SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

DOMAIN – INTERNET OF THINGS (IoT)
A PROJECT REPORT

SUBMITTED BY

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CONTENT

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 Overview:

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 waterborne 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 system the 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 ID will 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 .

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.

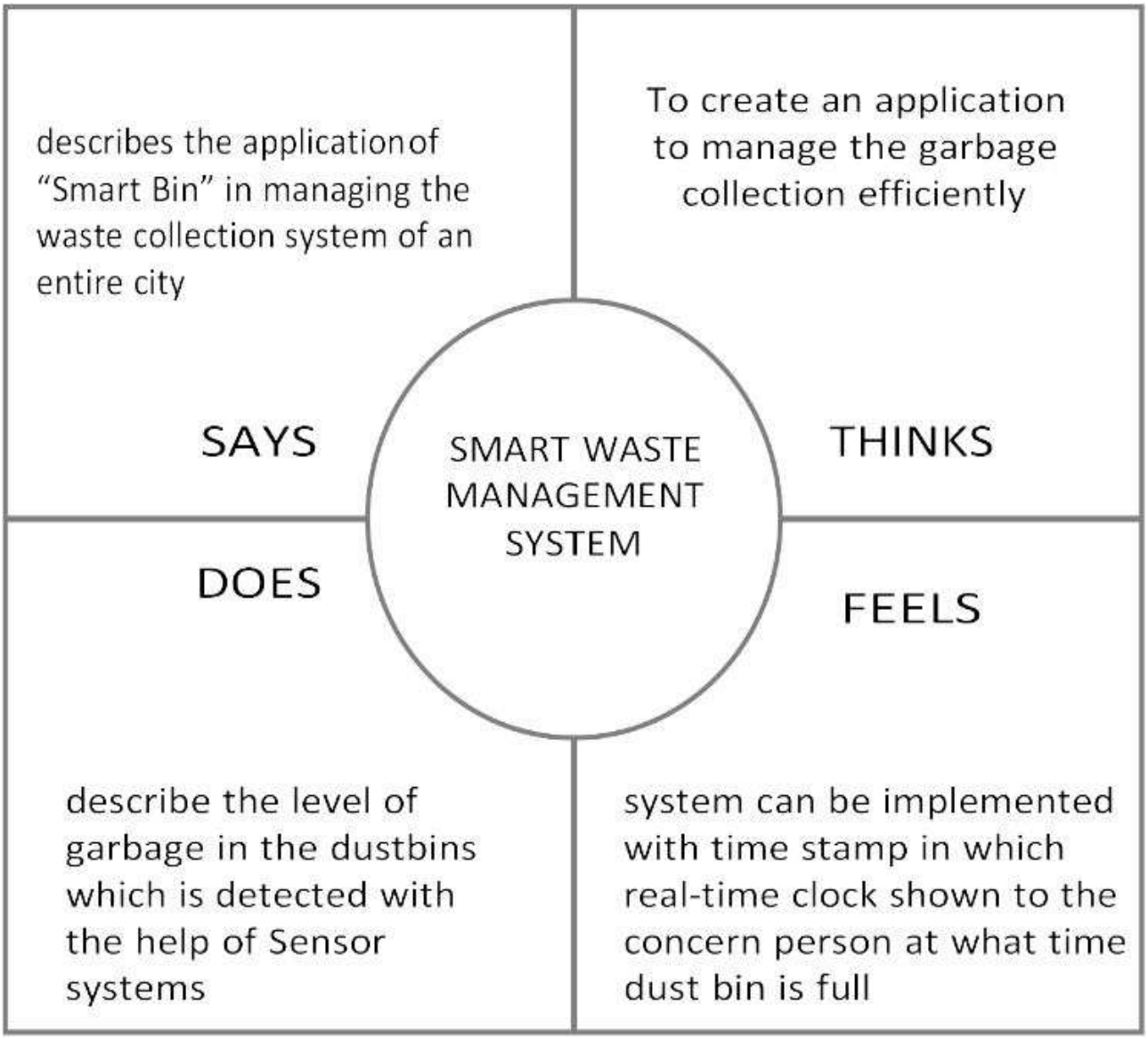
2.3. Problem Statement:

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.

Problem Statement (PS)	I'm (User)	I'm trying to	But	Because	Which makes me feel
PS - 1	Colony resident member	Put the waste into the waste bin	bin is already in the state of overflow	bin is not cleared by the corporation cleaners	So disgusting to see the spoiled area that stays as a major reason for many air-borne diseases.
PS - 2	Street Walkers	Throw the waste into the bin	There is no waste bin at all	Bin is not provided for the area	The main reason to make the surrounding unclean and unhygienic.

3. IDEATION & PROPOSED SOLUTION

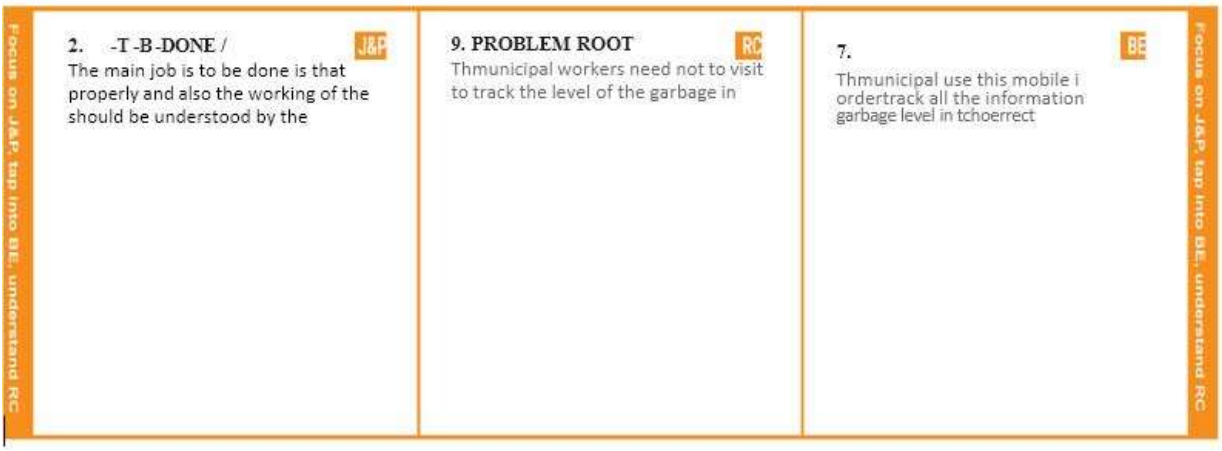
3.1. EMPATHY MAP CANVAS



3.2.PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	➢ Ravage and waste can cause environmental pollution. ➢ Rotting garbage is the cause to produce harmful gases in the air and cause breathing problem to people. ➢ Due to improper waste disposal, we may face several problems like unpleasant odour and severe health issues.
2.	Idea / Solution description	➢ To solve this problem of waste disposal , we can design a smart garbage bin with inbuilt sensors and IOT devices such like Arduino UNO , Raspberry pi, etc.... ➢ Garbage level and location intimation mechanism . ➢ AI Recycling Robots.
3.	Novelty / Uniqueness	➢ Identify potential waste streams. ➢ Create a waste management-focused community outreach plane.
4.	Social Impact / Customer Satisfaction	➢ Neighbourhood of landfills to communities, breeding of pests and loss in property values. ➢ The IOT solution uses the data and intimates the information to the local area of management department when it reaches the initial boundary line .
5.	Business Model (Revenue Model)	➢ It generates revenue through the provision of various waste management and disposal services. ➢ Recycling solutions to residential , commercial , industrial, and municipal clients.
6.	Scalability of the Solution	➢ Installing separate bins for collecting recyclable and non-recyclable wastes. ➢ Recycling not only save energy but also prevent the material from going to landfills & Incineration and provides raw materials for new products.

3.3.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 Authentication	Collecting data from the transmitted signal
FR-2	IBM Watson IOT Platform	Stores the sensed data and alerts.
FR-3	Node RED	Designs the wireframing and connection of user interface
FR-4	Web User Interface	Created by Node RED service connected to IBM Watson IOT platform
FR-5	Database	Fetched data is intimated and updated in the database
FR-6	Python script	Generates random data to the iot device and transmits to the Watson cloud.

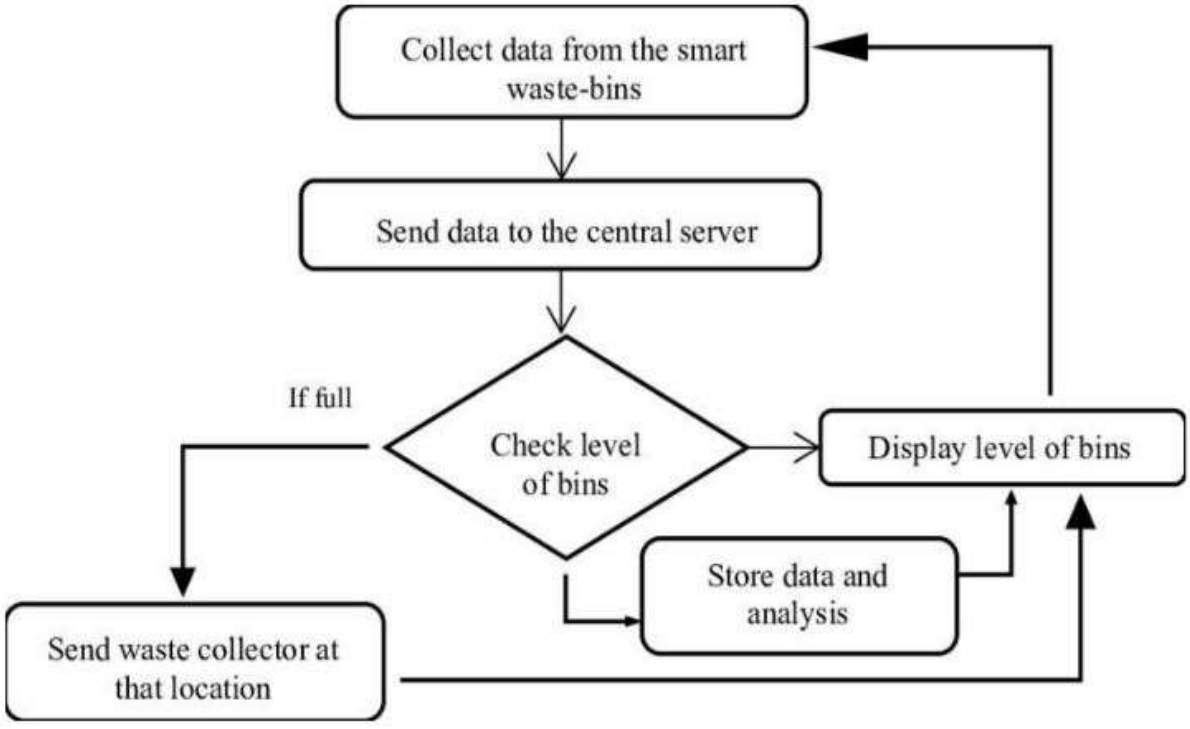
4.2.NON-FUNCTIONAL REQUIREMENT

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

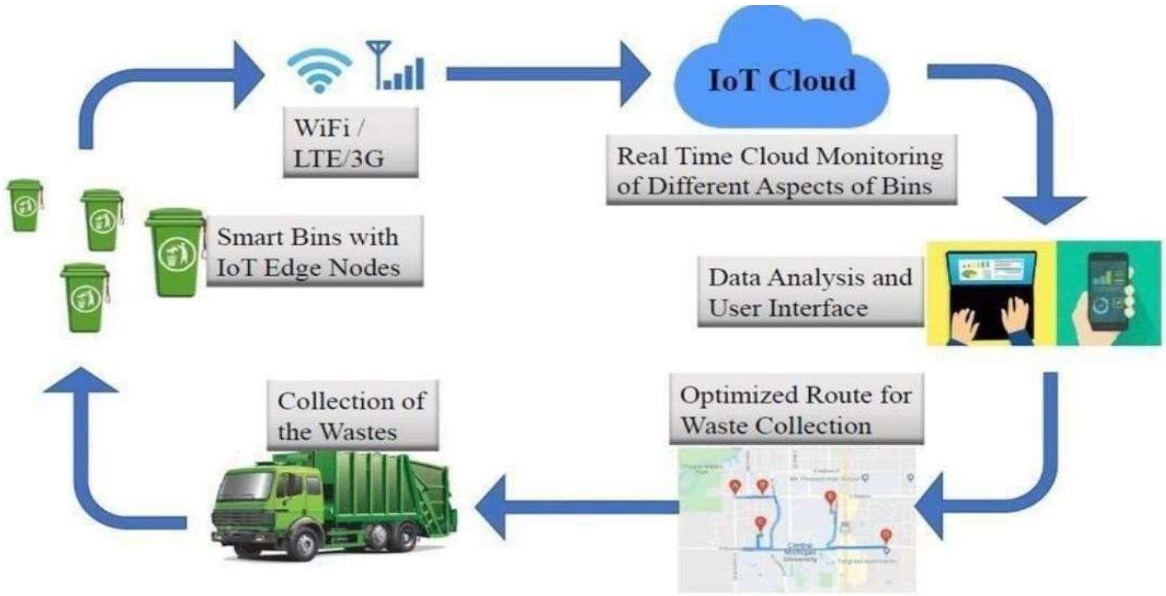
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Separate bins for recyclable and non
NFR-2	**Security**	Data fetched can be only accessed by authorized user
NFR-3	**Reliability**	Accurate data and availabity is displayed
NFR-4	**Performance**	Detects and intimates alerts on reaching fixed limit.
NFR-5	**Availability**	Accessible through 24/7 by user and authorizer
NFR-6	**Scalability**	Holds vast accessibility by the user

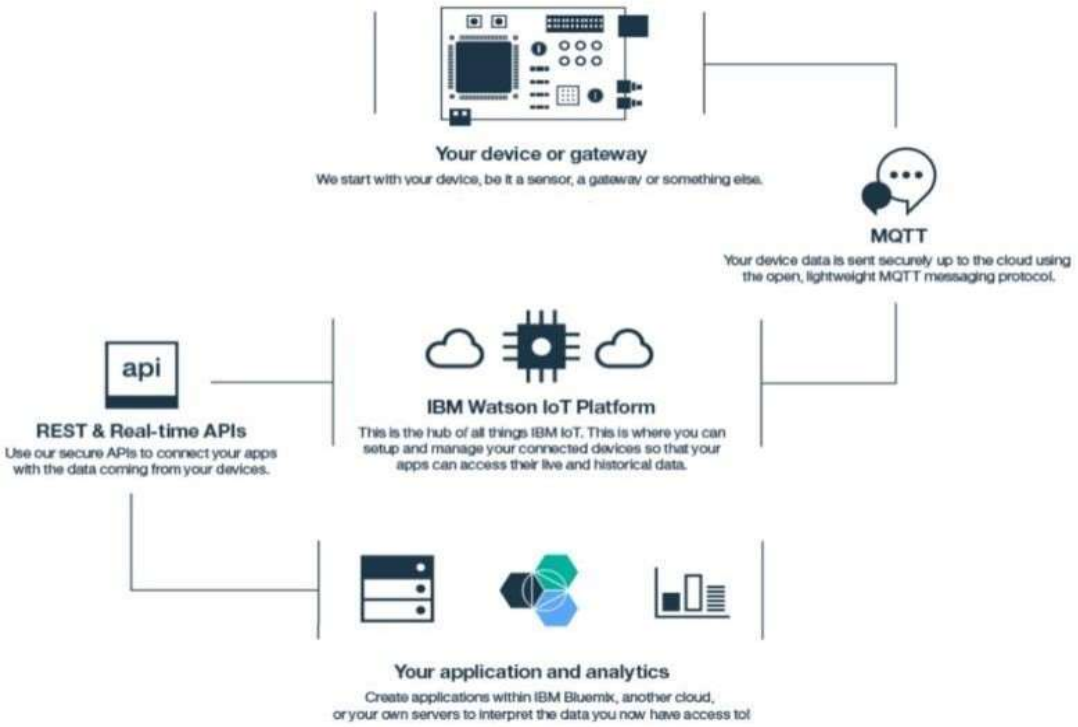
5.PROJECT DESIGN

5.1. DATA FLOW DIAGRAM



5.2.SOLUTION ARCHITECTURE AND TECHNICAL ARCHITECTURE





5.3.USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user / Web user)	Signup	USN-1	User can signup using their email and password and confirm the details.	I can access my account / dashboard	High	Sprint-1
		USN-2	A confirmation mail is sent to the user.	I can receive confirmation email & click confirm	High	Sprint-1
	Login	USN-3	User can login using login credentials	User can log on to the website	High	Sprint-1
	Dashboard	USN-4	User can specify the location and area to check the availability of bins.	User can access dashboard and search for bins in specified areas	High	Sprint-2
		USN-5	User can post the queries and grievances in the report section	Options are provided to solve user issues	Medium	Sprint-2

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 workers over there in municipality	10	High	LAVANYA V
Sprint- 1	Login	USN-2	As a Co-Admin, I'll control the waste level by monitoring them via real time web portal. Once the filling happens, I'll notify trash truck with location of bin with bin ID	10	High	NIVETHITHA P

Sprint-2	Dashboard	USN-3	As a Truck Driver, I'll follow Co- Admin's Instruction to reach the filling bin in short roots and save time	20	Low	PRIYANKA S

Sprint- 3	Dashboard	USN-4	As a Local Garbage Collector, I'II gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills	20	Medi um	PRIYANKA S
Sprint- 4	Dashboard	USN-5	As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems	20	High	PRIYA DARSHINI M D

6.2.DELIVERY SCHEDULE

Sprint	Total Story Points	Duration	Sprint StartDate	Sprint End Date (Planned)	Story Points Completed (ason Planned End Date)	Sprint Release Date(Act
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	30	30 OCT 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	49	6 NOV 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	50	7 NOV 2022

7.CODING AND SOLUTION

7.1.Wokwi code for Sensor transmission

```
#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 "s1e201"     // IBM organisation id
#define DEVICE_TYPE "lavi123"         // Device type mentioned in ibm watson iot platform
#define DEVICE_ID "12345"    // Device ID mentioned in ibm watson iot platform
#define TOKEN "23456789"    // Token

//customise above values

charserver[] = ORG ".messaging.internetofthings.ibmcloud.com";    // server name
charpublishTopic[] = "iot-2/evt/data/fmt/json";         // topic name and type of event perform and
format in which data to be send chartopic[] = "iot-2/cmd/led/fmt/String";   // cmd Represent type
and command is test format of strings
charauthMethod[] = "use-token-auth";//
authentication method chartoken[] = TOKEN;
charclientId[] = "d:"ORG ":"DEVICE_TYPE ":"DEVICE_ID;         //Client id

WiFiClient wifiClient;   //
creating instance for wificlient
PubSubClient client(server, 1883, wifiClient);

#defineECHO_PIN 12
#defineTRIG_PIN 13 floatdist; Stringdata3; voidsetup()
{
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();
```

```
}
floatreadcmCM()
{
digitalWrite(TRIG_PIN, LOW); delayMicroseconds(2); digitalWrite(TRIG_PIN, HIGH);
delayMicroseconds(10); digitalWrite(TRIG_PIN, LOW); intduration = pulseIn(ECHO_PIN, HIGH);
returnduration * 0.034/ 2;
}
voidloop()
{
lcd.clear();
publishData(); delay(500); if(!client.loop())
{
mqttConnect();          // function call to
connect to IBM
}
}
/*        retrieving to cloud
          */
voidwifiConnect()
{
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());
}
voidmqttConnect()
{
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();
}
```

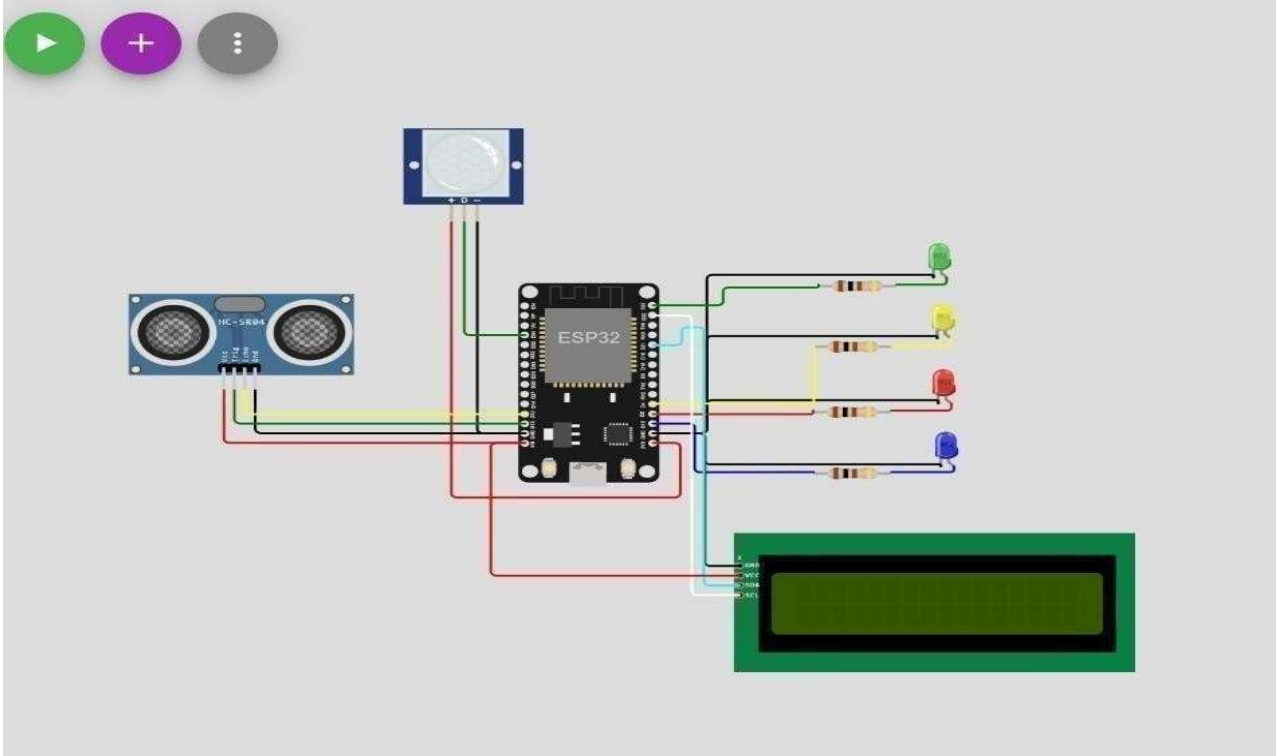
```
}
voidinitManagedDevice()
{
if(client.subscribe(topic))
{
Serial.println("IBM subscribe to cmd OK");
}
else
{
Serial.println("subscribe to cmd FAILED");
}
}
voidpublishData()
{
floatcm = readcmCM();
if(digitalRead(34))      //pir motion detection
{
Serial.println("Motion Detected"); Serial.println("Lid Opened"); digitalWrite(15, HIGH);
if(digitalRead(34)== true)
{
if(cm <= 60)    //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);
}
elseif(cm > 60&& cm < 120)
{
digitalWrite(4, HIGH);
Serial.println("Warning!!,Trash is about to cross 50% of bin level"); digitalWrite(2, LOW);
digitalWrite(23, LOW);
}
elseif(cm > 120)
{
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 <= 60)
{
digitalWrite(21,HIGH); Stringpayload = "{\"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");
}
}
elseif(cm <= 120)
{
digitalWrite(22,HIGH); Stringpayload = "{\"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
{
digitalWrite(23,HIGH); Stringpayload = "{\"Safe\":"; 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");
}
}
floatinches = (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
voidcallback(char* subscribetopic, byte* payload, unsignedintpayloadLength)
{
Serial.print("callback invoked for topic: "); Serial.println(subscribetopic);
for(inti = 0; i < payloadLength; i++) {
data3 += (char)payload[i];
}
Serial.println("data: "+ data3);
constchar*s =(char*) data3.c_str(); doublepincode = 0;
constchar*buf; intlen;
if(mjson_find(s, strlen(s), "$.command", &buf, &len)) // And print it
{
Stringcommand(buf,len); if(command=="\"Seal Bin\"")
{
Serial.println("Sealed");
}
}
data3="";
}
```

7.2.Sensor Connection Setup

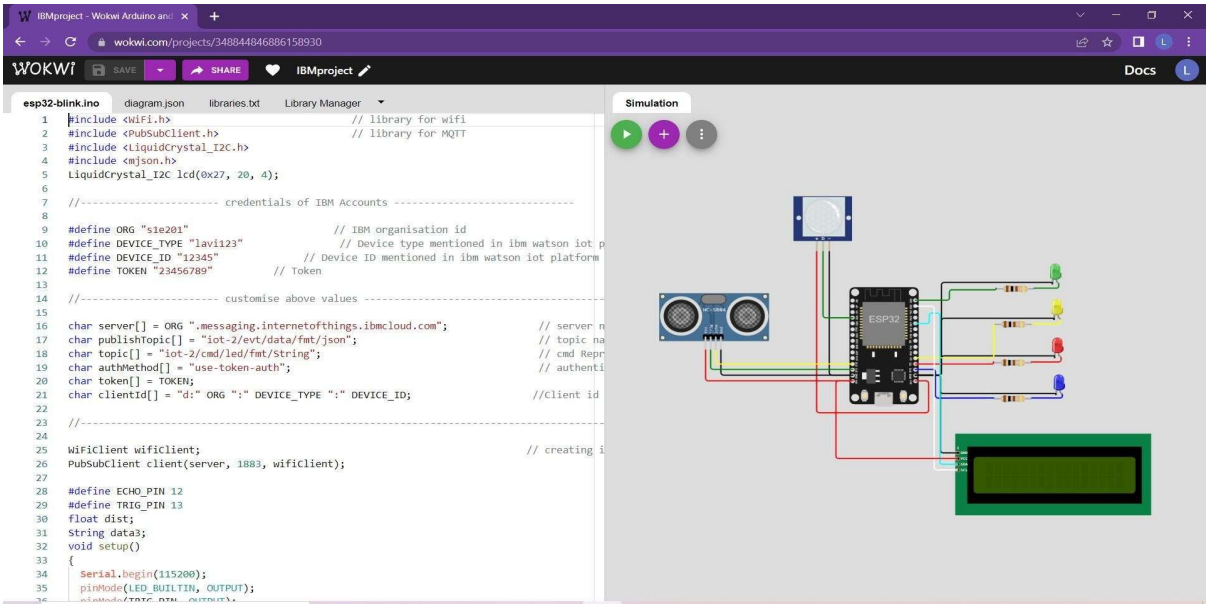


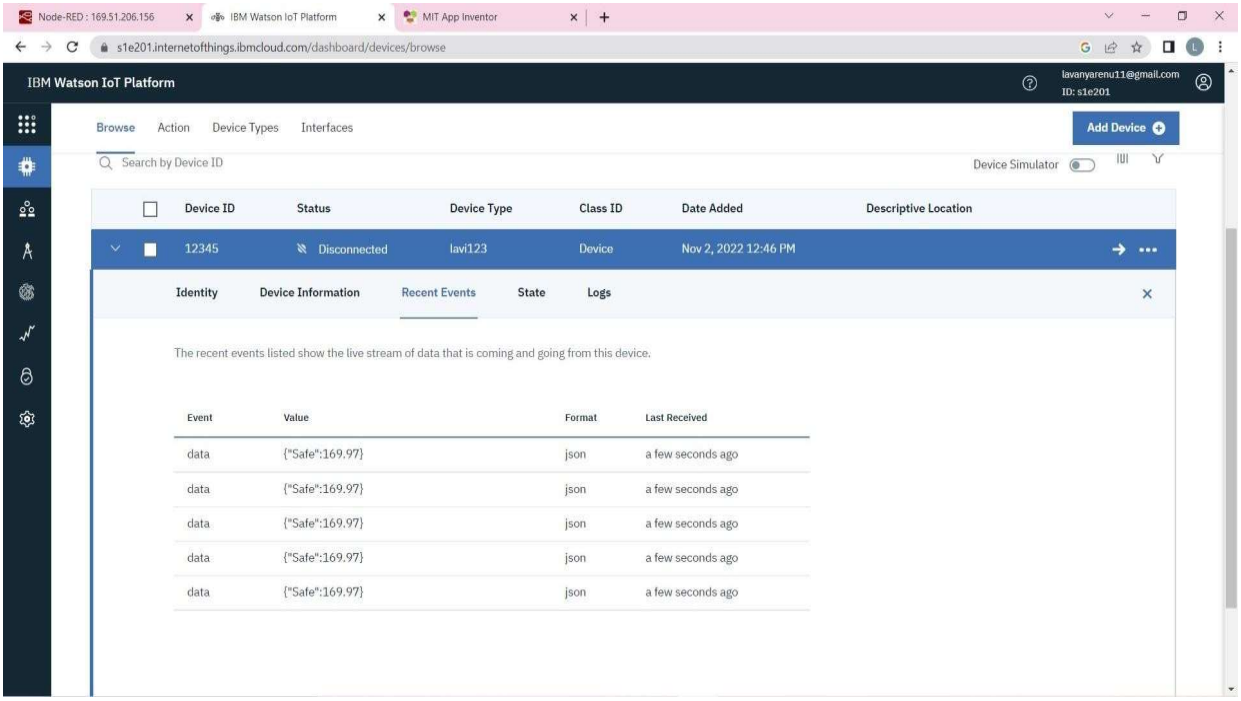
PHYSICAL COMPONENTS:

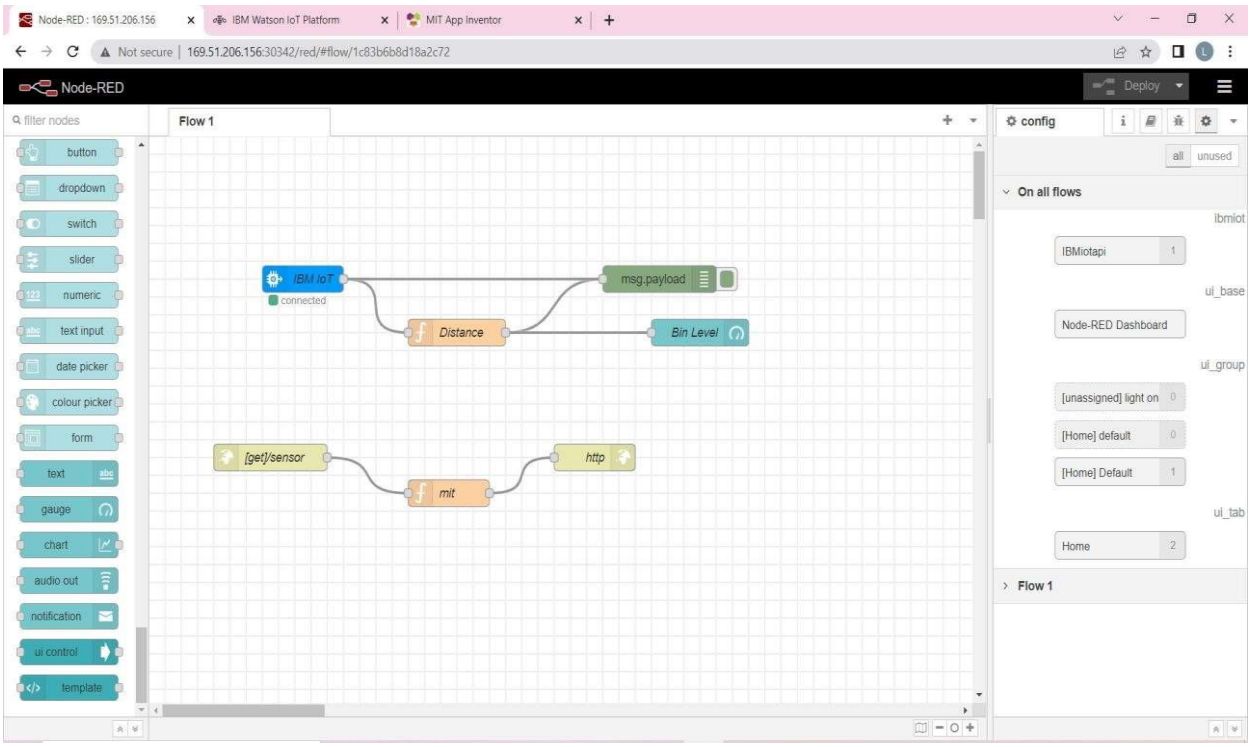
- PIR MOTION SENSOR
- ULTRASONIC DISTANCE SENSOR
- ESP32-ARDUINO MICROCONTROLLER

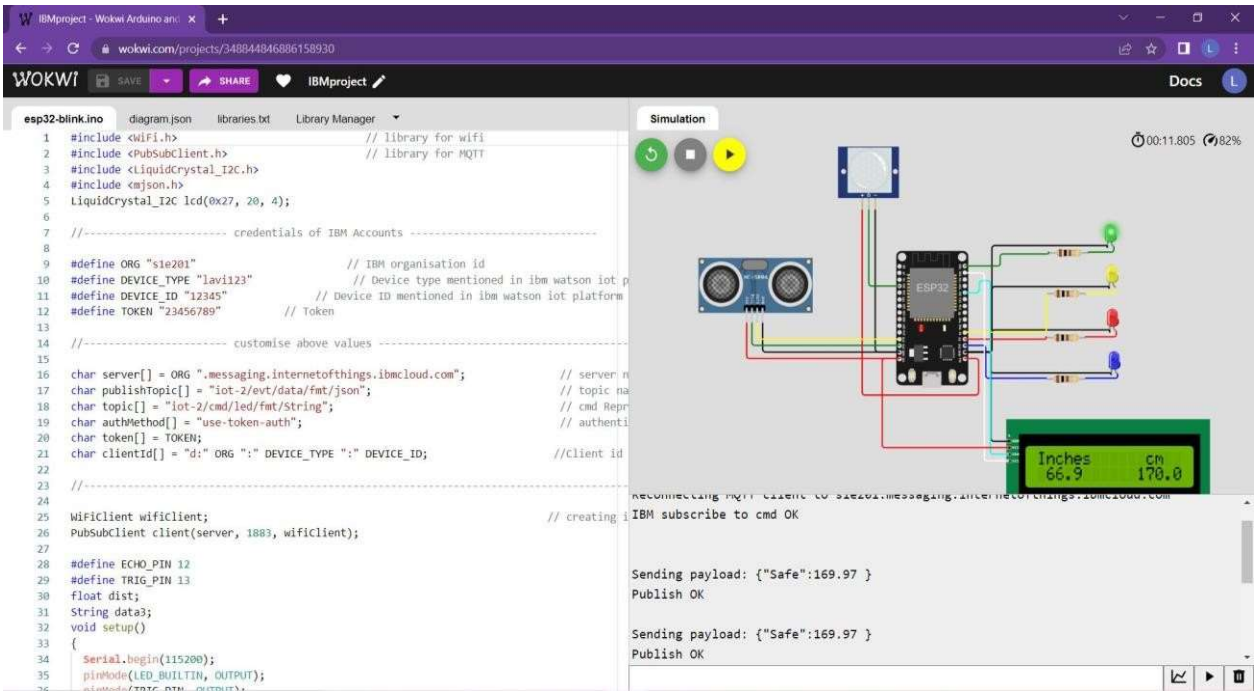
OUTPUT:

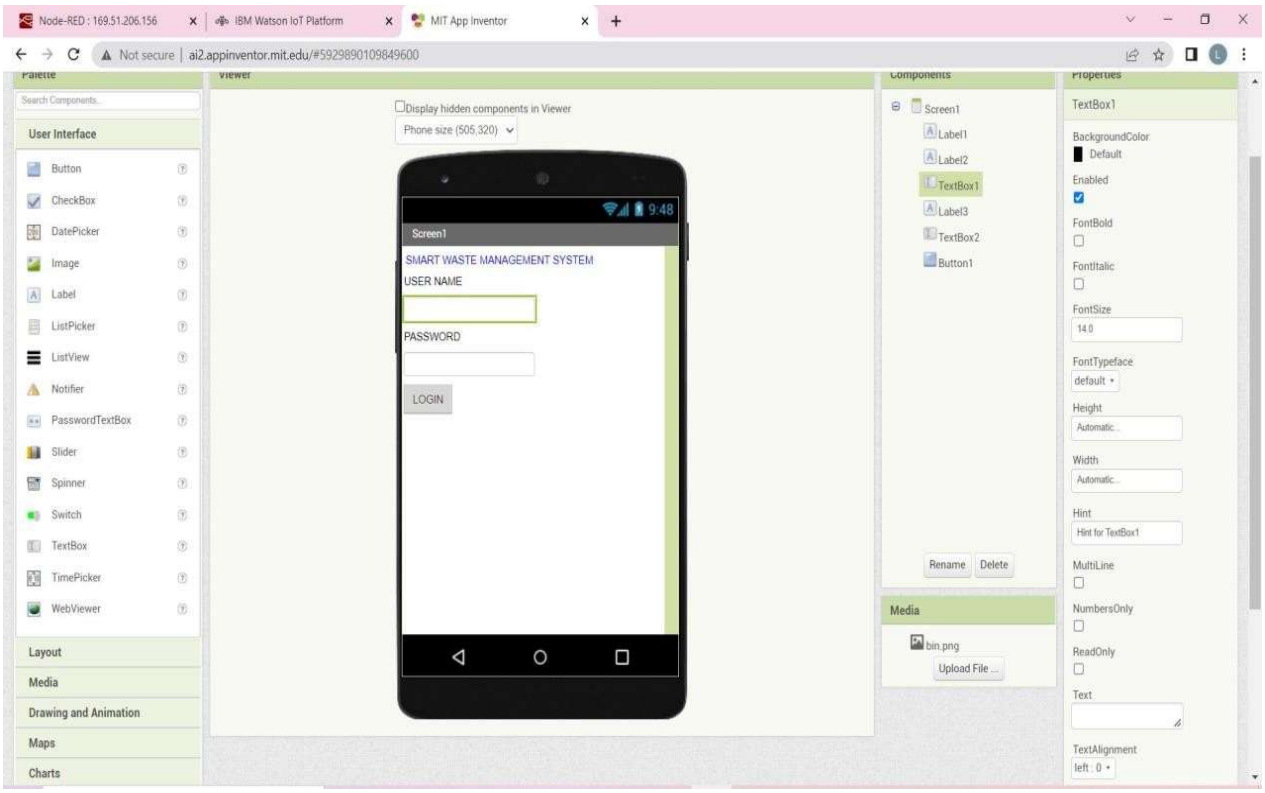
WOKWI SETUP






Node-RED : 169.51.206.156
IBM Watson IoT Platform
MIT App Inventor
Not secure | 169.51.206.156:30342/red/#flow/1c83b6b8d18a2c72
Node-RED
Deploy
filter nodes
Flow 1
button
dropdown
switch
slider
numeric
text input
date picker
colour picker
form
text
gauge
chart
audio out
notification
ui control
template
IBM IoT
connected
msg.payload
Distance
Bin Level
[get]/sensor
mit
http
config
all
unused
On all flows
ibmiot
IBMiotapi
ui_base
Node-RED Dashboard
ui_group
[unassigned] light on
[Home] default
[Home] Default
ui_tab
Home
Flow 1


IBMproject - Wokwi Arduino and
wokwi.com/projects/348844846886158930
WOKWI
SAVE
SHARE
IBMproject
Docs
esp32-blink.ino
diagram.json
libraries.txt
Library Manager
#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 "s1e201" // IBM organisation id
#define DEVICE_TYPE "lavi123" // Device type mentioned in ibm watson iot p
#define DEVICE_ID "12345" // Device ID mentioned in ibm watson iot platform
#define TOKEN "23456789" // Token
//---------- customise above values ----------
char server[] = ORG ".messaging.internetofthings.ibmcloud.com";
char publishTopic[] = "iot-2/evt/data/fmt/json";
char topic[] = "iot-2/cmd/led/fmt/String";
char authMethod[] = "use-token-auth";
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;
WiFiClient wifiClient;
PubSubClient client(server, 1883, wifiClient);
#define ECHO_PIN 12
#define TRIG_PIN 13
float dist;
String data3;
void setup()
{
Serial.begin(115200);
pinMode(LED_BUILTIN, OUTPUT);
Simulation
00:11.805
82%
Inches
66.9
cm
170.0
IBM subscribe to cmd OK
Sending payload: {"Safe":169.97 }
Publish OK
Sending payload: {"Safe":169.97 }
Publish OK


Node-RED : 169.51.206.156
IBM Watson IoT Platform
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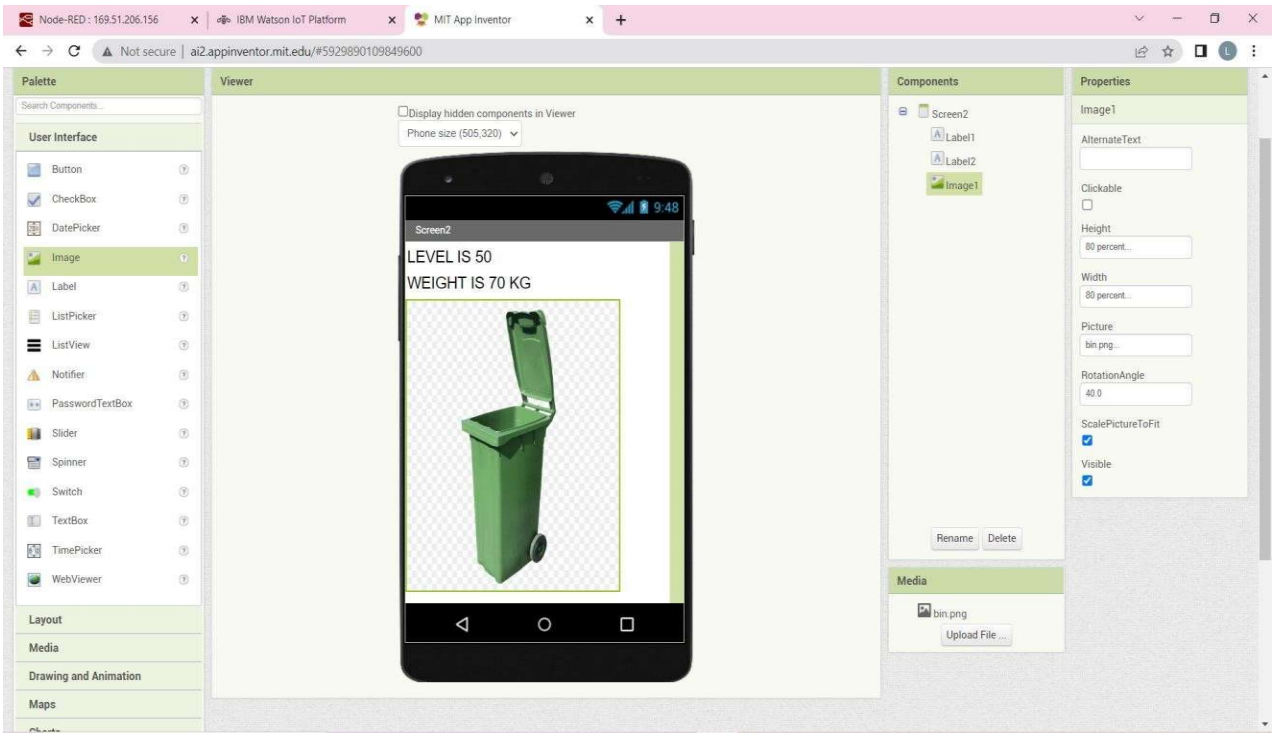
Palette
Viewer
Components
Properties
Search Components...
User Interface
Button
CheckBox
DatePicker
Image
Label
ListPicker
ListView
Notifier
PasswordTextBox
Slider
Spinner
Switch
TextBox
TimePicker
WebViewer
Layout
Media
Drawing and Animation
Maps
Charts
Display hidden components in Viewer
Phone size (505,320)
9:48
Screen1
SMART WASTE MANAGEMENT SYSTEM
USER NAME
PASSWORD
LOGIN
Screen1
Label1
Label2
TextBox1
Label3
TextBox2
Button1
Rename
Delete
Media
bin.png
Upload File ...
TextBox1
BackgroundColor
Default
Enabled
FontBold
FontItalic
FontSize
14.0
FontTypeface
default
Height
Automatic...
Width
Automatic...
Hint
Hint for TextBox1
MultiLine
NumbersOnly
ReadOnly
Text
TextAlignment
left : 0


Node-RED : 169.51.206.156
IBM Watson IoT Platform
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Palette
Viewer
Components
Properties
Search Components...
User Interface
Button
CheckBox
DatePicker
Image
Label
ListPicker
ListView
Notifier
PasswordTextBox
Slider
Spinner
Switch
TextBox
TimePicker
WebViewer
Layout
Media
Drawing and Animation
Maps
Display hidden components in Viewer
Phone size (505,320)
9:48
Screen2
LEVEL IS 50
WEIGHT IS 70 KG
Screen2
Label1
Label2
Image1
Rename
Delete
Media
bin.png
Upload File ...
Image1
AlternateText
Clickable
Height
80 percent...
Width
80 percent...
Picture
bin.png...
RotationAngle
40.0
ScalePictureToFit
Visible

The admin gets notification when the bin detects motion and if the bin level crosses 50 percent it indicates warning and if it crosses 90 percent it gives a High alert and closes the bin. If the admin wants to seal the bin the admin can command seal bin until it is accessed for cleaning.

8.1.Test Case:

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 access the bin , the location and status of the bin displayed to the admin.

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

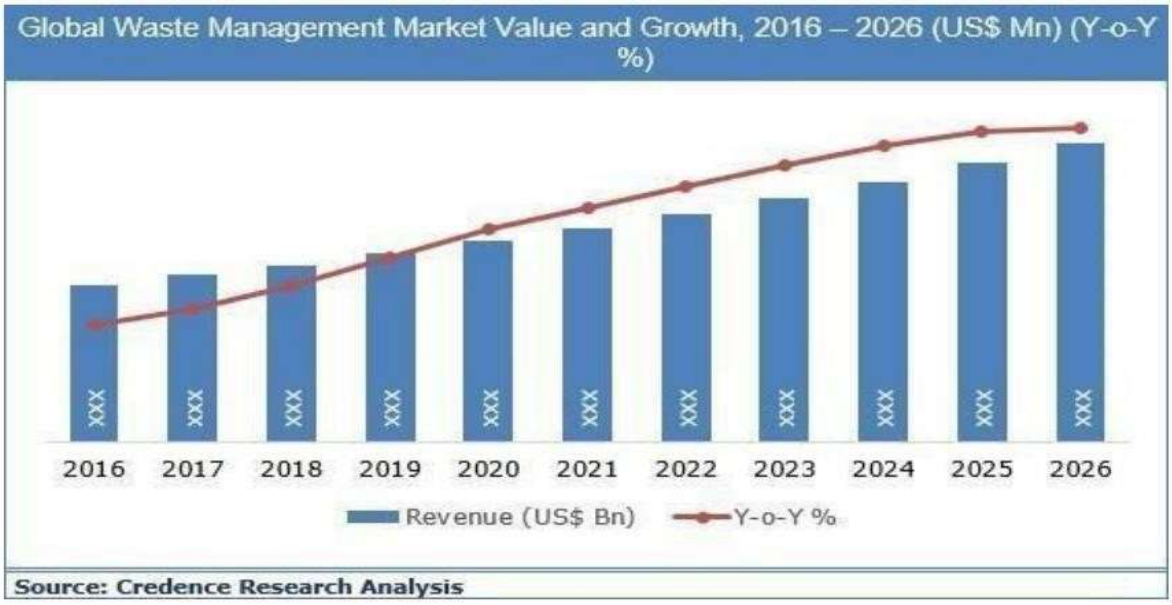
3.TEST CASE ANALYSIS

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

9.RESULTS

9.1.Performance Metrics



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 :

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 trashfree 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 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

Esp32 - Microcontroller :

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-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 the target by measuring the time between the emission and reception.

GITHUB LINK : https://github.com/IBM-EPBL/IBM-Project-32202-1660208574
WOKWI LINK : https://wokwi.com/projects/348844846886158930
PROJECT DEMO LINK:
https://drive.google.com/file/d/1SD0tpjA5eBR_YeKpmecRE4q4aYAvZP5u/view?usp=share_link