SMART WASTE MANAGEMENT FOR METROPOLITAN CITIES

IBM PROJECT

Team Id : PNT2022TMID18178

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1.INTRODUCTION

Internet of Things is nothing but the applications performing with the help of internet access. IoT Communication over the internet has grown from user - user interaction to device – device interactions these days. The IoT concepts were proposed years back but still it’s in the initial stage of commercial deployment. Home automation industry and transportation industries are seeing rapid growth with IoT. The basic project idea is to design a smart waste detection system which would automatically notify the officials about the current status of various garbage bins in the city, would have realtime monitoring capabilities, which would be remotely controlled using IoT techniques. This paper introduces you to the use of IoT on one such area, that is, Garbage Detection in smart ways using IoT and see how this can also be a major part of developing a city into a smart city.

1.1 PROJECT PREVIEW

A big challenge in the urban cities is that of waste management as there 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 can clean 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 send to the authorized person to collect the garbage from the particular area. The authorized person will sends the message from his web application to the garbage collectors by sending a SMS .This system maintain a dry waste and a wet waste separately. This will help to reduce the overflow of the garbage bin and thus keeping the environment clean.

1.2 PURPOSE

This project helps the citizens to make their surroundings and environment clean , pollution free and lead a healthy life throughout. It avoids the possibility garbage overflow, unhygienic environment, air-borne and water-borne disease , etc...

2. LITERATURE SURVEY

2.1 EXISTING PROBLEM

In the existing system garbage is collected by the corporation weekly once or twice. Sometimes the garbage stinks and overflows from the bin and spread over the roads and pollutes the environment. This also produces a heavy air pollution and routes to various air-borne diseases Many a times the street dogs and other animals eat these waste and scatter these waste around the surroundings which creates the spread of various diseases and situation of unclean environment.

Disadvantages of existing system:

- Time consuming and less effective.
- Overflow of waste from the bin.
- Unhygienic Environment and look of the city.
- Stinky smell and unpleasant situations.

PROPOSED SYSTEM :

In this proposed system there will be no issues repeated that of previous system. In this systemthe bin is designed in such a way that when the waste level reaches the threshold limit it automatically closes the bin and intimates the alert to the admin . The bins are provided with low cost embedded device which helps in tracking the level of the garbage bins and a unique IDwill be provided for every dustbin in the city .These details can be accessed by the concern authorities from their place with the help of internet and an immediate action can be made to clean the bin. The admin can monitor the level of the bin and can trace the location where it exists.

ADVANTAGES :

- Real time information on the fill level of the dustbin.
- Deployment of dustbin based on the actual needs.
- Cost Reduction and resource optimization.
- Improves Environment quality .

REFERENCES :

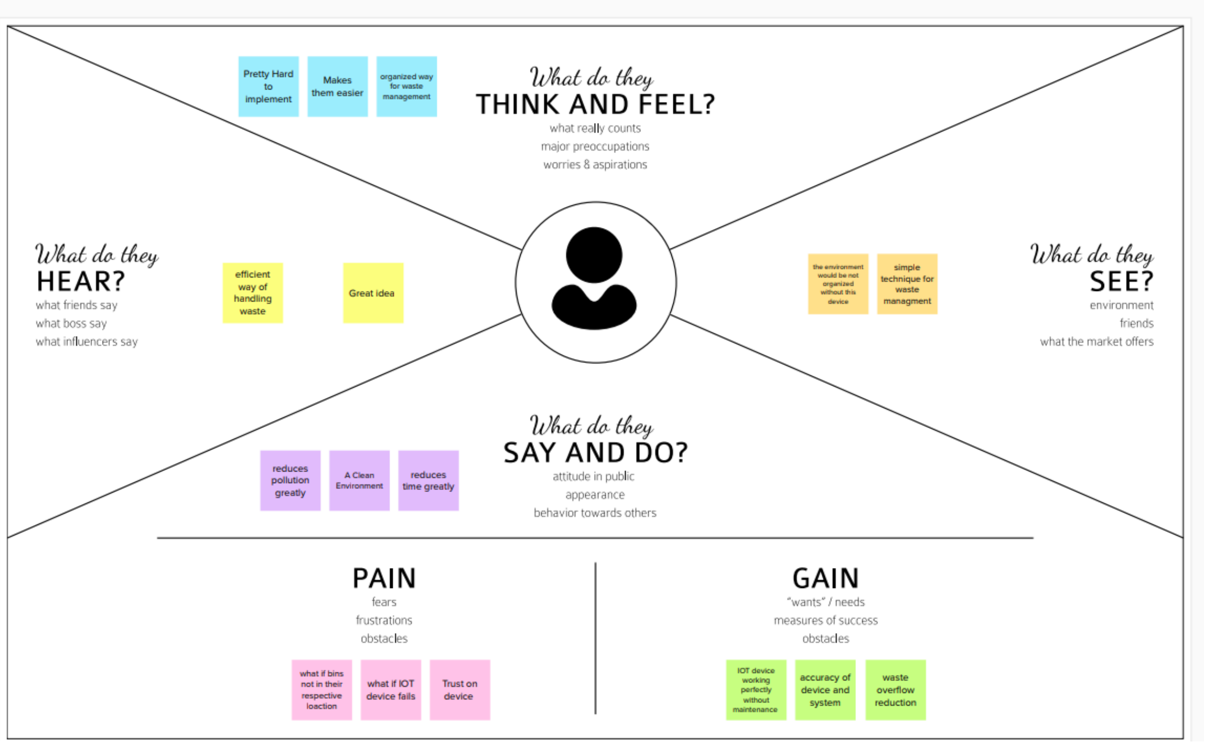
- A LoRaWan IoT –Enabled Trash Bin Level Monitoring System S.R. Jino Ramson , Member, IEEE, Vishnu S. , A. Alfred Kirubaraj, Theodoros Anagnostopoulos,and Adnan M. Abu-Mahfouz , Senior Member, IEEE(2022)-Through this paper the Trash Bin level monitoring was studied and the working condition of the bin was studied.
- IoT-Aware Waste Management System Based on Cloud Services and Ultra-Low-Power RFID Sensor-Tags,Luca Catarinucci , Member, IEEE, Riccardo Colella , Senior Member, IEEE, Stefano Irno Consalvo, Luigi Patrono , Member, IEEE, Claudia Rollo, and Ilaria Sergi(2020)-The transfer of the data from the Smart Bin to the server of the corporation has been studied from this paper.
- “Radio frequency identification and sensor networks based bin level monitoring systems”- S. R. J. Ramson, D. Bhavanam, S. Draksharam, R. Kumar, D. J. Moni, and A. A. Kirubaraj-IEEE Paper-The basic construction model of the wireless sensor network has been gained from this paper.
- S. Longhi et al., “Solid waste management architecture using wireless sensor network technology,”Sauro Longhi,Davide Marzioni, Emanuele Alidori, Gianluca Di Buò, Mariorosario Prist, Massimo Grisostomi, Matteo Pirro.-The architecture of the smart waste management has been studied from this paper.
- IoT based route recommendation for intelligent waste management, Mohammadhossein Ghahramani , Member, IEEE, MengChu Zhou , Fellow, IEEE, Anna Molter, and Francesco Pilla(2022) IEEE Paper- The optimal route for the truck to be followed has been generated through the idea of this paper.

2.3 PROBLEM STATEMENT

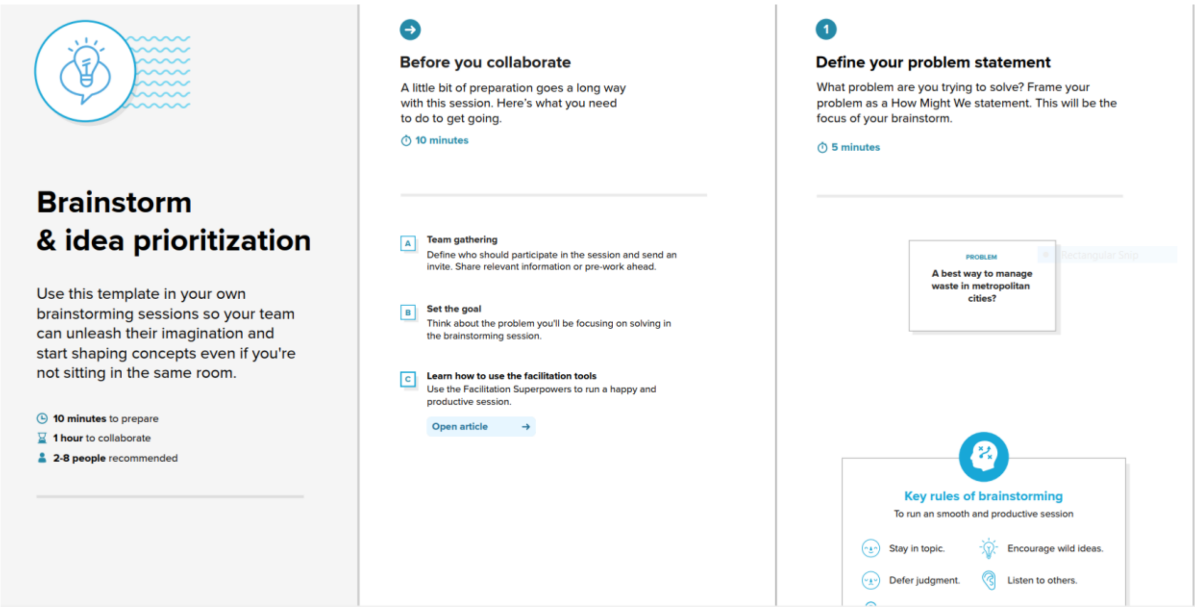
The waste management system provided earlier are not very reliable, efficient, cost effective and does not have any advanced processing features like automatic close of bin and alert intimations system .The following is a well articulated problem statement that allows you to find the ideal solution for the challenges faced.

3. IDEATION MAP AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS



3.2 BRAINSTROMING MAP



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

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.

Open article →

1 Define your problem statement

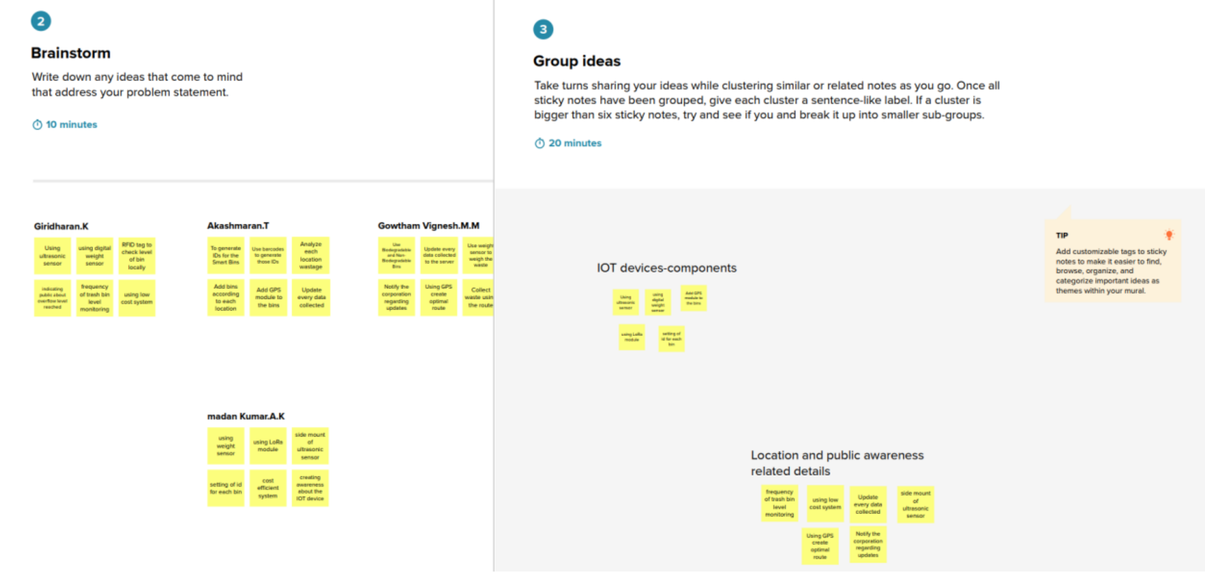
What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

5 minutes

PROBLEM
A best way to manage waste in metropolitan cities?

Key rules of brainstorming
To run an smooth and productive session

Stay in topic. Encourage wild ideas.
Defer judgment. Listen to others.



2 Brainstorm

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

10 minutes

Giridharan.K
Using ultrasonic sensor | using digital weight sensor | RFID tag to check level of bin locally
indicating public about overflow level reached | frequency of trash bin level monitoring | using low cost system

Akashmaran.T
To generate IDs for the Smart Bins | Use barcodes to generate those IDs | Analyze each location wastage
Add bins according to each location | Add GPS module to the bins | Update every data collected

Gowtham Vignesh.M.M
Use Biodegradable and Non-Biodegradable Bins | Update every data collected to the server | Use weigh sensor to weigh the waste
Notify the corporation regarding updates | Using GPS create optimal route | Collect waste usin the route

madan Kumar.A.K
using weight sensor | using LoRa module | side mount of ultrasonic sensor
setting of id for each bin | cost efficient system | creating awareness about the IOT device

3 Group ideas

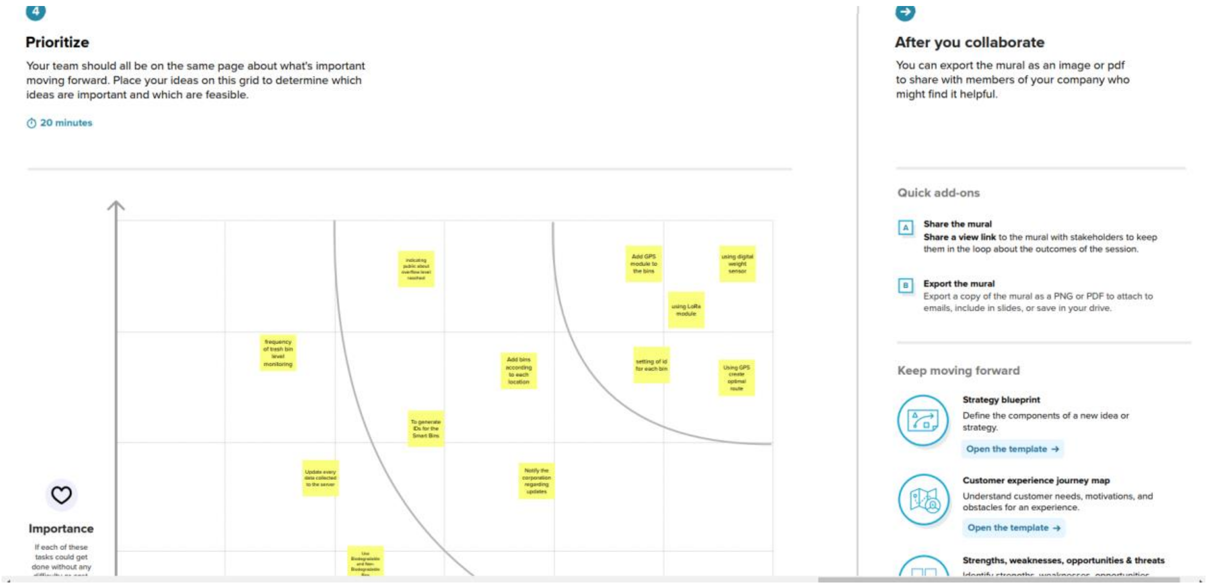
Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

20 minutes

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

IOT devices-components
Using ultrasonic sensor | using digital weight sensor | Add GPS module to the bins
using LoRa module | setting of id for each bin

Location and public awareness related details
frequency of trash bin level monitoring | using low cost system | Update every data collected | side mount of ultrasonic sensor
Using GPS create optimal route | Notify the corporation regarding updates



4

Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

⏱ 20 minutes

indicating public about overflow level reached
Add GPS module to the bins
using digital weight sensor
using LoRa module
frequency of trash bin level monitoring
Add bins according to each location
setting of id for each bin
Using GPS create optimal route
To generate IDs for the Smart Bins
Update every data collected to the server
Notify the corporation regarding updates
Use Biodegradable and Non-Biodegradable Bins

♡

Importance

If each of these tasks could get done without any

➔

After you collaborate

You can export the mural as an image or pdf to share with members of your company who might find it helpful.

Quick add-ons

A **Share the mural**
Share a view link to the mural with stakeholders to keep them in the loop about the outcomes of the session.

B **Export the mural**
Export a copy of the mural as a PNG or PDF to attach to emails, include in slides, or save in your drive.

Keep moving forward

Strategy blueprint
Define the components of a new idea or strategy.
Open the template →

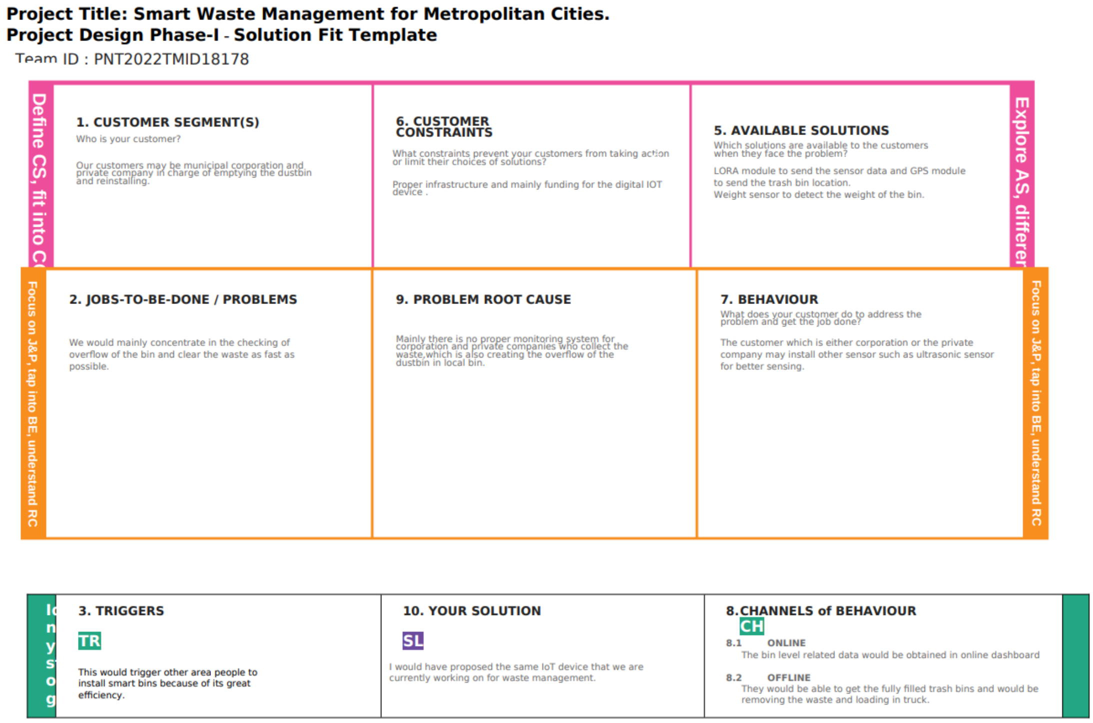
Customer experience journey map
Understand customer needs, motivations, and obstacles for an experience.
Open the template →

Strengths, weaknesses, opportunities & threats

3.3 PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	• Metropolitan Waste Management remains a major problem in urban areas ,leading to serious health and environmental issues. • Consequently ,trash bins are placed in many places to handle the waste ,but these bins can overflow spreading all around the area ,polluting the environment and causing inconvenience to public .
2.	Idea / Solution description	• By designing an IoT enabled system, we can monitor the levels of the bins. • The data collected will be uploaded in the cloud. • The trash collecter will collect the trash as soon as the smart bins are filled.
3.	Novelty / Uniqueness	• There will be Bio-degradable and Non-Biodegradable Smart Bins. • The weight Sensor and Ultrasonic sensor is used to detect the level of the bins.
4.	Social Impact / Customer Satisfaction	• By implementing this system the environmental and health issues will be reduced. • The people feel it very easy to dipose the waste.
5.	Business Model (Revenue Model)	• Through this smart system the cost spent in cleaning the city can be reduced. • The Bio-degradable waste can be made as natural fertilizers for the agriculture. • The Non Bio-degradable waste can be recycled instead of production.
6.	Scalability of the Solution	• From this solution the envirinment will be kept clean. • As it is automated monitoring the time consumption will be minimized.

3.4 PROBLEM SOLUTION FIT



Project Title: Smart Waste Management for Metropolitan Cities.
Project Design Phase-I - Solution Fit Template
Team ID : PNT2022TMID18178

1. CUSTOMER SEGMENT(S)
Who is your customer?

Our customers may be municipal corporation and private company in charge of emptying the dustbin and reinstalling.

6. CUSTOMER CONSTRAINTS
What constraints prevent your customers from taking action or limit their choices of solutions?

Proper infrastructure and mainly funding for the digital IOT device .

5. AVAILABLE SOLUTIONS
Which solutions are available to the customers when they face the problem?

LORA module to send the sensor data and GPS module to send the trash bin location.
Weight sensor to detect the weight of the bin.

2. JOBS-TO-BE-DONE / PROBLEMS

We would mainly concentrate in the checking of overflow of the bin and clear the waste as fast as possible.

9. PROBLEM ROOT CAUSE

Mainly there is no proper monitoring system for corporation and private companies who collect the waste,which is also creating the overflow of the dustbin in local bin.

7. BEHAVIOUR
What does your customer do to address the problem and get the job done?

The customer which is either corporation or the private company may install other sensor such as ultrasonic sensor for better sensing.

3. TRIGGERS
TR

This would trigger other area people to install smart bins because of its great efficiency.

10. YOUR SOLUTION
SL

I would have proposed the same IoT device that we are currently working on for waste management.

8.CHANNELS of BEHAVIOUR
CH

8.1 **ONLINE**
The bin level related data would be obtained in online dashboard

8.2 **OFFLINE**
They would be able to get the fully filled trash bins and would be removing the waste and loading in truck.

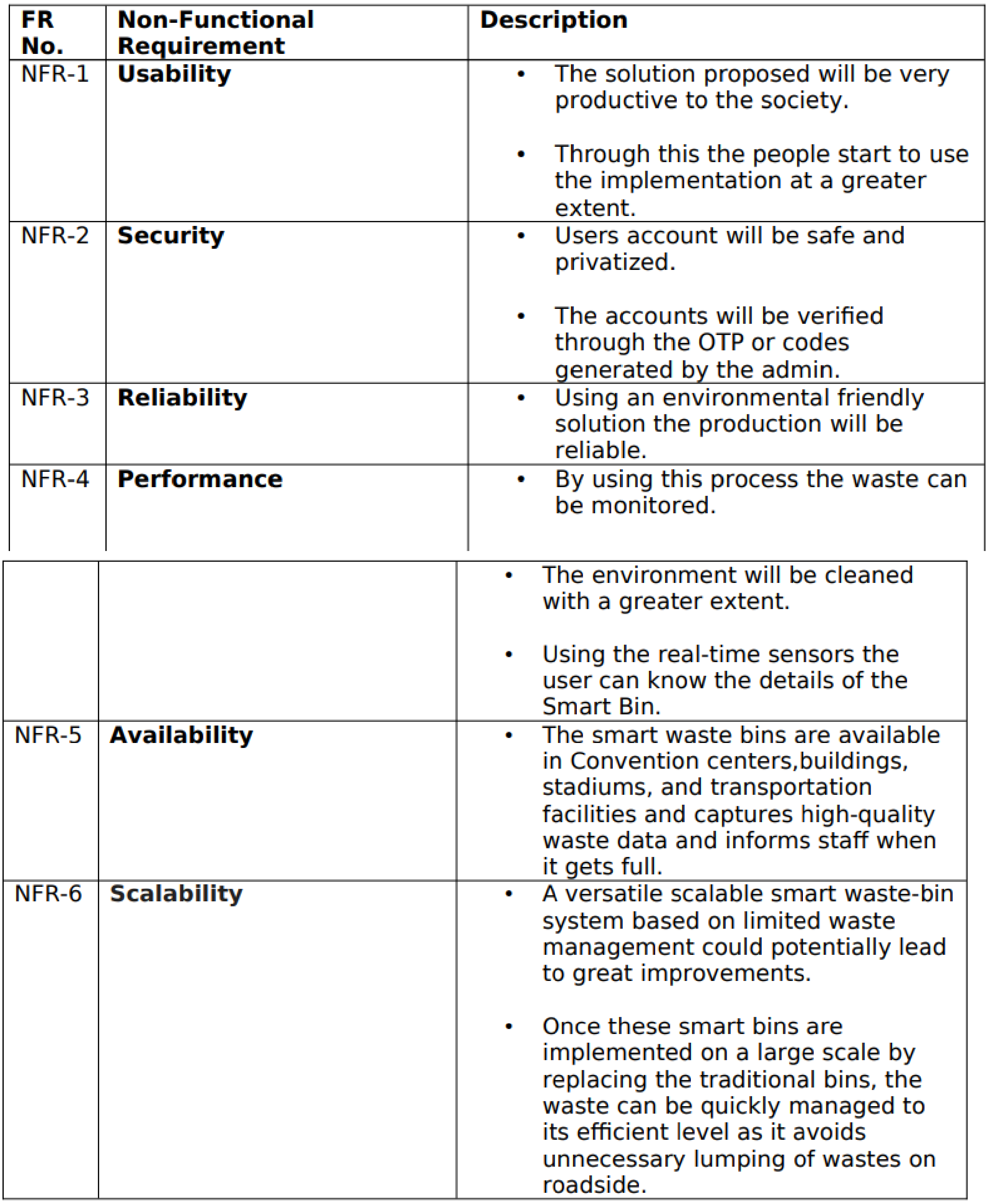
Define CS, fit into C
Explore AS, differer
Focus on J&P, tap into BE, understand RC
Focus on J&P, tap into BE, understand RC
Id n y s o g

4.REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENTS

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Gmail (or) Registration through LinkedIN
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	GPS Access	To locate the location of the Samrt Bin
FR-4	Bin Level Analysis	Using the weight sensor and the ultrasonic sensor the level of the bin can be measured
FR-5	Updation in Website	The levels of the bins will be uploaded in the website through the cloud platform
FR-6	Collection of garbage	The workers will collect the garbage according to the level of the bins filled.

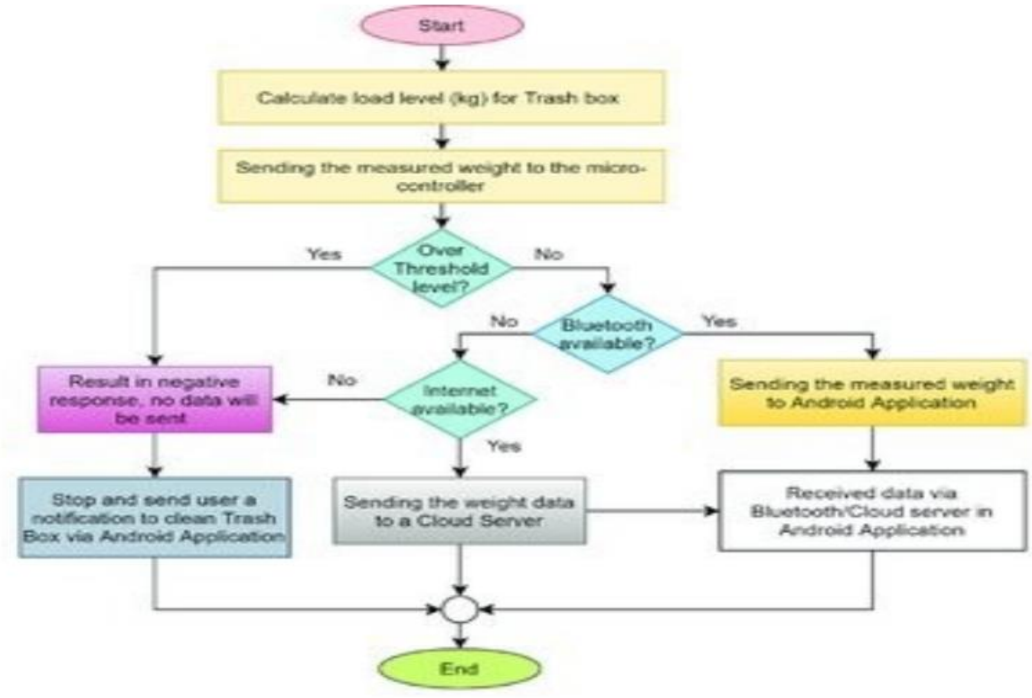
4.2 NON-FUNCTIONAL REQUIREMENTS



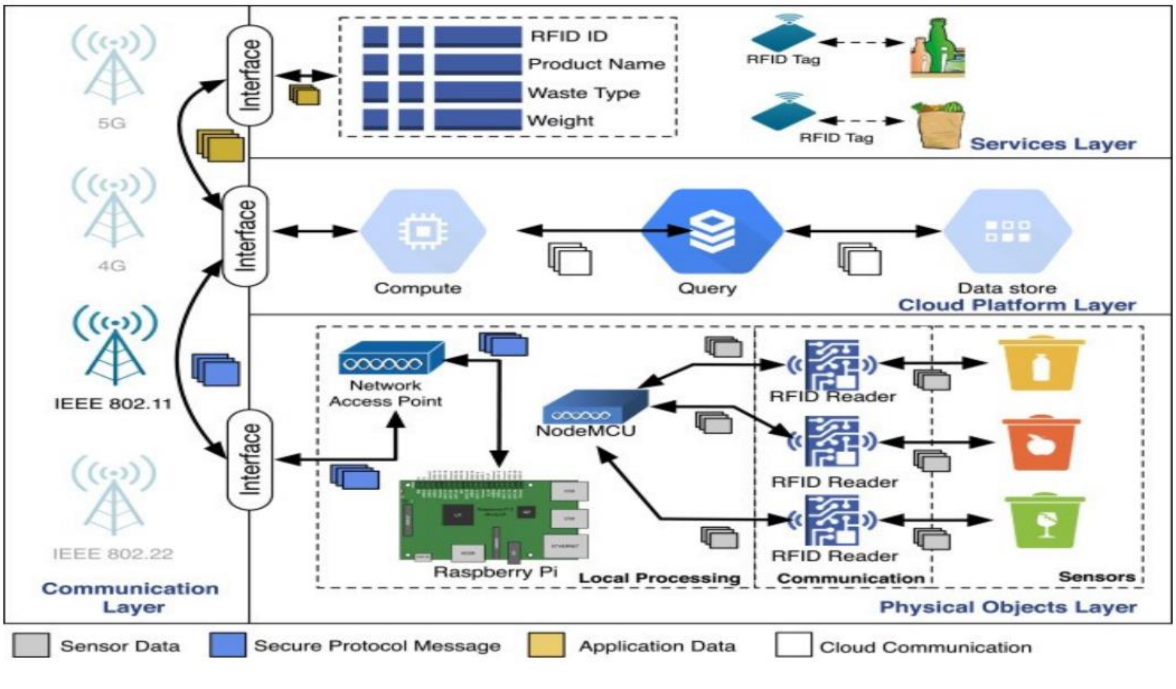
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	• The solution proposed will be very productive to the society. • Through this the people start to use the implementation at a greater extent.
NFR-2	**Security**	• Users account will be safe and privatized. • The accounts will be verified through the OTP or codes generated by the admin.
NFR-3	**Reliability**	• Using an environmental friendly solution the production will be reliable.
NFR-4	**Performance**	• By using this process the waste can be monitored. • The environment will be cleaned with a greater extent. • Using the real-time sensors the user can know the details of the Smart Bin.
NFR-5	**Availability**	• The smart waste bins are available in Convention centers,buildings, stadiums, and transportation facilities and captures high-quality waste data and informs staff when it gets full.
NFR-6	**Scalability**	• A versatile scalable smart waste-bin system based on limited waste management could potentially lead to great improvements. • Once these smart bins are implemented on a large scale by replacing the traditional bins, the waste can be quickly managed to its efficient level as it avoids unnecessary lumping of wastes on roadside.

5.PROJECT DESIGN

5.1 DATFLOW DIAGRAM


Start
Calculate load level (kg) for Trash box
Sending the measured weight to the micro-controller
Over Threshold level?
Yes
No
Bluetooth available?
No
Yes
Result in negative response, no data will be sent
No
Internet available?
Yes
Sending the measured weight to Android Application
Stop and send user a notification to clean Trash Box via Android Application
Sending the weight data to a Cloud Server
Received data via Bluetooth/Cloud server in Android Application
End

5.2. SOLUTION ARCHITECTURE AND TECHNICAL ARCHITECTURE



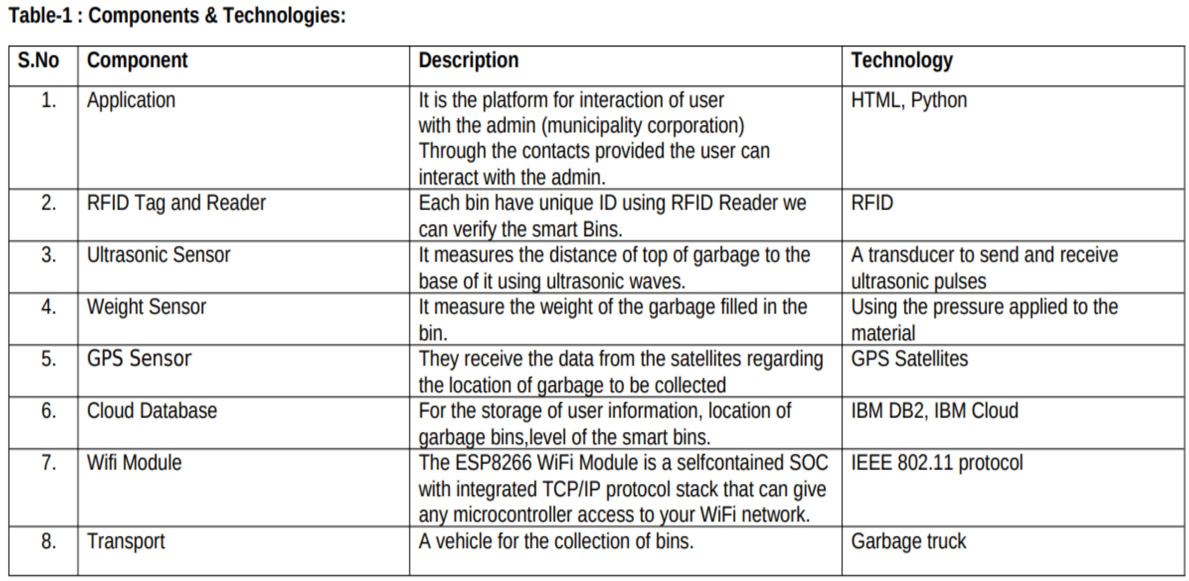
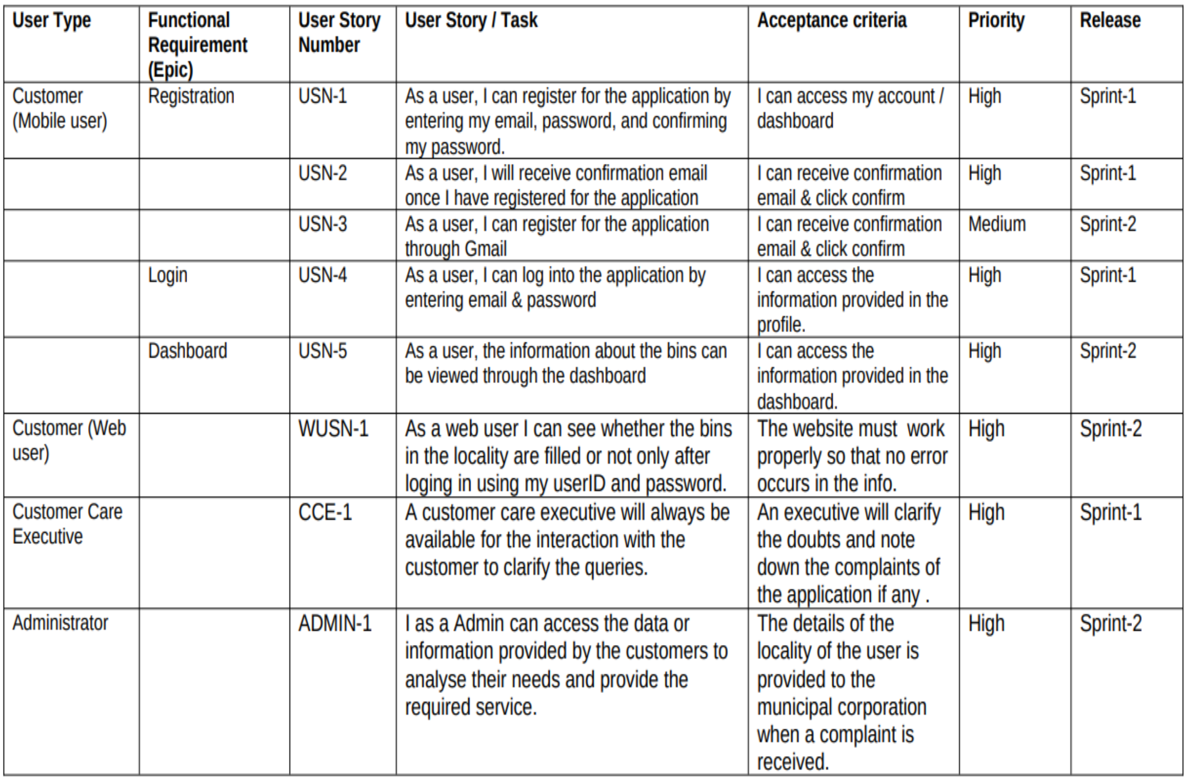


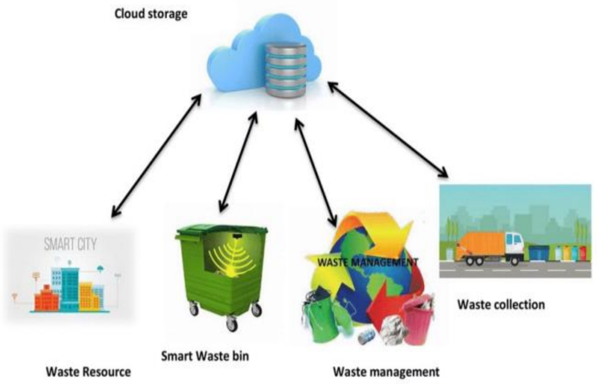
Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	Application	It is the platform for interaction of user with the admin (municipality corporation) Through the contacts provided the user can interact with the admin.	HTML, Python
2.	RFID Tag and Reader	Each bin have unique ID using RFID Reader we can verify the smart Bins.	RFID
3.	Ultrasonic Sensor	It measures the distance of top of garbage to the base of it using ultrasonic waves.	A transducer to send and receive ultrasonic pulses
4.	Weight Sensor	It measure the weight of the garbage filled in the bin.	Using the pressure applied to the material
5.	GPS Sensor	They receive the data from the satellites regarding the location of garbage to be collected	GPS Satellites
6.	Cloud Database	For the storage of user information, location of garbage bins,level of the smart bins.	IBM DB2, IBM Cloud
7.	Wifi Module	The ESP8266 WiFi Module is a selfcontained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network.	IEEE 802.11 protocol
8.	Transport	A vehicle for the collection of bins.	Garbage truck

5.3USER STORIES



User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
		USN-3	As a user, I can register for the application through Gmail	I can receive confirmation email & click confirm	Medium	Sprint-2
	Login	USN-4	As a user, I can log into the application by entering email & password	I can access the information provided in the profile.	High	Sprint-1
	Dashboard	USN-5	As a user, the information about the bins can be viewed through the dashboard	I can access the information provided in the dashboard.	High	Sprint-2
Customer (Web user)		WUSN-1	As a web user I can see whether the bins in the locality are filled or not only after loging in using my userID and password.	The website must work properly so that no error occurs in the info.	High	Sprint-2
Customer Care Executive		CCE-1	A customer care executive will always be available for the interaction with the customer to clarify the queries.	An executive will clarify the doubts and note down the complaints of the application if any .	High	Sprint-1
Administrator		ADMIN-1	I as a Admin can access the data or information provided by the customers to analyse their needs and provide the required service.	The details of the locality of the user is provided to the municipal corporation when a complaint is received.	High	Sprint-2



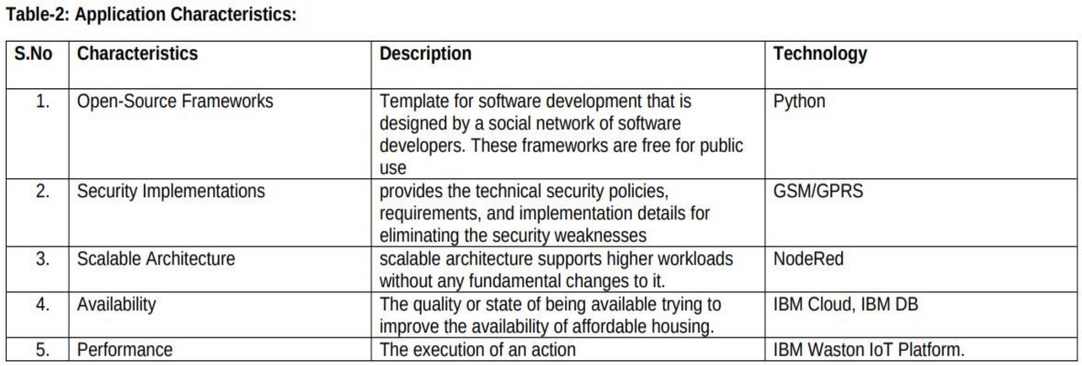
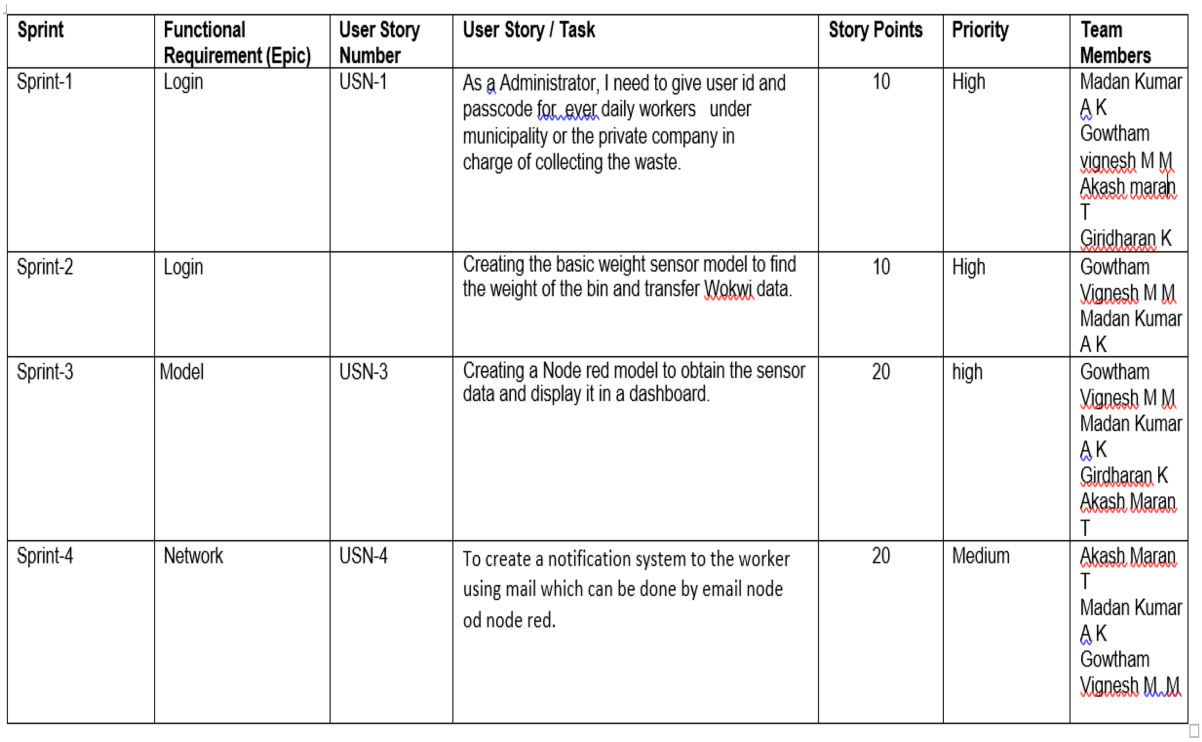


Table-2: Application Characteristics:

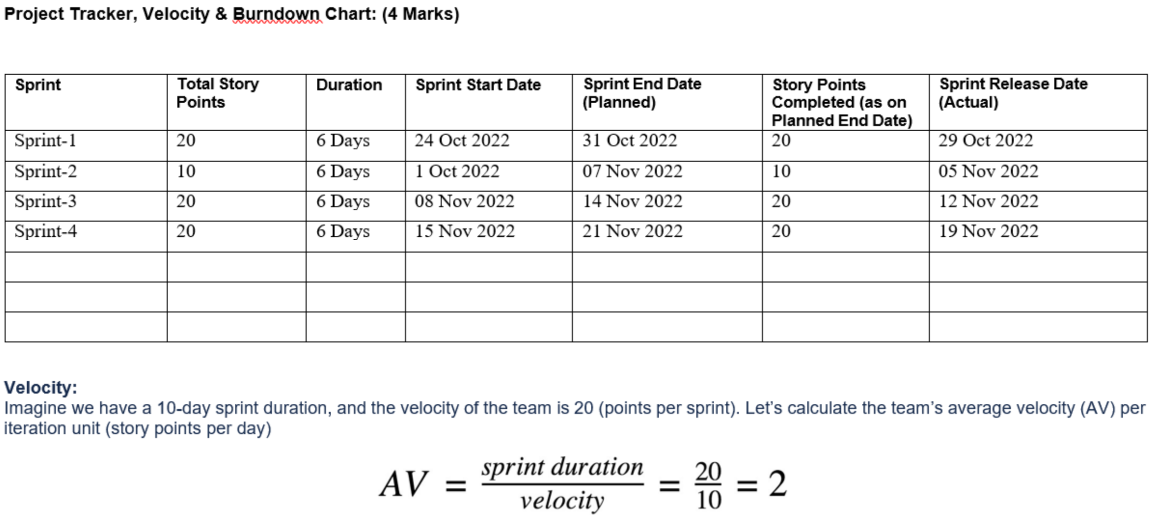
S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Template for software development that is designed by a social network of software developers. These frameworks are free for public use	Python
2.	Security Implementations	provides the technical security policies, requirements, and implementation details for eliminating the security weaknesses	GSM/GPRS
3.	Scalable Architecture	scalable architecture supports higher workloads without any fundamental changes to it.	NodeRed
4.	Availability	The quality or state of being available trying to improve the availability of affordable housing.	IBM Cloud, IBM DB
5.	Performance	The execution of an action	IBM Waston IoT Platform.

6. PROJECT PLANNING AND 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 a Administrator, I need to give user id and passcode for ever daily workers under municipality or the private company in charge of collecting the waste.	10	High	Madan Kumar A K Gowtham vignesh M M Akash maran T Giridharan K
Sprint-2	Login		Creating the basic weight sensor model to find the weight of the bin and transfer Wokwi data.	10	High	Gowtham Vignesh M M Madan Kumar A K
Sprint-3	Model	USN-3	Creating a Node red model to obtain the sensor data and display it in a dashboard.	20	high	Gowtham Vignesh M M Madan Kumar A K Girdharan K Akash Maran T
Sprint-4	Network	USN-4	To create a notification system to the worker using mail which can be done by email node od node red.	20	Medium	Akash Maran T Madan Kumar A K Gowtham Vignesh M. M



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	31 Oct 2022	20	29 Oct 2022
Sprint-2	10	6 Days	1 Oct 2022	07 Nov 2022	10	05 Nov 2022
Sprint-3	20	6 Days	08 Nov 2022	14 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	15 Nov 2022	21 Nov 2022	20	19 Nov 2022

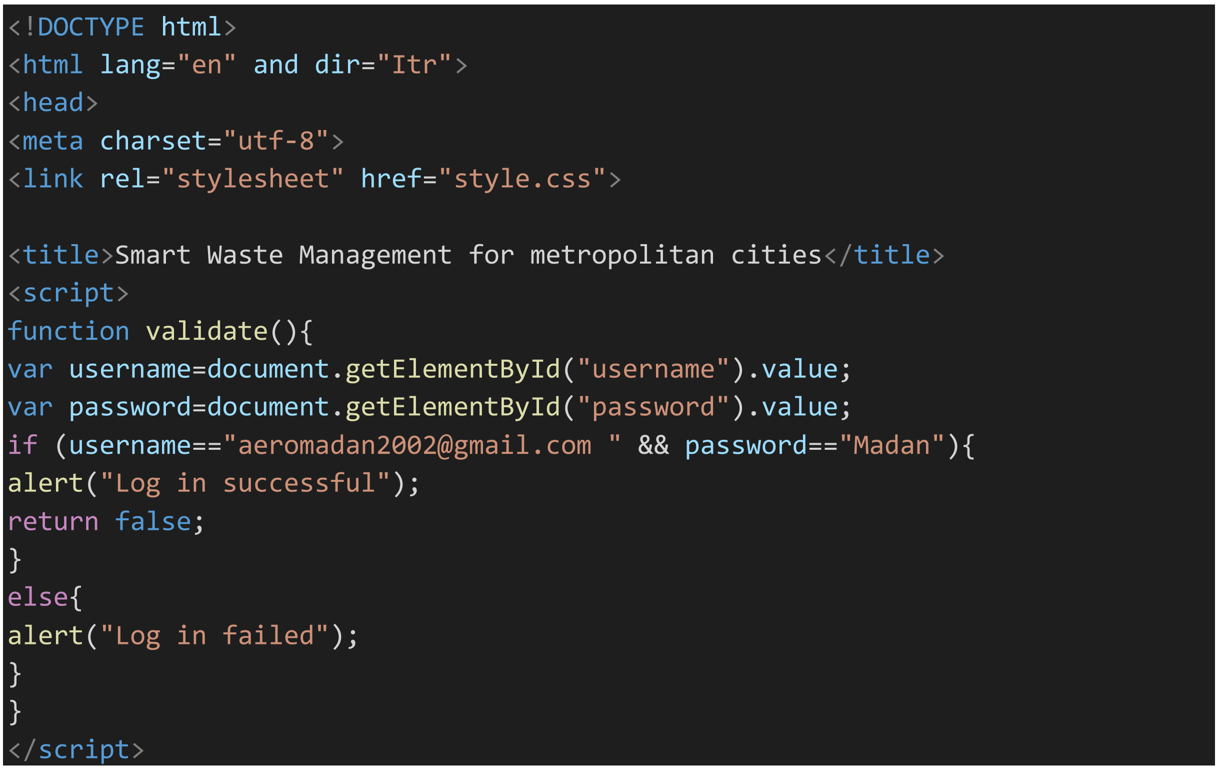
Velocity:
Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

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

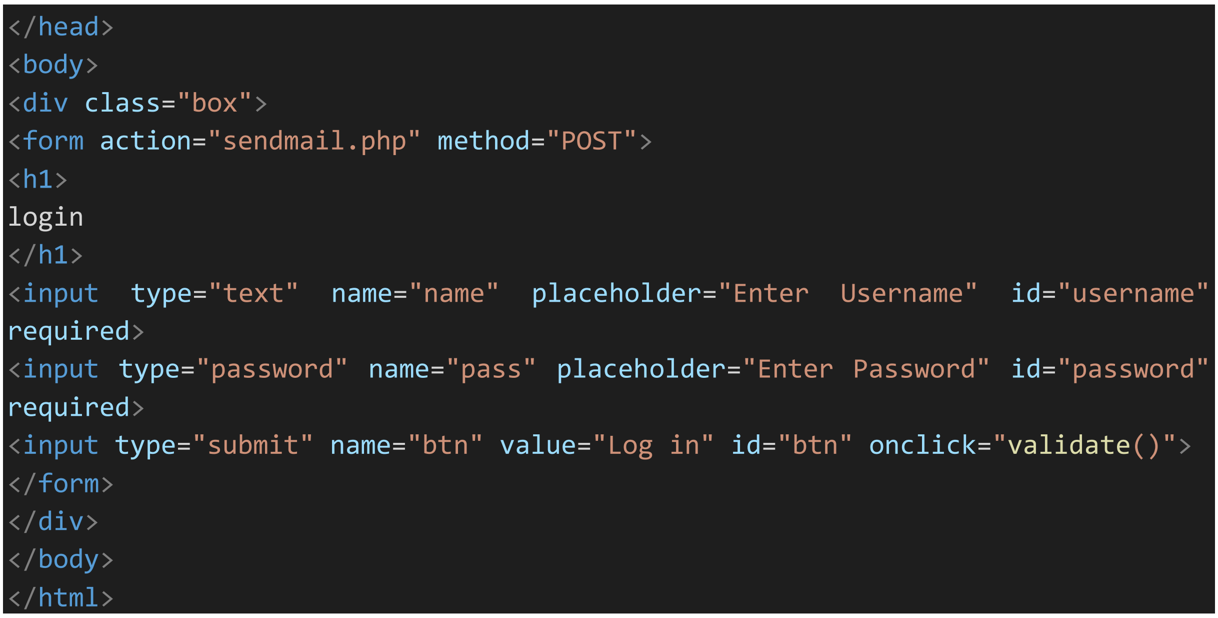
7. CODING & SOLUTIONING

7.1FEATURE 1

HTML Code for login page:

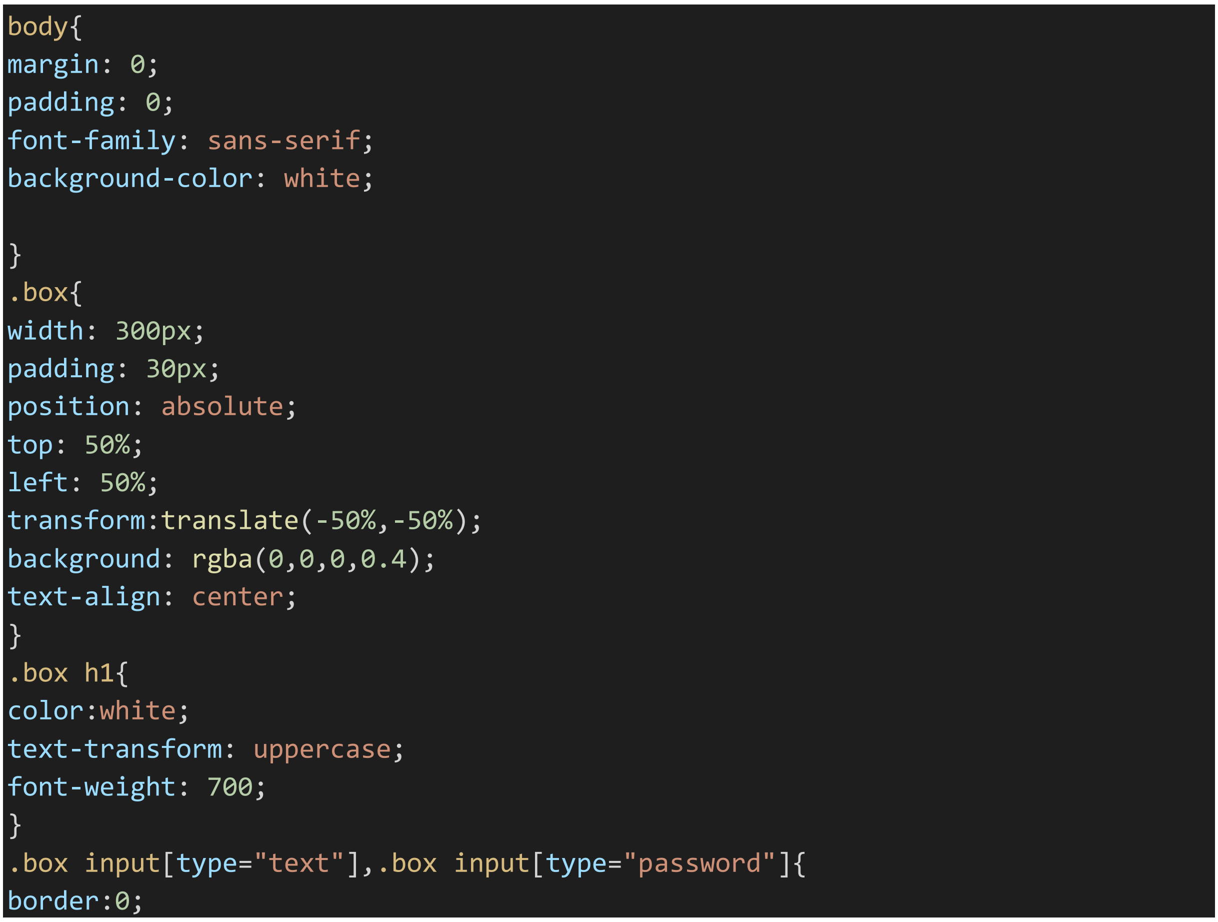


```
<!DOCTYPE html>
<html lang="en" and dir="Itr">
<head>
<meta charset="utf-8">
<link rel="stylesheet" href="style.css">

<title>Smart Waste Management for metropolitan cities</title>
<script>
function validate(){
var username=document.getElementById("username").value;
var password=document.getElementById("password").value;
if (username=="aeromadan2002@gmail.com " && password=="Madan"){
alert("Log in successful");
return false;
}
else{
alert("Log in failed");
}
}
</script>
```

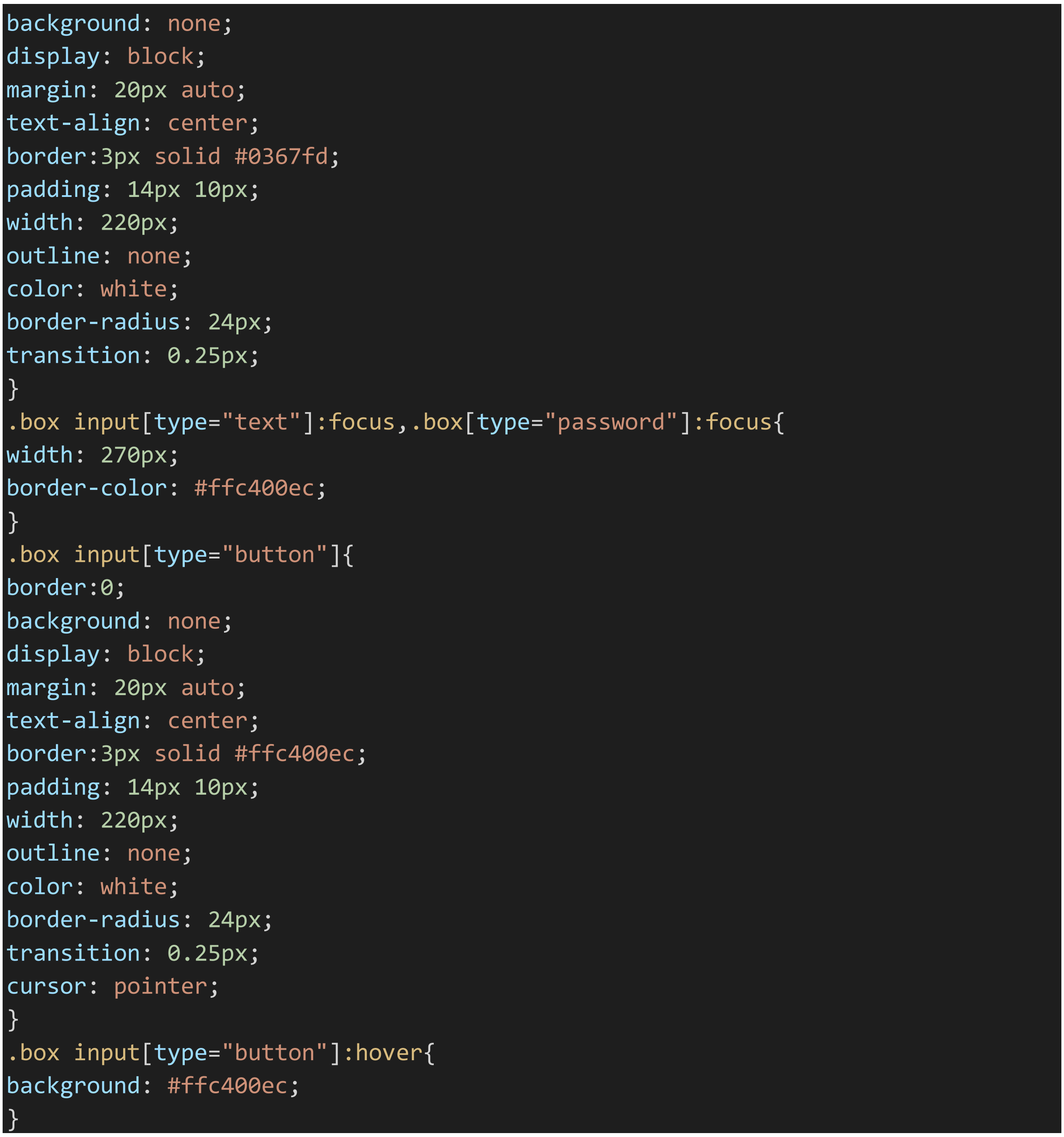


```html
</head>
<body>
<div class="box">
<form action="sendmail.php" method="POST">
<h1>
login
</h1>
<input  type="text"  name="name"  placeholder="Enter  Username"  id="username"
required>
<input type="password" name="pass" placeholder="Enter Password" id="password"
required>
<input type="submit" name="btn" value="Log in" id="btn" onclick="validate()">
</form>
</div>
</body>
</html>
```

CSS for the above HTML code:



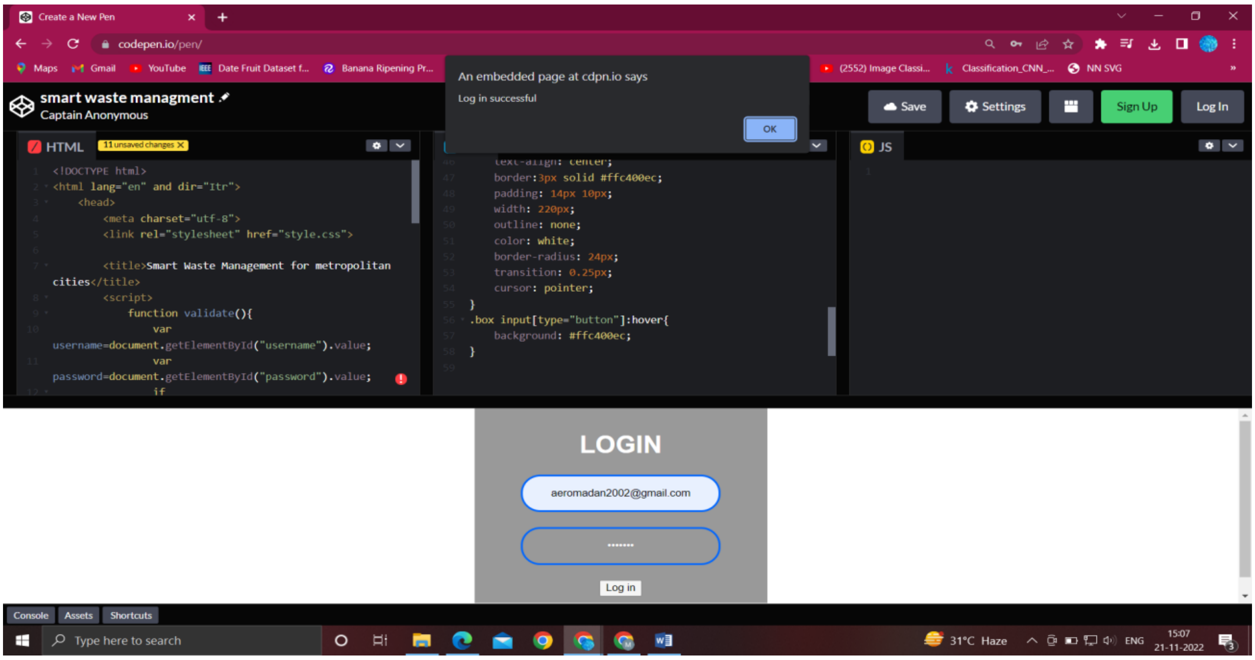
```css
body{
margin: 0;
padding: 0;
font-family: sans-serif;
background-color: white;

}
.box{
width: 300px;
padding: 30px;
position: absolute;
top: 50%;
left: 50%;
transform:translate(-50%,-50%);
background: rgba(0,0,0,0.4);
text-align: center;
}
.box h1{
color:white;
text-transform: uppercase;
font-weight: 700;
}
.box input[type="text"],.box input[type="password"]{
border:0;
```



```css
background: none;
display: block;
margin: 20px auto;
text-align: center;
border:3px solid #0367fd;
padding: 14px 10px;
width: 220px;
outline: none;
color: white;
border-radius: 24px;
transition: 0.25px;
}
.box input[type="text"]:focus,.box[type="password"]:focus{
width: 270px;
border-color: #ffc400ec;
}
.box input[type="button"]{
border:0;
background: none;
display: block;
margin: 20px auto;
text-align: center;
border:3px solid #ffc400ec;
padding: 14px 10px;
width: 220px;
outline: none;
color: white;
border-radius: 24px;
transition: 0.25px;
cursor: pointer;
}
.box input[type="button"]:hover{
background: #ffc400ec;
}
```

Output

Execution in Code pen:



smart waste managment
Captain Anonymous

An embedded page at cdpn.io says
Log in successful

```
<!DOCTYPE html>
<html lang="en" and dir="Itr">
    <head>
        <meta charset="utf-8">
        <link rel="stylesheet" href="style.css">

        <title>Smart Waste Management for metropolitan cities</title>
        <script>
            function validate(){
                var username=document.getElementById("username").value;
                var password=document.getElementById("password").value;
                if
```

```
    text-align: center;
    border:3px solid #ffc400ec;
    padding: 14px 10px;
    width: 220px;
    outline: none;
    color: white;
    border-radius: 24px;
    transition: 0.25px;
    cursor: pointer;
}
.box input[type="button"]:hover{
    background: #ffc400ec;
}
```

LOGIN

aeromadan2002@gmail.com

Explanation:

HTML code is written along with Java script to ensure validation of the login credentials entered by the user. CSS is used to beautify the HTML page.

The HTML and CSS codes are used in Node Red with HTTP in, HTTP response, Function and Template components and the login page is successfully implemented using Node Red.

7.2 FEATURE 2

Code for data transfer for Wokwi:

```
#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 "46kqz9"                              // IBM organisation id
#define DEVICE_TYPE "raspberrypi"                     // Device type mentioned
```

```
in ibm watson iot platform
#define DEVICE_ID "123"              // Device ID mentioned in ibm watson iot platform
#define TOKEN "12345678"          // 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);

```

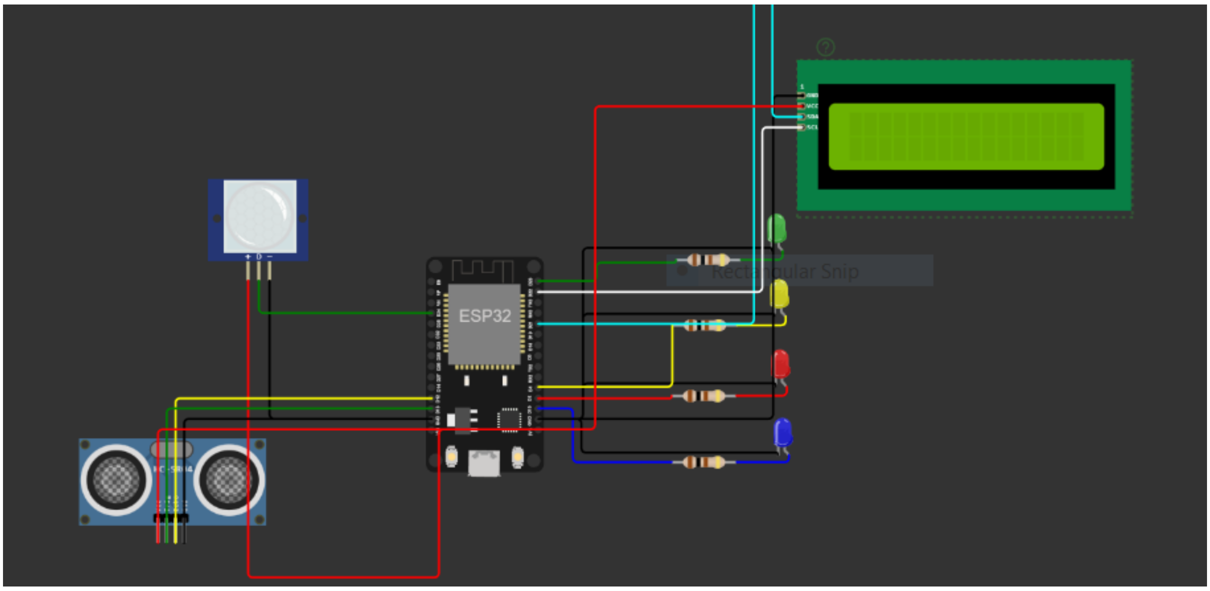
```

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 = "{\"Level\":";
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 = "{\"Level\":";
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 = "{\"Level\":";
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="";
}
```

Circuit Diagram:



Link for execution of code:

https://wokwi.com/projects/349226501832442451

8. TEST CASES

8.1 TEST CASES USING NODE-RED

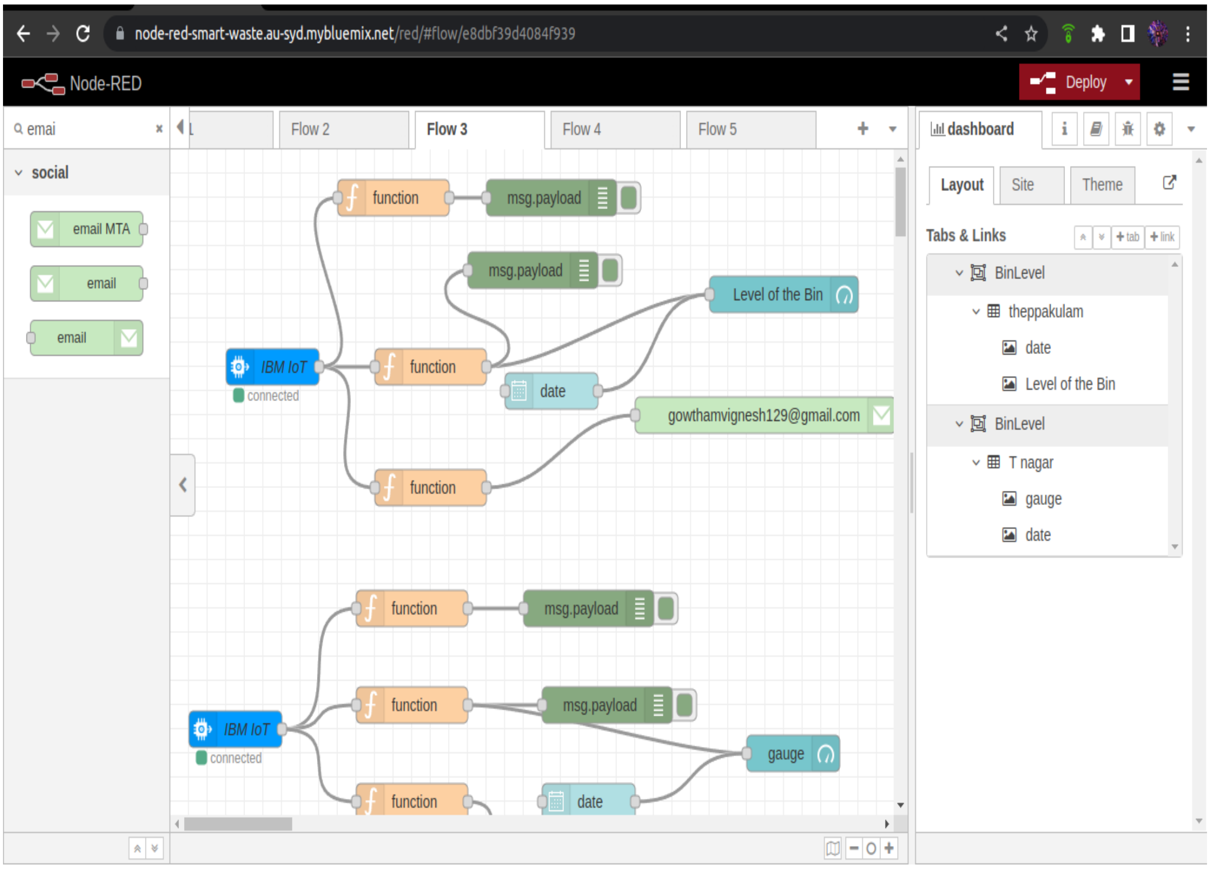
Node red :

IBM iot device is connected which returns values of the bin level based on sensor data .By using function node these data is modified based on need .

Operations performed:

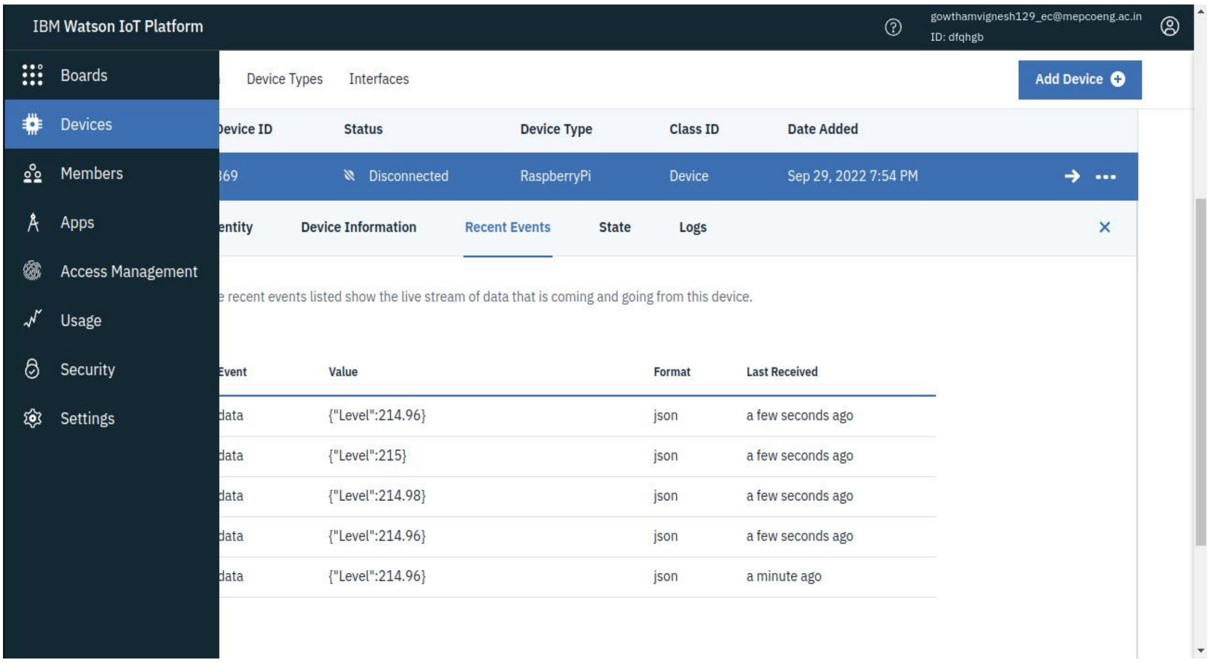
-Mail sending when the bin is almost full .

-Date is attached and the bin level is indicated to the user using dashboard.



Cloud data received are given as follow:

IOT device 1 : Cloud events

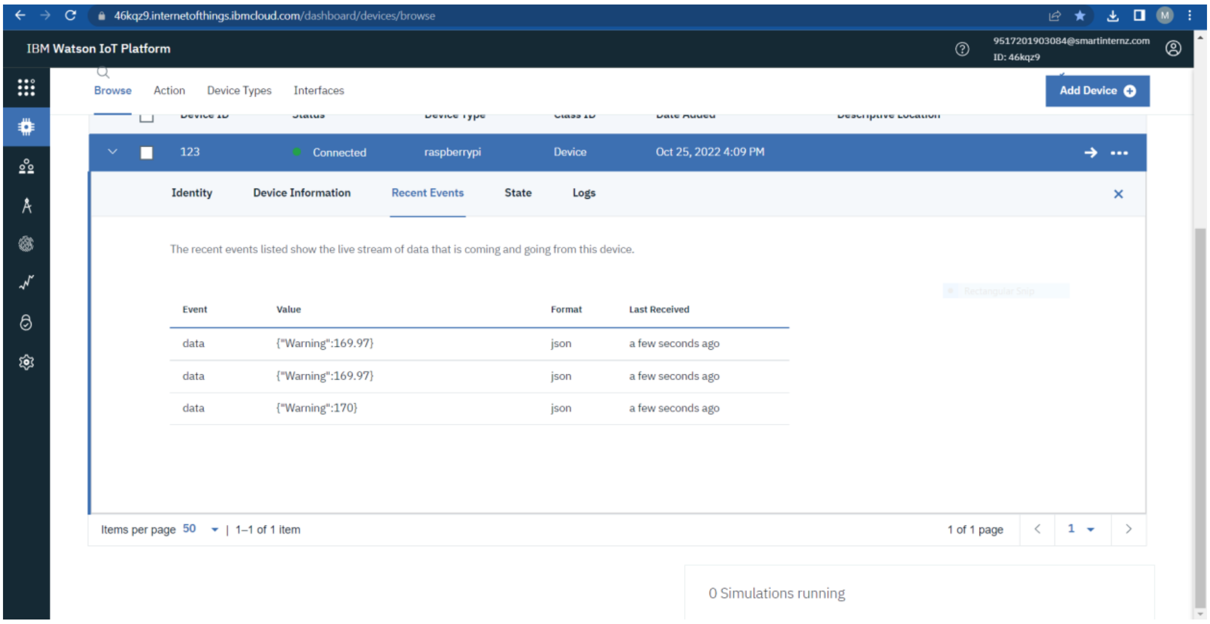


evice ID	Status	Device Type	Class ID	Date Added
69	Disconnected	RaspberryPi	Device	Sep 29, 2022 7:54 PM

e recent events listed show the live stream of data that is coming and going from this device.

Event	Value	Format	Last Received
data	{"Level":214.96}	json	a few seconds ago
data	{"Level":215}	json	a few seconds ago
data	{"Level":214.98}	json	a few seconds ago
data	{"Level":214.96}	json	a few seconds ago
data	{"Level":214.96}	json	a minute ago

IOT device 2: Cloud events



Device ID	Status	Device Type	Class ID	Date Added
123	Connected	raspberrypi	Device	Oct 25, 2022 4:09 PM

The recent events listed show the live stream of data that is coming and going from this device.

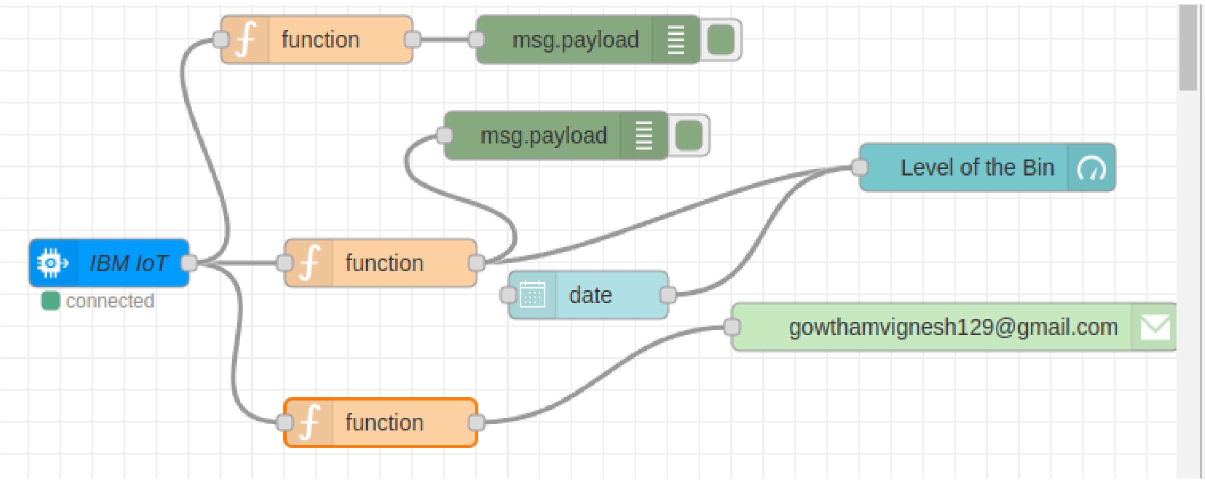
Event	Value	Format	Last Received
data	{"Warning":169.97}	json	a few seconds ago
data	{"Warning":169.97}	json	a few seconds ago
data	{"Warning":170}	json	a few seconds ago

Items per page 50 | 1–1 of 1 item

1 of 1 page

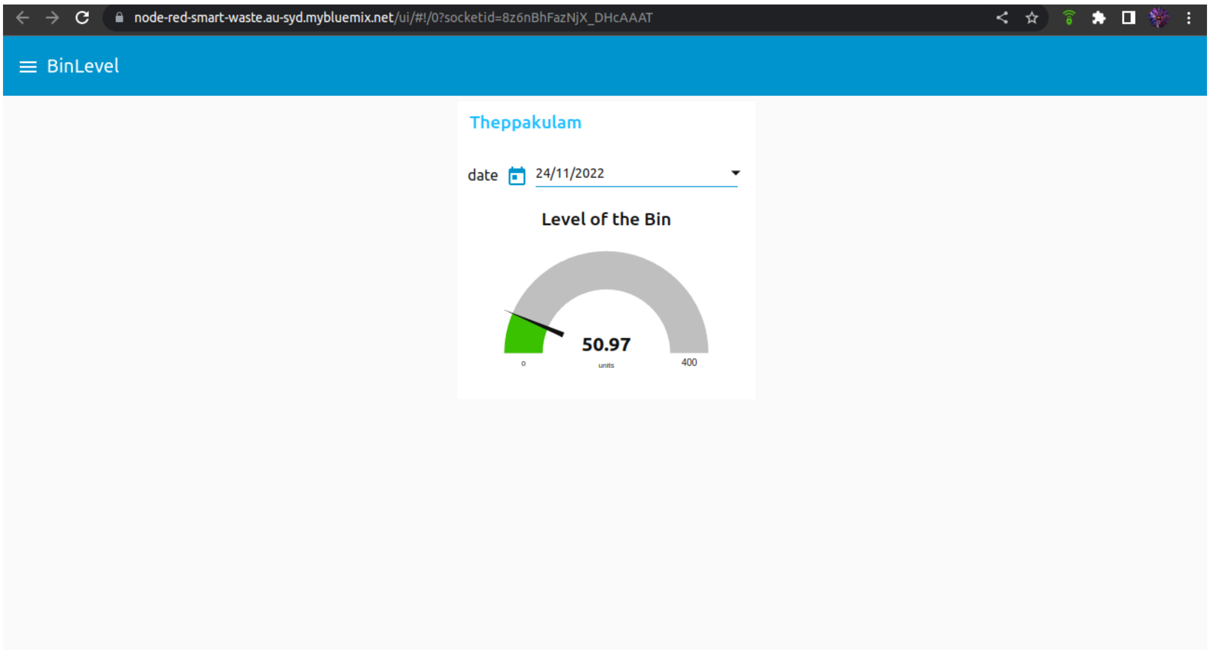
0 Simulations running

NODE CONNECTION FOR DEVICE 1:



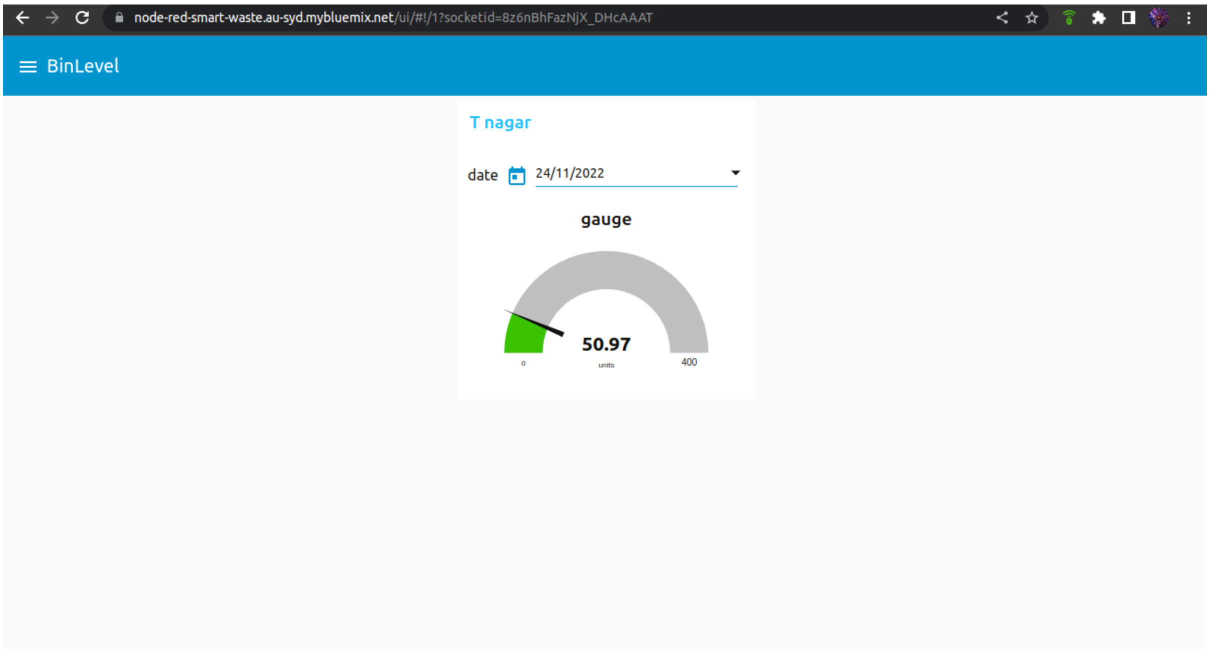
Similarly, other devices can be connected through the same interface.

Dashboard for Theppakulam area :


node-red-smart-waste.au-syd.mybluemix.net/ui/#!/0?socketid=8z6nBhFazNjX_DHcAAAT

date 24/11/2022

Dashboard for Tnagar area :


node-red-smart-waste.au-syd.mybluemix.net/ui/#!/1?socketid=8z6nBhFazNjX_DHcAAAT

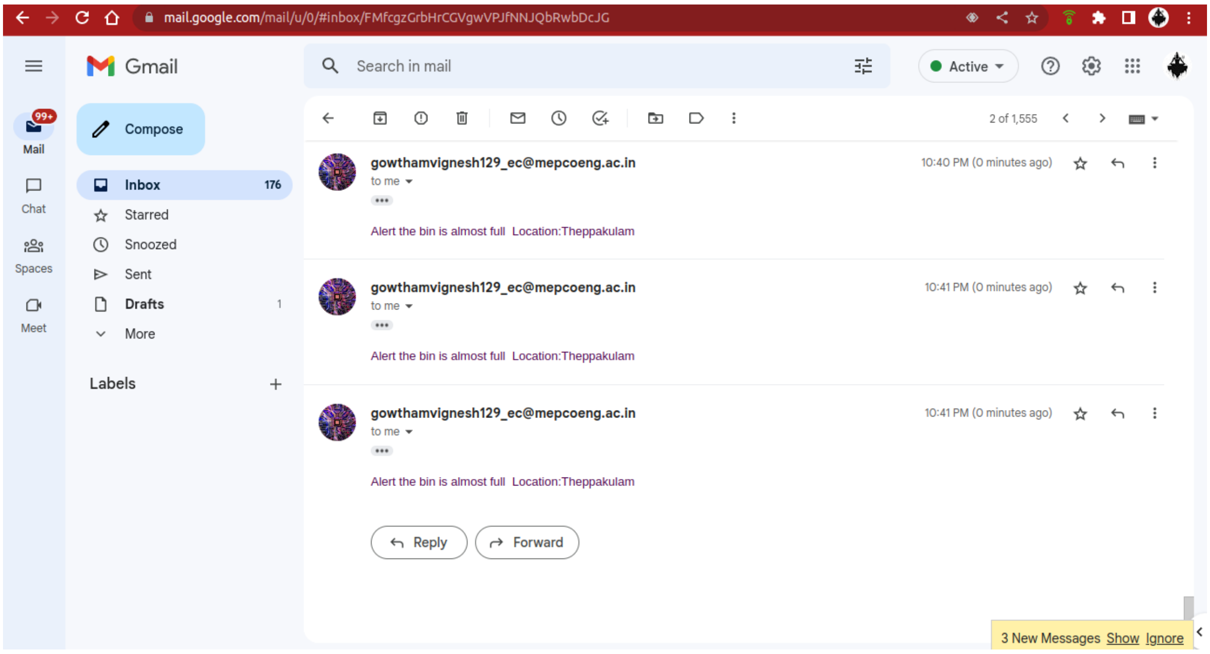
BinLevel

T nagar

date 24/11/2022

Mail sent to the worker:

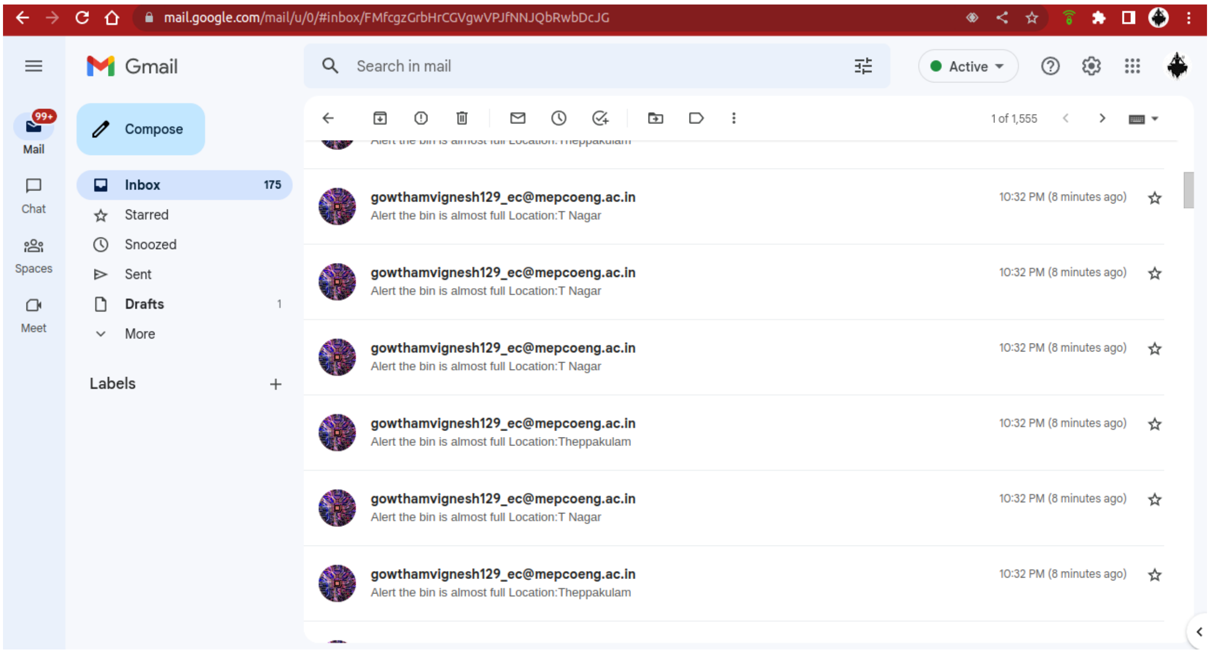
Mail would be sent to the worker who are in charge of the bin and reinstall would be notified along with the location of the bin .


mail.google.com/mail/u/0/#inbox/FMfcgzGrbHrCGVgwVPJfNNJQbRwbDcJG

gowthamvignesh129_ec@mepcoeng.ac.in
to me
10:40 PM (0 minutes ago)
Alert the bin is almost full Location:Theppakulam

gowthamvignesh129_ec@mepcoeng.ac.in
to me
10:41 PM (0 minutes ago)
Alert the bin is almost full Location:Theppakulam

gowthamvignesh129_ec@mepcoeng.ac.in
to me
10:41 PM (0 minutes ago)
Alert the bin is almost full Location:Theppakulam



Alert the bin is almost full Location:Theppakulam

gowthamvignesh129_ec@mepcoeng.ac.in Alert the bin is almost full Location:T Nagar 10:32 PM (8 minutes ago)

gowthamvignesh129_ec@mepcoeng.ac.in Alert the bin is almost full Location:T Nagar 10:32 PM (8 minutes ago)

gowthamvignesh129_ec@mepcoeng.ac.in Alert the bin is almost full Location:T Nagar 10:32 PM (8 minutes ago)

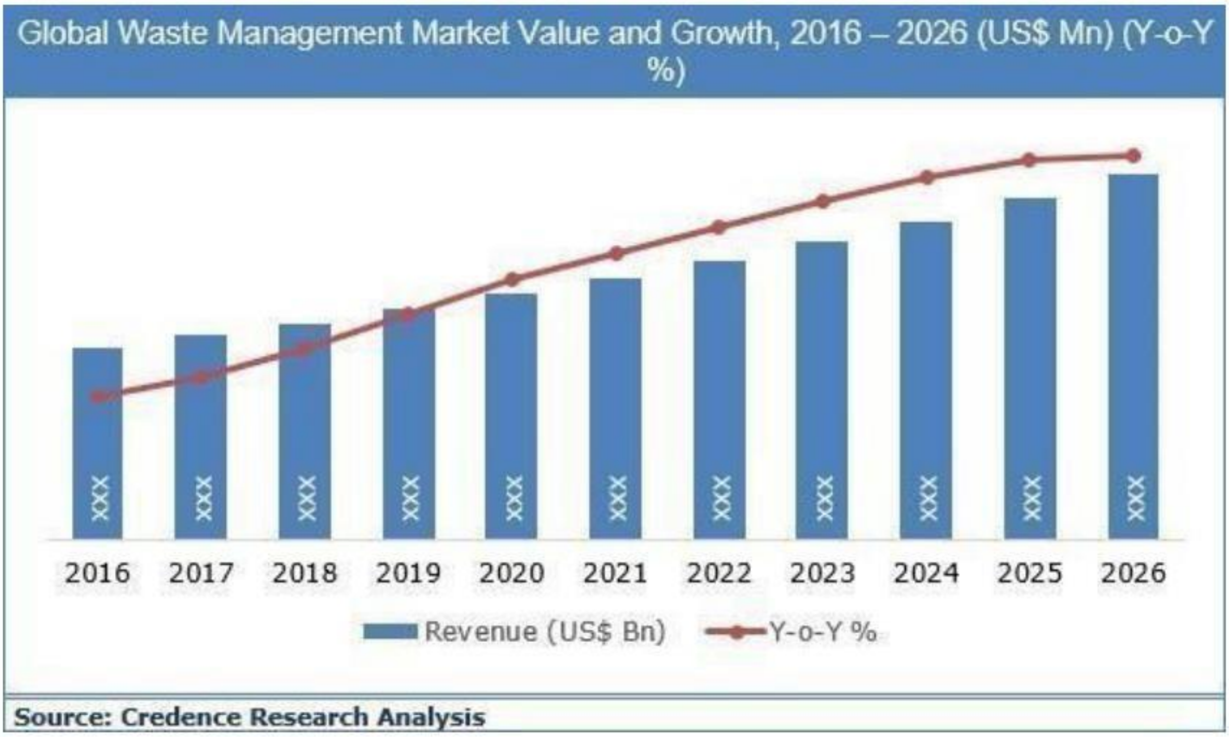
gowthamvignesh129_ec@mepcoeng.ac.in Alert the bin is almost full Location:Theppakulam 10:32 PM (8 minutes ago)

gowthamvignesh129_ec@mepcoeng.ac.in Alert the bin is almost full Location:T Nagar 10:32 PM (8 minutes ago)

gowthamvignesh129_ec@mepcoeng.ac.in Alert the bin is almost full Location:Theppakulam 10:32 PM (8 minutes ago)

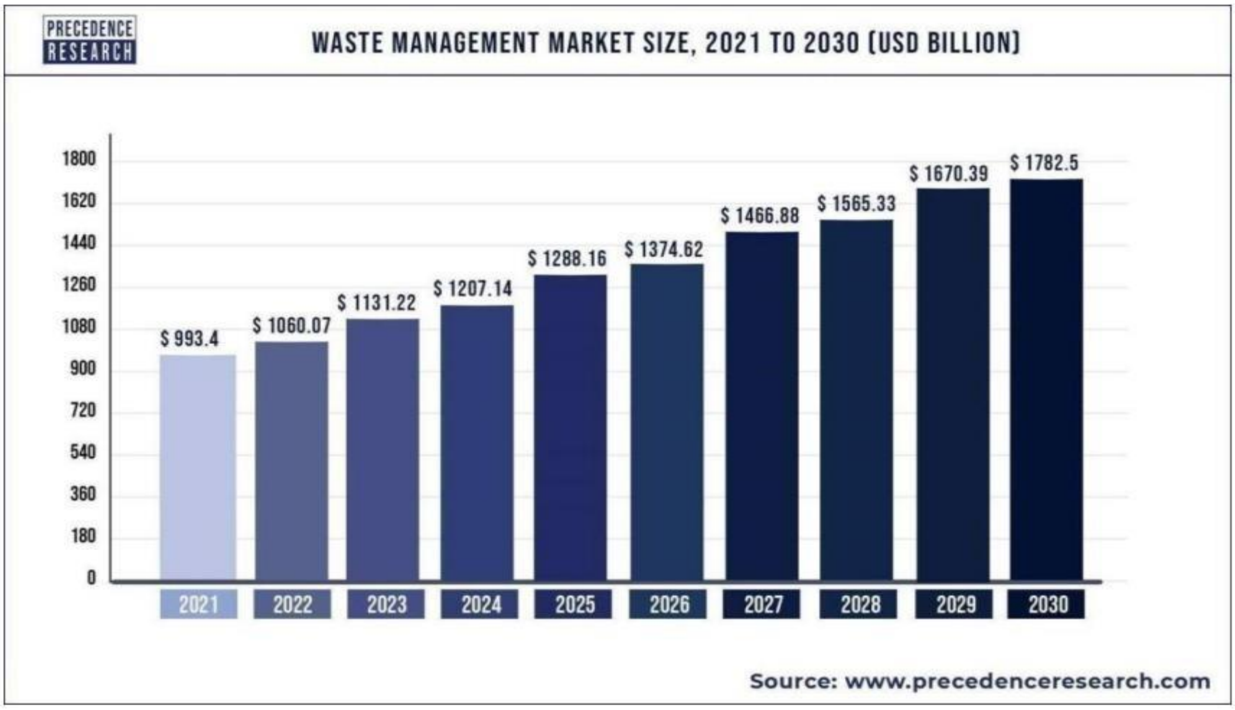
9. RESULTS

9.1. PERFORMANCE METRICS



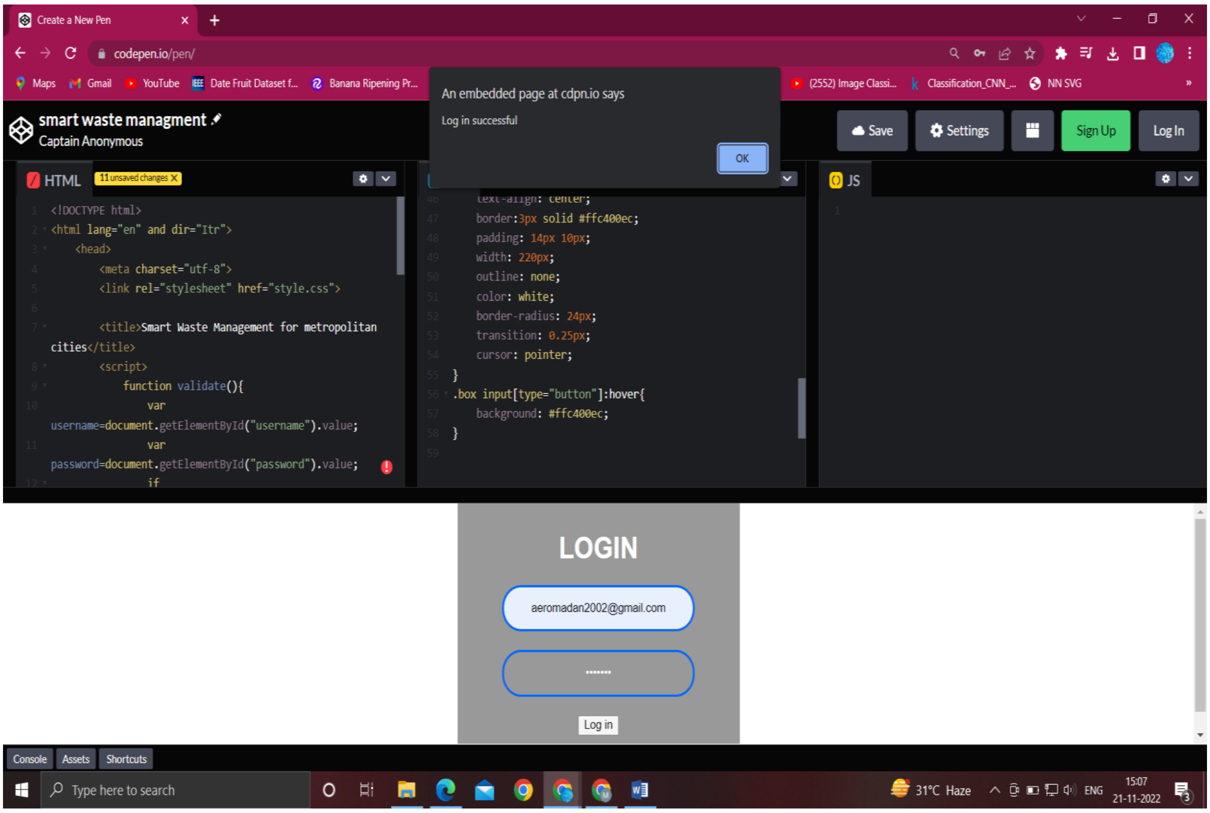
Global Waste Management Market Value and Growth, 2016 – 2026 (US$ Mn) (Y-o-Y %)

Source: Credence Research Analysis



Source: www.precedenceresearch.com

9.2WEB UI DESIGN:



An embedded page at cdpn.io says

Log in successful

OK

```
<!DOCTYPE html>
<html lang="en" and dir="Itr">
    <head>
        <meta charset="utf-8">
        <link rel="stylesheet" href="style.css">

        <title>Smart Waste Management for metropolitan
cities</title>
        <script>
            function validate(){
                var
username=document.getElementById("username").value;
                var
password=document.getElementById("password").value;
                if
```

```
    text-align: center;
    border:3px solid #ffc400ec;
    padding: 14px 10px;
    width: 220px;
    outline: none;
    color: white;
    border-radius: 24px;
    transition: 0.25px;
    cursor: pointer;
}
.box input[type="button"]:hover{
    background: #ffc400ec;
}
```

LOGIN

aeromadan2002@gmail.com

•••••••

Log in

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 perpopulation 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 :

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

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 inprotecting 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

Esp32 - Microcontroller :

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi anddual-mode Bluetooth.

- Memory: 320 KiB
- SRAM CPU: Tensilica Xtensa LX6 microprocessor @ 160 or 240 MHz
- Power: 3.3 V DC
- Manufacturer: Espressif Systems
- Predecessor: ESP8266

□ Sensors :

- PIR motion sensor: PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range.
- Ultrasonic Distance Sensor : Ultrasonic Sensors measure the distance to thetarget by measuring the time between the emission and reception.

GitHub Link :

https://github.com/IBM-EPBL/IBM-Project-5667-1658812881

Project Demo Video Link:

https://youtu.be/YALZWlc2ikw