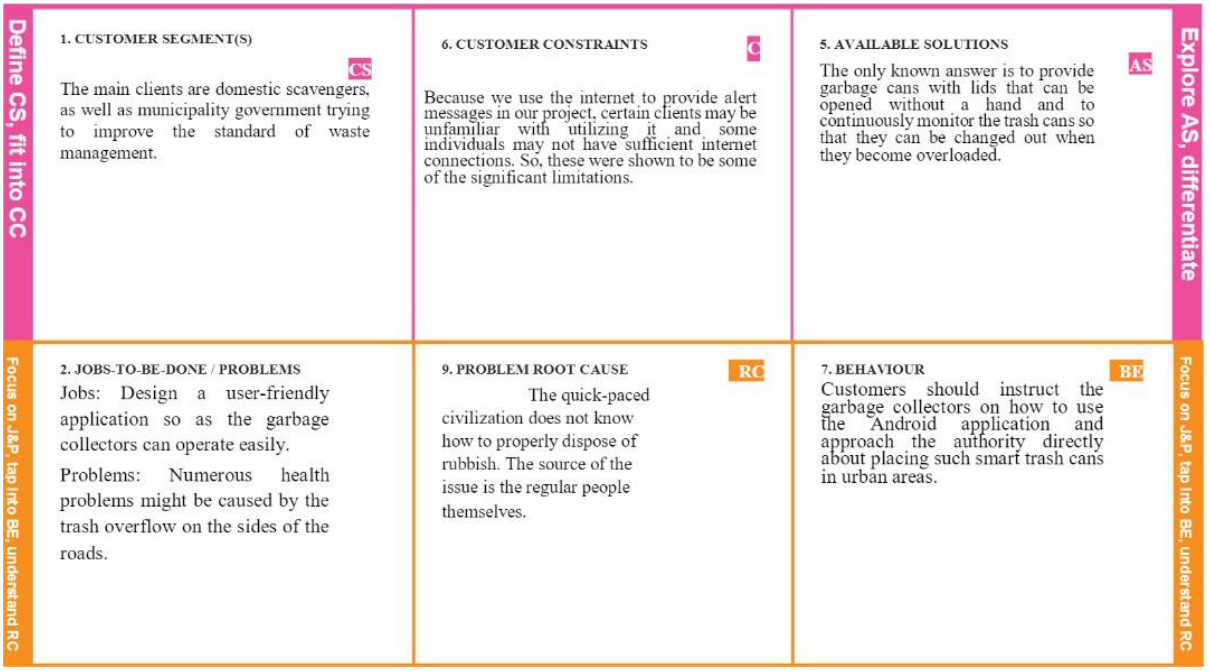


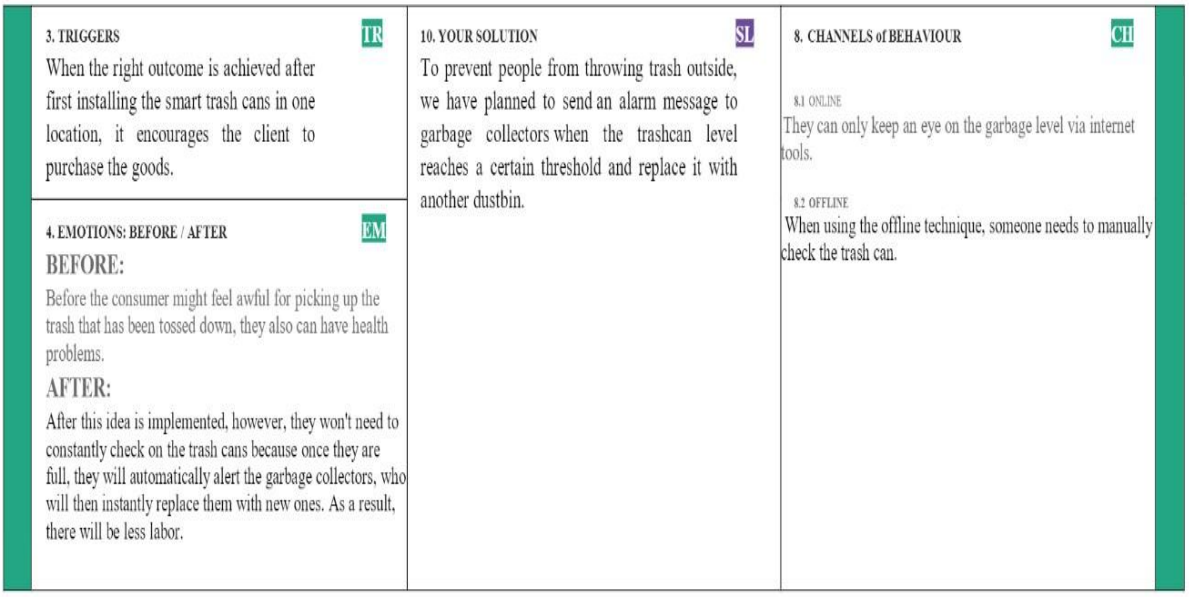
Step-3: Idea Prioritization

3.3 Proposed Solution

S. No	Parameter	Description
1.	Problem Statement (Problem to be solved)	To prevent overflow of waste from the dumpsters. To notify the garbage collector to ensure timely disposal of the waste
2.	Idea / Solution description	Once the garbage level reaches 3/4th of the dumpster, it must be detected by the sensors. Then it must immediately notify the garbage collector providing location details and efficient route to the dumpster.
3.	Novelty / Uniqueness	Without manual intervention, the dumpsters are sensed and the garbage collectors are alerted, thus ensuring efficient collection and disposal of wastes.
4.	Social Impact / Customeí Satisfaction	Infra-red sensor enabled dumpsters prevents garbage overflow. Rotting of garbage and unpleasant odour due to the release of Methane gas is prevented thus promoting social health and improving air quality. Difficult, demeaning and dangerous job of human is replaced effectively by this technology.
5.	Business Model (Revenue Model)	This effective IoT based Smart waste management system can be an optimal solution for municipalities corporations, industries, residential areas by offering this automated waste management and disposal services. This can also generate income by producing biogas from the collected waste

3.4 Problem Solution fit





4. REQUIREMENT ANALYSIS

4.1 Functional Requirement

Following are the functional requirements of the proposed solution.

ÏR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-task)
FR-1	Product Installation	Trash bin installation of embedded components such as sensors and Raspberry Pi
FR-2	User Interface	Getting the sensor readings from the ultrasonic sensor and load cell
FR-3	Pushing data to Database	Storing the data in cloud for backup When the threshold level is reached, 1. Notifies the user 2. Sends the GPS location
FR-4	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.
FR-5	Eliminate inefficient picks	Eliminate the collection of half-empty bins. The sensors recognize picks. By using real-time data on fill-levels and pick recognition, we can show you how full the bins you collect are. The report shows how full the bin was when picked. You immediately see any inefficient picks below 80% full.
FR-6	Detailed bin inventory.	On the map, you can see every monitored bin and stand, and you can use Google Street View at any time to visit them. On the map, bins of stands appeal as green, orange, of red circles. The Dashboard displays information about each bin, including its capacity, trash kind, most recent measurement, GPS position, and pick-up schedule.

4.2 Non-Functional requirements

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

SR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	IoT device verifies that usability is a special and important perspective to analyze user requirements, which can further improve the design quality.
NFR-2	**Security**	Use reusable bottles Use reusable grocery bags Purchase wisely and recycle Avoid single use food and drink containers
NFR-3	**Reliability**	The users are notified and get the location of bins in a very efficient way, which reduces human effort.
NFR-4	**Performance**	By developing& deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter
NFR-5	**Availability**	By developing& deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter
NFR-6	**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 move to smarter.

PROJECT DESIGN

1.1 Data Flow Diagrams

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

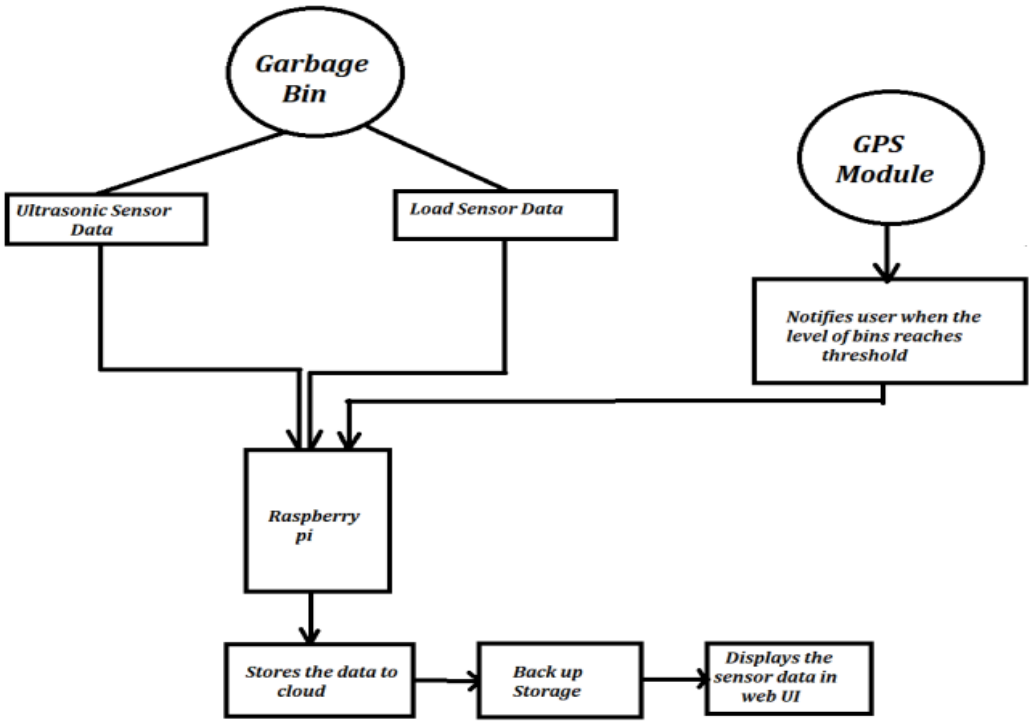
A smart waste management platform uses analytics to translate the data gather in your

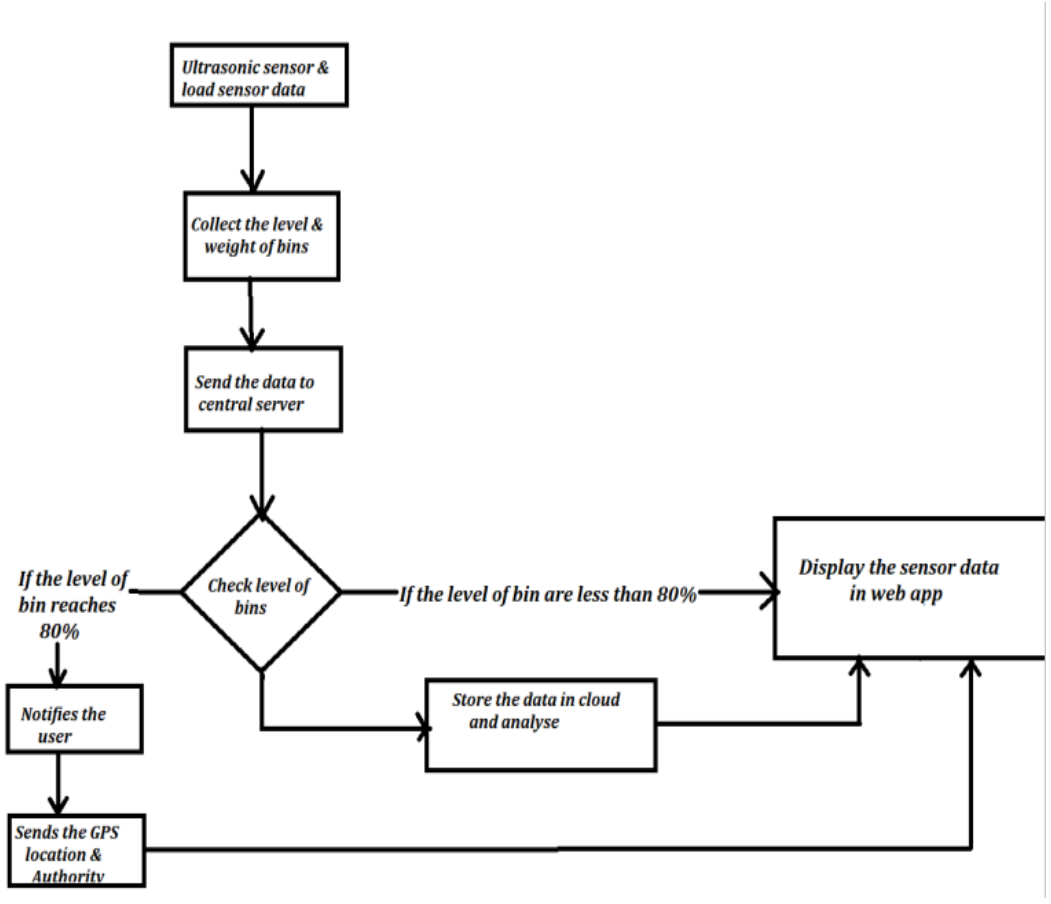
bins into actionable insights to help you improve your waste services.

You can receive data on metric such as:

- the first test conducted is the situation where the garbage bin is empty or its garbage levelis 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 waning 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

Data flow diagram:





1.2 **Solution & technical Architecture:**

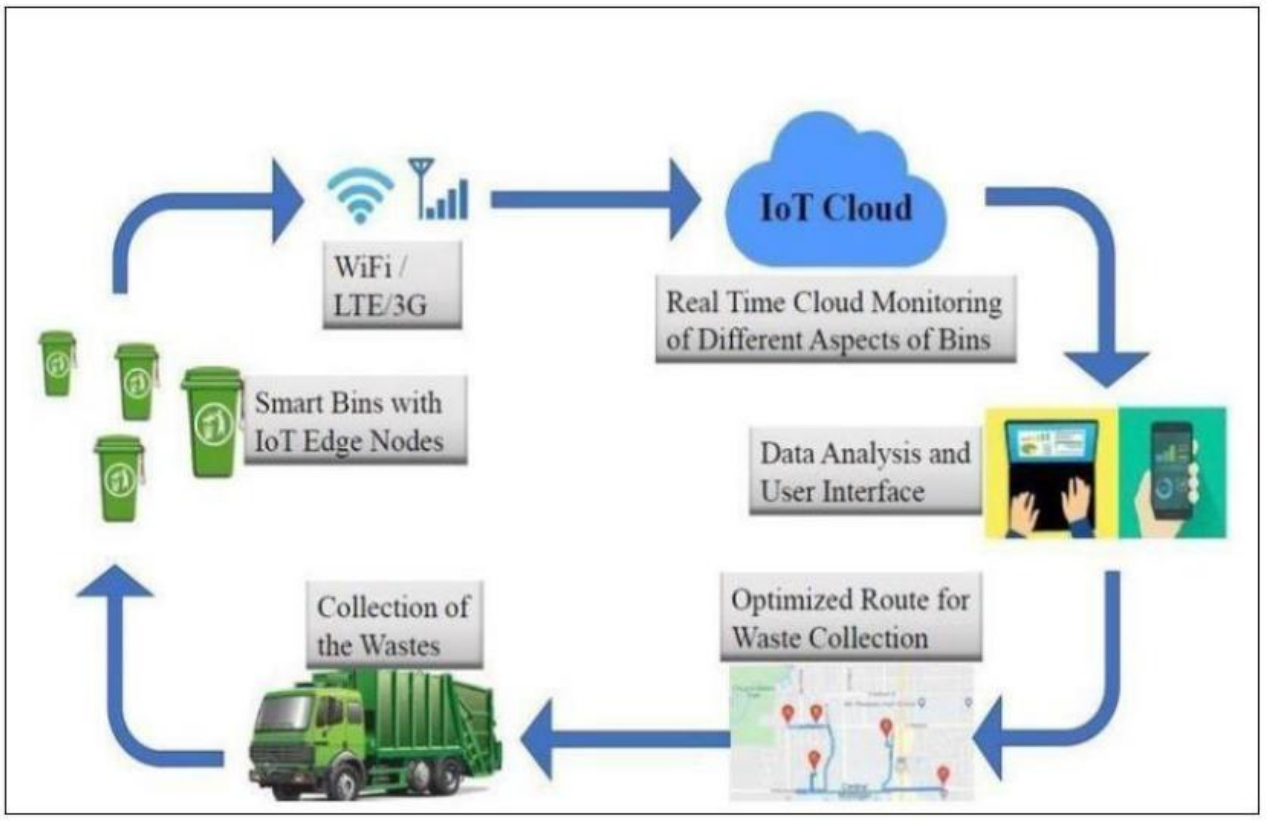


Table-1: Components & Technologies:

S.no	Component	Description	Technology
1.	User Interface	website for Admin users and garbage collectors to interact with the application.	HTML, CSS, JavaScript.
2.	Application Logic	To detect the level of the dumpster and display the real time level in web portal. Detected by ultrasonic sensor, data transmitted and the alert message generated with python script to web portal to notify the garbage collectors.	Ultrasonic sensors
3.	Application Logic-2	To determine the weight of the garbage and show the real time weight in web portal. This info provided by load cell, alert message activated with python to web portal. This allows the admin users to determine the appropriate vehicle to be sent to collect the garbage.	Force Sensors
4.	Application Logic - 3	To identify the location of each Garbage bin	GPS/ Geo location API
5.	User Interface for users	Application to guide the truck drivers to the location of the dumpster.	HTML, CSS, React Native
6.	Infrastructure (Service / Cloud)	To store the data like level, weight of the garbage, location of truck and dumpster to track the collection of wastes	IBM DB2

Table-2:

Application Characteristics:

S.no	Characteristics	Description	technology
1.	Open-Source Frameworks	Node Red ,Python ,IBM Simulator.	IoT
2.	Security Implementations	Raspberry Pi is connected to the internet and in order to broadcast live data, further security measures are recommended and use the UFW(uncomplicated Firewall).	IoT
3.	Scalable Architecture	Raspberry pi: Specifications Soc: rips 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: Micro SD GPIO: 40-pin GPIO header, populated 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	IoT

4.	Availability	hese 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.

User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Admin	Login	USN-1	As an administration, I assigned user names and passwords to each employee and managed them.	I can control my online account and dashboard.	Medium	Sprint-1
Co-Admin	Login	USN-2	As a Co-Admin, I'll control the waste level monitor. If a garbage filling alert occurs, I will notify the trash truck of the location and rubbish ID.	I can handle the waste collection.	High	Sprint-2
Truck Driver	Login	USN-3	As a truck driver I'll follow Co- Admin's instructiont to each the filled garbage.	I can take the shortest pathto reach the waste Filled route specified.	Medium	Sprint-3
Local Garbage Collector	Login	USN-4	As a Local Garbage Collection, I'II gather all the waste from the garbage, load it onto a garbage truck, and Deliver it to Landfills	I can collect the trash pull it to the truck, and send it out.	Medium	Sprint-4
Municipality officer	Login	USN-5	As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems.	All of these processes are under my control.	High	Sprint-5

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1. PROJECT PLANNING & SCHEDULING

Sprint Planning & Estimation

Title	Description	Details
Literature Survey & Information Gathering	Literature survey on the selected project & gathering information by referring the, technical papers,research publication etc .	25 SEPTEMBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem Statements.	21 SEPTEMBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	23 SEPTEMBER 2022
Proposed Solution	Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc.	20 SEPTEMBER 2022
Problem Solution Fit	Prepare problem - solution fit Document.	29 SEPTEMBER 2022
Solution Architecture	Prepare solution architecture Document.	15 OCTOBER 2022
Customer Journey	Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit).	20 OCTOBER 2022

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6.2. Sprint Delivery Schedule

Product Backlog, Sprint Schedule, and Estimation (4 Marks)

Use the below template to create product backlog and sprint schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirmingmy password.	2	High	A.PRIYADHARSHINI
Sprint-1		USN-2	As a user, I will receive confirmation email oncel have registered for the application	1	High	G.MANI KANDAN
Sprint-2		USN-3	As a user, I can register for the application through Facebook	2	Low	S.NAGA SUBRAMANIAN
Sprint-1		USN-4	As a user, I can register for the application through Gmail	2	Medium	M.MOHAMED SHAIK WASIM
Sprint-1	Login	USN-5	As a user, I can log into the application byEntering email & password	1	High	A.PRIYADHARSHINI

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	09 Nov 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	10 Nov 2022	30	30 OCT 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	49	6 NOV 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	50	7 NOV 2022

Velocity:

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

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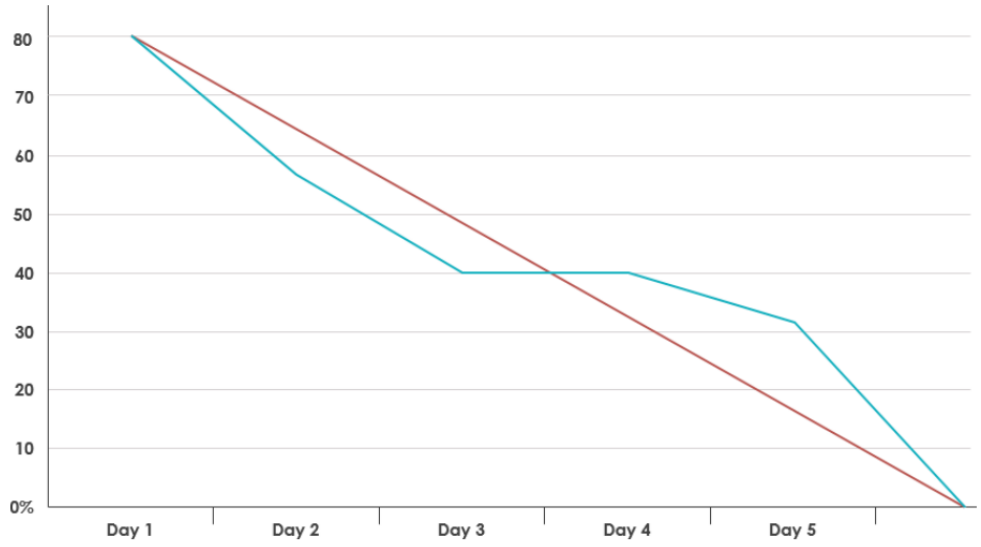
Burndown Chart



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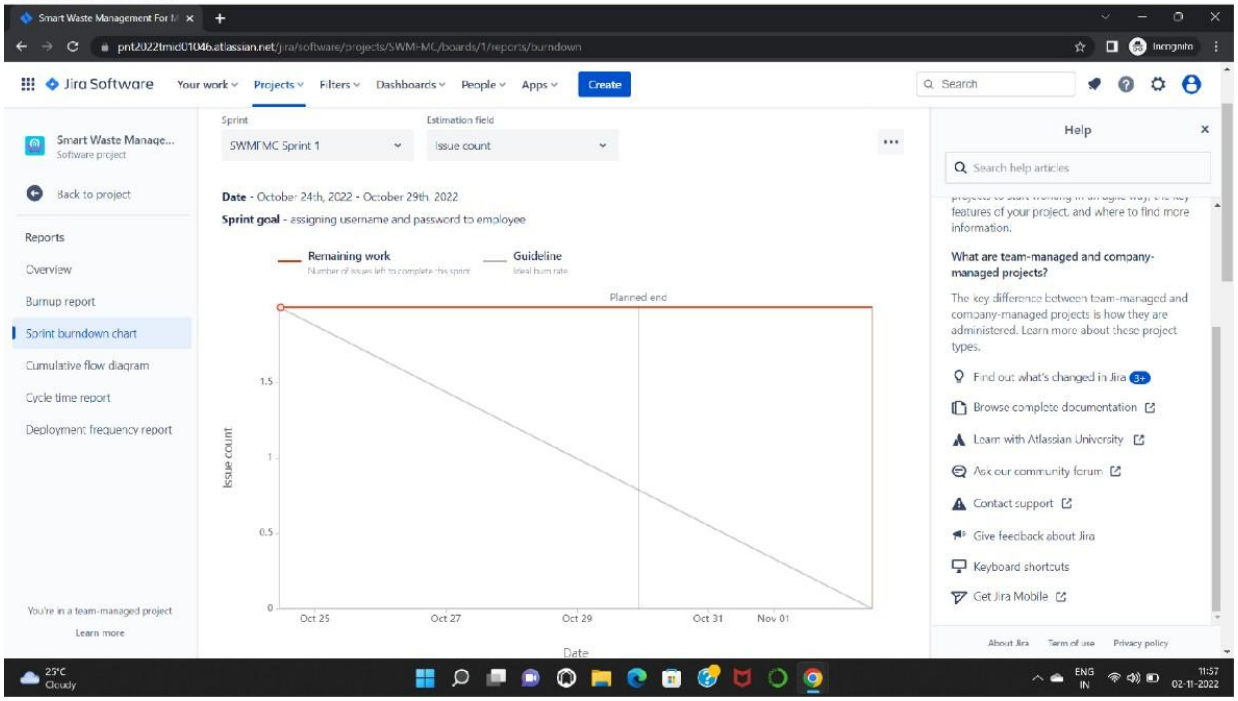
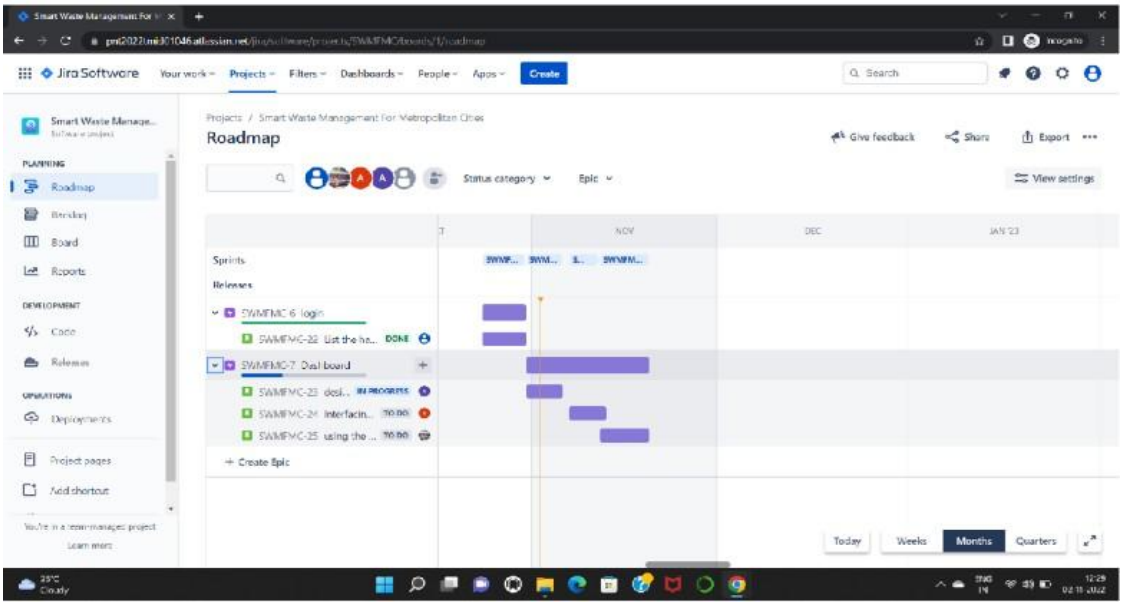
6.3 Reports from JIRA

BURNOUT CHART:



Jira Software Screenshots:

ROADMAP



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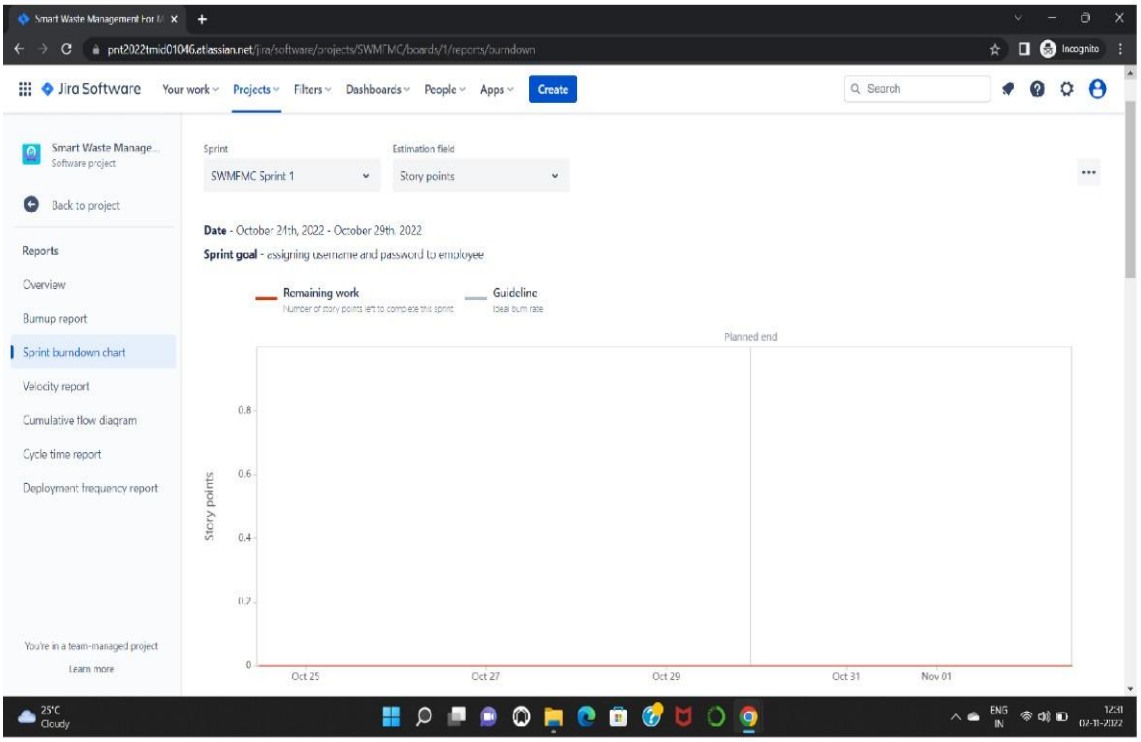
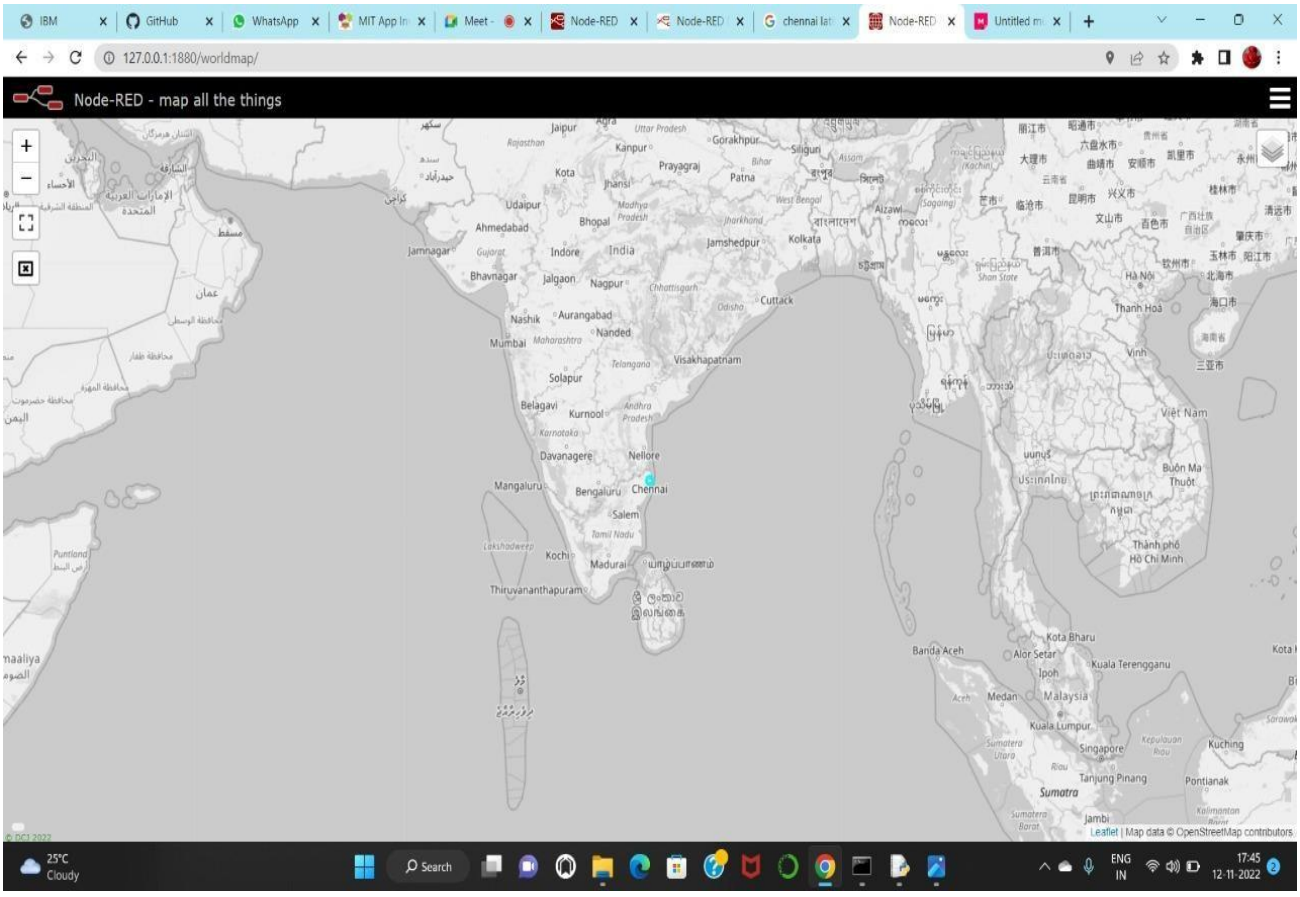
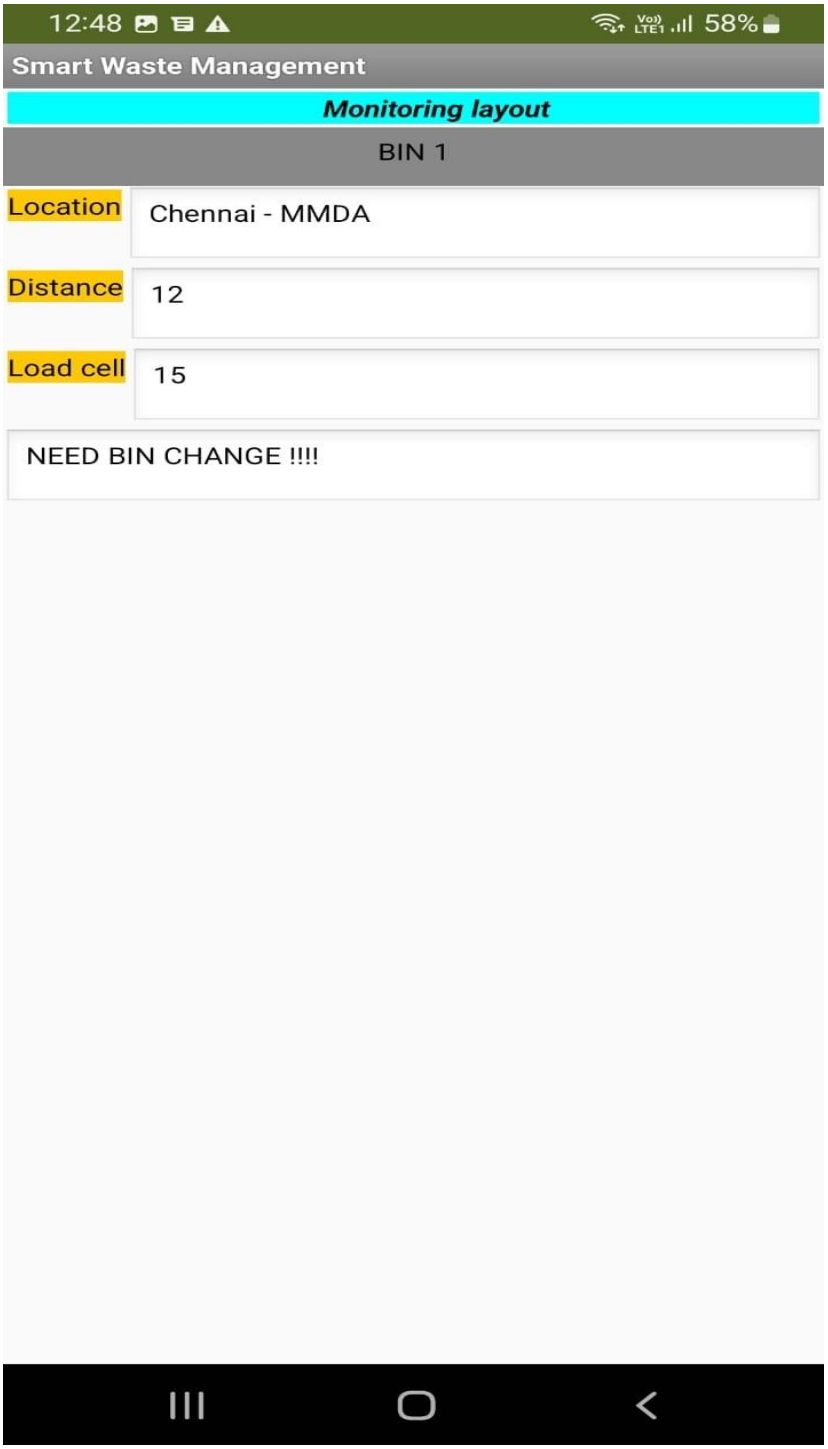


1. CODING & SOLUTIONING(Explain the features added in the project along with code)7.Feature 1-LOCATION TRACKER

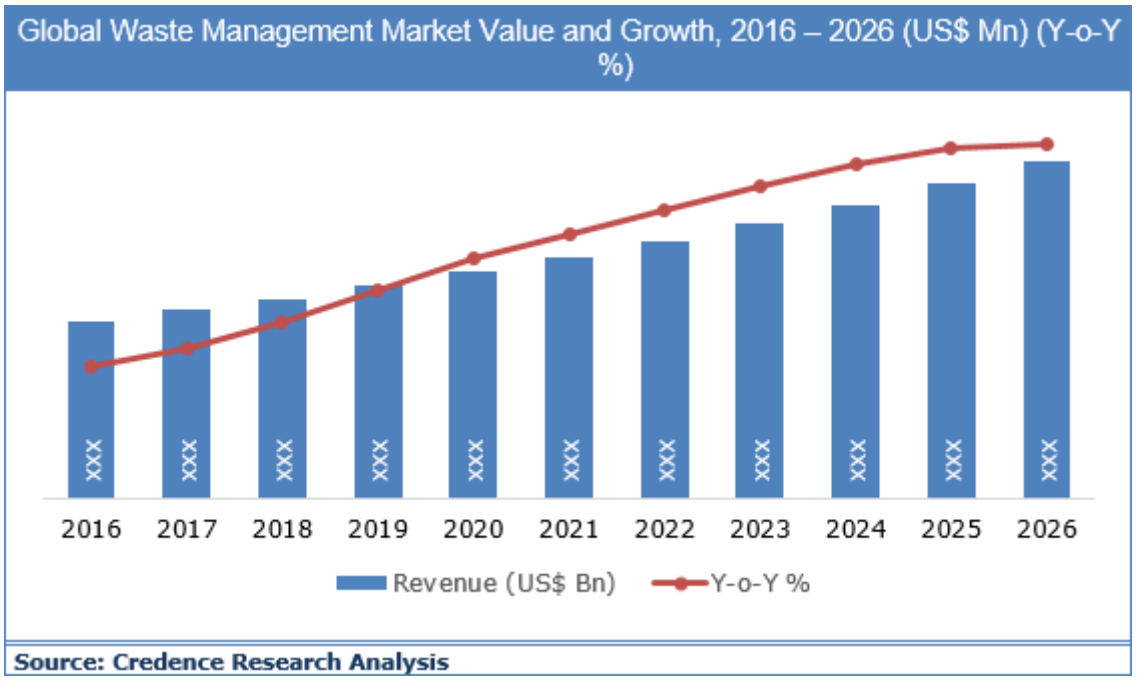


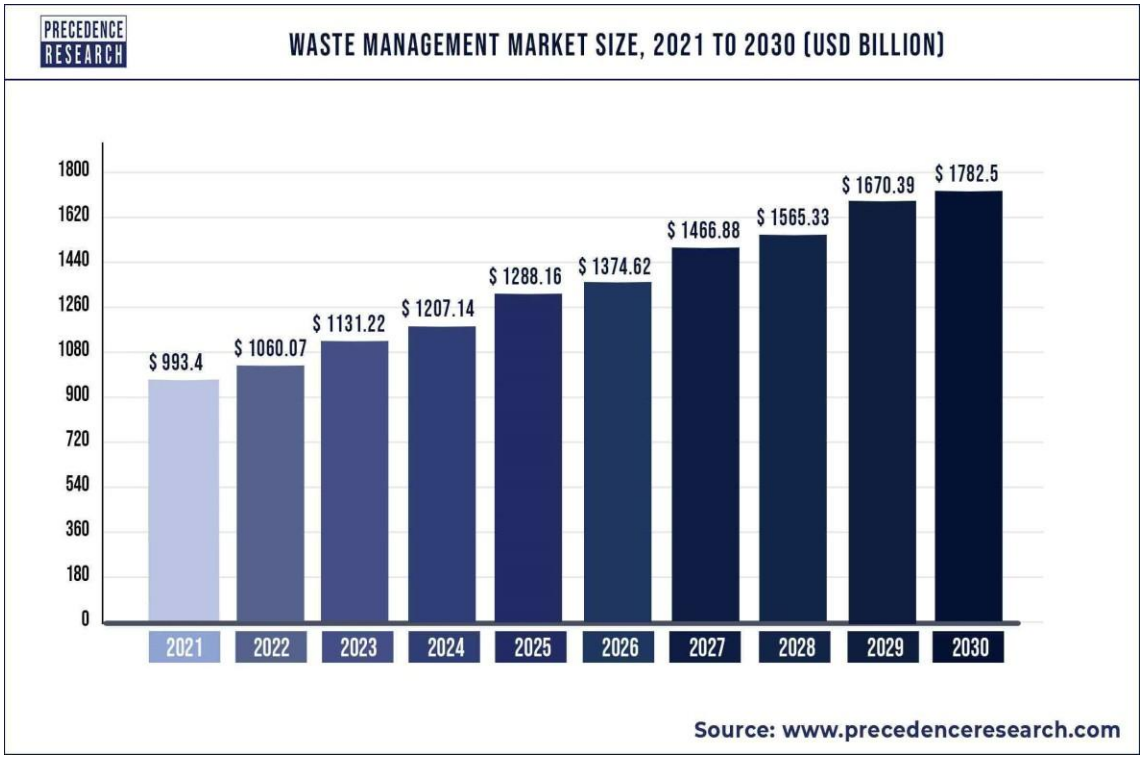
7.2 Feature - LIVE Update ON Collected Data



RESULTS

7.3 Performance Metrics





Advantages & Disadvantages

ADVANTAGES

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

DISADVANTAGES

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

3.CONCLUSION

A Smart Waste Management system that is more effective than the one in use now is achievable by using sensor 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 contained would be able to hold enough solid trash for a single unit. the price might be high.

4.FUTURE SCOPE

There are several future works and improvements for the proposed system, includingthe 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 Swatch 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 Serve's and Android's graphical interfaces

12) APPENDIX

Source Code

```
# Project : Smart Waste Management
# Team ID : PNT2022TMID05290
import requests
import json
import ibmiotf.application
import ibmiotf.device
import time
import random
import sys

# watson device details

organization = "ms9s4l"
devicType = "Project"
deviceId = "TMID01046"
authMethod= "token"
authToken= "13150415"

#generate random values for randomo variables for distance and loadcell



def myCommandCallback(cmd):
    global a
    print("command recieved:%s" %cmd.data['command'])
    control=cmd.data['command']
    print(control)

try:
        deviceOptions={"org": organization, "type": devicType,"id":
deviceId,"auth-method":authMethod,"auth-token":authToken}
        deviceCli = ibmiotf.device.Client(deviceOptions)
except Exception as e:
        print("caught exception connecting device %s" %str(e))
        sys.exit()

#connect and send a datapoint "distance and loadcell" with value integer value
into the cloud as a type of event for every 10 seconds
deviceCli.connect()

while True:

    distance= random.randint(10,70)
    loadcell= random.randint(5,15)
```

```
    data= {'dist':distance,'load':loadcell}


    if loadcell < 13 and loadcell > 15:
        load = "90 %"

    elif loadcell < 8 and loadcell > 12:
          load = "60 %"

    elif loadcell < 4 and loadcell > 7:
          load = "40 %"
    else:
          load = "0 %"

    if distance < 15:
          dist = 'Risk warning:' 'Dumpster poundage getting high, Time to
collect :) 90 %'


    elif distance < 40 and distance >16:
          dist = 'Risk warning:' 'dumpster is above 60%'

    elif distance < 60 and distance > 41:
          dist = 'Risk warning:' '40 %'
    else:
          dist = 'Risk warning:' '17 %'



    if load == "90 %" or distance == "90 %":
          warn = 'alert :' 'Risk Warning: Dumpster poundage getting high,
Time to collect :)'

    elif load == "60 %" or distance == "60 %":

          warn = 'alert :' 'dumpster is above 60%'
    else :
          warn = 'alert :' 'No need to collect right now '
    if distance <20:
        warn={'alert':'NEED BIN CHANGE!!!!!!'}

    def myOnPublishCallback(lat=10.939091,long=78.135731):
        print("Chennai")
        print("published distance = %s " %distance,"loadcell:%s "
%loadcell,"lon = %s " %long,"lat = %s" %lat)
        print(load)
        print(dist)
        print(warn)
```

GitHub Link:

https://github.com/IBM-EPBL/IBM-Project-8671-1658926276792