PROJECT REPORT

SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

TEAM ID- PNT2022TMID17698

SUBMITTED BY

ROLL NO	NAME
713319EC084	RAJAVEL K.S
713319EC095	SANJAI J
713319EC103	SEENIVASAN P
713319EC065	MOHAMAD ASANSHA A

CONTENT

ABSTRACT:

A big challenge in the urban cities is that of waste management asthere is a rapid growth in the rate of urbanization and thus there is a need of sustainable urban development plans. As the concept of smart cities is very much trending these days and the smart cities cannot be complete without smart waste management system. There needs to be system that gives prior information of the filling of the bin that alerts the municipality so that they canclean the bin on time and safeguard the environment. To avoid all such situations, we intend to propose a solution for this problem "Smart Garbage Bin", which will alarm and inform the authorized person when the garbage bin is about to fill. Then message will be sent to the authorized person to collect the garbage from the particular area. The authorized person will send the message from his web application to the garbage collectors by sending a SMS. This system maintains a dry waste and a wet waste separately. This will help toreduce the overflow of the garbage bin and thus keeping the environment clean.

1.INTRODUCTION

1.1.PROJECT OVERVIEW:

Our waste generation is constantly growing to form a global garbage crisis. Even though we indulge in creating a more sustainable and greener, we still fail to handle our waste generation and management. Combining technology support with a vision of social, economic and environmental sustainability is the best way out of this problem. It is done in the following manner. The smart bin system undergoes a thorough system check and battery level monitoring in order to function efficiently. If the battery level is found to be low, it has to be recharged immediately, else it can proceed to the next step. The threshold level levels of the bin are indicated my multiple sensors attached to bin. If the garbage exceeds the level, then an alert message is sent to the garbage collectors as well as to the municipality or area administration. The area in which garbage is found to overflow is allocated to respective garbage collectors in the form of messages through GSM system. Once the waste bin is emptied, an information update is sent to the municipality and server is updated. This is how the waste from bins can be efficiently handled and managed using technology which in turn keeps the environment clean and healthy.

1.2.PURPOSE:

We introduce 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. 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.LITERATURE SURVEY

2.1 EXISTING PROBLEM:

The waste collection process is a critical aspect for the service providers. The traditional way of manually monitoring the wastes in waste bins is a complex, cumbersome process and utilizes more human effort, time and cost which is not compatible with the present-day technologies. Irregular management of waste typically domestic waste, industrial waste and environmental waste is a root cause of many of human problems such as pollution, diseases and has adverse effects on the hygiene of living beings. In order to overcome all these problems, we are proposing the idea of a smart waste management system which helps in the auto-management of waste without human interaction in order to maintain a clean environment.

2.2 REFERENCES:

[1] Ikuo Ihara; Nagaoka University of Technology; Ultrasonic Sensing: Fundamentals and Its Applications to Non-destructive Evaluation.

[2] Arduino, “Available at http://www.arduino.cc,” 2010.

[3] M. Batty, “Smart Cities, Big Data,” Environment and Planning B: Planning and Design 2012, vol. 39, pp. 191– 93.

[4] Xu Li, Student Member, IEEE, Performance Evaluation of Vehicle-Based Mobile Sensor Networks for Traffic Monitoring.

[5] Yusuf Abdullahi Badamasi, The Working Principle Of An Arduino, Electronics, Computer and Computation (ICECCO), 2014 11th International Conference on 29 Sept.-1 Oct. 2014.

[6] IOT enabled solid waste management in smart cities

Publisher: S. Vishnu 1 , S. R. Jino Ramson 1,2,3,* , Samson Senith 4 , Theodoros Anagnostopoulos 5 , Adnan M. Abu-Mahfouz 6 , Xiaozhe Fan 2 , S. Srinivasan 3 and A. Alfred Kirubaraj 4

Reference: https://www.mdpi.com/2624-6511/4/3/53/pdf

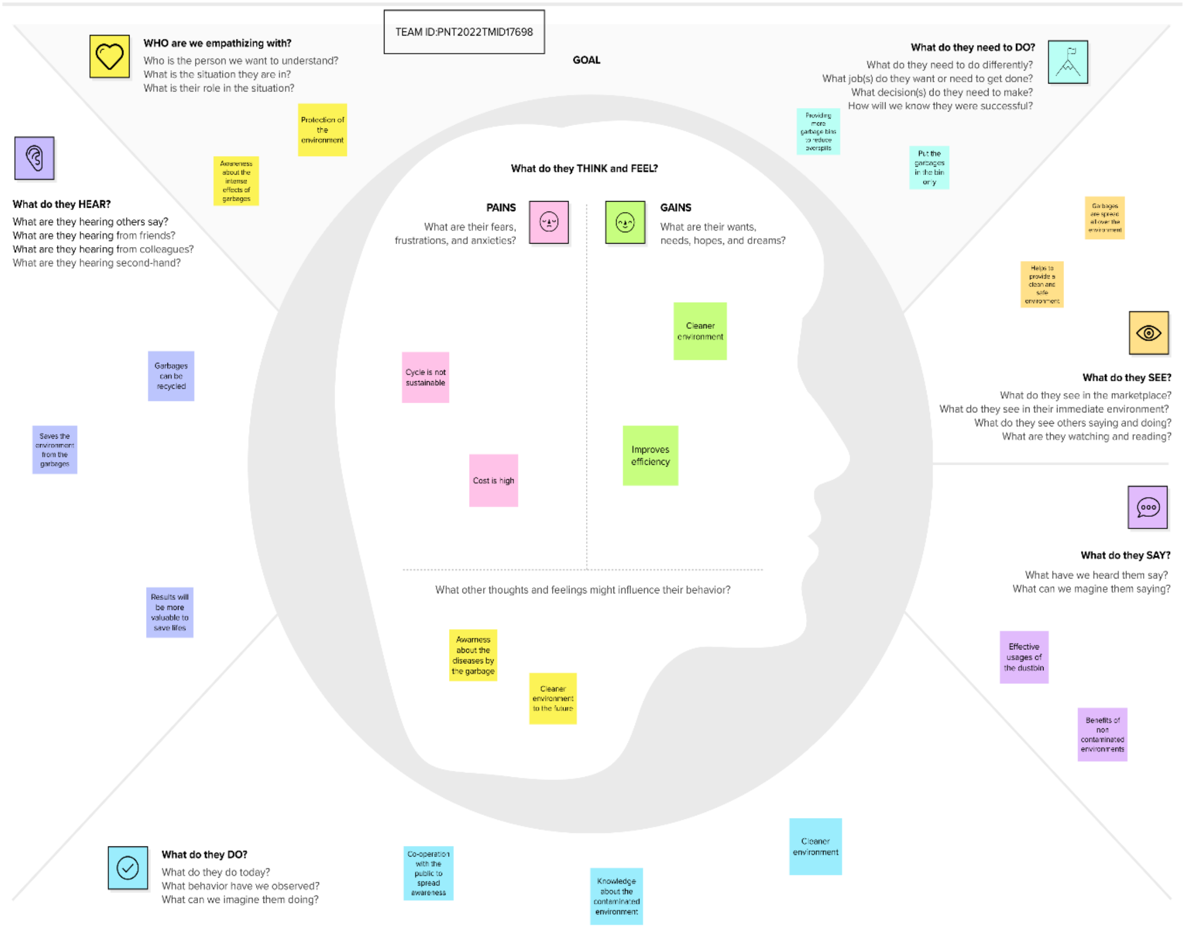
[7] A Survey on Garbage Collection and Monitoring System for Smart cities using IOT **Publisher**: Dept of Computer Engineering, Terna Engineering College,Nerul,Navi Mumbai **Reference**: https://www.irjet.net/archives/V5/i2/IRJET-V5I2118.pdf

2.3 PROBLEM STATEMENT DEFINITION:

Problem Statement (PS)	**I am (Customer)**	**I am trying to**	**But**	**Because**	**Which makes me feel**
PS-1	Council	Monitor the waste in my city	I have not much effective system for monitoring	Because of high cost	unhygienic
PS-2	Council	Manage the waste in my city	I have not much effective system for managing	Because of more time consuming	unsafe

3. IDEATION & PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS:



TEAM ID:PNT2022TMID17698

GOAL

WHO are we empathizing with?

Who is the person we want to understand?
What is the situation they are in?
What is their role in the situation?

Protection of the environment

Awareness about the intense effects of garbages

What do they HEAR?

What are they hearing others say?
What are they hearing from friends?
What are they hearing from colleagues?
What are they hearing second-hand?

Garbages can be recycled

Saves the environment from the garbages

Results will be more valuable to save lifes

What do they THINK and FEEL?

PAINS

What are their fears, frustrations, and anxieties?

Cycle is not sustainable

Cost is high

GAINS

What are their wants, needs, hopes, and dreams?

Cleaner environment

Improves efficiency

What other thoughts and feelings might influence their behavior?

Awarness about the diseases by the garbage

Cleaner environment to the future

What do they need to DO?

What do they need to do differently?
What job(s) do they want or need to get done?
What decision(s) do they need to make?
How will we know they were successful?

Providing more garbage bins to reduce overspills

Put the garbages in the bin only

Garbages are spread all over the environment

Helps to provide a clean and safe environment

What do they SEE?

What do they see in the marketplace?
What do they see in their immediate environment?
What do they see others saying and doing?
What are they watching and reading?

What do they SAY?

What have we heard them say?
What can we magine them saying?

Effective usages of the dustbin

Benefits of non contaminated environments

What do they DO?

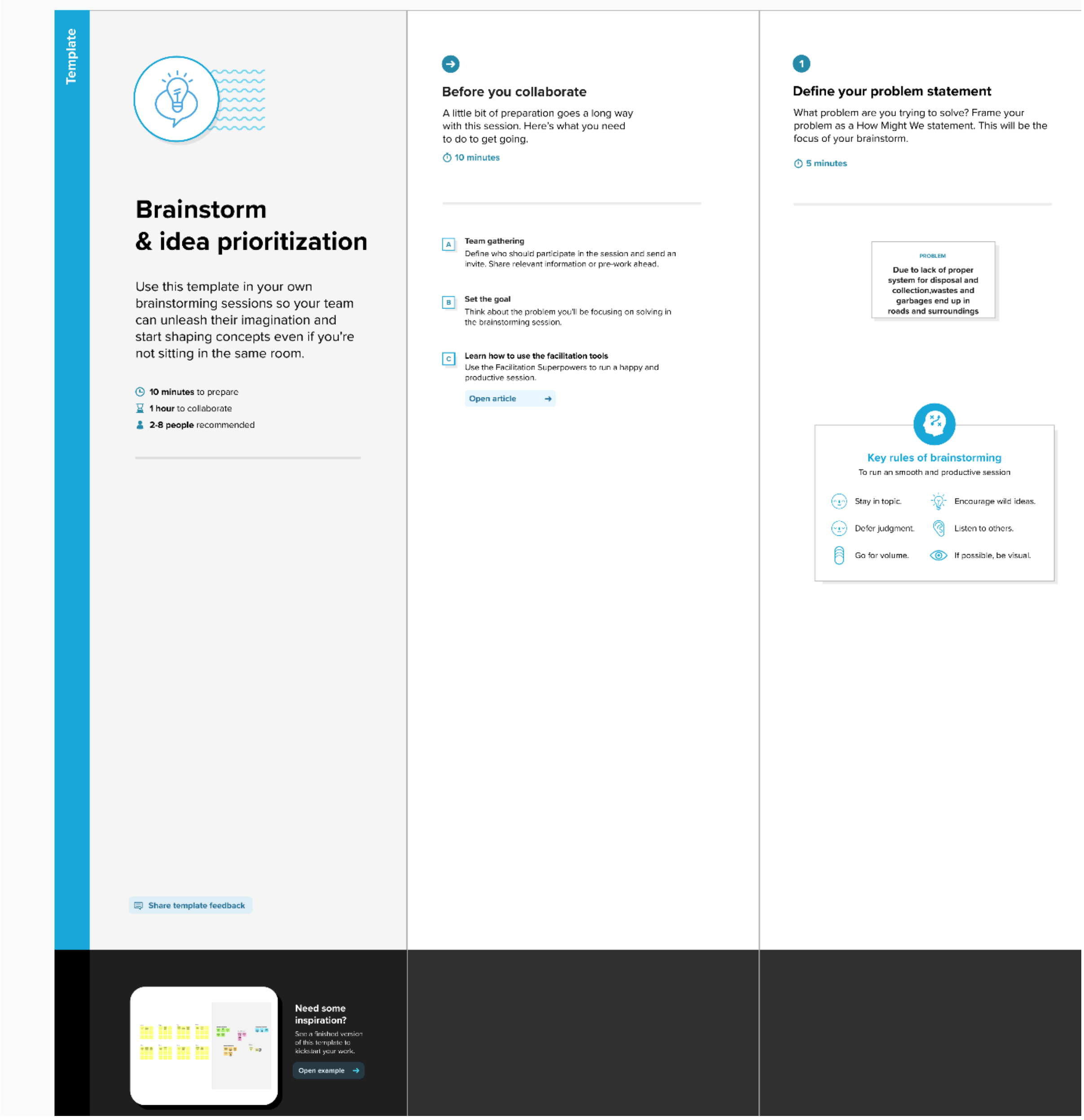
What do they do today?
What behavior have we observed?
What can we imagine them doing?

Co-operation with the public to spread awareness

Knowledge about the contaminated environment

Cleaner environment

3.2 IDEATION AND BRAINSTORMING:



Brainstorm
& idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

10 minutes to prepare
1 hour to collaborate
2-8 people recommended

Need some inspiration?
See a finished version of this template to kickstart your work.

Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

10 minutes

A **Team gathering**
Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.

B **Set the goal**
Think about the problem you'll be focusing on solving in the brainstorming session.

C **Learn how to use the facilitation tools**
Use the Facilitation Superpowers to run a happy and productive session.

1 Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

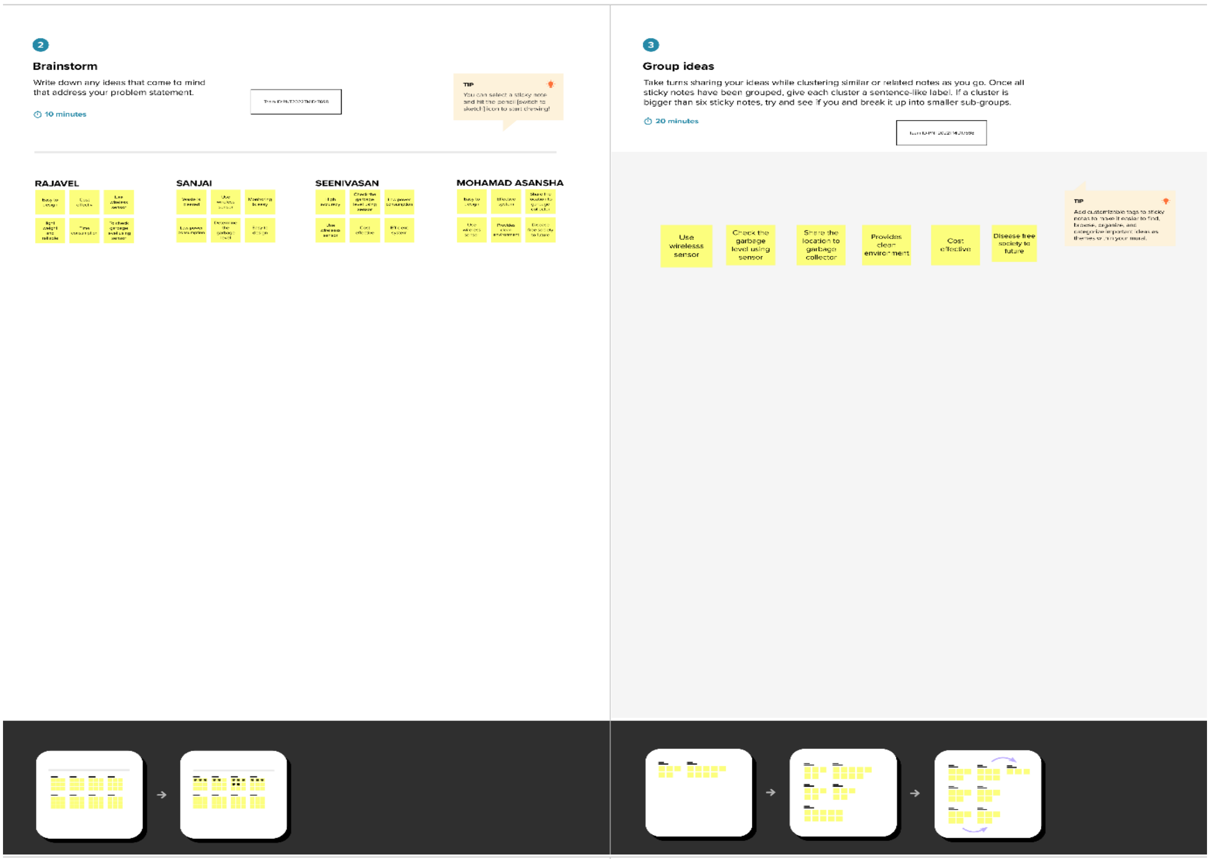
5 minutes

PROBLEM

Due to lack of proper system for disposal and collection,wastes and garbages end up in roads and surroundings

Key rules of brainstorming
To run an smooth and productive session

Stay in topic.
Encourage wild ideas.
Defer judgment.
Listen to others.
Go for volume.
If possible, be visual.



2

Brainstorm

Write down any ideas that come to mind that address your problem statement.

10 minutes

Team ID: PNT2022TMID[illegible]

TIP

You can select a sticky note and hit the pencil [switch to sketch] icon to start drawing!

RAJAVEL

Easy to design
Cost effective
Use Wireless sensor
light weight and reliable
Time consumption
To check garbage level using sensor

SANJAI

Waste is cleaned
Use wireless sensor
Monitoring is easy
Low power consumption
Determine the garbage level
Easy to design

SEENIVASAN

High accuracy
Check the garbage level using sensor
Low power consumption
Use Wireless sensor
Cost effective
Efficient system

MOHAMAD ASANSHA

Easy to design
Effective system
Share the location to garbage collector
Use wireless sensor
Provides clean environment
Disease free society to future

3

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

20 minutes

Team ID: PNT2022TMID[illegible]

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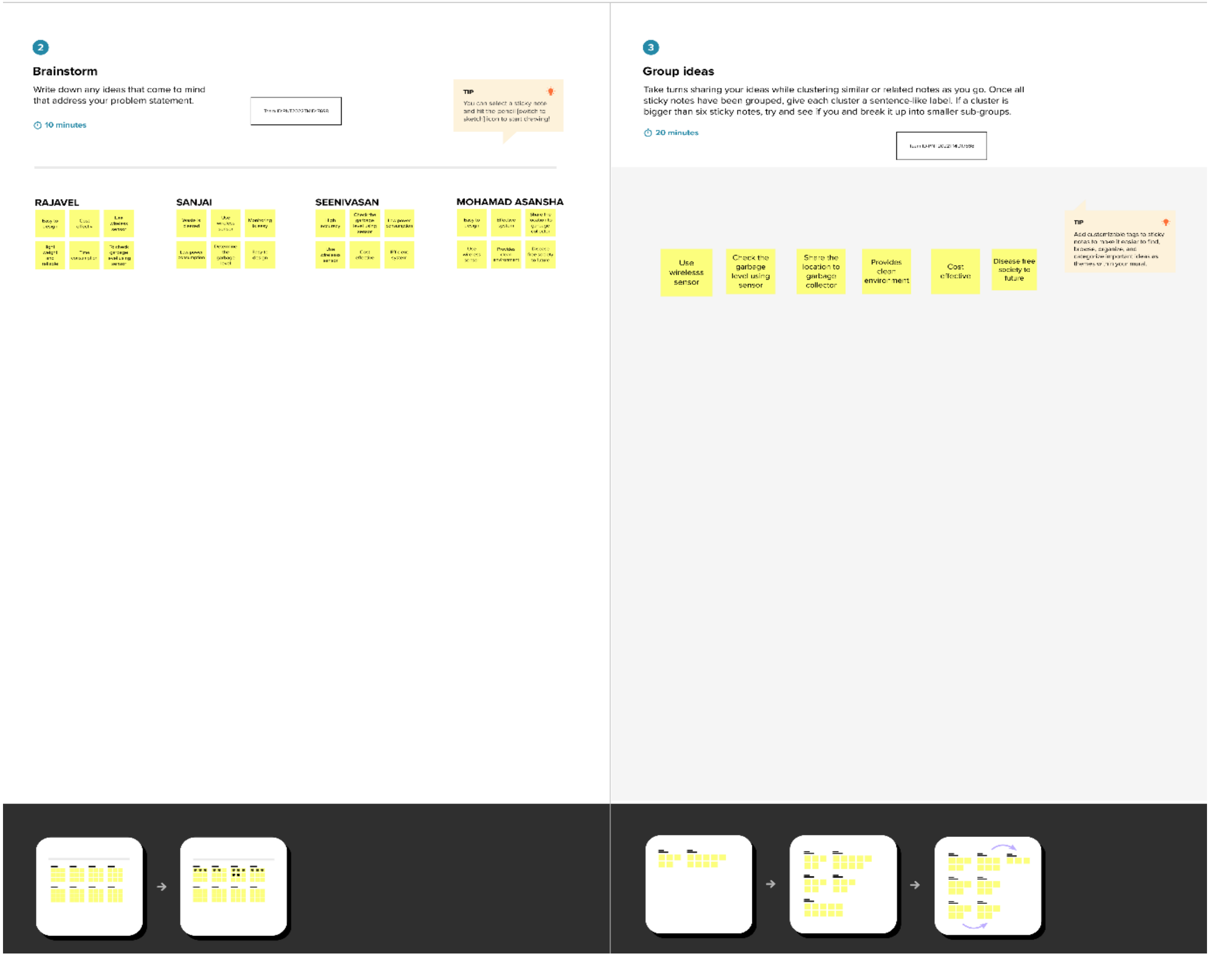
TIP

Add customizable tags to sticky notes to make it easier to find, browse, organize, and categorize important ideas as themes within your mural.



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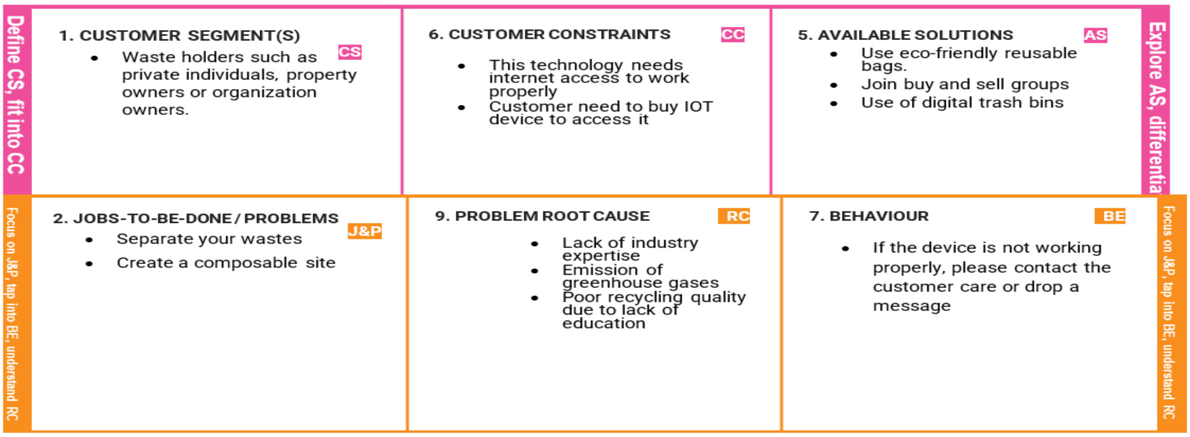
3.3 PROPOSED SOLUTION:

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	This project enables the organizations to meet their needs of smart garbage management systems. This system allows the authorized 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 bin gets filled this is acknowledged by placing 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 monitoring control system.

3.	Novelty / Uniqueness	We are going to establish SWM in our college but the real hard thing is that janitor (cleaner) doesn’t know to operate these things practically so here our team planned to build a wrist band to them, that indicate via light blinking when the dustbin fills 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 in property values.

5.	Business Model (Revenue Model)	Waste Management organizes 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 function.
6.	Scalability of the Solution	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 SOLUTION FIT



Define CS, fit into CC
Explore AS, differentia
Focus on J&P, tap into BE, understand RC
Focus on J&P, tap into BE, understand RC

1. CUSTOMER SEGMENT(S) CS

- Waste holders such as private individuals, property owners or organization owners.

6. CUSTOMER CONSTRAINTS CC

- This technology needs internet access to work properly
- Customer need to buy IOT device to access it

5. AVAILABLE SOLUTIONS AS

- Use eco-friendly reusable bags.
- Join buy and sell groups
- Use of digital trash bins

2. JOBS-TO-BE-DONE / PROBLEMS J&P

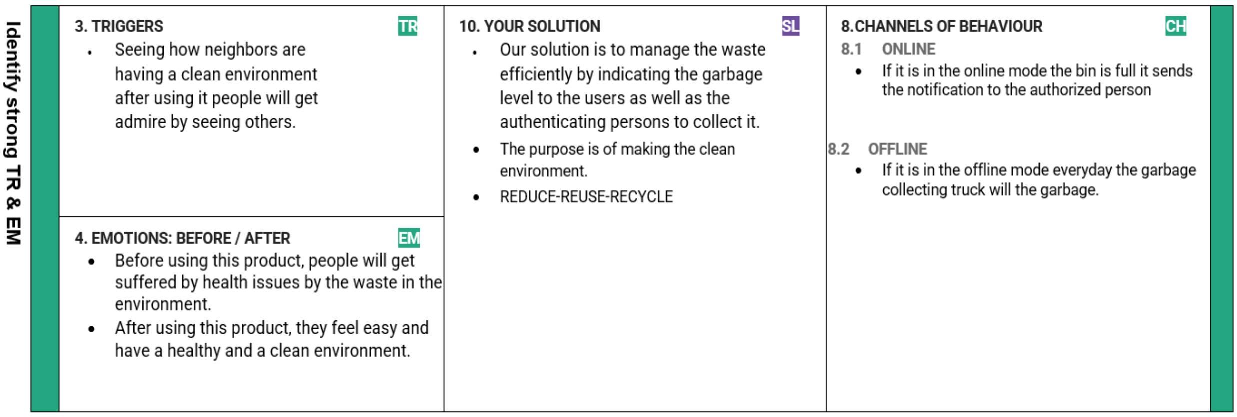
- Separate your wastes
- Create a composable site

9. PROBLEM ROOT CAUSE RC

- Lack of industry expertise
- Emission of greenhouse gases
- Poor recycling quality due to lack of education

7. BEHAVIOUR BE

- If the device is not working properly, please contact the customer care or drop a message



Identify strong TR & EM

3. TRIGGERS TR

- Seeing how neighbors are having a clean environment after using it people will get admire by seeing others.

4. EMOTIONS: BEFORE / AFTER EM

- Before using this product, people will get suffered by health issues by the waste in the environment.
- After using this product, they feel easy and have a healthy and a clean environment.

10. YOUR SOLUTION SL

- Our solution is to manage the waste efficiently by indicating the garbage level to the users as well as the authenticating persons to collect it.
- The purpose is of making the clean environment.
- REDUCE-REUSE-RECYCLE

8.CHANNELS OF BEHAVIOUR CH

8.1 ONLINE

- If it is in the online mode the bin is full it sends the notification to the authorized person

8.2 OFFLINE

- If it is in the offline mode everyday the garbage collecting truck will the garbage.

4. REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENT:

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Detailed bin inventory.	All monitored bins and stands can be seen on the map, and you can visit them at any time via the Street View feature from Google. You can see bin details in the Dashboard – capacity, waste type, last measurement, GPS location and collection schedule or pick recognition.
FR-2	Real time bin monitoring.	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 as well; so, you can check when the bin was last collected. With real-time data and predictions, you can eliminate the overflowing bins and stop collecting half-empty ones.
FR-3	Expensive bins.	We help you identify bins that drive up your collection costs. The tool calculates a rating for

		each bin in terms of collection costs. The tool considers the average distance bin discharge in the area. The tool assigns bin a rating (1-10) and calculates distance from bin discharge.
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. Based on the historical data, you can adjust bin capacity or location where necessary.

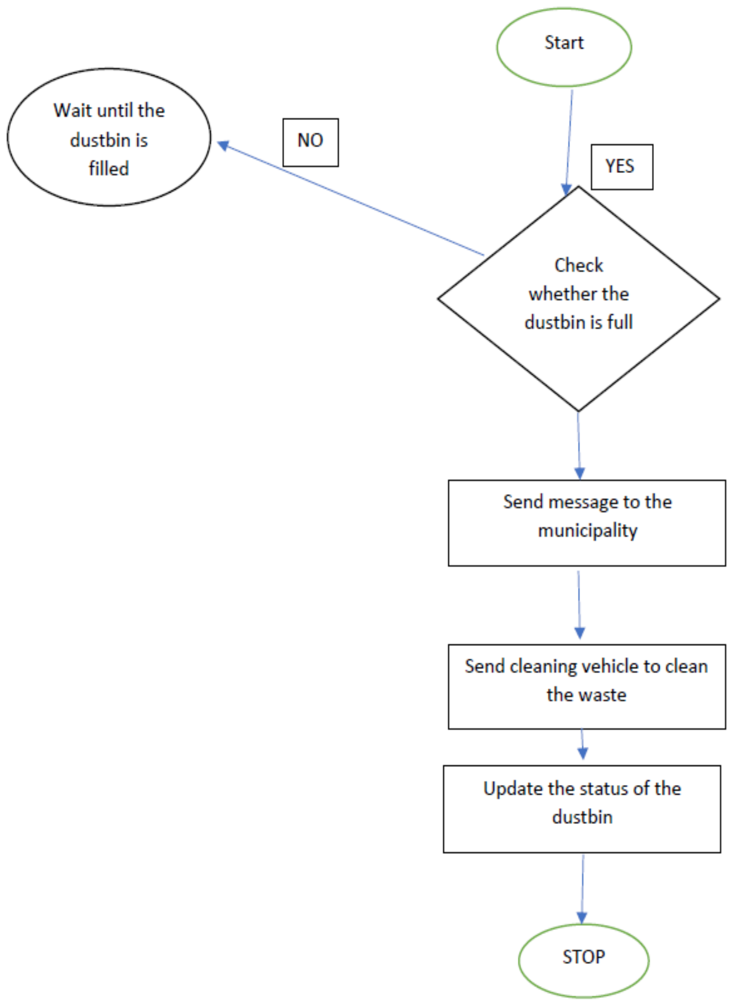
4.2 NON-FUNCTIONAL REQUIREMENTS:

NFR No.	**Non-Functional Requirement**	**Description**
NFR-1	**Usability**	IoT device verifies that usability is a special and important perspective to analyse user requirements, which can further improve the design quality. In the design process with user experience as the core, the analysis of users' product usability can indeed help designers better understand users' potential needs in waste management, behaviour and experience.
NFR-2	**Security**	Use reusable bottles Use reusable grocery bags Compost it Purchase wisely and recycle Avoid using use and throw food and drink containers.
NFR-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.
NFR-4	**Performance**	The Smart Sensors use ultrasound technology to measure the fill levels (along with other data) in bins several times a day. Using a variety of IoT networks (NB-IoT,GPRS), the sensors send the data to Sensors. Smart Waste Management Software System, a powerful cloud-based platform, for data driven daily operations, available also as a waste management app. Customers are hence provided data-driven decision making, and optimization of waste collection routes, frequencies, and vehicle loads resulting in route reduction by at least 30%.

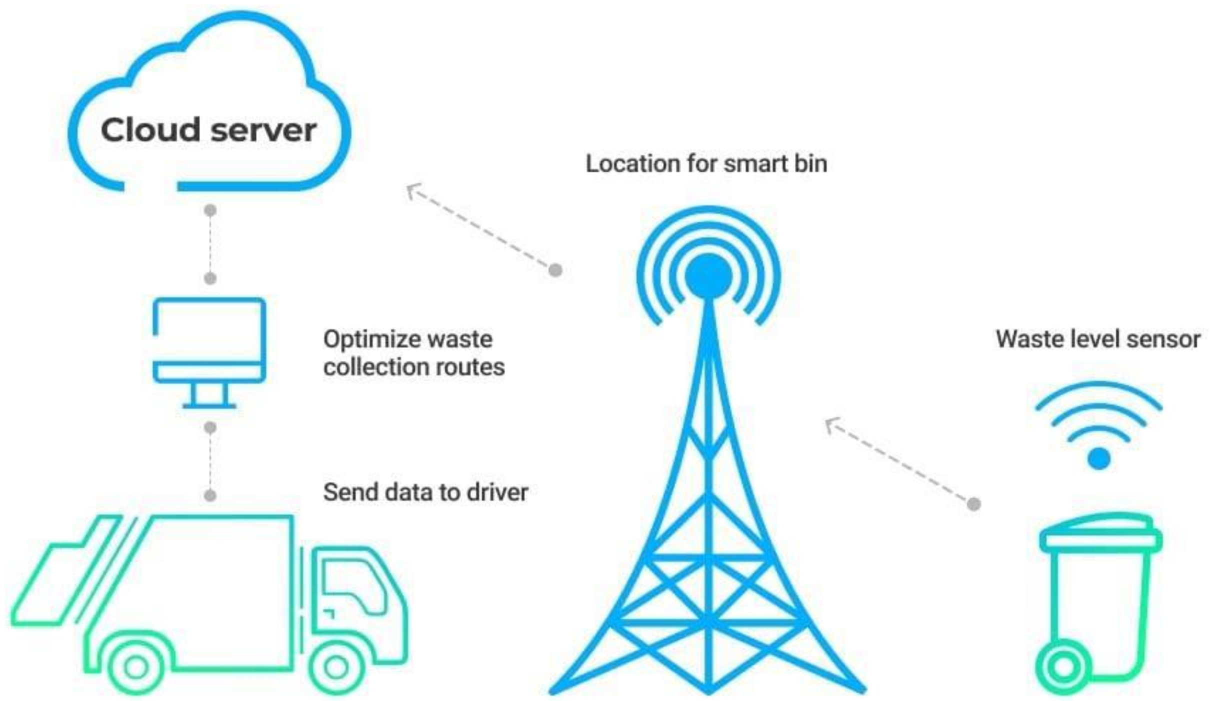
5.PROJECT DESIGN

5.1 DATA FLOW DIAGRAMS:


Start
Wait until the dustbin is filled
NO
YES
Check whether the dustbin is full
Send message to the municipality
Send cleaning vehicle to clean the waste
Update the status of the dustbin
STOP

5.2 SOLUTION & TECHNICAL ARCHITECTURE:

1. Our proposed model provides real time monitoring to the garbage bins placed in various locations.
2. The garbage bins are built with a sensor module(Ultrasonic sensor) which continuously monitors the garbage bin.
3. Any moment the garbage level passes over the critical level (i.e., 80%),the system generates a notification to the monitoring panel (admin panel /Garbage cleaning team) and so the cleaning team collects the garbage from the identified garbage bin.



5.3 USER STORIES:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Authorized Person(Manages web app)	Login	USN-1	As an authorized person, I gave user id and password for every worker and manage them.	I can access web page /Dashboard	Medium	Sprint-2
Admin	Login	USN-2	As an admin, I will manage garbage level monitor. When garbage gets filling alert, I will post location and garbage Id to trash truck.	I can manage garbage monitoring.	High	Sprint-1
Truck Driver	Login	USN-3	As a driver, I'll follow the route sent by user to reach the filled garbage location.	I can drive to reach the garbage filled route in dynamic route given.	Medium	Sprint-2
Garbage Collector	Login	USN-4	As a garbage collector, I'll collect all the garbage from garbage bin and load it to the truck and send them to landfill.	I can collect garbage and pulled to truck.	Medium	Sprint-2
Municipality	Login	USN-5	As a municipality, I'll check the process are happening in discipline manner without any issues.	I can manage all the process going well.	High	Sprint-1

6. PROJECT PLANNING & SCHEDULING

6.1 SPRINT PLANNING AND ESTIMATION:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Login	USN-1	As an Administrator, I need to give a user id and passcode to every worker over there in the municipality	10	High	Rajavel
Sprint-1	Login	USN-2	As a Co-Admin, I'll control the waste level by monitoring them via a real-time web portal. Oncethe filling happens, I'll notify the trash truck withlocation of the bin with bin ID	10	High	Sanjai
Sprint-2	Dashboard	USN-3	As a Truck Driver, I'll follow Co-Admin's Instructions to reach the filling bin in short rootsand save time	20	Low	Seenivasan
Sprint-3	Dashboard	USN-4	As a Local Garbage Collector, I'II gather all the waste from the garbage, load it onto a garbagetruck and deliver it to Landfills	20	Medium	Mohamad Asansha
Sprint-4	Dashboard	USN-5	As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems	20	High	Rajavel

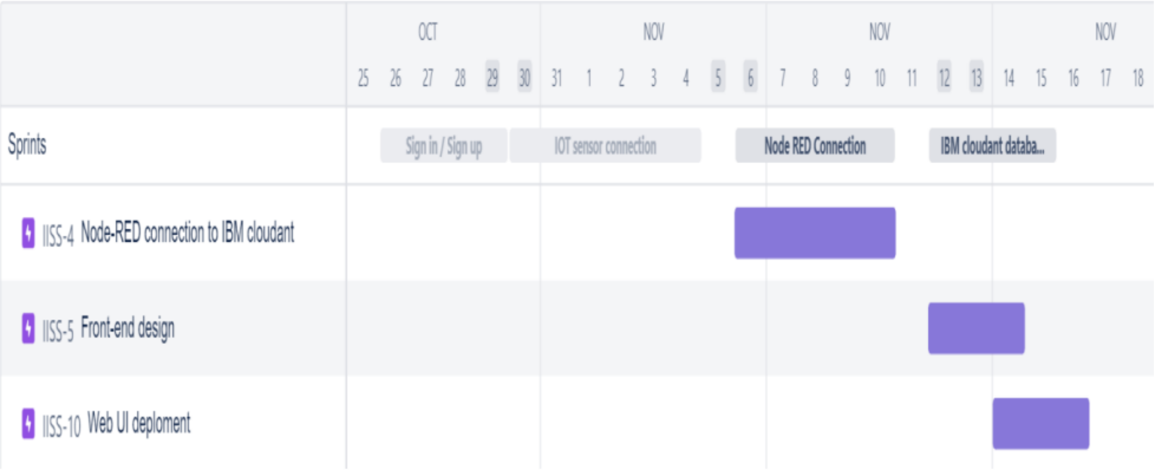
6.2 SPRINT DELIVERY SCHEDULE:

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	Literature survey on the selected project & gathering information by referring to the technical papers, research publications, etc.	28 SEPTEMBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user's Pains & Gains, Prepare a list of problem statements	24 SEPTEMBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on their 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

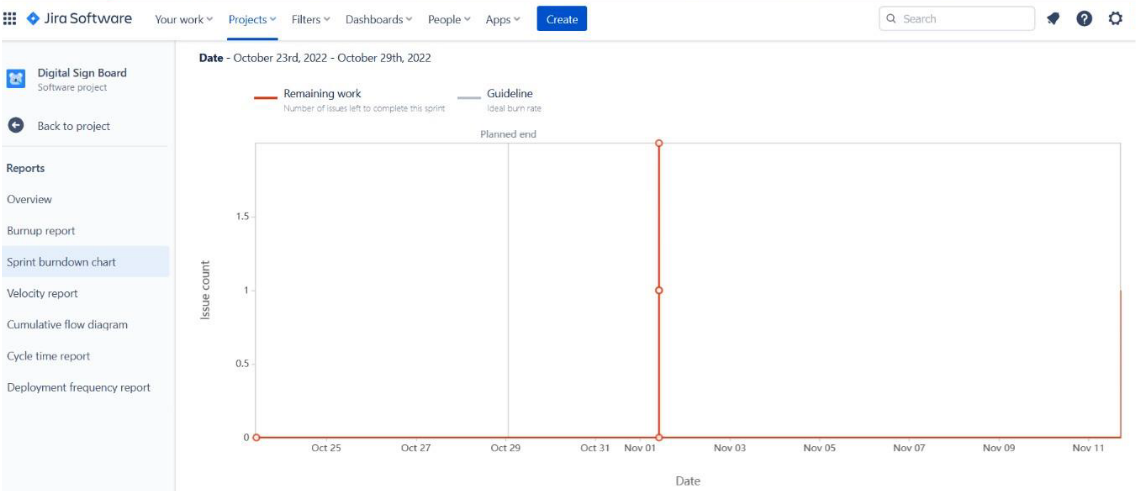
Customer Journey	Prepare the customer journeymaps to understand the user interactions & experiences with the application (entry to exit).	20 OCTOBER 2022
Functional Requirement	Prepare the functional requirement document.	26 OCTOBER 2022
Data Flow Diagrams	Draw the data flow diagrams and submitthem for review.	28 OCTOBER 2022
Technology Architecture	Prepare the technology architecture diagram.	28 OCTOBER 2022
Prepare Milestone & Activity List	Prepare the milestones &activity list of the project.	04 November 2022
Project Development - Delivery of Sprint-1, 2, 3 & 4	Develop & submit the developed code by testing it.	08 November 2022

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

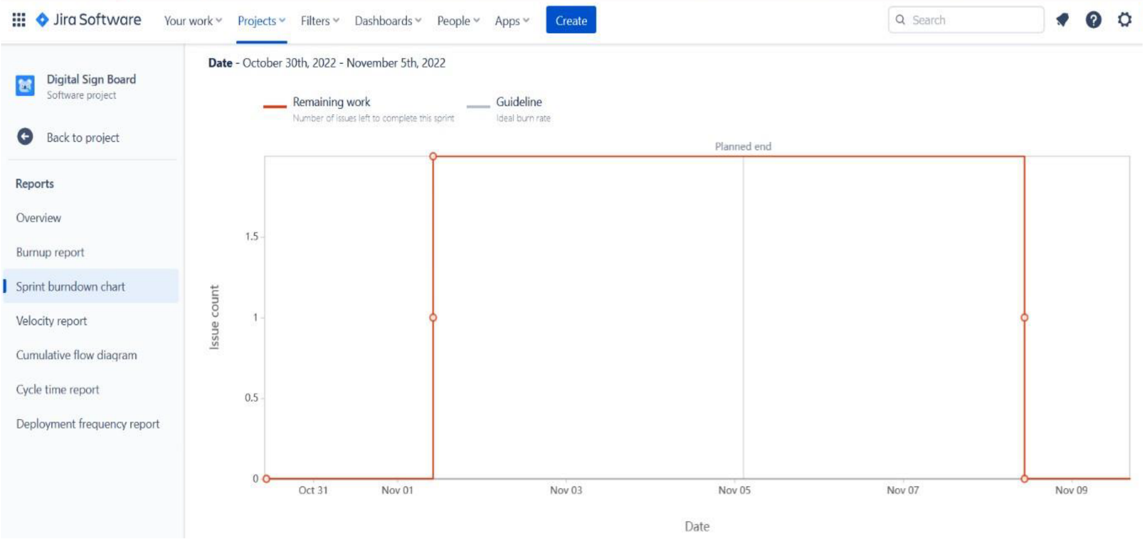
6.3 REPORTS FROM JIRA:



SPRINT 1:

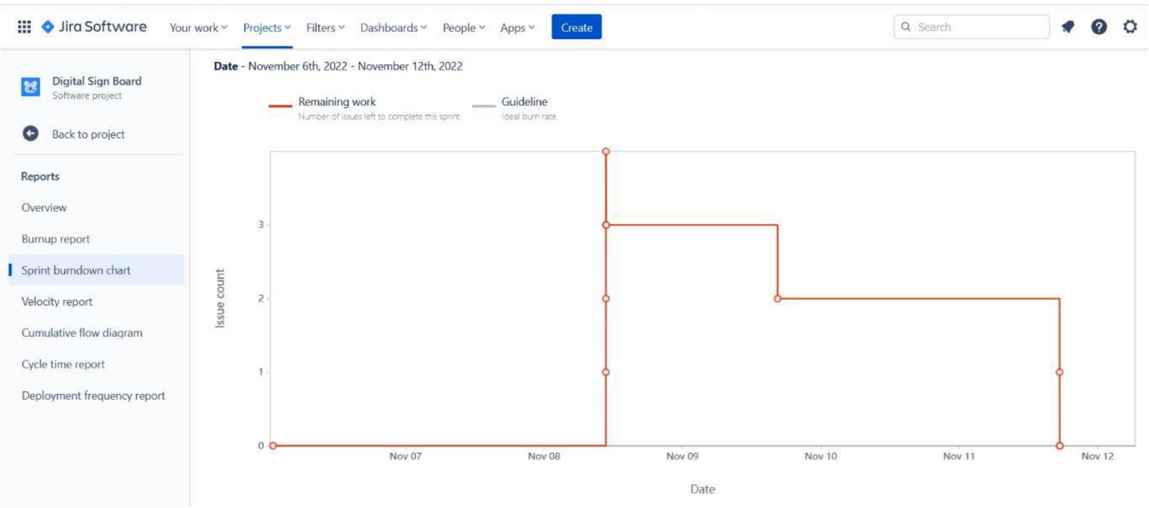


SPRINT 2:



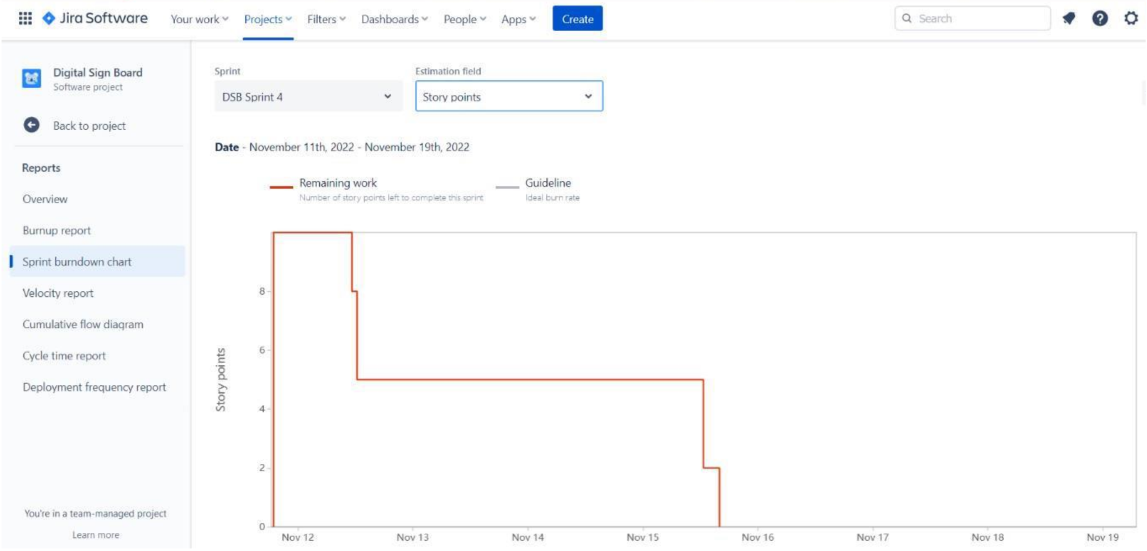
Date - October 30th, 2022 - November 5th, 2022

SPRINT 3:



Date - November 6th, 2022 - November 12th, 2022

SPRINT 4 :



Sprint: DSB Sprint 4

Estimation field: Story points

Date - November 11th, 2022 - November 19th, 2022

7.CODING & SOLUTIONING:

7.1 WOKWI CODE:

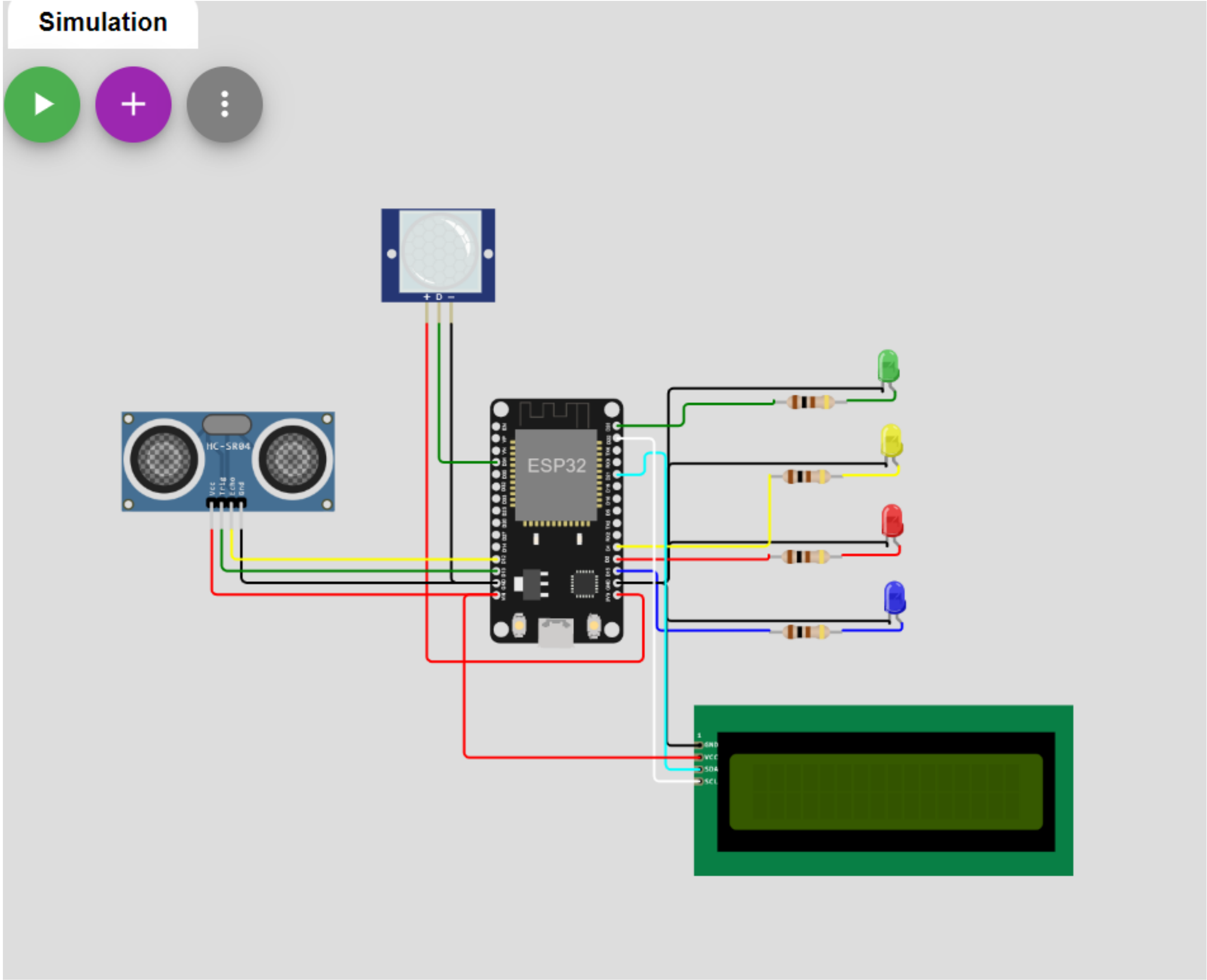
```
#include <WiFi.h> // library for wifi
#include <PubSubClient.h> // library for MQTT
#include <LiquidCrystal_I2C.h>
#include <mjson.h>
LiquidCrystal_I2C lcd(0x27, 20, 4);
//----------------------- credentials of IBM Accounts ------------------------------
#define ORG "9gbe4w" // IBM organisation id
#define DEVICE_TYPE "SWMSMC" // Device type mentioned in ibm watson iot platform
#define DEVICE_ID "ibmproject" // Device ID mentioned in ibm watson iot platform
#define TOKEN "sUNA41tG6-Pq)0rk5X" // Token
//----------------------- customise above values -----------------------------------------------------
char server[] = ORG ".messaging.internetofthings.ibmcloud.com"; // server name
char publishTopic[] = "iot-2/evt/data/fmt/json"; // topic name and type of event perform and format in which data to be send
char topic[] = "iot-2/cmd/led/fmt/String"; // cmd Represent type and command is test format of strings
char authMethod[] = "use-token-auth"; // authentication method
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID; //Client id
//----------------------------------------------------------------------------------------------------------------------



WiFiClient wifiClient; // creating instance for wificlient
PubSubClient client(server, 1883, wifiClient);
#define ECHO_PIN 12
#define TRIG_PIN 13
float dist;
String data3;
bool SealBin = true;
void setup()
{
Serial.begin(115200);
pinMode(LED_BUILTIN, OUTPUT);
pinMode(TRIG_PIN, OUTPUT);
pinMode(ECHO_PIN, INPUT);
//pir pin
pinMode(34, INPUT);
//ledpins
pinMode(23, OUTPUT);
pinMode(2, OUTPUT);
pinMode(4, OUTPUT);
pinMode(15, OUTPUT);

lcd.init();
lcd.backlight();
lcd.setCursor(1, 0);
lcd.print("");
wifiConnect();
mqttConnect();
}

float readcmCM()
{
digitalWrite(TRIG_PIN, LOW);
```

```
delayMicroseconds(2);
digitalWrite(TRIG_PIN, HIGH);
delayMicroseconds(10);
digitalWrite(TRIG_PIN, LOW);
int duration = pulseIn(ECHO_PIN, HIGH);
return duration * 0.034 / 2;
}
void loop()
{
lcd.clear();

publishData();
delay(500);
if (!client.loop())
{
mqttConnect(); // function call to connect to IBM
}
}
/* --------------------------------retrieving to cloud---------------------------------------
--------------*/



void wifiConnect()
{
Serial.print("Connecting to ");
Serial.print("Wifi");
WiFi.begin("Wokwi-GUEST", "", 6);
while (WiFi.status() != WL_CONNECTED)
{
delay(500);
Serial.print(".");
}
Serial.print("WiFi connected, IP address: ");
Serial.println(WiFi.localIP());
}
void mqttConnect()
{
if (!client.connected())
```

```
{
Serial.print("Reconnecting MQTT client to ");
Serial.println(server);
while (!client.connect(clientId, authMethod, token))
{
Serial.print(".");
delay(500);
}
initManagedDevice();
Serial.println();
}
}
void initManagedDevice()
{
if (client.subscribe(topic))
{
Serial.println("IBM subscribe to cmd OK");
}
else
{
Serial.println("subscribe to cmd FAILED");
}
}
void publishData()
{
float cm = readcmCM();
if(digitalRead(34)) //pir motion detection
{
Serial.println("Motion Detected");
Serial.println("Lid Opened");
digitalWrite(15, HIGH);
if(digitalRead(34)== true)
{
if(cm <= 100) //Bin level detection
{
digitalWrite(2, HIGH);
Serial.println("High Alert!!!,Trash bin is about to be full");
Serial.println("Lid Closed");
lcd.print("Full! Don't use");
delay(2000);
lcd.clear();
digitalWrite(4, LOW);
digitalWrite(23, LOW);
}
else if(cm > 100 && cm < 180)
{
digitalWrite(4, HIGH);
Serial.println("Warning!!,Trash is about to cross 50% of bin level");
digitalWrite(2, LOW);
digitalWrite(23, LOW);
}
else if(cm > 180)
{
digitalWrite(23, HIGH);
Serial.println("Bin is available");
digitalWrite(2,LOW);
digitalWrite(4, LOW);
}
delay(10000);
Serial.println("Lid Closed");
}
else
{
Serial.println("No motion detected");
digitalWrite(2, LOW);
digitalWrite(15, LOW);
digitalWrite(4, LOW);
digitalWrite(23, LOW);
}
}
else
{
digitalWrite(15, LOW);
}
if(cm <= 100)
{
digitalWrite(21,HIGH);
String payload = "{\"High_Alert\":";
payload += cm;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
Serial.println(payload);
if (client.publish(publishTopic, (char*) payload.c_str())) // if data is uploaded to
cloud successfully,prints publish ok else prints publish failed
{
```

```
Serial.println("Publish OK");
}
}
else if(cm <= 180)
{
digitalWrite(22,HIGH);
String payload = "{\"Warning\":";
payload += cm ;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
Serial.println(payload);
if(client.publish(publishTopic, (char*) payload.c_str()))
{
Serial.println("Publish OK");
}
Else
{
Serial.println("Publish FAILED");
}
}
else if(cm > 180)
{
digitalWrite(23,HIGH);
String payload = "{";
payload += cm;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
Serial.println(payload);
if (client.publish(publishTopic, (char*) payload.c_str())) // if data is uploaded to
cloud successfully,prints publish ok else prints publish failed
{
Serial.println("Publish OK");
}
}
float inches = (cm / 2.54); //print on lcd
lcd.setCursor(0,0);
lcd.print("Inches");
lcd.setCursor(4,0);
lcd.setCursor(12,0);
lcd.print("cm");
lcd.setCursor(1,1);
lcd.print(inches, 1);
lcd.setCursor(11,1);
lcd.print(cm, 1);
lcd.setCursor(14,1);
delay(1000);
lcd.clear();
}
//handles commands from user side
void callback(char* subscribetopic, byte* payload, unsigned int payloadLength)
{
Serial.print("callback invoked for topic: ");
Serial.println(subscribetopic);
for (int i = 0; i < payloadLength; i++) {
data3 += (char)payload[i];
}
Serial.println("data: "+ data3);
const char s =(char) data3.c_str();
double pincode = 0;
const char *buf;
int len;
if (mjson_find(s, strlen(s), "$.command", &buf, &len)) // And print it
{
String command(buf,len);
if(command=="\"SealBin\"")
{
SealBin = true;
}
}
data3="";
}
```

7.2 CONNECTION SETUP:



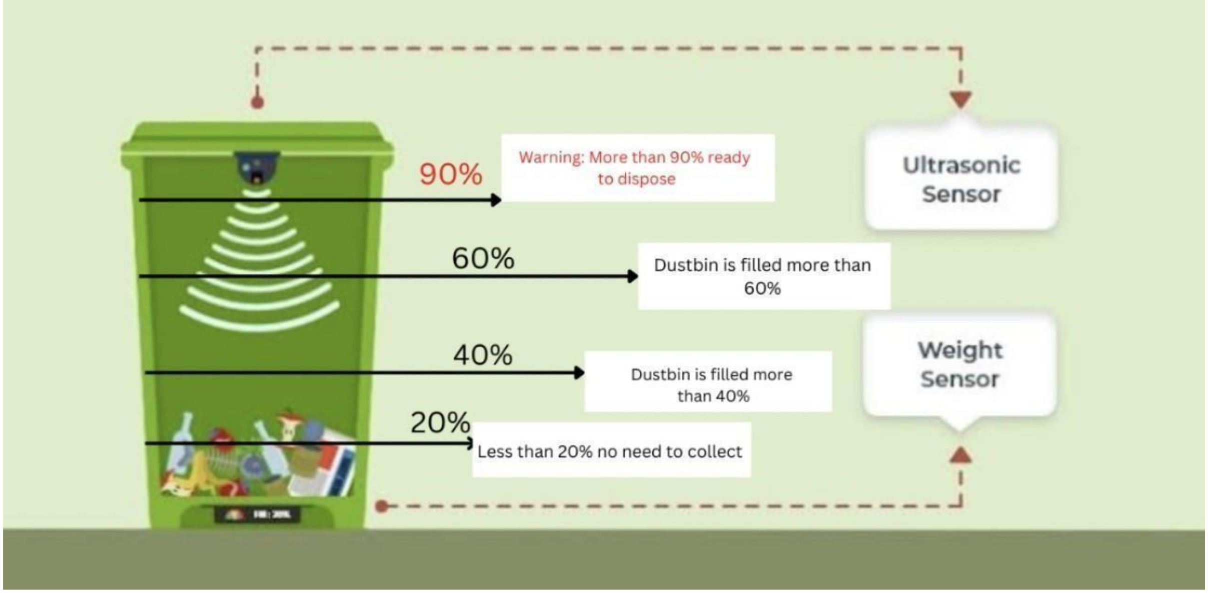
7.3 WEBPAGE CODE:

```
<!DOCTYPE html>
<html lang="en">
<head>
<title>Smart Waste Management System For Metropolitan Cities</title>
<meta charset="UTF-8">
<meta name="viewport" content="width=device-width, initial-scale=1">
<!--
=========================================================
=================
=====================-->
<link rel="icon" type="image/png" href="/static/images/icons/favicon.ico"/>
<!--
=========================================================
=================
=====================-->
<link rel="stylesheet" type="text/css"
href="/static/vendor/bootstrap/css/bootstrap.min.css">
<!--
=========================================================
=================
=====================-->
<link rel="stylesheet" type="text/css" href="/static/fonts/font-awesome-
4.7.0/css/font-awesome.min.css">
<!--
=========================================================
=================
=====================-->
<link rel="stylesheet" type="text/css" href="/static/fonts/Linearicons-Free-
v1.0.0/icon-font.min.css">
<!--
=========================================================
=================
=====================-->
<link rel="stylesheet" type="text/css"
href="/static/vendor/animate/animate.css">
<!-- =====================-->
<link rel="stylesheet" type="text/css" href="/static/vendor/css-
hamburgers/hamburgers.min.css">
<!-- =====================-->
<link rel="stylesheet" type="text/css"
href="/static/vendor/animsition/css/animsition.min.css">
<!--
=========================================================
=================
=====================-->
<link rel="stylesheet" type="text/css"
href="/static/vendor/select2/select2.min.css">
<link rel="stylesheet" type="text/css"
href="/static/vendor/daterangepicker/daterangepicker.css">
<link href="{{ url_for('static', path='/css/main.css') }}"
rel="stylesheet">
<link href="{{ url_for('static', path='/css/util.css') }}"
```

```
rel="stylesheet">
<!-- =====================-->




</head>
<body>
<div class="limiter">
<div class="container-login100" style="background-image: url({{
url_for('static', path='/images/bg1.jpg') }});">
<div class="wrap-login100 p-l-110 p-r-110 p-t-62 p-b-33">
<form class="login100-form validate-form flex-sb flex-w">
<span class="login100-form-title p-b-53"> Sign In With
</span>
<a href="#" class="btn-face m-b-20">
<i class="fa fa-facebook-official"></i> Facebook
</a>
<a href="#" class="btn-google m-b-20">
<img src="static/icons/icon-google.png" alt="GOOGLE"> Google
</a>
<div class="p-t-31 p-b-9">
<span class="txt1"> Username
</span>
</div>
<div class="wrap-input100 validate-input" data-validate = "Username is
required">
<input class="input100" type="text" name="username" >
<span class="focus-input100"></span>
</div>
<div class="p-t-13 p-b-9">
<span class="txt1"> Password
</span>
<a href="#" class="txt2 bo1 m-l-5"> Forgot?
</a>
</div>
<div class="wrap-input100 validate-input" data-validate = "Password is
required">
<input class="input100" type="password" name="pass" >
<span class="focus-input100"></span>
</div>
<div class="container-login100-form-btn m-t-17">
```

```
<button class="login100-form-btn"> Login
</button>
</div>
<div class="w-full text-center p-t-55">
<span class="txt2"> Not a member?
</span>
<a href="#" class="txt2 bo1"> Sign up now
</a>
</div>
</form>
</div>
</div>
</div>
<div id="dropDownSelect1"></div>
<!--
=========================================================
=================
=====================-->
<script src="/static/vendor/jquery/jquery-3.2.1.min.js"></script>
<!--
=========================================================
=================
=====================-->



<script src="/static/vendor/animsition/js/animsition.min.js"></script>
<!--
=========================================================
=================
=====================-->
<script src="/static/vendor/bootstrap/js/popper.js"></script>
<script src="/static/vendor/bootstrap/js/bootstrap.min.js"></script>
<!--
=========================================================
=================
=====================-->
<script src="/static/vendor/select2/select2.min.js"></script>
<!--
=========================================================
=================
=====================-->
```

```
<script src="/static/vendor/daterangepicker/moment.min.js"></script>
<script src="/static/vendor/daterangepicker/daterangepicker.js"></script>
<!--
=========================================================
=================
=====================-->
<script src="/static/vendor/countdowntime/countdowntime.js"></script>
<!--
=========================================================
=================
=====================-->
<script src="/static/js/main.js"></script>
</body>
</html>
```


90%
Warning: More than 90% ready to dispose
60%
Dustbin is filled more than 60%
40%
Dustbin is filled more than 40%
20%
Less than 20% no need to collect
Ultrasonic Sensor
Weight Sensor

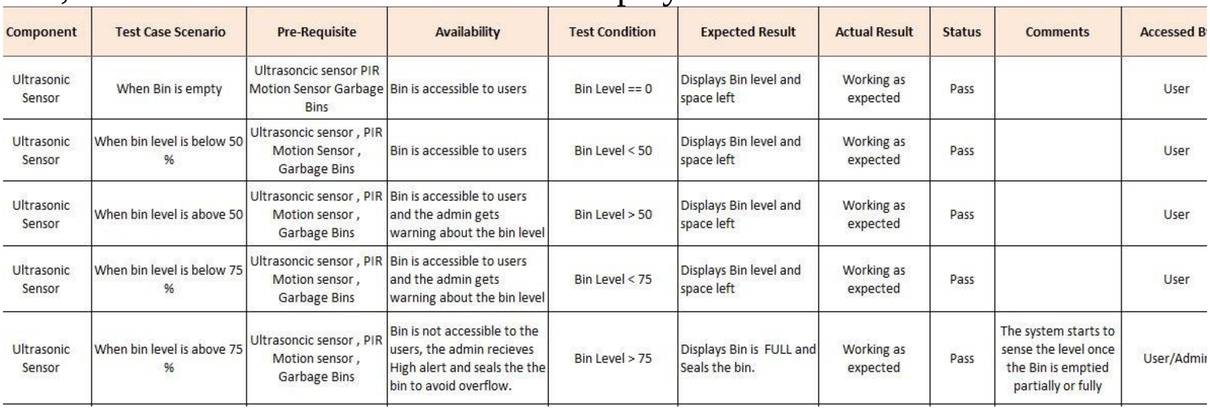
8. TESTING

8.1 TEST CASES:

Maximum Size of Bin : 200 cm
Safe limit: below 100 cm
Minimum threshold limit of bin: 100 cm
Maximum threshold limit of bin: 180 cm

S.no	Bin Level (cm filled)	Bin Status	Location
1	45	Safe	Kanyakumari
2	78	Safe	Coimbatore
3	112	Warning	Trichy
4	169	Warning	Chennai
5	186	Warning	Ooty
6	193	High_Alert	Tirunelveli
8	0	Safe	Chengalpattu
9	35	Safe	Madurai
10	101	Warning	Salem
11	132	Warning	Thanjavore
12	158	Warning	Vellore
13	93	High_Alert	Erode
14	93	High_Alert	Karur
15	93	High_Alert	Cuddalore
16	30	Safe	Kumbakonam
17	110	Warning	Ambur
18	180	Warning	Sivakasi
19	195	High_Alert	Neyveli
20	80	Safe	Krishnagiri

Note: The bin location provided above is default. When the user accesses the bin , the location and status of the bin displayed to the admin.



Component	Test Case Scenario	Pre-Requisite	Availability	Test Condition	Expected Result	Actual Result	Status	Comments	Accessed B
Ultrasonic Sensor	When Bin is empty	Ultrasoncic sensor PIR Motion Sensor Garbage Bins	Bin is accessible to users	Bin Level == 0	Displays Bin level and space left	Working as expected	Pass		User
Ultrasonic Sensor	When bin level is below 50 %	Ultrasoncic sensor , PIR Motion Sensor , Garbage Bins	Bin is accessible to users	Bin Level < 50	Displays Bin level and space left	Working as expected	Pass		User
Ultrasonic Sensor	When bin level is above 50	Ultrasoncic sensor , PIR Motion sensor , Garbage Bins	Bin is accessible to users and the admin gets warning about the bin level	Bin Level > 50	Displays Bin level and space left	Working as expected	Pass		User
Ultrasonic Sensor	When bin level is below 75 %	Ultrasoncic sensor , PIR Motion sensor , Garbage Bins	Bin is accessible to users and the admin gets warning about the bin level	Bin Level < 75	Displays Bin level and space left	Working as expected	Pass		User
Ultrasonic Sensor	When bin level is above 75 %	Ultrasoncic sensor , PIR Motion sensor , Garbage Bins	Bin is not accessible to the users, the admin recieves High alert and seals the the bin to avoid overflow.	Bin Level > 75	Displays Bin is FULL and Seals the bin.	Working as expected	Pass	The system starts to sense the level once the Bin is emptied partially or fully	User/Admi

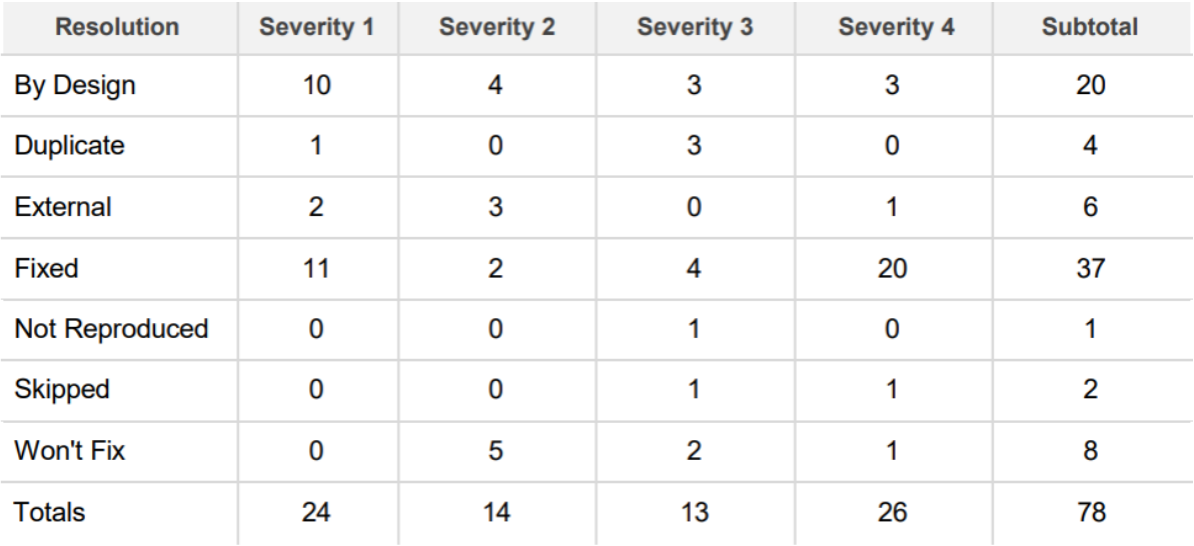
8.2 USER ACCEPTANCE TESTING:

1. Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the Smart Waste Management System project at the time of the release to User Acceptance Testing (UAT).

2. Defect Analysis

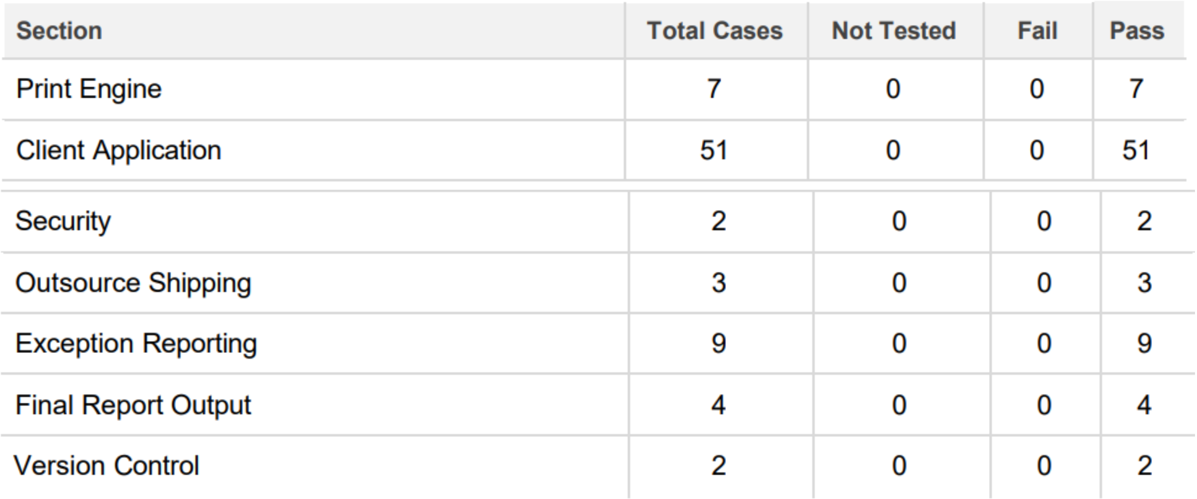
This report shows the number of resolved or closed bugs at each severity level, and how they were resolved.



Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	4	3	3	20
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	11	2	4	20	37
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	5	2	1	8
Totals	24	14	13	26	78

3. TEST CASE ANALYSIS

This report shows the number of test cases that have passed , failed and untested.



Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	51	0	0	51
Security	2	0	0	2
Outsource Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

TEST CASE 1:
WEIGHT: 0 KG
STATUS: NOT FILLED, DUSTBIN IS EMPTY

TEST CASE 2:
WEIGHT: 10KG
STATUS:20% FILLED, NOT READY TO DISPOSE

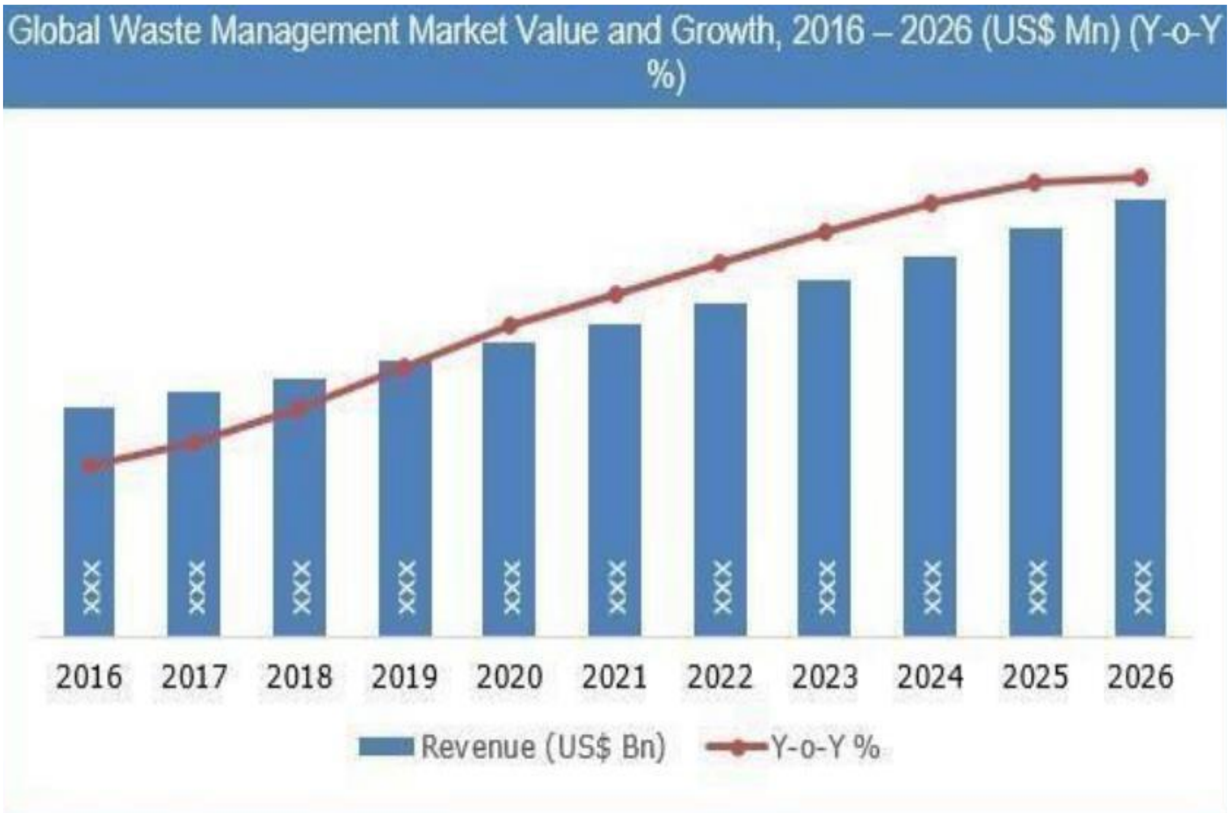
TEST CASE 3:
WEIGHT: 20KG
STATUS: 40% FILLED, NOT READY TO DISPOSE

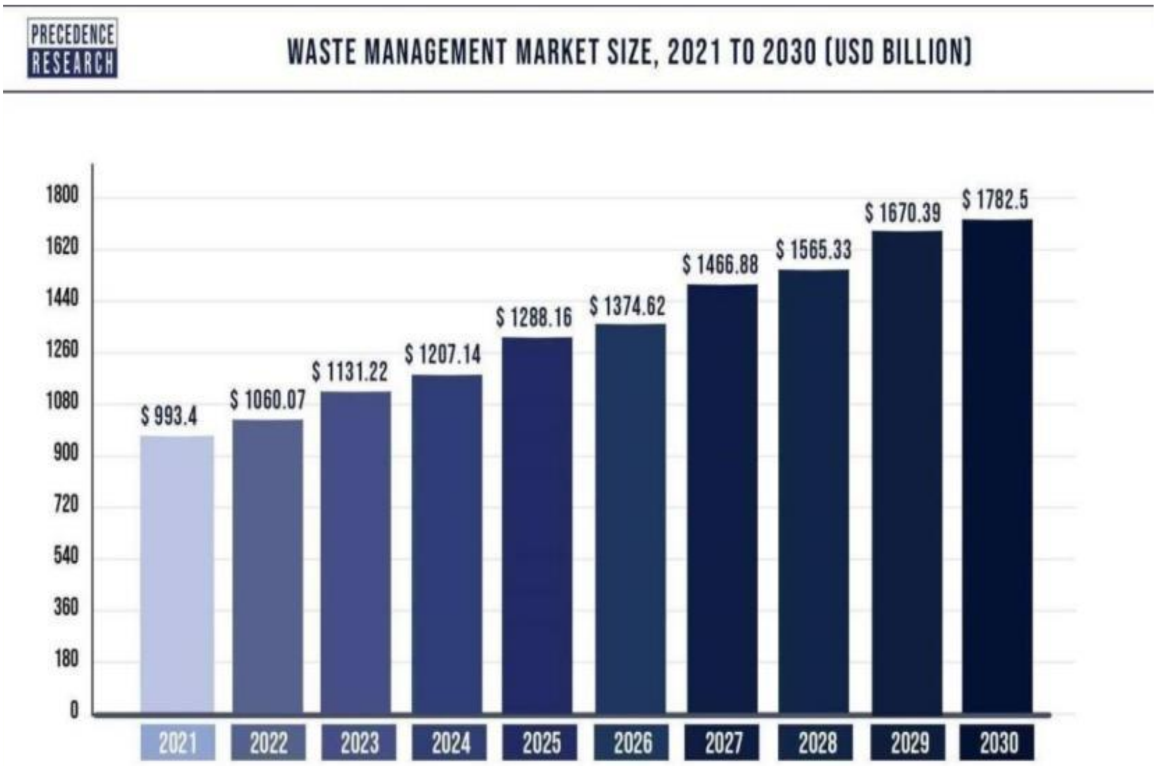
TEST CASE 4:
WEIGHT: 30KG
STATUS: 60% FILLED, NOT READY TO DISPOSE

TEST CASE 5:
WEIGHT: 45KG
STATUS: 90% FILLED, READY TO DISPOSE

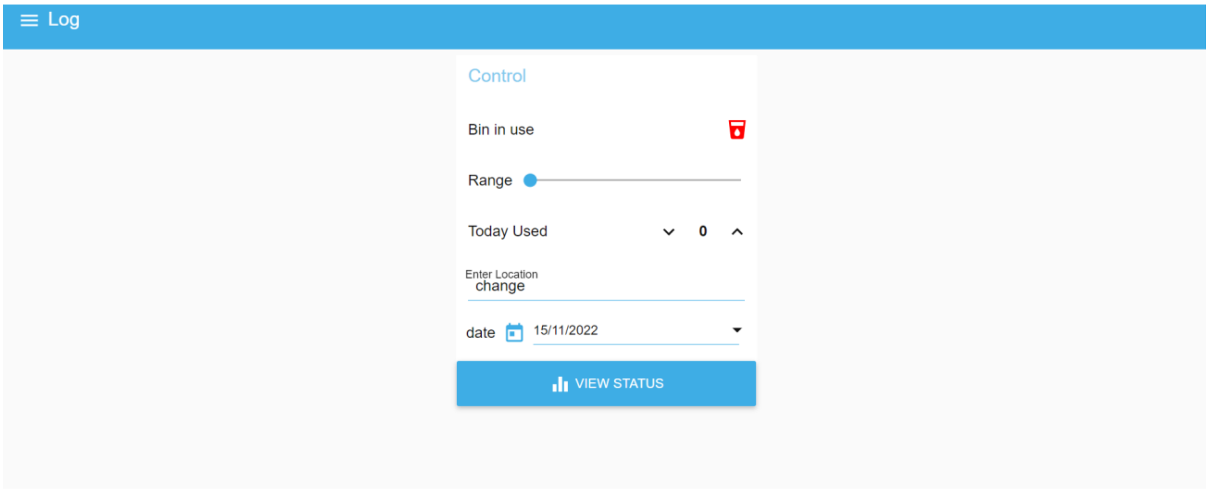
9. RESULTS

9.1 PERFORMANCE METRICS:





9.2 ADMIN WEB UI:



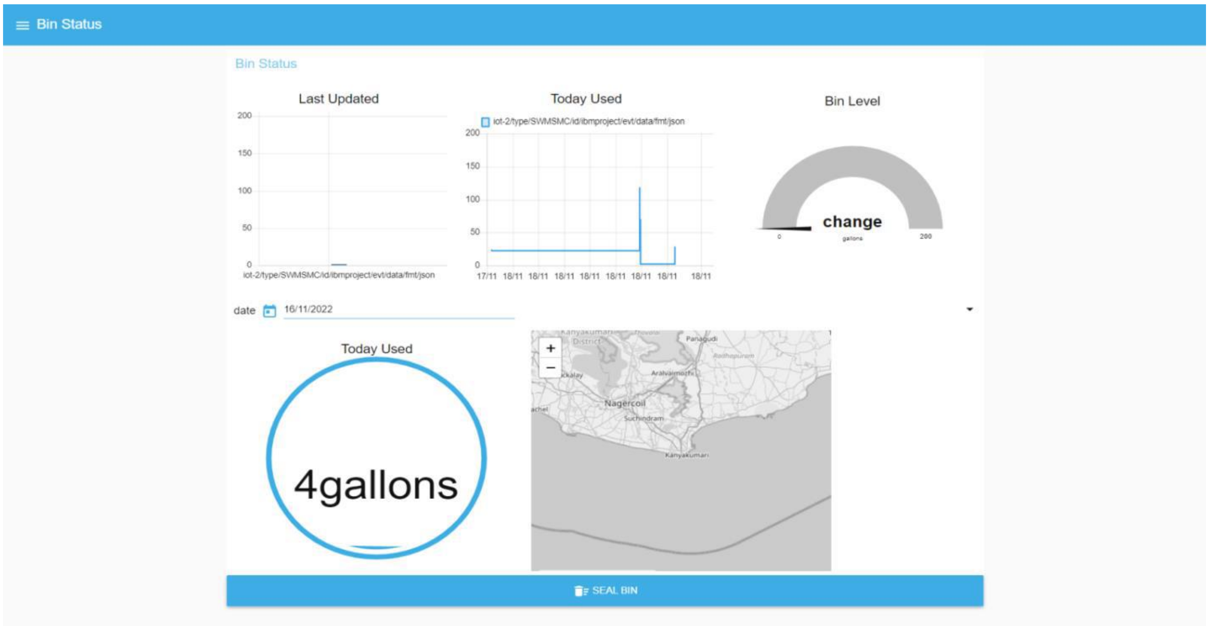
Bin in use

Range

Today Used 0

Enter Location: change

date 15/11/2022



date 16/11/2022

10. ADVANTAGES AND DISADVANTAGES:

10.1. ADVANTAGES

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

10.2 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.

11. CONCLUSION

Monitoring the fullness of bins through the use of sensors, it is possible to achieve a more efficient system than the current existing. Our idea of "Smart waste management system", mainly concentrates on Monitoring the waste management, providing a smart technology for waste system, avoiding human intervention, reducing human time and effort and which results in healthy and waste ridden environment.

The proposed idea can be implemented for smart cities where the residents would be busy enough with their hectic schedule and wouldn't have enough time for managing waste. The bins can be implemented in a city if desired where there would be a large bin that can have the capacity to accumulate the waste of solid type for a single apartment. The cost could be distributed among the residents leading to cheaper service provision.

12. FUTURE SCOPE:

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

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

- 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'.
- Having case study or data analytics on the type and times waste is collected on different days or seasons, making the bin level predictable and remove the reliance on electronic components, and fixing the coordinates.
- Improving the Server's and Android's graphical interfaces.

13.APPENDIX:

13.1 SOURCE CODE

```
#include <WiFi.h> // library for wifi

#include <PubSubClient.h> // library for MQTT

#include <LiquidCrystal_I2C.h>

#include <mjson.h>

LiquidCrystal_I2C lcd(0x27, 20, 4);

//----------------------- credentials of IBM Accounts ------------------------------

#define ORG "9gbe4w" // IBM organisation id

#define DEVICE_TYPE "SWMSMC" // Device type mentioned in ibm watson iot platform

#define DEVICE_ID "ibmproject" // Device ID mentioned in ibm watson iot platform

#define TOKEN "sUNA41tG6-Pq)0rk5X" // Token

//----------------------- customise above values -----------------------------------------------------

char server[] = ORG ".messaging.internetofthings.ibmcloud.com"; // server name

char publishTopic[] = "iot-2/evt/data/fmt/json"; // topic name and type of event perform and format in which data to be send
char topic[] = "iot-2/cmd/led/fmt/String"; // cmd Represent type and command is test format of strings
char authMethod[] = "use-token-auth"; // authentication method
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID; //Client id
//-------------------------------------------------------------------------------------------------------------
WiFiClient wifiClient; // creating instance for wificlient
PubSubClient client(server, 1883, wifiClient);
#define ECHO_PIN 12
#define TRIG_PIN 13
float dist;
String data3;
bool SealBin = true;
void setup()
{
Serial.begin(115200);
pinMode(LED_BUILTIN, OUTPUT);
pinMode(TRIG_PIN, OUTPUT);
pinMode(ECHO_PIN, INPUT);
//pir pin
pinMode(34, INPUT);
//ledpins
pinMode(23, OUTPUT);
pinMode(2, OUTPUT);
pinMode(4, OUTPUT);
pinMode(15, OUTPUT);
```

```
lcd.init();
lcd.backlight();
lcd.setCursor(1, 0);
lcd.print("");
wifiConnect();
mqttConnect();
}

float readcmCM()
{
digitalWrite(TRIG_PIN, LOW);
delayMicroseconds(2);
digitalWrite(TRIG_PIN, HIGH);
delayMicroseconds(10);
digitalWrite(TRIG_PIN, LOW);
int duration = pulseIn(ECHO_PIN, HIGH);
return duration * 0.034 / 2;
}
void loop()
{
lcd.clear();

publishData();
delay(500);
if (!client.loop())
{
mqttConnect(); // function call to connect to IBM
```

```
}
}
/* --------------------------------retrieving to cloud------------------------------------------------------*/



void wifiConnect()
{
Serial.print("Connecting to ");
Serial.print("Wifi");
WiFi.begin("Wokwi-GUEST", "", 6);
while (WiFi.status() != WL_CONNECTED)
{
delay(500);
Serial.print(".");
}
Serial.print("WiFi connected, IP address: ");
Serial.println(WiFi.localIP());
}
void mqttConnect()
{
if (!client.connected())
{
Serial.print("Reconnecting MQTT client to ");
Serial.println(server);
while (!client.connect(clientId, authMethod, token))
{
```

```
Serial.print(".");
delay(500);
}
initManagedDevice();
Serial.println();
}
}
void initManagedDevice()
{
if (client.subscribe(topic))
{
Serial.println("IBM subscribe to cmd OK");
}
else
{
Serial.println("subscribe to cmd FAILED");
}
}
void publishData()
{
float cm = readcmCM();
if(digitalRead(34)) //pir motion detection
{
Serial.println("Motion Detected");
Serial.println("Lid Opened");
digitalWrite(15, HIGH);
if(digitalRead(34)== true)
```

```
{
if(cm <= 100) //Bin level detection
{
digitalWrite(2, HIGH);
Serial.println("High Alert!!!,Trash bin is about to be full");
Serial.println("Lid Closed");
lcd.print("Full! Don't use");
delay(2000);
lcd.clear();
digitalWrite(4, LOW);
digitalWrite(23, LOW);
}
else if(cm > 100 && cm < 180)
{
digitalWrite(4, HIGH);
Serial.println("Warning!!,Trash is about to cross 50% of bin level");
digitalWrite(2, LOW);
digitalWrite(23, LOW);
}
else if(cm > 180)
{
digitalWrite(23, HIGH);
Serial.println("Bin is available");
digitalWrite(2,LOW);
digitalWrite(4, LOW);
}
delay(10000);
```

```
Serial.println("Lid Closed");
}
else
{
Serial.println("No motion detected");
digitalWrite(2, LOW);
digitalWrite(15, LOW);
digitalWrite(4, LOW);
digitalWrite(23, LOW);
}
}
else
{
digitalWrite(15, LOW);
}
if(cm <= 100)
{
digitalWrite(21,HIGH);
String payload = "{\"High_Alert\":";
payload += cm;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
Serial.println(payload);
if (client.publish(publishTopic, (char*) payload.c_str())) // if data is uploaded to
cloud successfully,prints publish ok else prints publish failed
{
Serial.println("Publish OK");
```

```
}
}
else if(cm <= 180)
{
digitalWrite(22,HIGH);
String payload = "{\"Warning\":";
payload += cm ;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
Serial.println(payload);
if(client.publish(publishTopic, (char*) payload.c_str()))
{
Serial.println("Publish OK");
}
Else
{
Serial.println("Publish FAILED");
}
}
else if(cm > 180)
{
digitalWrite(23,HIGH);
String payload = "{";
payload += cm;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
Serial.println(payload);
if (client.publish(publishTopic, (char*) payload.c_str())) // if data is uploaded to cloud successfully,prints publish ok else prints publish failed
{
Serial.println("Publish OK");
}
}
float inches = (cm / 2.54); //print on lcd
lcd.setCursor(0,0);
lcd.print("Inches");
lcd.setCursor(4,0);
lcd.setCursor(12,0);
lcd.print("cm");
lcd.setCursor(1,1);
lcd.print(inches, 1);
lcd.setCursor(11,1);
lcd.print(cm, 1);
lcd.setCursor(14,1);
delay(1000);
lcd.clear();
}
//handles commands from user side
void callback(char* subscribetopic, byte* payload, unsigned int payloadLength)
{
Serial.print("callback invoked for topic: ");
Serial.println(subscribetopic);
for (int i = 0; i < payloadLength; i++) {
```

```
data3 += (char)payload[i];
}
Serial.println("data: "+ data3);
const char s =(char) data3.c_str();
double pincode = 0;
const char *buf;
int len;
if (mjson_find(s, strlen(s), "$.command", &buf, &len)) // And print it
{
String command(buf,len);
if(command=="\"SealBin\"")
{
SealBin = true;
}
}
data3="";
}
```

13.2 GIT HUB LINK:

https://github.com/IBM-EPBL/IBM-Project-44711-1660726399

13.3 WOKWI SIMULATION LINK

https://wokwi.com/projects/347953099383505492