Vel Tech Multi Tech Dr. Rangarajan Dr. Sakunthala Engineering College

SMART WASTE MANGEMENT SYSTEM FOR METEROPOLITAN CITIES

TEAM ID:PNT2022TMID22430

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5. Kotteshwari D -113119UG04051

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1. INTRODUCTION

1.1 Project Overview

The amount of waste produced everyday by the industries and the households is increasing at an appalling rate, and the major reason for this is soaring use of packaged items, textiles, paper, food, plastics, metals, glass etc, thus management of this refuse becomes a crucial part in our everyday life.in most of the developed countries there are many efficient techniques which are used for the proper management of this waste, but in some countries especially the developing ones the careless attitude of people towards maintaining clean surroundings, along with this many issues such as no stringent laws for using the biodegradable materials, no proper environ policies ,no laws for sustainable development are the seed for the fatal results of waste management. Due to the increasing waste, the public bins which are used for collecting this waste are overflowing, the locality is jumbled of trash, causing not only malodorous streets but also a negative impact on the health and environment. We segregate the waste at our homes for ease at processing and recycling. We observed trash vans come irregular to homes creating a despoliation of households. Due to this many civilians empty their overloaded dustbins in open spaces. This in turn increases environmental pollution. The waste is a great hassle for our health and the environment it has many effects which are dreadful. Trash is breeding ground for bacteria, insects, flies these flies are the same that roam around the eatable and drop the off springs. Thus they increase the risk with food poisoning, typhoid, gastroentetritis, salmonella, the insects cause malaria dengue etc. Here a waste management system is introduced in which each dumpster is embedded in a monitoring system which will notify the corresponding personal if the dumpster is full. In this system, it is also possible to separate wet and dry waste into two separate containers. This system provides an effective solution to waste management problem.

1.2 Purpose

1. To ensure the protection of the environment through effective waste management.
2. Ensure separation at source in all metropolitan and local municipalities.
3. Preventing pollution and ecological degradation.
4. To protect the health and wellbeing of people by providing an affordable waste collection service.

2.LITERATURE SURVEY

	Advantages and disadvantages of different smart waste management systems		
	Name of the paper	Advantages	Disadvantages
1	Cloud-based Smart Waste Management for Smart Cities	Timely waste collection, Route optimization Recycling and disposal, Resource management, Food industry planning Taxation, Big Data analytics Health care waste- based energy production	System requires number of waste bins for separate waste collection
2	IOT Based Smart Garbage alert system using Arduino UNO	It is transportable low price RFID tag. The system provides options for the customers to lodge their complaints in case of discrepancies.	Complex design of dustbin compared to other methods
3	RFID-based Real-time Smart Waste Management System (2007)	Waste disposal charge can be calculated and, can Track missing/ stolen bins quickly and accurately without human intervention, automate customer invoices, Enhanced cost savings Improve security.	Metal objects or liquid containers difficult to tag and track with a RFID system, The RFID tag is also affected by objects surrounding it especially metallic objects.
4	Smart Recycle Bin (2014)	Usefulness – to increase the utilization of the particular bin for waste disposal. Assist the authority to effectively and efficiently improve the collection of recyclable waste. The recycling process rewarding points to the user who contribute to waste recycling Increase the awareness among citizens	System requires 3R card for waste disposal
5	Smart bin: Smart Waste Management System (2016)	Obtain litter bin utilization - utilization information shows how a bin has been utilized litter bin daily seasonality information- shows the time when a bin is usually full.	The sensor node was deployed with battery power. Low power consumption sensor node must

			be used because of its limited power. The sensor node had limited memory size.
6	INTERNET OF BINS : Trash Management in India (20117)	Less expensive Lock based System with acknowledgment alert system. Two threshold limits are being fixed. Reduces fuel usage. Provides clean locality	ZigBee are short range, low complexity, and low data speed.

2.2 REFERENCES

[1] Mohammad Aazam, Marc St-Hilaire, Chung-Horng Lung, Ioannis Lambadaris , (2016),"Cloud-based Smart Waste Management for Smart Cities", IEEE

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[8] Bharadwaj B, M Kumudha, Gowri Chandra N, Chaithra G, (2017) "Automation of Smart Waste Management Using IoT to Support "Swachh Bharat Abhiyan" – a practical Approach " IEEE

[9] Shubham Thakker, R.Narayanamoorthi, (2015), "Smart and Wireless Waste

Management An innovative way to manage waste and also produce energy" 2nd International Conference on Innovations in Information Embedded and Communication Systems ICIIECS'15 , IEEE

[10] Artemios G. Voyiatzis, John Gialelis, and Dimitrios Karadimas, (2014) "Dynamic Cargo Routing on-the- Go: The Case of Urban Solid Waste Collection" 2 nd IEEE WiMob 2014 international workshop on smart city and ubiquitous computing application , IEEE

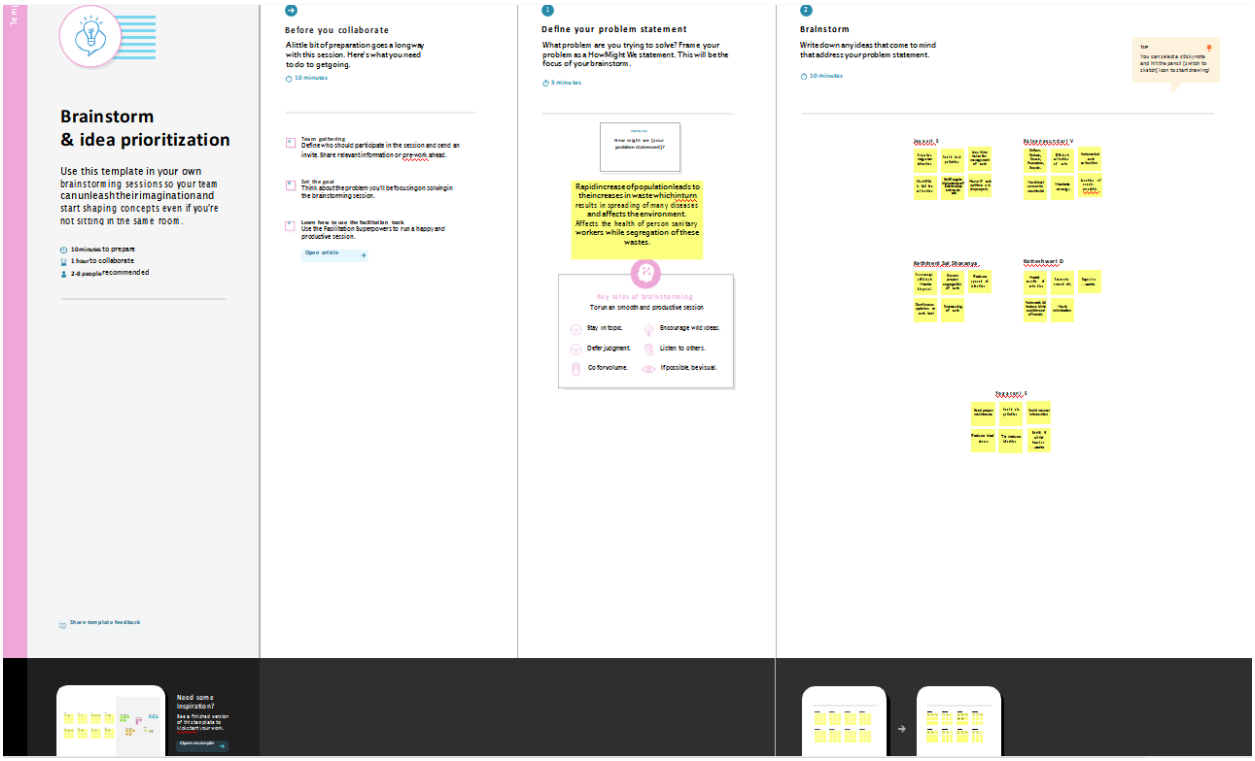
2.3 PROBLEM STATEMENTS

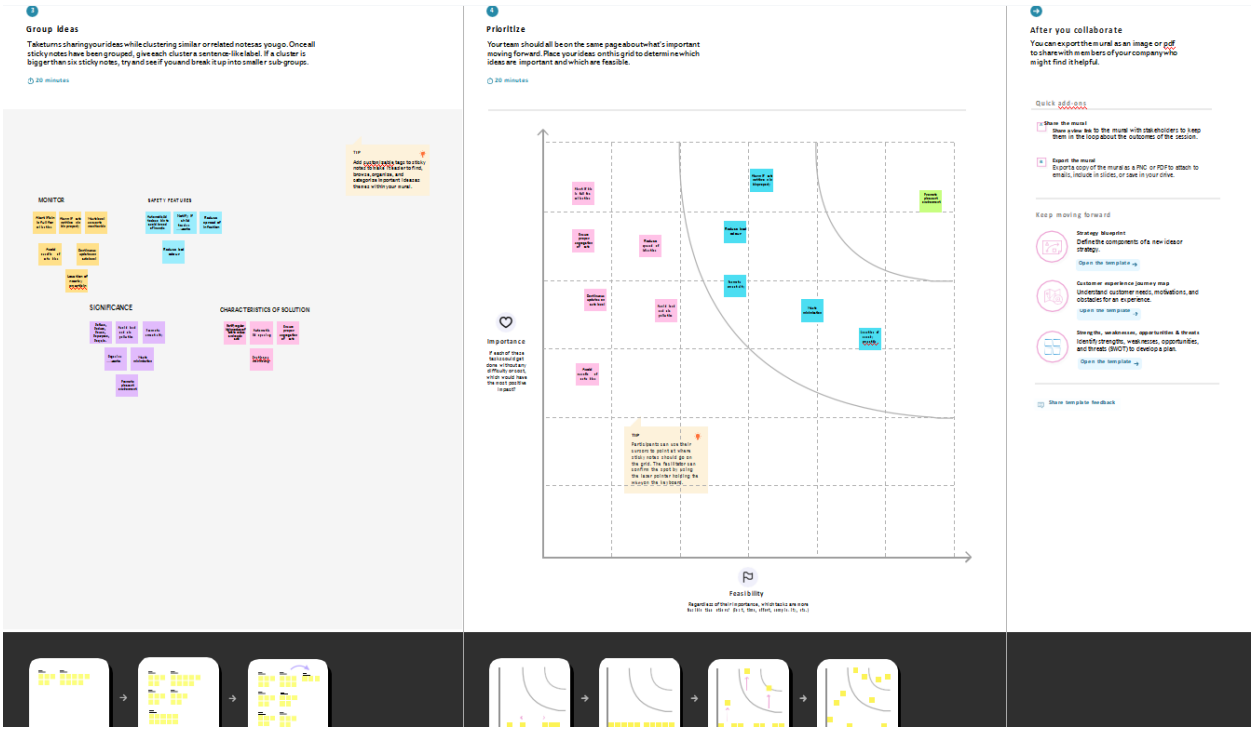
3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas:

Build empathy and keep your focus on the user by putting yourself in their shoes.

3.2 Ideation & Brainstorming

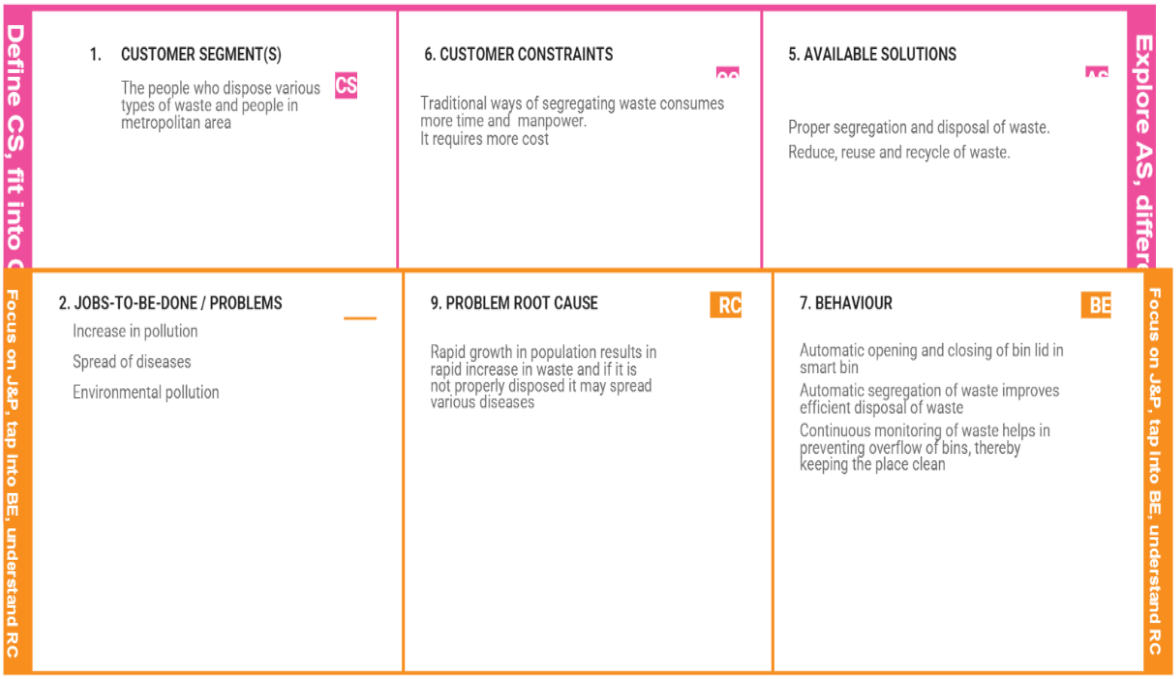




3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Rapid increase of population leads to the increases in waste. Increasing volume of wastes results in spreading of many diseases and affects the environment. The traditional method of waste segregation is time consuming and also affects the health of person who is involved in segregation.
2.	Idea / Solution description	IoT based Automatic Waste Segregator for efficient recycling and waste collection bins using Wi-Fi technology are used.
3.	Novelty / Uniqueness	Our undertaking utilizes Thing Speak IoT which permits us to total, picture and dissect live information streams in the cloud. A portion of the key capacities of Thing Speak incorporate the capacity to: Easily design gadgets to send information to Thing Speak utilizing main stream IoT conventions Visualize your sensor information continuously.
4.	Social Impact / Customer Satisfaction	Waste collection and segregation becomes easier. Monitoring of bins helps in making city cleaner. It is easy to handle and cheaper.
5.	Business Model (Revenue Model)	Smart dustbin can be used at each house to get maximum benefit out of this model. The components used are easily available in the market for bulk production.
6.	Scalability of the Solution	It is scalable and efficient way of waste management wherein the increased amount of waste, if generated, can be monitored and disposed properly using this project model.

3.4 Problem solution fit



4. REQUIREMENT ANALYSIS

4.1 Functional requirement

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	GPS and Cloud	GPS location of the registered bin to be received. The data collected is to be stored in cloud. So cloud registration must be done.
FR-4	Bin details and its monitoring	The data about the bin is collected- The size, the capacity, the type of waste it holds, the time it takes approximately to get filled etc. Displays real-time data on fill-levels of bins monitored by smart sensors. With real-time data and predictions, you can eliminate the overflowing bins and stop collecting half-empty ones.
FR-5	Plan waste collection routes	Based on current bin fill-levels and predictions of reaching full capacity, you are ready to respond and schedule waste collection. Inefficient picks are thus avoided
FR-6	Bin distribution	Identify areas with either dense or sparse bin distribution. Based on the data collected on capacity or location, the bin can be adjusted, if necessary.

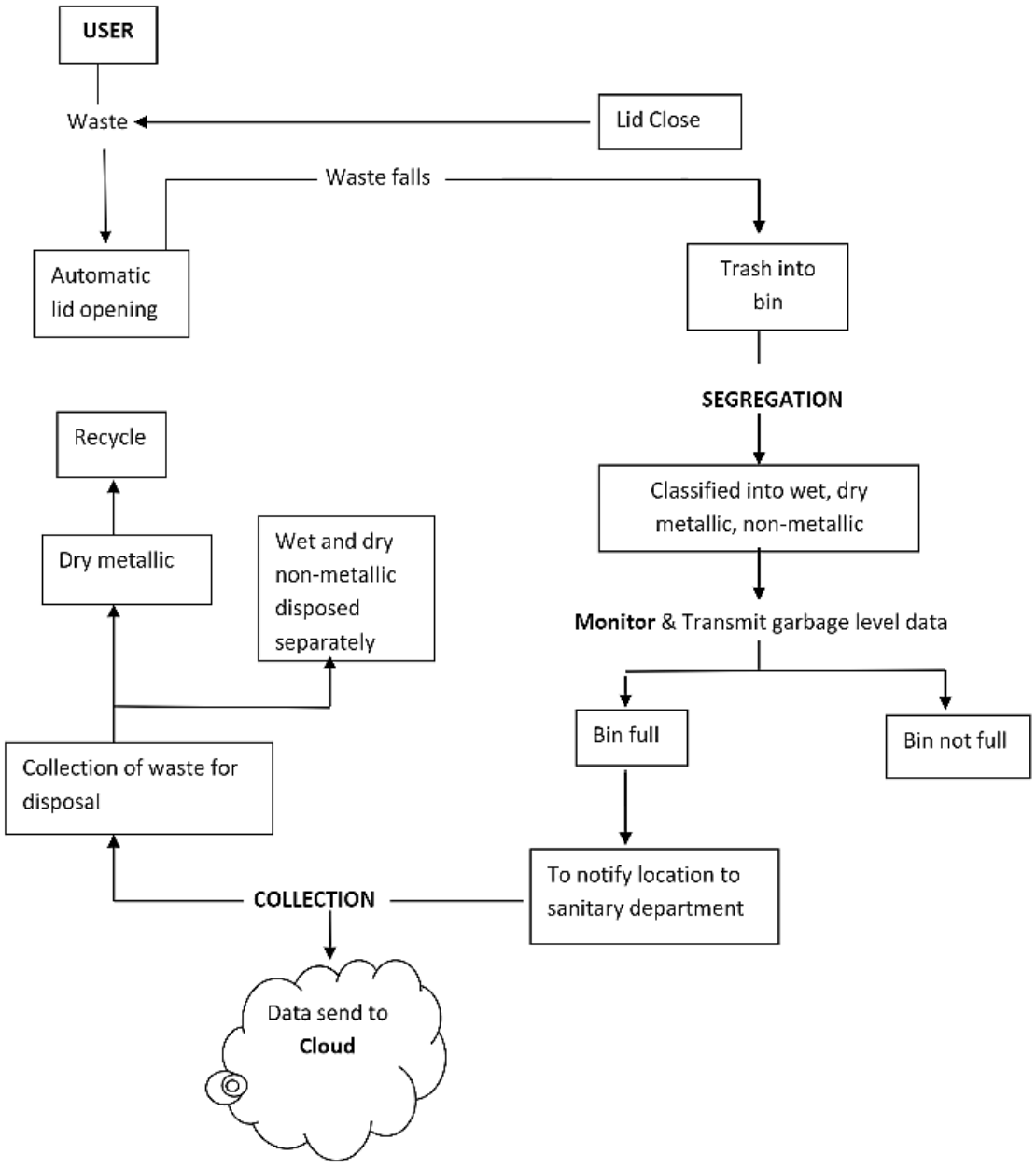
4.2 Non-functional Requirements

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

NFR-1	**Usability**	IoT device verifies and analyses user requirements, which can further improve the design quality. In the design process, with user experience as the core knowledge, 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 Purchase wisely and recycle Avoid single use 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 (ultrasonic sensor) to measure the fill levels in bins several times a day and saved in cloud which helps in performing many data driven operations in waste management app. Customers are hence provided with data-driven decision making, and optimization of waste collection routes, frequencies, and vehicle loads resulting in route reduction by at least 30%
NFR-5	**Availability**	By developing & deploying effective hardware and apt software we can empower cities to manage waste smarter
NFR-6	**Scalability**	Using smart waste bins, reduces the number of bins inside town or cities because we able to monitor the garbage 24/7 more cost effect and scalability when we move to smarter.

5. PROJECT DESIGN

5.1 Data Flow Diagrams



5.2 Solution & Technical Architecture

Solution Architecture:

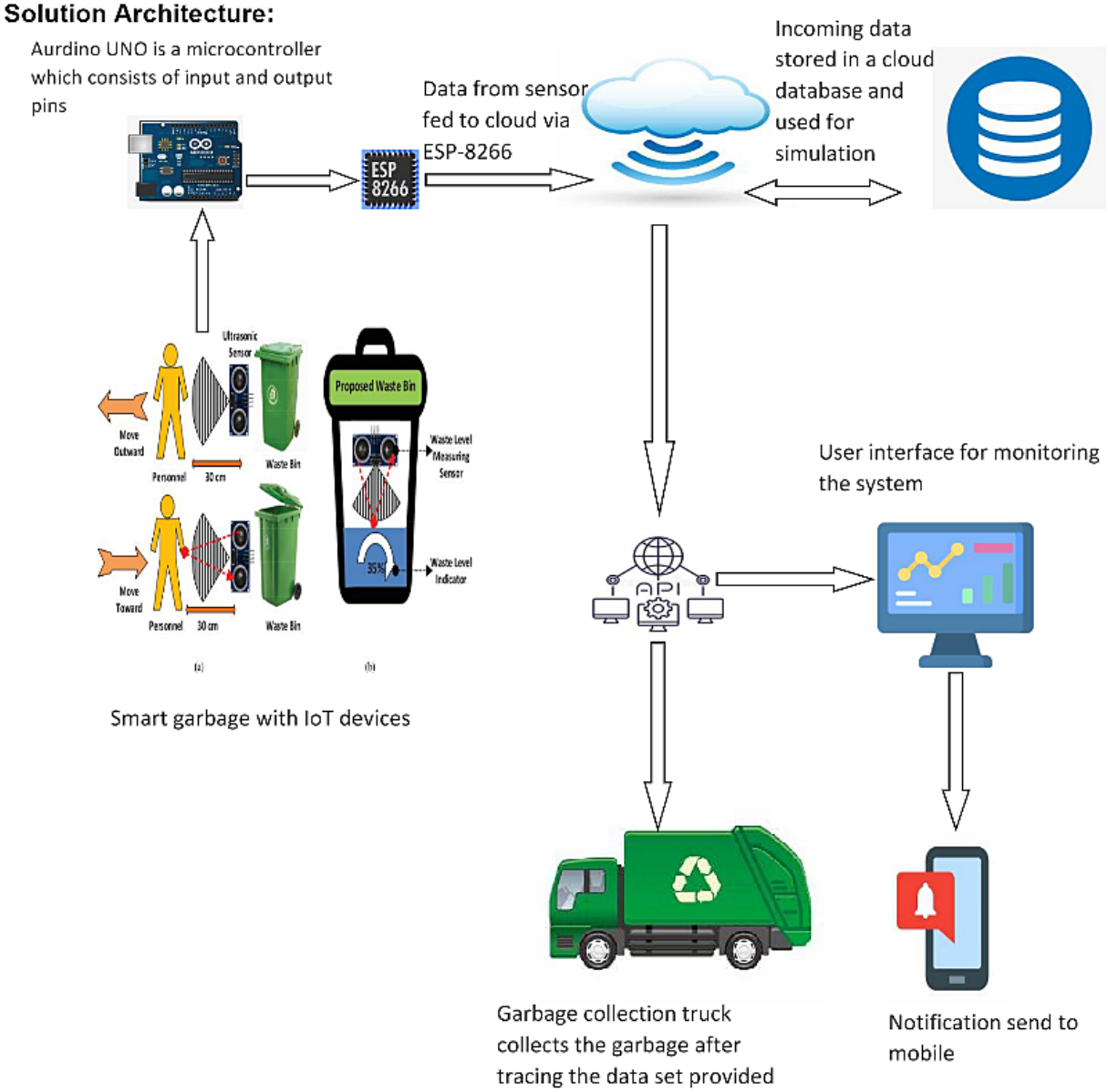


Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	The user interacts with application with Web UI	HTML, CSS, JavaScript / Angular Js / React Js etc.
2.	Application Logic-1	To trace the truck, to locate the bin and to show the trash level in the bin (i.e) the data from the	Java / Python

		ultrasonic sensor and alert through the mobile application	
3.	Database	Data Type, Configurations etc.	MySQL, NoSQL, etc.
4.	Cloud Database	Database Service on Cloud	IBM Cloudant etc.
5.	File Storage	File storage requirements	IBM Block Storage or Other Storage Service or Local Filesystem
6.	Ultransonic sensor	Monitors the trash level in bin	Distance recognition model
7.	External API-1	API is used to fetch the data of the trash bin	API
8.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: Local host Cloud Server Configuration : IBM cloud	Local, Cloud Foundry, Kubernetes, etc.

Table-2: Application Characteristics:

S. No	Characteristics	Description	Technology
1.	Open-Source Frameworks	NodeRed, Python, IBM simulator	Python
2.	Security Implementations	Request authentication using Encryptions and Firewall for network security to secure the data of the user.	Encryptions and decryptions
3.	Scalable Architecture	Scalability consists of 3 tier architecture	Database server: IBM cloud. IBM Kubernetes provide

			better accuracy. Web Server: HTML, CSS, Javascript Application server: Python
4.	Availability	Available for all cloud users and Municipality department of the city. They can access through mobile application	IBM cloud hosting, Android or IoS
5.	Performance	Performance can be increased by Analysing data and through machine learning	Machine learning

5.3 User Stories

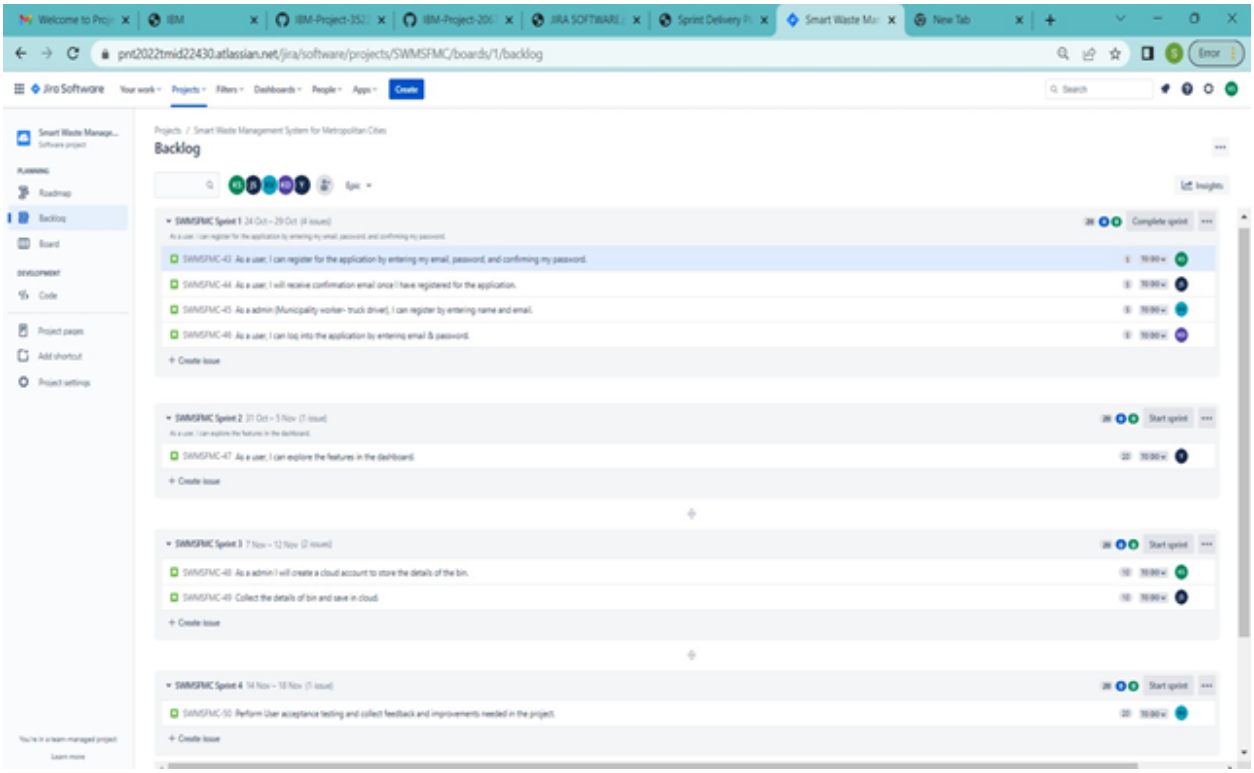
User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Admin (who manages web server)	Login	USN-1	As an admin, I gave user ID and password for every worker and manage them.	I can manage my account / dashboard	High	Sprint-1
Co admin	Login	USN-2	As a co admin, I will manage garbage level monitor. If garbage get filled I will send alert and will post location and garbage ID to trash truck.	I can manage monitoring	High	Sprint-1
Truck driver	Login	USN-3	As a Truck driver, I will follow the route sent by co admin to reach the filled garbage.	I can drive to reach the garbage filled route in shortest route given	Medium	Sprint-2
Local garbage collector	Login	USN-4	As a Waste collector, I will collect all the trash from garbage and load into	I can collect trash and load it to truck and	Medium	Sprint-2

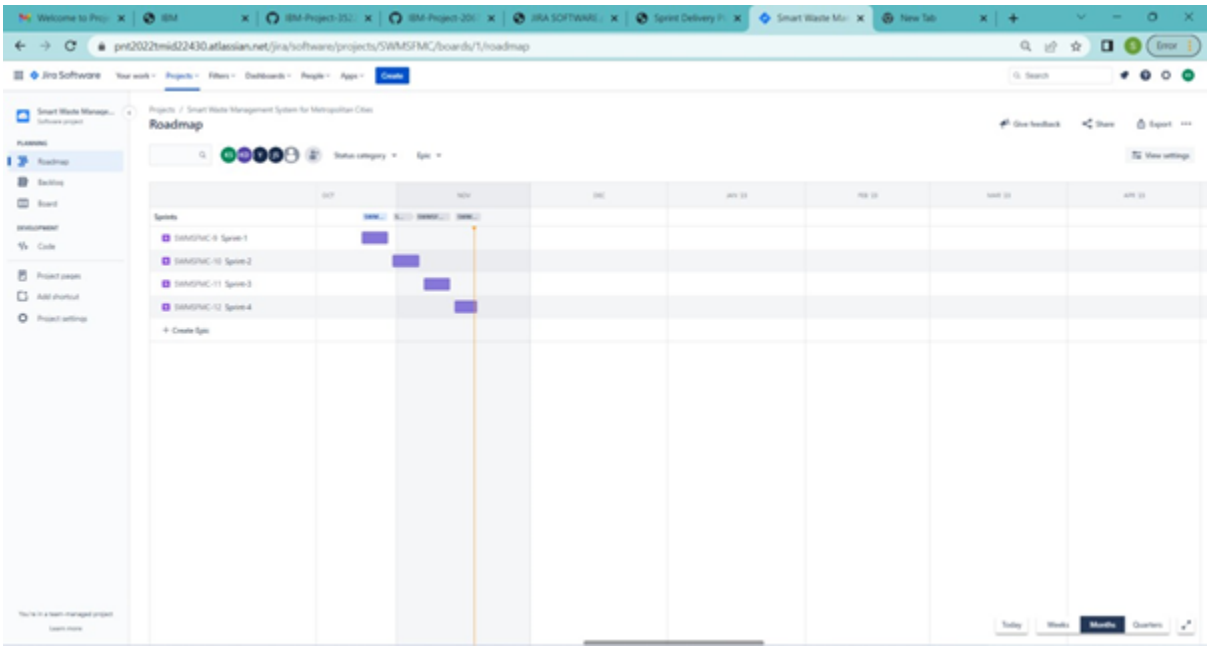
			garbage truck and send them to landfill.	send off		
Municipality	Login	USN-5	As a Municipality, I will check the process if they are happening in disciplined manner without any issues.	I can manage all these process if going good	High	Sprint-1

6. PROJECT PLANNING & SCHEDULING

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration (User)	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	5	High	Jayasri S
Sprint-1	Registration (User)	USN-2	As a user, I will receive confirmation email once I have registered for the application	5	Low	Yogarani S
Sprint-1	Admin Registration	USN-3	As a admin (Municipality worker- truck driver), I can register by entering name and email	5	High	Kotteshwari and Sai Sharanya
Sprint-1	Login	USN-4	As a user, I can log into the application by entering email & password	5	High	Kalyana sundari
Sprint-2	Dashboard	USN-5	As a user, I can explore the features in the dashboard.	20	High	Jayasri, Yogarani and Kalyana sundari
Sprint-3	Cloud registration	USN-6	As a admin I will create a cloud account to store the details of the bin	10	High	Kotteshwari
Sprint-3	Monitoring	USN-7	Collect the details of bin and save in cloud	10	Medium	Sai Sharanya
Sprint	**Functional Requirement (Epic)**	**User Story Numb**	**User Story / Task**	**Story Points**	**Priority**	**Team Members**

		er				
Sprint-4	Testing	USN-8	Perform User acceptance testing and collect feedback and improvements needed in the project	20	High	Jayasri, Yogarani, Kalyana sundari, Kotteshwari and Sai Sharanya





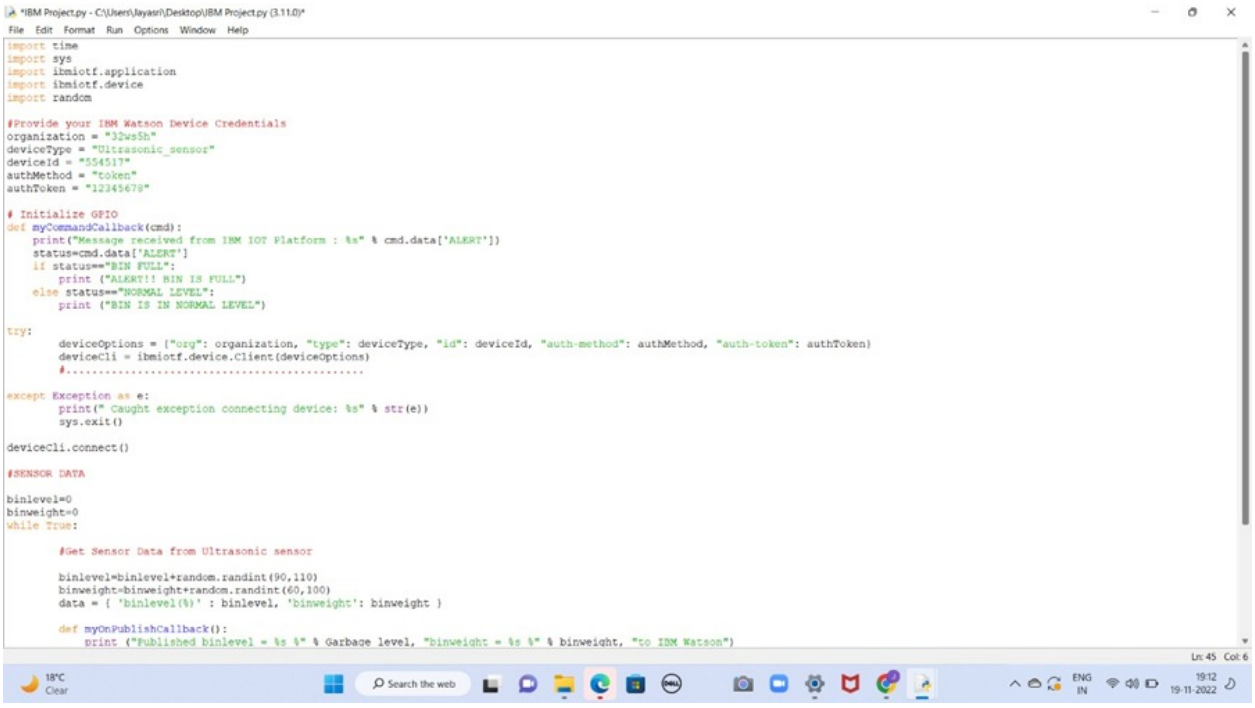
7. CODING & SOLUTIONING

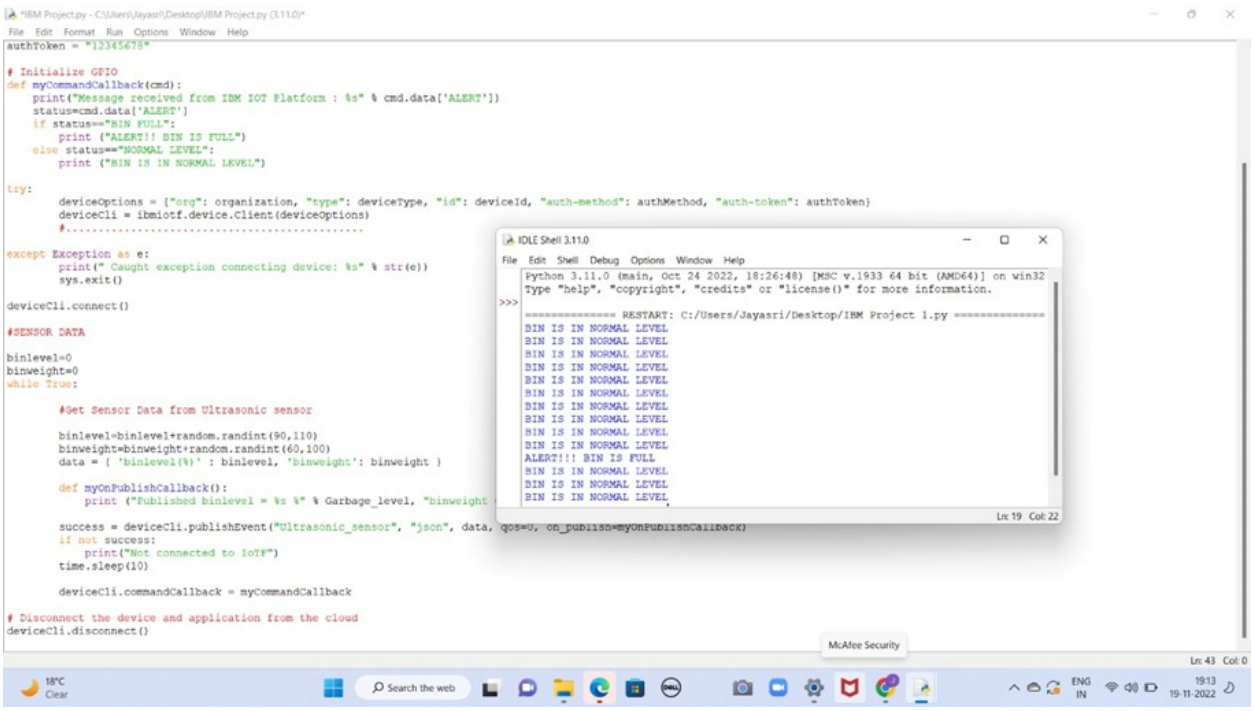
```
import time
import sys
import ibmiotf.application
import ibmiotf.device
import random

#Provide your IBM Watson Device Credentials
organization = "32ws5h"
deviceType = "Ultrasonic_sensor"
deviceId = "554517"
authMethod = "token"
authToken = "12345678"

# Initialize GPIO
def myCommandCallback(cmd):
    print("Message received from IBM IOT Platform : %s" % cmd.data['ALERT'])
    status=cmd.data['ALERT']
    if status=="BIN FULL":
        print ("ALERT!! BIN IS FULL")
```

```
   else status=="NORMAL LEVEL":
      print ("BIN IS IN NORMAL LEVEL")

try:
  deviceOptions = {"org": organization, "type": deviceType, "id": deviceId, "auth-method":
authMethod, "auth-token": authToken}
  deviceCli = ibmiotf.device.Client(deviceOptions)
  #.....................................

except Exception as e:
  print(" Caught exception connecting device: %s" % str(e))
  sys.exit()

deviceCli.connect()

#SENSOR DATA

binlevel=0
binweight=0
while True:

      #Get Sensor Data from Ultrasonic sensor

      binlevel=binlevel+random.randint(90,110)
      binweight=binweight+random.randint(60,100)
      data = { 'binlevel' : binlevel, 'binweight': binweight }

      def myOnPublishCallback():
         print ("Published binlevel = %s %" % Garbage_level, "binweight = %s %" % binweight,
"to IBM Watson")

      success = deviceCli.publishEvent("Ultrasonic_sensor", "json", data, qos=0,
on_publish=myOnPublishCallback)
      if not success:
         print("Not connected to IoTF")
      time.sleep(10)
```

deviceCli.commandCallback = myCommandCallback

# Disconnect the device and application from the cloud
deviceCli.disconnect()





8.TESTING

TEST CASE ID	FEATURE TYPE	COMPONENT	TEST SCENARIO	PREREQUISITE	STEPS TO EXECUTE	TEST DATA	EXPECTED RESULT	ACTUAL RESULT	STAT US	COMMENTS
LOGIN PAGE_TC_001	FUNCTIONAL	HOME PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WEN USER CLICK ON MY ACCOUNT BUTTON		1.ENTER URL AND CLICK GO 2.VERIFY LOGIN/SIGN UP	https://169.51.204.219.30106	L0gin page is visible	Working as expected	PASS	Successful
LOGIN PAGE_TC_002	UI	HOME PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WEN USER CLICK ON MY		1.ENTER URL AND CLICK GO 2.VERIFY LOGIN/SIGN UP	https://169.51.204.219.30106	Application should show below UI element	Working as expected	PASS	Successful

			ACCOUNT BUTTON		Elements a.ID text box B. password text box c..login button D.new user E.already have an account					
LOG IN PAGE _TC_ 003	FUNCTI ONAL	LOGIN PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WEN USER CLICK ON MY ACCOUNT BUTTON		1.enter url and click go 2.click on my account 3.Enter valid ID 4.Enter valid password 5.click on login button	Id:1111 password:5678	User should navigate your home page.	Working as expected	PASS	Successful
LOG IN PAGE _TC_ 004	FUNCTI ONAL	LOGIN PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WEN USER CLICK ON MY ACCOUNT BUTTON		1.enter url and click go 2.click on my account 3.Enter valid ID 4.Enter valid password 5.click on login butvton	Id:1111 password:5678	Confirmation message sent	Working as expected	PASS	Successful
LOG IN PAGE _TC_ 005	UI	LOGIN PAGE	VERIFY THE USER IS ABLE TO SEE THE LOGIN/SIGN UP WEN USER CLICK ON MY ACCOUNT BUTTON		1.enter url and click go 2.click on my account 3.Enter valid ID 4.Enter valid password 5.click on login button	Id:1111 password:5678	Confirmation message sent	Working as expected	PASS	Successful

8.1 User Acceptance Testing

UAT Execution & Report Submission

Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issuesof the [ProductName] project at the time of the release to User Acceptance Testing (UAT).

Defect Analysis

This report showsthe 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	12	6	4	3	25
Duplicate	1	0	2	0	3
External	3	2	0	1	6
Fixed	13	4	3	18	38
Not Reproduced	0	0	1	0	1
Skipped	0	1	0	1	2
Won't Fix	0	4	2	1	7
Totals	29	17	12	24	82

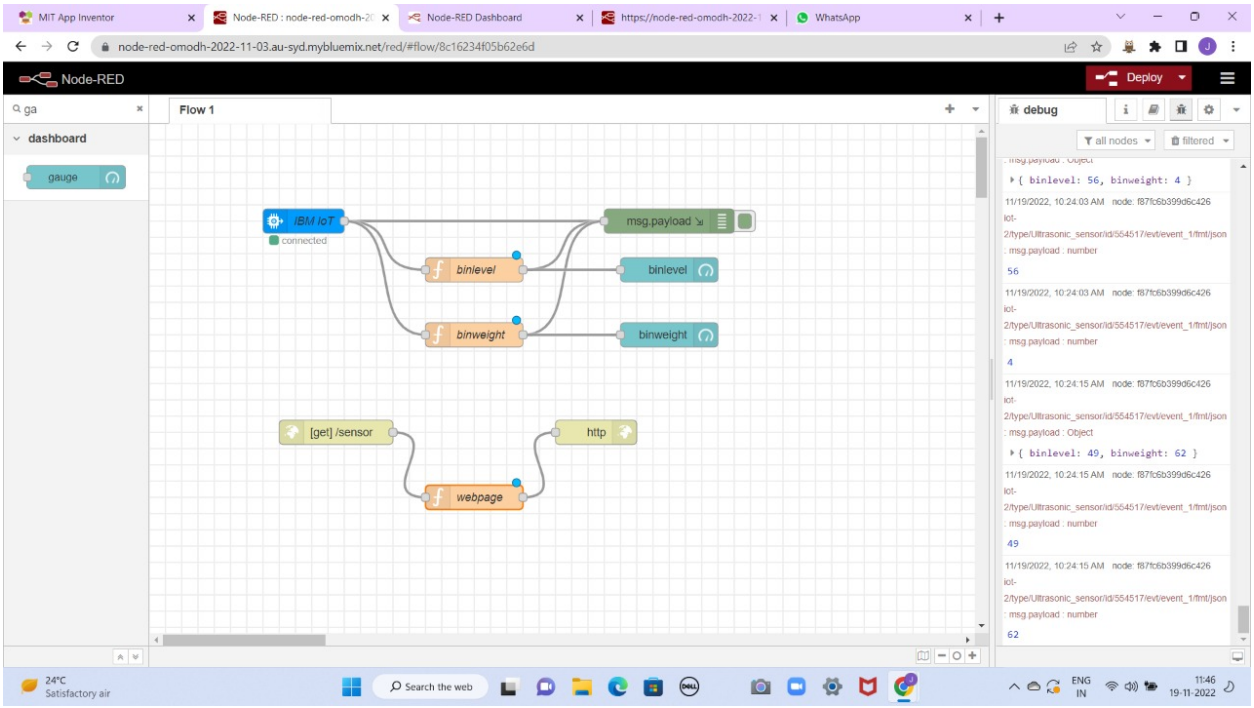
8.2 Test Case Analysis

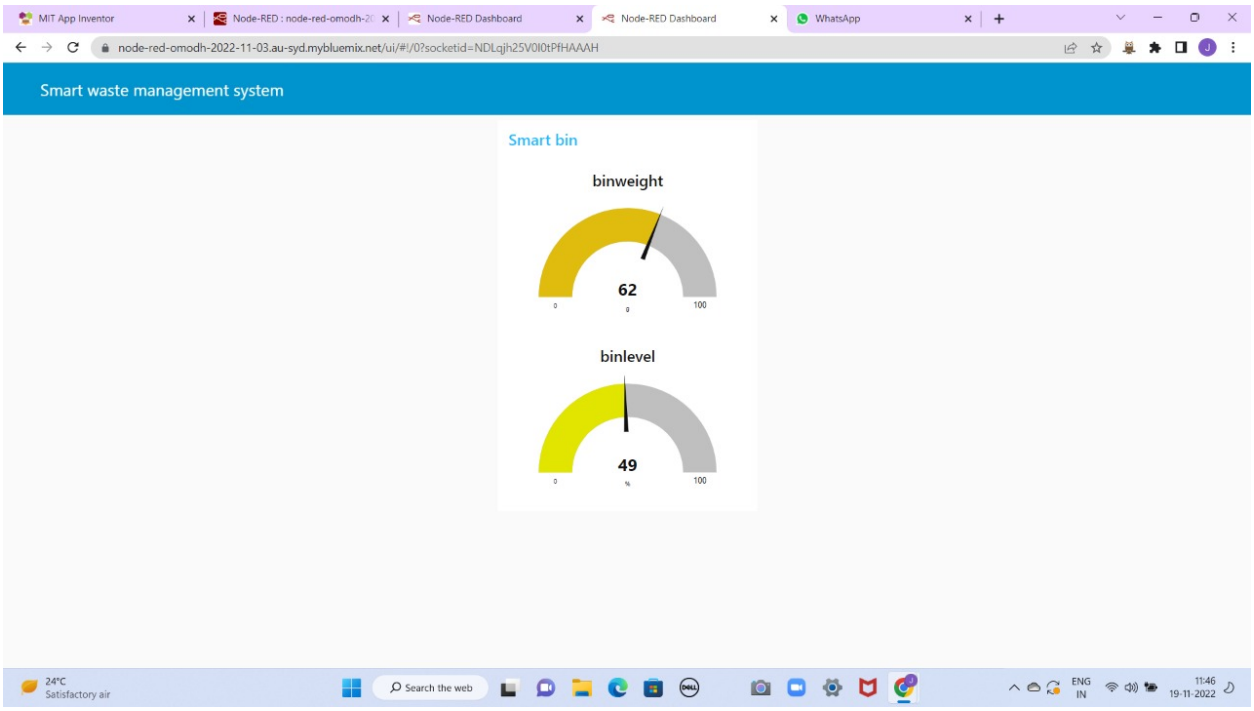
This report shows the number of test cases that have passed, failed,and untested

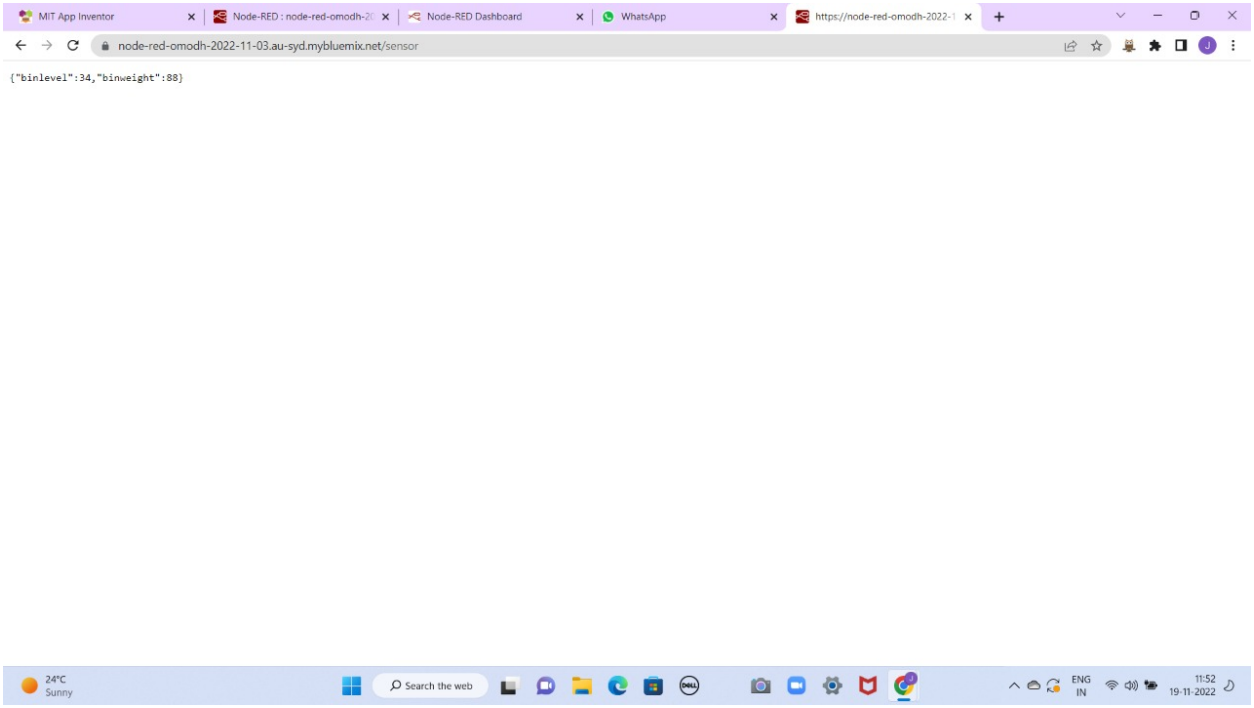
Section	Total Cases	Not Tested	Fail	Pass
Print Engine	6	0	0	6
Client Application	48	0	0	48
Security	2	0	0	2

Outsource Shipping	2	0	0	2
Exception Reporting	7	0	0	7
Final Report Output	3	0	0	3
Version Control	1	0	0	1

9. RESULTS




MIT App Inventor
Node-RED : node-red-omodh-2
Node-RED Dashboard
Node-RED Dashboard
WhatsApp
node-red-omodh-2022-11-03.au-syd.mybluemix.net/ui/#!/0?socketid=NDLqjh25V0l0tPfHAAAH
Smart waste management system
Smart bin
binweight
62
0
100
binlevel
49
%
0
100
24°C
Satisfactory air
Search the web
ENG
IN
11:46
19-11-2022


MIT App Inventor
Node-RED : node-red-omodh-2
Node-RED Dashboard
WhatsApp
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node-red-omodh-2022-11-03.au-syd.mybluemix.net/sensor
{"binlevel":34,"binweight":88}
24°C
Sunny
Search the web
ENG
IN
11:52
19-11-2022

10. ADVANTAGES & DISADVANTAGES

ADVANTAGES

- Practice is highly lucrative.
- Keeps the environment clean and fresh.
- Saves the earth and conserves energy.
- Reduces environmental pollution.
- Waste management will help to earn money.
- Create more employments.

DISADVANTAGES

- The process is not always cost-effective.
- The resultant product has a short life.
- The sites are often dangerous.
- The practices are not done uniformly.
- Waste management can cause more problems.

11. Conclusion

In this project, we have implemented the Smart bin. The bin level is monitored using Ultrasonic sensor and if the bin level exceeds a particular level we get alert. The application for smart waste management system, created using MIT app inventor displays the output from the IBM IOT platform using node-red

12. Future Scope

Smart waste management is important as the waste generation increases day by day. This project can be enhanced by segregation the waste as wet, dry, metallic and green waste so that disposal of these waste becomes easier. There can be automatic lid opening mechanism in this project to enhance the ambience of the environment.

13. APPENDIX

Esp8266 - Microcontroller :

ESP8266 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth

Memory: 320 KB SRAM

CPU: Tensilica Xtensa LX6 microprocessor @ 160 or 240 MHz

Power: 3.3 V DC
Manufacturer: Espressif Systems
Predecessor: ESP8266
Sensors : Ultrasonic sensor

Ultrasonic sensors measure distance by using ultrasonic waves.The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception

13.1: SOURCE CODE - Wokwi Code

```
#include <WiFi.h>//library for wifi
#include <PubSubClient.h>//library for MQtt
#define SOUND_SPEED 0.034//define sound speed in cm/uS
#define LED 13
const int trigPin = 12;
const int echoPin = 14;

void callback(char* subscribetopic, byte* payload, unsigned int
payloadLength);

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

#define ORG "32ws5h"
#define DEVICE_TYPE "Ultrasonic_sensor"
#define DEVICE_ID "554517"
#define TOKEN "12345678"
String data3;
float d;
long duration;


//-------- Customise the 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 subscribetopic[] = "iot-2/cmd/command/fmt/String";// cmd  REPRESENT
command type AND COMMAND IS TEST OF FORMAT STRING
char authMethod[] = "use-token-auth";// authentication method
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;//client id


//-------------------------------------------
WiFiClient wifiClient; // creating the instance for wificlient
PubSubClient client(server, 1883, callback ,wifiClient); //calling the
predefined client id by passing parameter like server id,portand
wificredential


void setup()// configureing the ESP32
{
  Serial.begin(115200); // Starts the serial communication
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  pinMode(LED,OUTPUT);
  delay(10);
  Serial.println();
  wificonnect();
  mqttconnect();
}

void loop()// Recursive Function
{

  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
```

```
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);

  // Calculate the distance
  d = duration * SOUND_SPEED/2;
  if (d<100)
  {
    Serial.print("Alert distance:");
    Serial.println(d);
  }


if(d<100)
{
  PublishData(d);
}
  delay(1000);
  if (!client.loop()) {
    mqttconnect();
  }
}
/*.....................................retrieving to
Cloud.............................*/
void PublishData(float d) {
  mqttconnect();//function call for connecting to ibm
  /*
     creating the String in in form JSon to update the data to ibm cloud
  */
  String payload = "{\"Alert\":";
  payload += d;
  payload += "}";
```

```
  Serial.print("Sending payload: ");
  Serial.println(payload);

  if (client.publish(publishTopic, (char*) payload.c_str())) {
    Serial.println("Publish ok");// if it sucessfully upload data on the
cloud then it will print publish ok in Serial monitor or else it will
print publish failed
  } else {
    Serial.println("Publish failed");
  }
 }


void mqttconnect() {
  if (!client.connected()) {
    Serial.print("Reconnecting client to ");
    Serial.println(server);
    while (!!!client.connect(clientId, authMethod, token)) {
      Serial.print(".");
      delay(500);
    }

     initManagedDevice();
     Serial.println();
  }
}
void wificonnect() //function defination for wificonnect
{
  Serial.println();
  Serial.print("Connecting to ");

  WiFi.begin("Wokwi-GUEST", "", 6);//passing the wifi credentials to
establish the connection
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
```

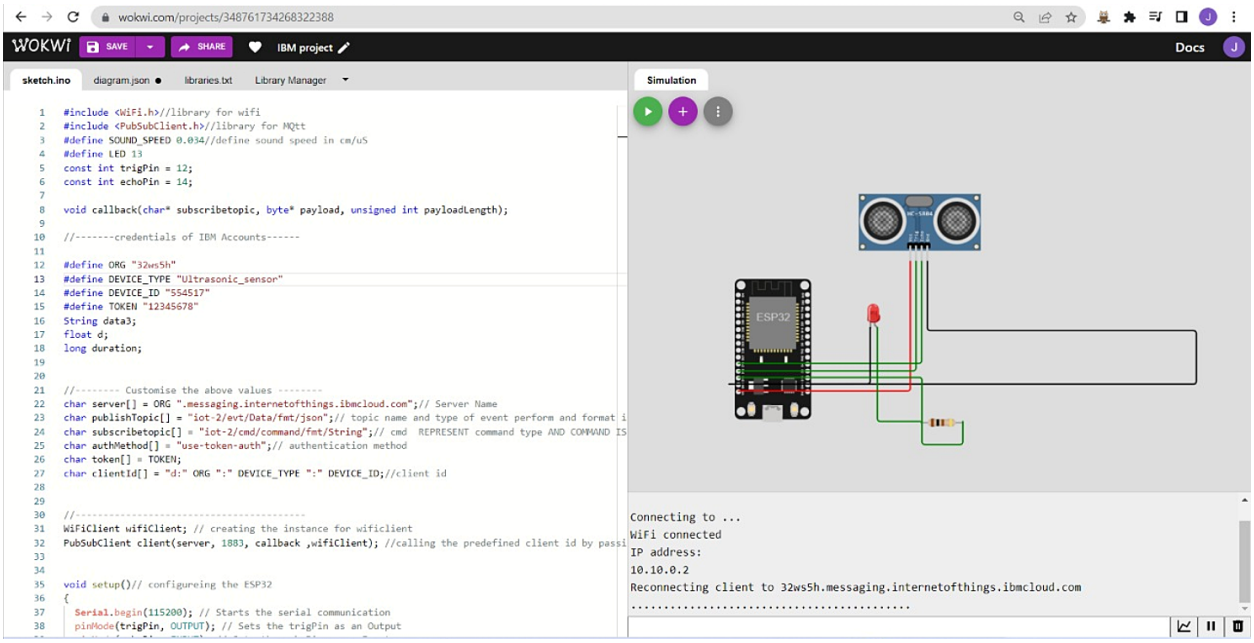
```
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
}

void initManagedDevice() {
  if (client.subscribe(subscribetopic)) {
    Serial.println((subscribetopic));
    Serial.println("subscribe to cmd OK");
  } else {
    Serial.println("subscribe to cmd FAILED");
  }
}

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++) {
    //Serial.print((char)payload[i]);
    data3 += (char)payload[i];
  }
  Serial.println("data: "+ data3);
  if(data3=="lighton")
  {
Serial.println(data3);
digitalWrite(LED,HIGH);
  }
  else
  {
```

```
Serial.println(data3);
digitalWrite(LED,LOW);
   }
data3="";
}
```



13.2: GITHUB & DEMO VIDEO LINK

GITHUB LINK:

https://github.com/IBM-EPBL/IBM-Project-20671-1659760138

DEMO VIDEO LINK:

https://youtu.be/fahMhgVetm8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