SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES DOMAIN – INTERNET OF THINGS (IoT)

SUBMITTED BY,

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FINAL REPORT

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.

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.

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
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 .

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.

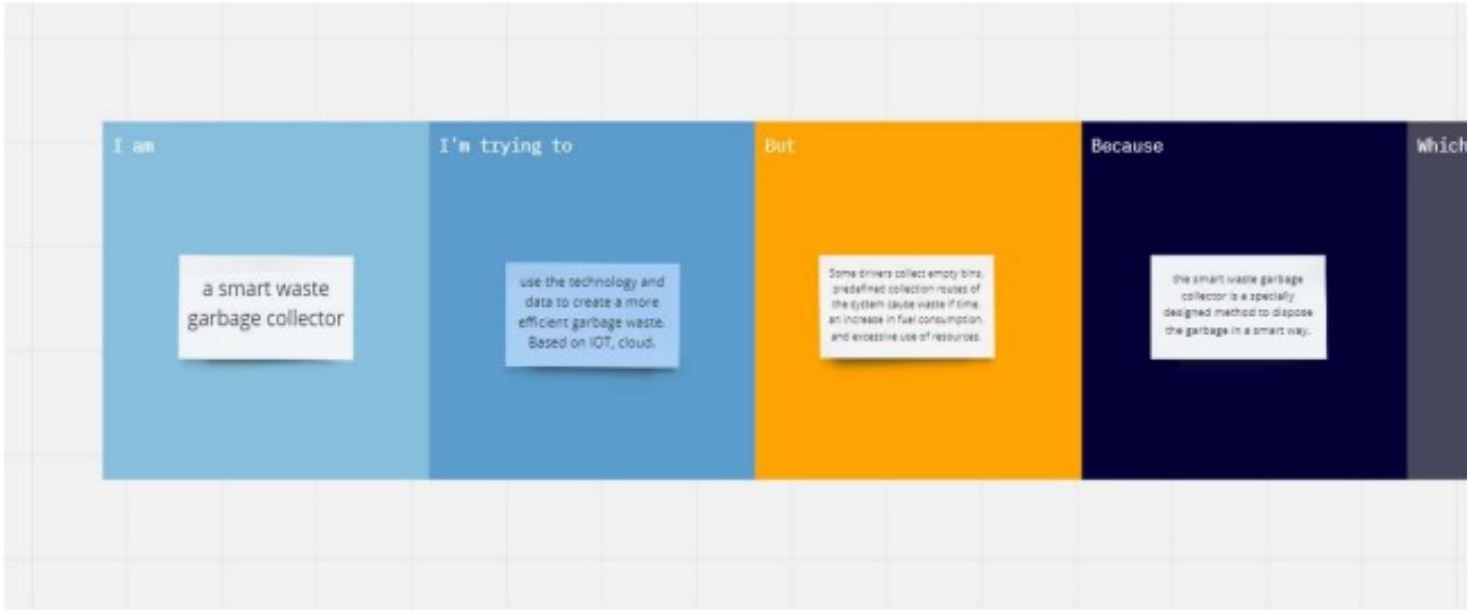
[4] Xu Li, Student Member, IEEE, Performance Evaluation of Vehicle-Based Mobile Sensor Networks for Traffic Monitoring.

[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.

Problem Statement

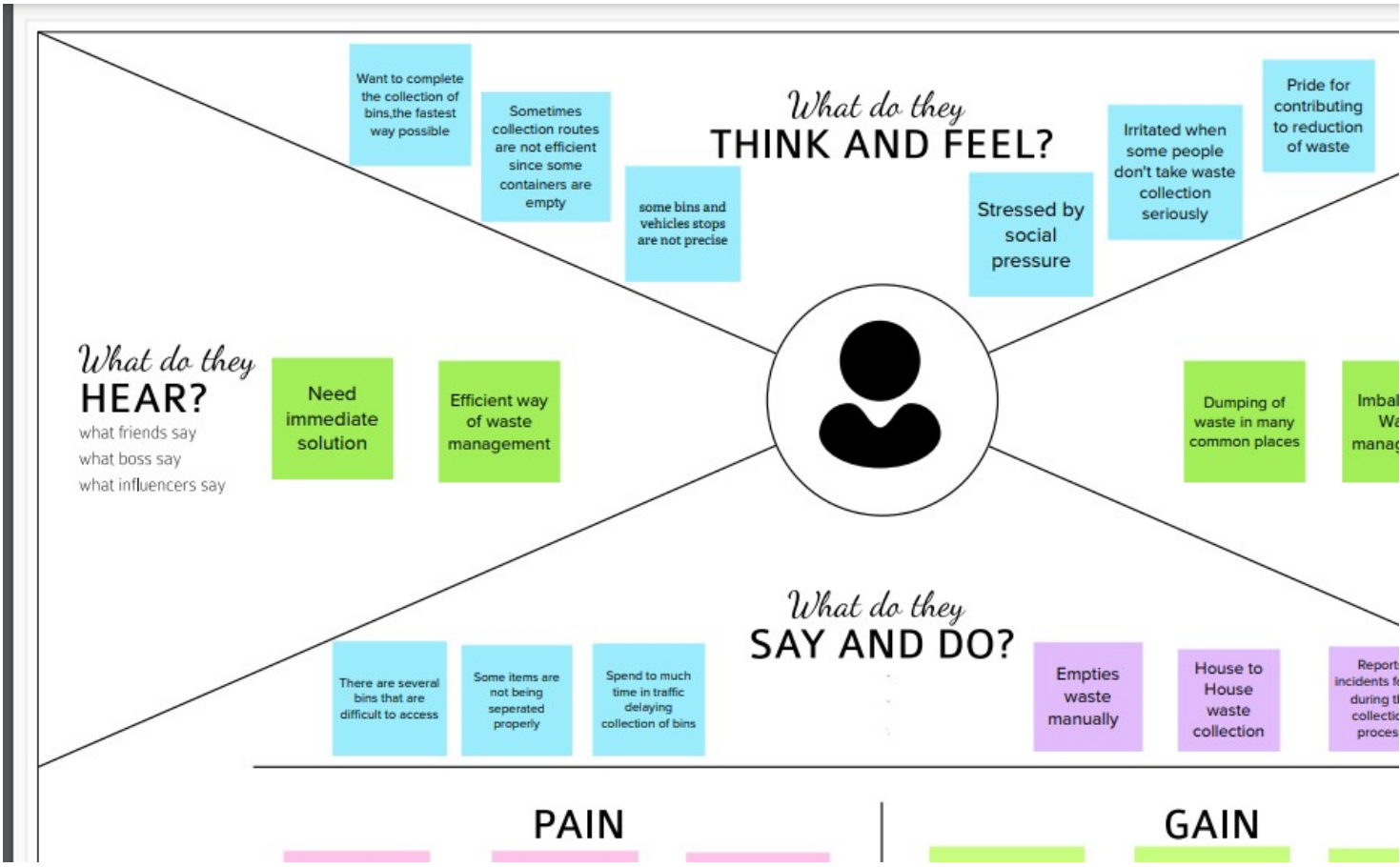
The waste management system provided earlier are not very reliable, efficient, cost effective and does not have any advanced processing features like automatic close of bin and alert intimations system .The following is a well articulated problem statement that allows you to find the ideal solution for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



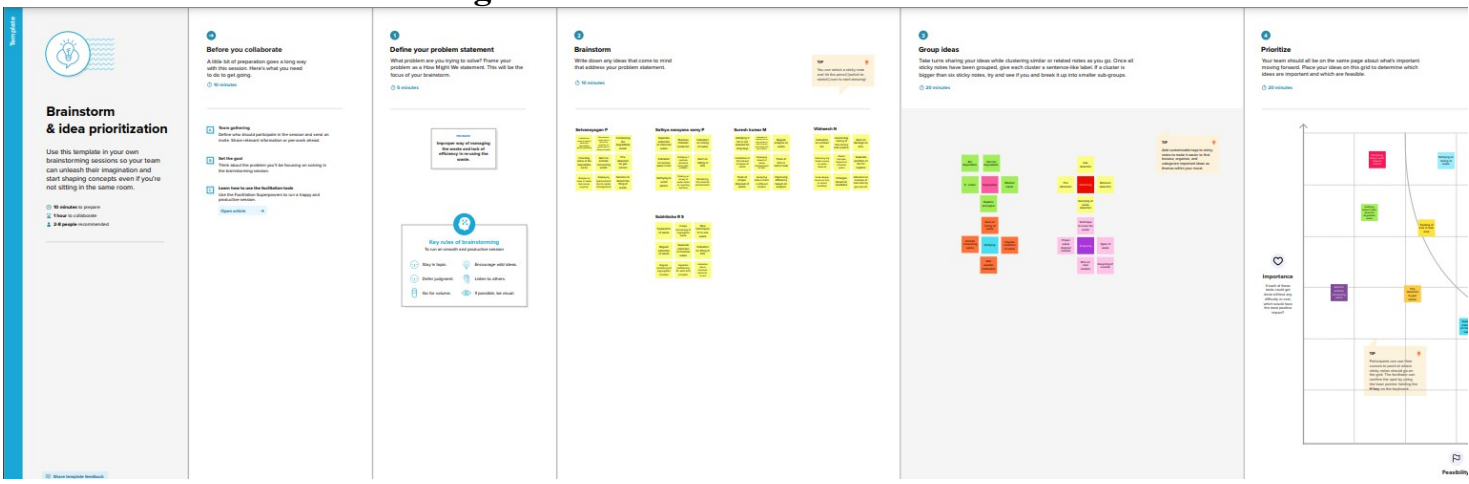
Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Whic
PS-1	A small waste garbage collector.	Use the technology and data to create a more efficient garbage waste. Based on IOT & Cloud.	Some drivers collect empty bins, predefined collection routes of the system cause waste of	The smart waste garbage collector is a specially designed method to dispose the garbage in a smart way.	When issues countr

2. IDEATION & PROPOSED SOLUTION

EMPATHY MAP CANVAS



Ideation and Brainstorming



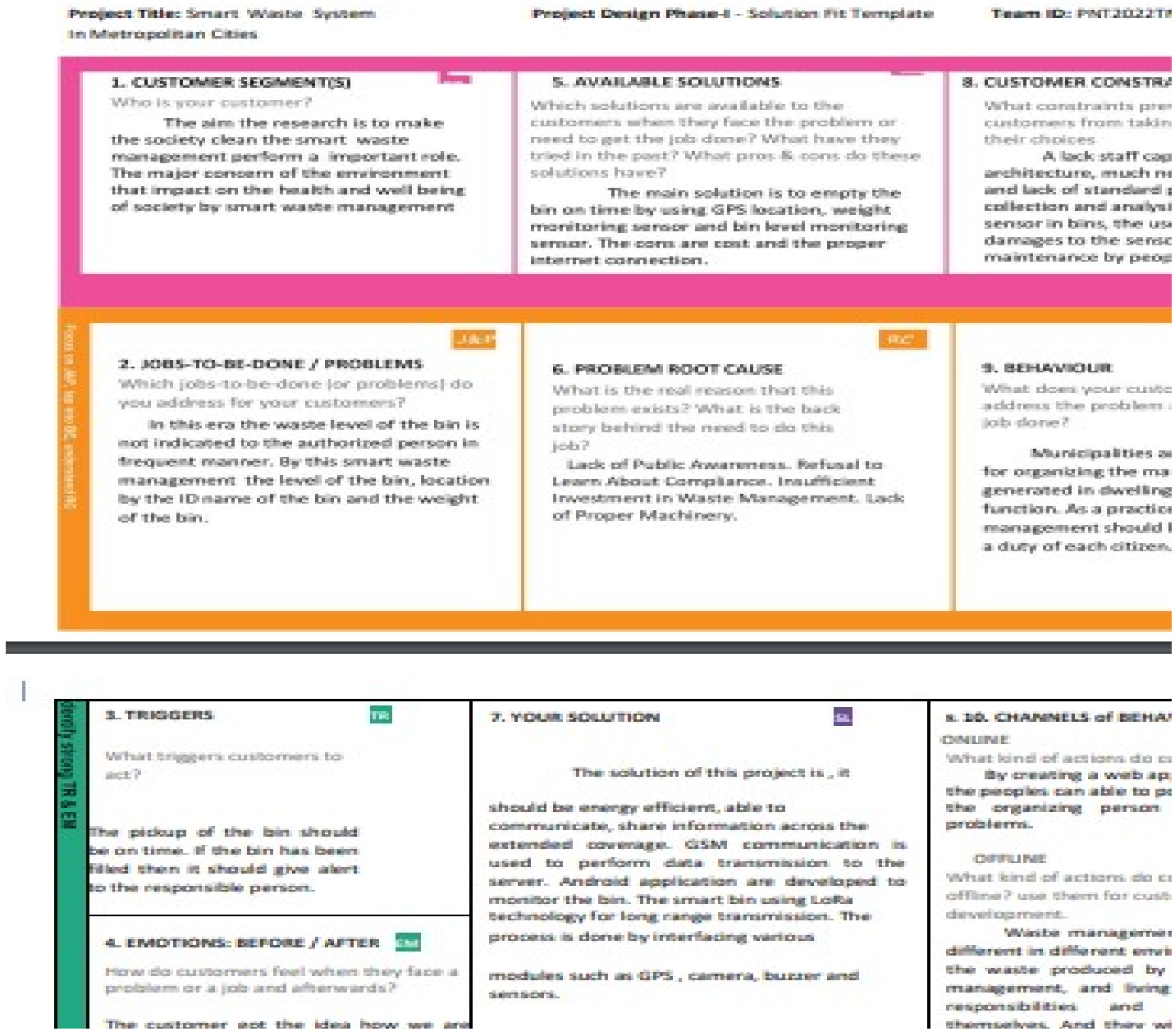
PROBLEM SOLUTON

S.NO	PARAMETER	DESCRIPTION
1	**Problem Statement (Problem to be solved)**	This project is dealing with the problem of waste management in cities, when the garbage collection system is not optimized. This system allows the authorised person to know the fill level of each garbage bin in a locality or city at all times and time saving to the truck drivers.
2	**Idea / Solution description**	• In the proposed system, whenever the waste bins gets filled this is the acknowledged by placing the circuit at the waste bin,which transmit it to the receiver at the desired place in the area . • The received signal indicates the waste bin status at monitoring and controlling system.The solution of this project is , it shouldbe energy efficient,able to communicateand share information across the extended area coverage. The smart binusing LoRatechnology for long transmission . GSM module is used to perform data transmission to the server.Android application are developed monitor the bin. • The overall process is done by interfacing various modules such as GPS, CAMERA, BUZZER and SENSORS. • Gas sensor has been usd tocapture the odour and smell and sends alert to the authorized person if theodour affects the people
3	**Novelty / Uniqueness**	This paper presented the smart waste

		management system by implementing sensors to monitor the status of bin, LoRa communication protocol for low power and long range data transmission and Tensor flow based object detection to performwaste identification and classification. The segregation of waste is interfaced and coordinated well between the object detectioncan be done using Raspberry pi
4	**Social Impact /Customer Satisfaction**	From the public perception as worst impact of present solid waste disposal practices are seen direct social impact such as neighbourhood of land fills to communities breeding of pests and loss in property value.Poor waste management contributes to climate change andair pollution and directly affect theeco systemand species.
5	**Business Model (Revenue Model)**	• **Solid Waste**, comprising the Company's waste collection, transfer, recycling andresource recovery, and disposal services, which are operated and managed locally by the Company's various subsidiaries, which focus on distinct geographic areas; and • **Corporate and Other**, comprising the Company's other activities, including itsdevelopment and operation of landfill gas-to-energy facilities in the US, and its recycling brokerage services, as well as variouscorporate functions.
6	**Scalability of the Solution**	This paper presented an efficient IoT-based and real-time waste management model for improving the living environment in cities. The proposed system uses sensors and communication technologies where waste data is collected from the smart bin ,in real

		time and then transmitted to an online platform where the authorized person can access and check the availability of the compartment scattered around the city.

PROBLEM SOLUTION FIT



4 . REQUIREMENT ANALYSIS

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.

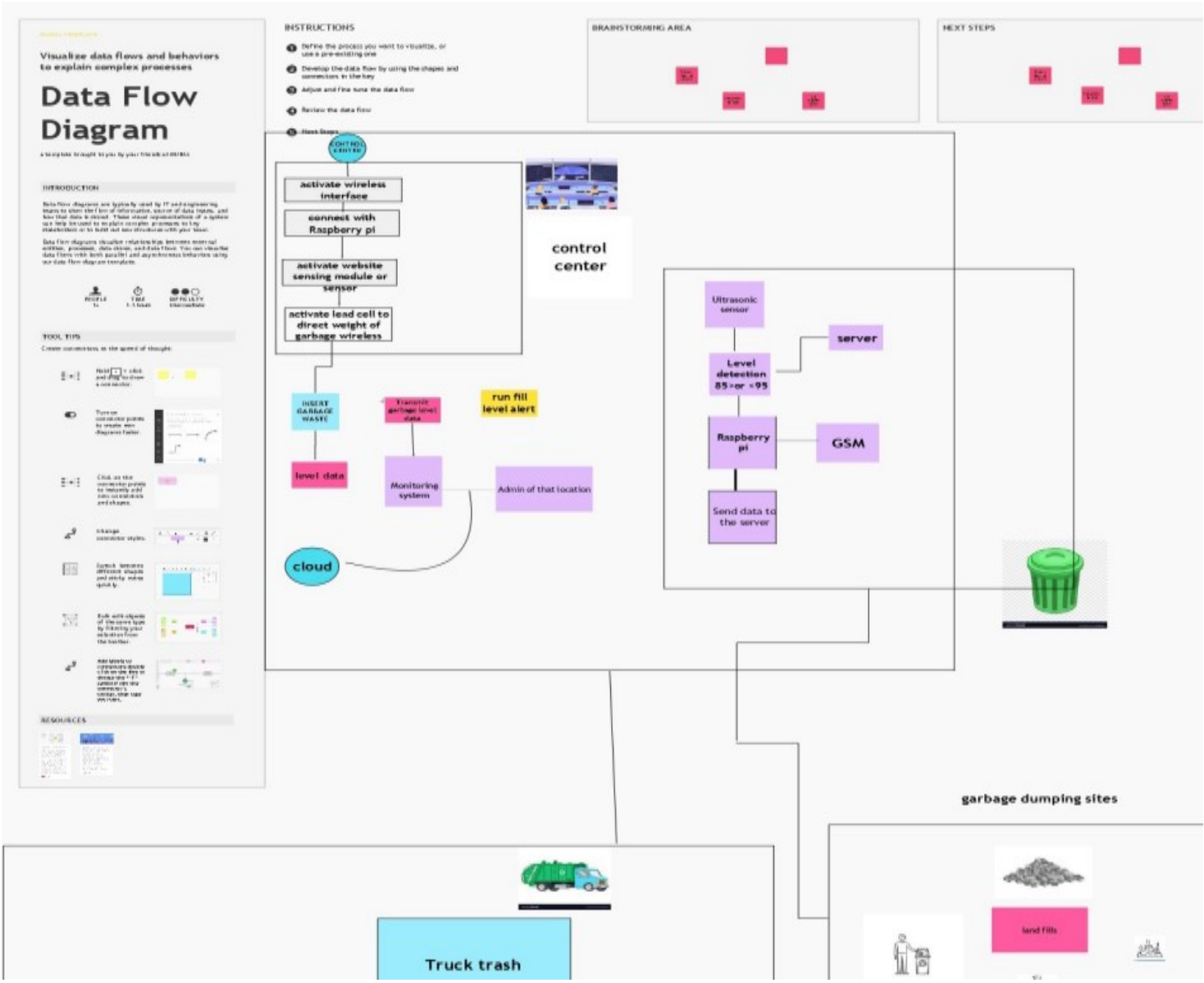
NON-FUNCTIONAL REQUIREMENT

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

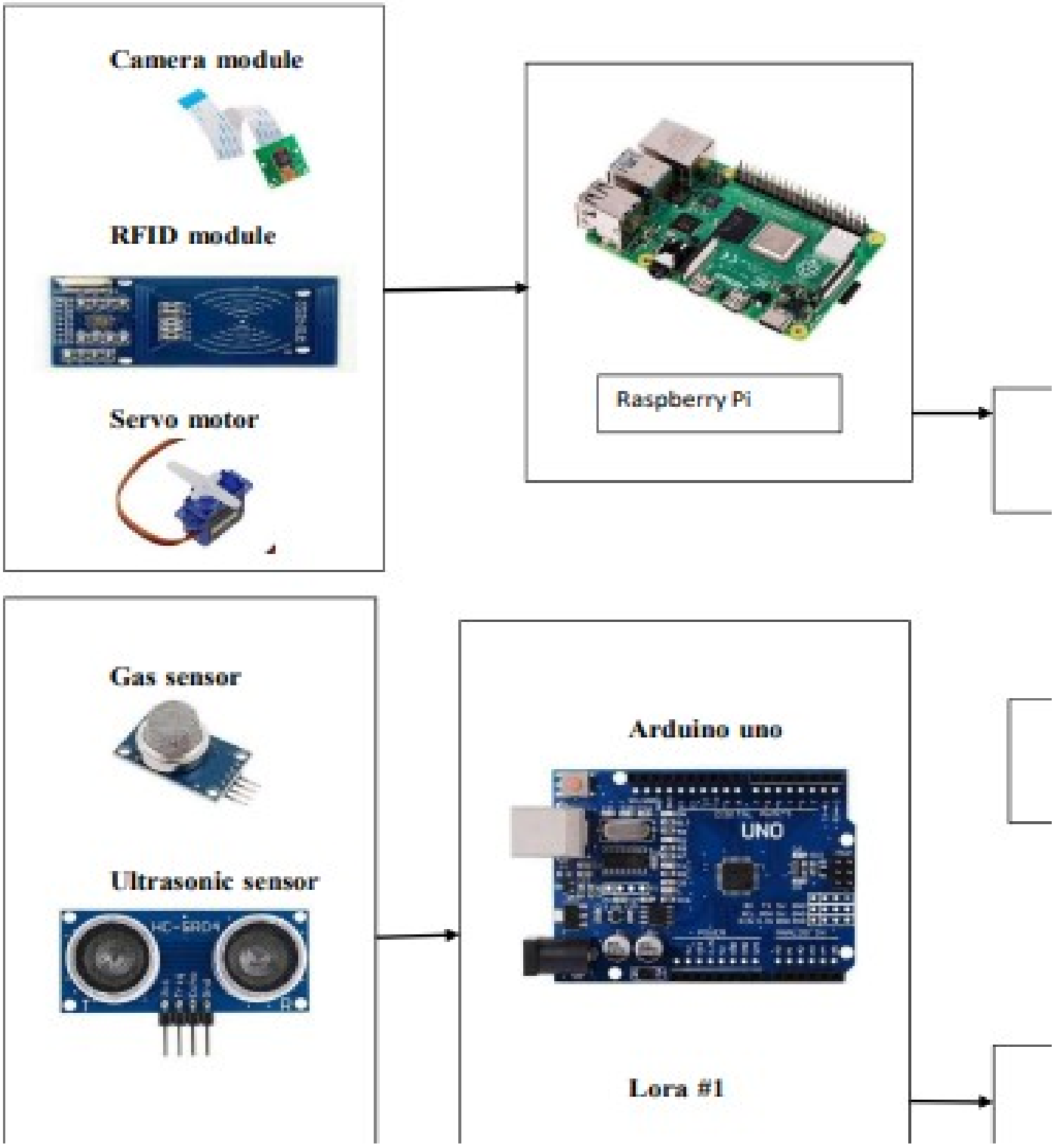
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Separate bins for recyclable and non
NFR-2	**Security**	Data fetched can be only accessed by authorized user
NFR-3	**Reliability**	Accurate data and availabity is displayed
NFR-4	**Performance**	Detects and intimates alerts on reaching 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

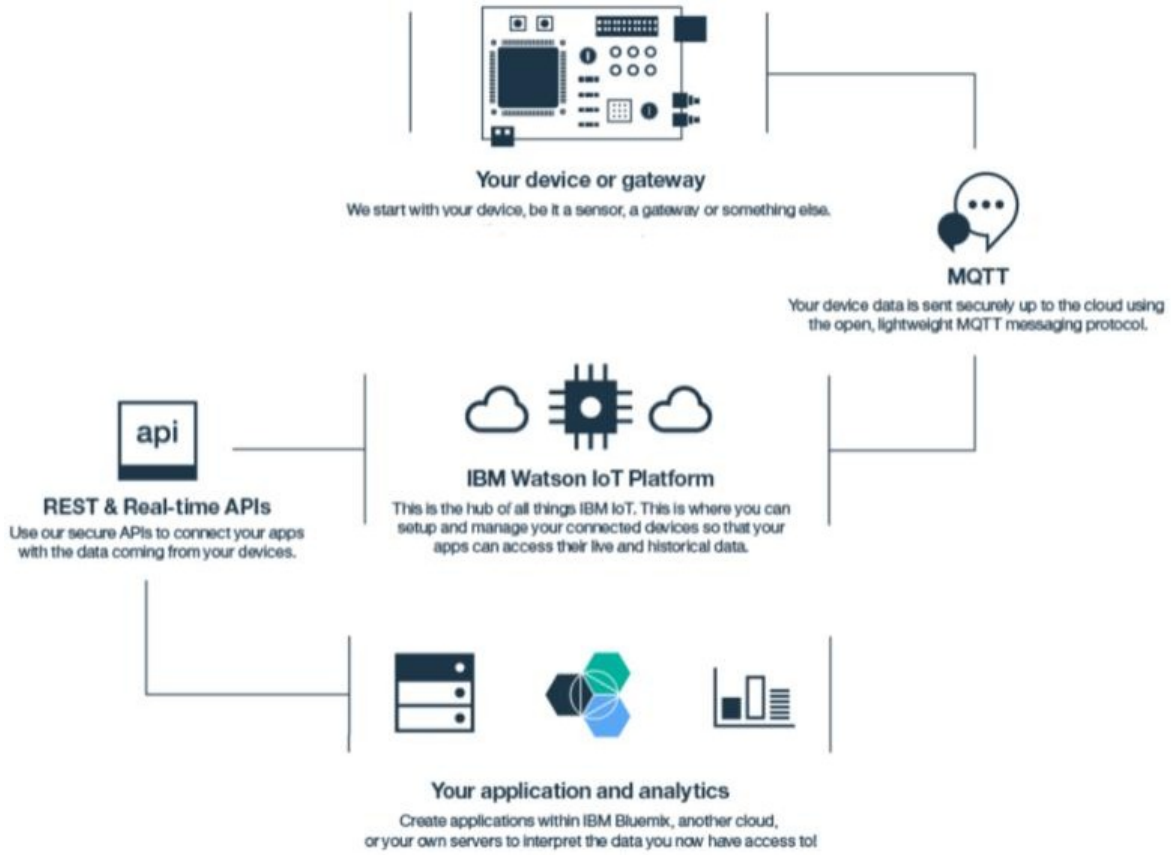
. DATA FLOW DIAGRAM



5.2. SOLUTION ARCHITECTURE AND TECHNICAL ARCHITECTURE


Camera module
RFID module
Servo motor
Raspberry Pi
Gas sensor
Ultrasonic sensor
Arduino uno
UNO
Lora #1

TECHNOLOGY STACK



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

. SPRINT PLANNING AND ESTIMATION

TITLE	DESCRIPTION	REI
Literature Survey and Information Gathering	Surveying on the topic of selected project & gathering information by referring the, technical papers ,research publications etc.	18
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user pains & gains on particular issue.	10
Brainstroming	Jot down the ideas by organizing the brainstorming session and prioritize the top 3ideas based on the feasibility & importance.	20
Proposed Solution	Prepare your proposed solution of the project which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc.	19
Problem Solution Fit	Prepare problem - solutionfit document.	19
Solution Architecture	Prepare solution architecture document.	19
Customer Journey Map	Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit)	19
Functional Requirement	Prepare the functional requirement for the project.	18
Data Flow Diagrams	Draw the data flow diagrams to understand the flow of executionof the project.	19
Technology Architecture	Prepare the technology architecture diagram.	19

SPRINT DELIVERY SCHEDULE

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Sign up / Sign in	USN - 1	User can signup using their email and password and confirm the details.	10	High	ASHRITHA H A
Sprint-1		USN - 2	A confirmation mail is sent to the user.	10	High	
Sprint-2	Login	USN - 3	User can login using login credentials and is authenticated.	20	Low	GOHUL J P
Sprint-3	Dashboard	USN - 4	User can view the previous login activities of the account and updates.	10	Medium	ASHIK SINHA J
Sprint - 4	Search Location	USN - 5	User can search for the bins available around the location.	10	High	ASHRITHA H A
Sprint - 4	Results / Grievances	USN - 6	User can post their grievances related to the bins and gets the results of bin status around the location from IBM Cloud.	10	High	AKASH K B

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	4 Days	26 Oct 2022	29 Oct 2022	20	30 Oct 2022
Sprint-2	20	4 Days	31 Oct 2022	04 Nov 2022	20	05 Nov 2022
Sprint-3	20	4 Days	06 Nov 2022	10 Nov 2022	20	11 Nov 2022
Sprint-4	20	4 Days	12 Nov 2022	16 Nov 2022	20	17 Nov 2022

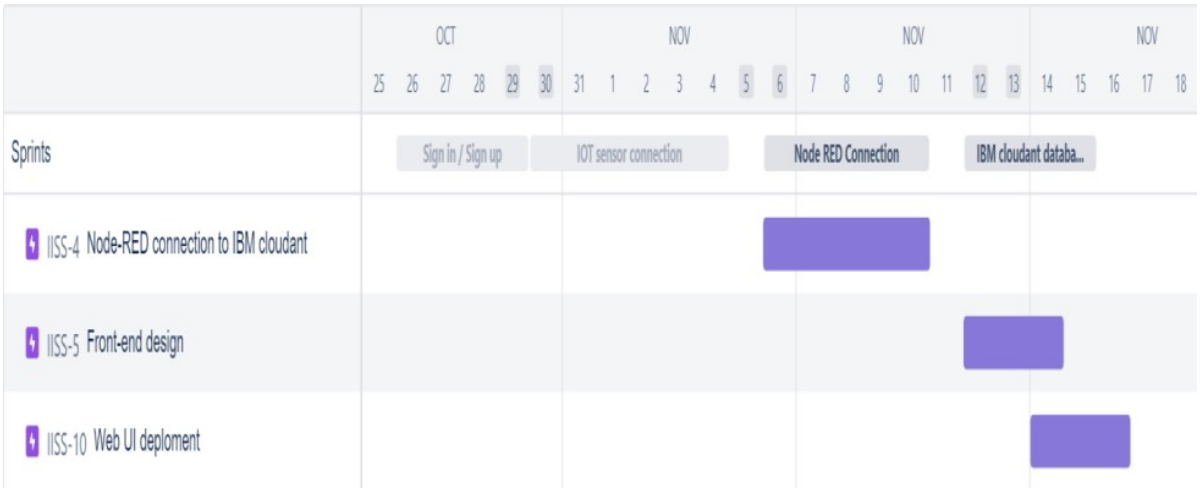
Velocity:

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)

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

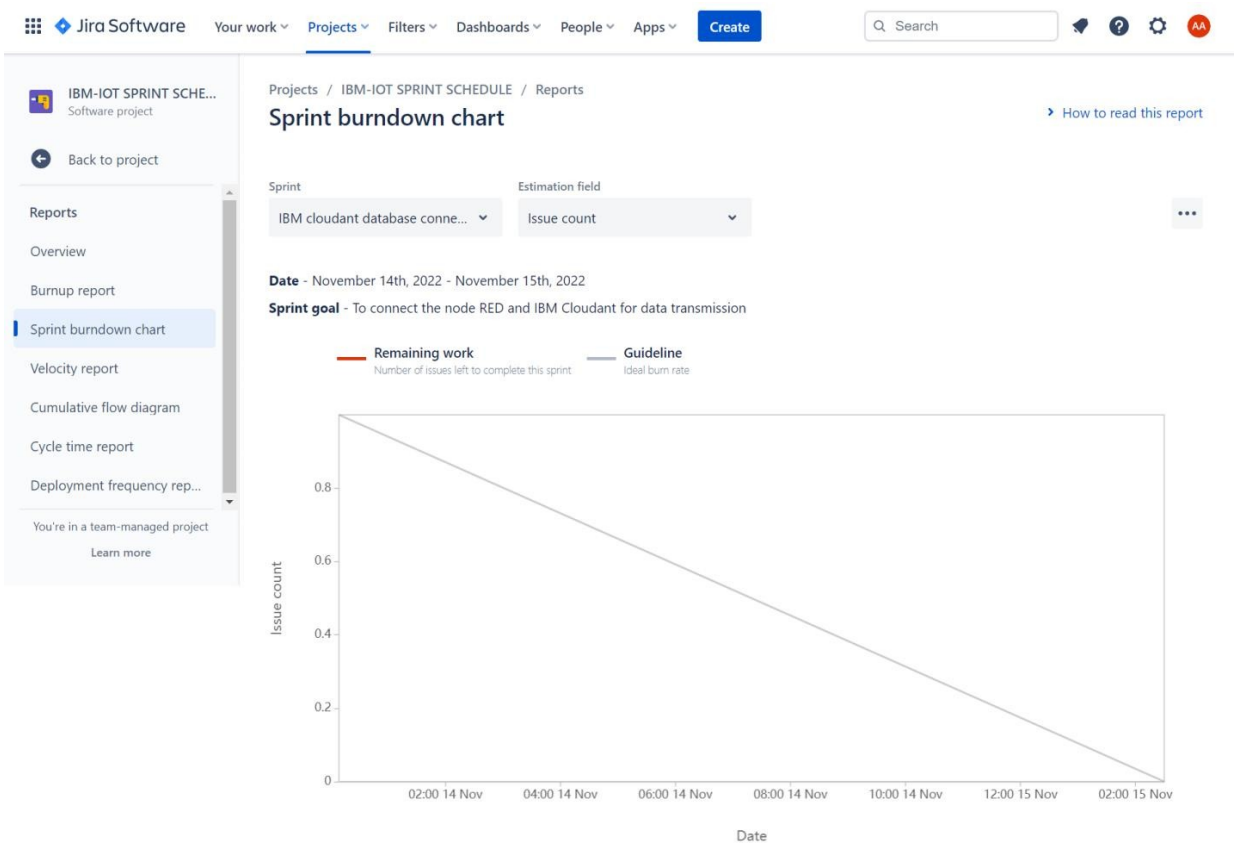
JIRA

REPORTS



ROADMAP

SPRINT BURNDOWN CHART


Jira Software
Your work
Projects
Filters
Dashboards
People
Apps
Create
Search
IBM-IOT SPRINT SCHE...
Software project
Back to project
Reports
Overview
Burnup report
Sprint burndown chart
Velocity report
Cumulative flow diagram
Cycle time report
Deployment frequency rep...
You're in a team-managed project
Learn more
Projects / IBM-IOT SPRINT SCHEDULE / Reports
Sprint burndown chart
How to read this report
Sprint
IBM cloudant database conne...
Estimation field
Issue count
Date - November 14th, 2022 - November 15th, 2022
Sprint goal - To connect the node RED and IBM Cloudant for data transmission
Remaining work
Number of issues left to complete this sprint
Guideline
Ideal burn rate
Issue count
0
0.2
0.4
0.6
0.8
02:00 14 Nov
04:00 14 Nov
06:00 14 Nov
08:00 14 Nov
10:00 14 Nov
12:00 15 Nov
02:00 15 Nov
Date

7. CODING AND SOLUTION

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 "9gbe4w"       // IBM organisation id
#define DEVICE_TYPE "SWMSMC"      //  Device  type
mentioned in ibm watson iot platform#define DEVICE_ID
"ibmproject"                    // Device ID mentioned in ibm
watson  iot  platform  #define  TOKEN  "sUNA41tG6-
Pq)0rk5X"                    // Token

//                    customise above values

char server[] = ORG ".messaging.internetofthings.ibmcloud.com";   // server name
char publishTopic[] = "iot-2/evt/data/fmt/json";   // topic name and type of event
perform and formatin which data to be send
char topic[] = "iot-2/cmd/led/fmt/String";          //  cmd  Represent  type  and
command is test format ofstrings
char authMethod[] = "use-token-auth";               //
authentication methodchar token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;     //Client id

//

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

#define ECHO_PIN 12
#define
```

```
TRIG_PIN
13float dist;
String data3;
bool
SealBin     =
true;      void
setup()
{
  Serial.begin(1152
  00);
  pinMode(LED_B
  UILTIN,
  OUTPUT);
  pinMode(TRIG_P
  IN,      OUTPUT);
  pinMode(ECHO_
  PIN, INPUT);
  //pir        pin
  pinMode(3
  4, INPUT);

  //ledpins
  pinMode(23
  , OUTPUT);
  pinMode(2,
  OUTPUT);
  pinMode(4,
  OUTPUT);
  pinMode(15
  , OUTPUT);

  lcd.init();
  lcd.backligh
  t();
  lcd.setCurso
  r(1,          0);
  lcd.print("");
```

```
  wifiConnect
  ();
  mqttConnect
  ();
}

float readcmCM()
{
  digitalWrite(TRI
  G_PIN,     LOW);
  delayMicrosecond
  s(2);
  digitalWrite(TRI
  G_PIN,     HIGH);
  delayMicrosecond
  s(10);
  digitalWrite(TRI
  G_PIN, LOW);
  int          duration          =
  pulseIn(ECHO_PIN,
  HIGH);  return   duration   *
  0.034 / 2;
}
```

```
void loop()
 {

  lcd.clear();

  publish
  Data();
  delay(50
  0);
  if (!client.loop())
    {
      mqttConnect();                    // function call to connect to IBM
    }
}

/*                          retrieving                  to                  cloud
                            */void wifiConnect()
{
  Serial.print("Connecti
  ng          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("Motio
    n              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("Li
  d          Closed");
  lcd.print("Full!
  Don't        use");
  delay(2000);
  lcd.clear();
  digitalWrite(
  4,      LOW);
  digitalWrite(
  23, LOW);
 }
 else if(cm > 100 && cm < 180)
 {
  digitalWrite(4, HIGH);
  Serial.println("Warning!!,Trash is about to cross
  50% of bin level");digitalWrite(2, LOW);
  digitalWrite(23, LOW);

 }
 else if(cm > 180)
 {
  digitalWrite(23,
  HIGH);
  Serial.println("Bin   is
  available");
  digitalWrite(2,LOW);
  digitalWrite(4,
  LOW);

 }
  delay(10000);
  Serial.println("Lid Closed");
}
else
{
 Serial.println("No
  motion      detected");
  digitalWrite(2,  LOW);
```

```
    digitalWrite(15,
    LOW);  digitalWrite(4,
    LOW);
    digitalWrite(23,
    LOW);
 }

}
  else
  {
    digitalWrite(15, LOW);

  }


  if(cm <= 100)
{
digitalWrite(21,HIGH);
String      payload      =
"{\"High_Alert\":";
payload += cm;
payload    +=    "    }";
Serial.print("\n");
Serial.print("Sending
payload:                 ");
Serial.println(payloa
d);

if (client.publish(publishTopic, (char*) payload.c_str()))        //     if     data     is
uploaded to cloud successfully,prints publish okelse prints publish failed
{
Serial.println("Publish OK");
}
}
else if(cm <= 180)
{
digitalWrite(22,HIGH);
String     payload     =
```

```
"{\"Warning\":";
payload += cm ;
payload    +=    "    }";
Serial.print("\n");
Serial.print("Sending
payload:                 ");
Serial.println(payloa
d);
if(client.publish(publishTopic, (char*) payload.c_str()))
{
Serial.println("Publish OK");
}
else
```

```
{
Serial.println("Publish FAILED");
}
}
else if(cm > 180)
{
digitalWrite(2
3,HIGH);
String
payload      =
"{";   payload
+= cm;
payload   +=   "   }";
Serial.print("\n");
Serial.print("Sending
payload:               ");
Serial.println(payloa
d);

if (client.publish(publishTopic, (char*) payload.c_str()))        // if data is
uploaded to cloud successfully,prints publish okelse prints publish failed
{
Serial.println("Publish OK");
}

}

  float inches = (cm / 2.54);                    //print
  on lcdlcd.setCursor(0,0);
  lcd.print("Inc
  hes");
  lcd.setCursor
  (4,0);
  lcd.setCursor
  (12,0);
  lcd.print("cm
  ");
```

```
  lcd.setCursor
  (1,1);
  lcd.print(inc
  hes,          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
        {
```

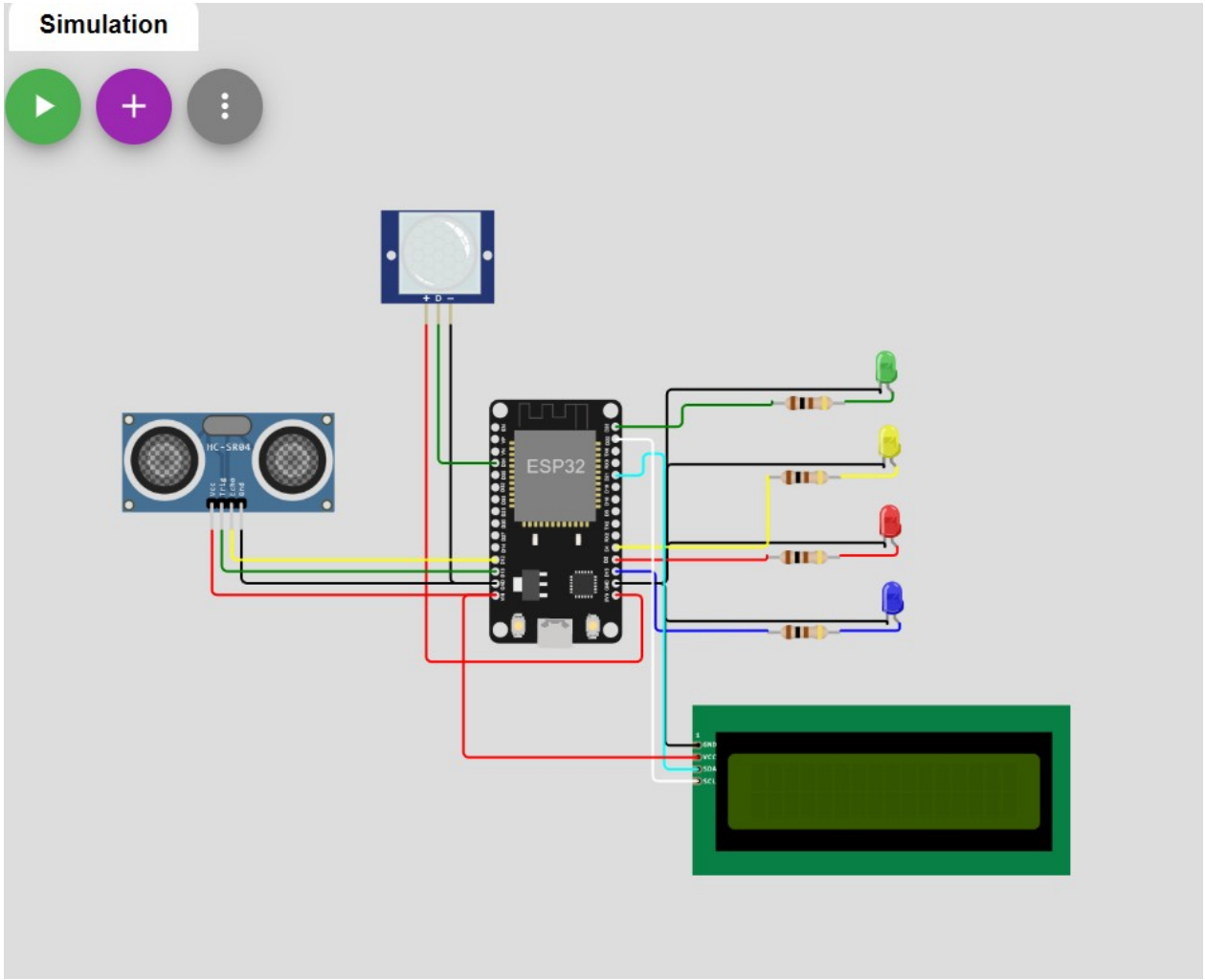
```
        String
        command(buf,len);
        if(command=="\"Seal
        Bin\"")
        {
          SealBin = true;

        }


        }

  data3="";
}
```

. Sensor Connection Setup



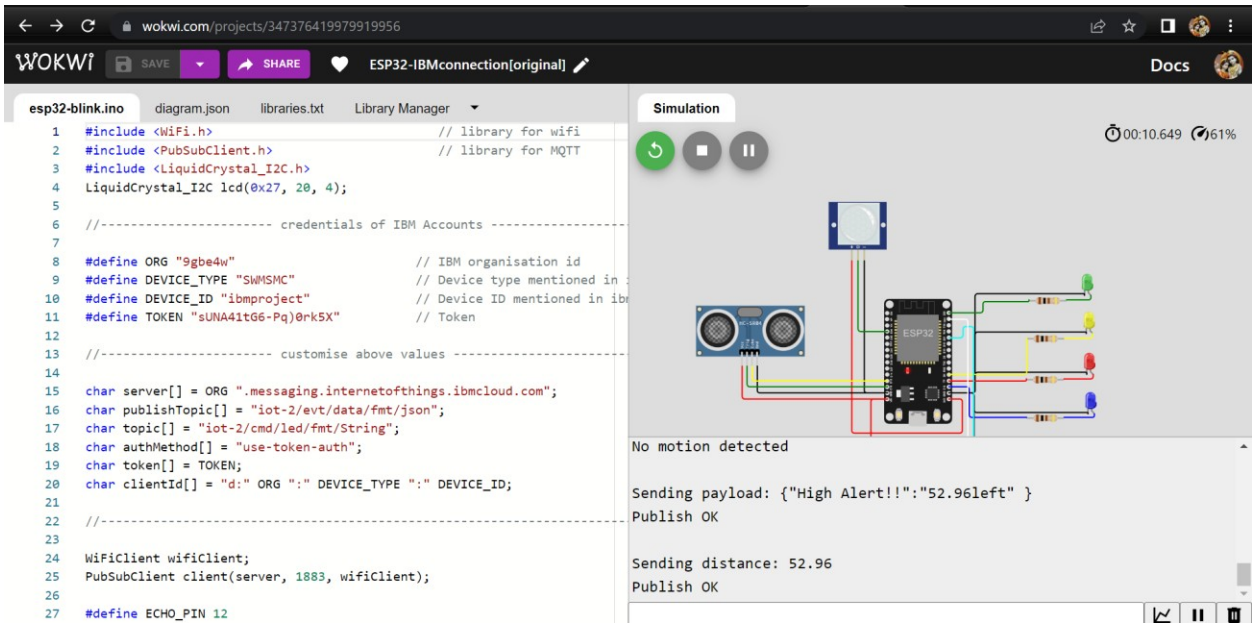
PHYSICAL COMPONENTS:

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

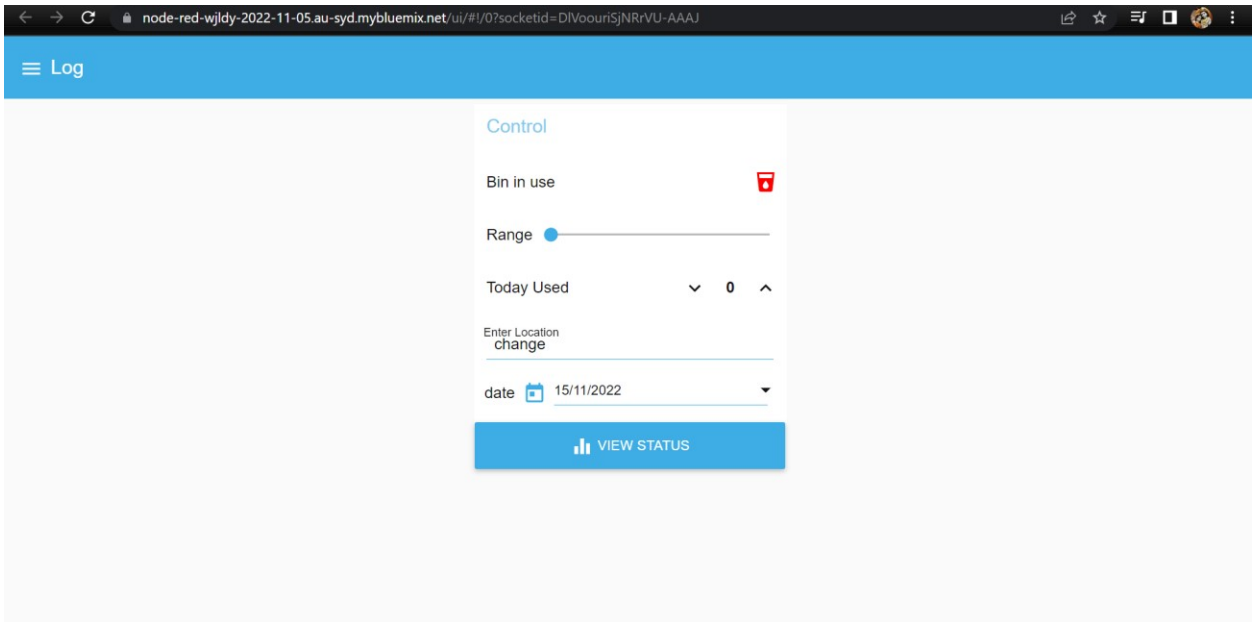
OUTPUT:

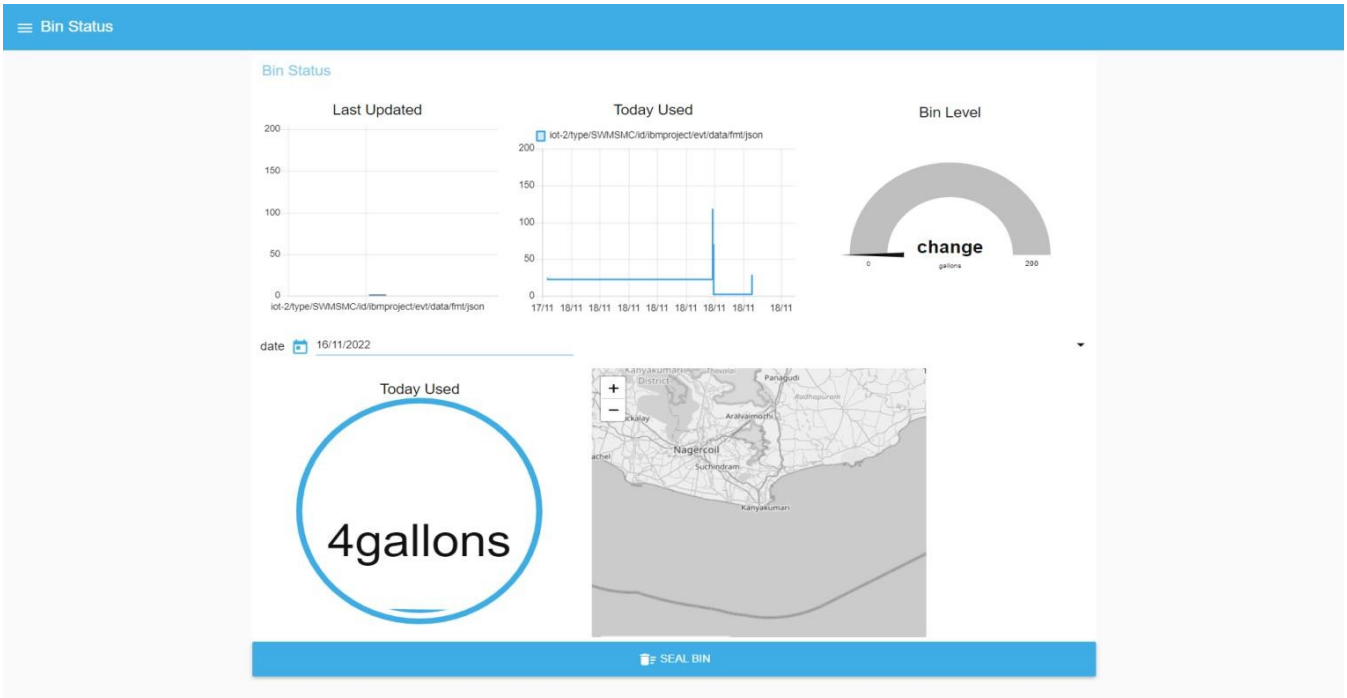
WOKWI

SETUP


wokwi.com/projects/347376419979919956
WOKWI
SAVE
SHARE
ESP32-IBMconnection[original]
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>
LiquidCrystal_I2C lcd(0x27, 20, 4);
//---------- credentials of IBM Accounts ----------
#define ORG "9gbe4w" // IBM organisation id
#define DEVICE_TYPE "SWMSMC" // Device type mentioned in
#define DEVICE_ID "ibmproject" // Device ID mentioned in ib
#define TOKEN "sUNA41tG6-Pq)0rk5X" // 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
Simulation
00:10.649
61%
ESP32
No motion detected
Sending payload: {"High Alert!!":"52.96left" }
Publish OK
Sending distance: 52.96
Publish OK

WEB UI


node-red-wjldy-2022-11-05.au-syd.mybluemix.net/ui/#!/0?socketid=DlVoouriSjNRrVU-AAAJ
Log
Control
Bin in use
Range
Today Used
0
Enter Location
change
date
15/11/2022
VIEW STATUS



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.

Test Case:

Maximum Size of Bin : 200 cm Safe limit: below 100 cmMinimum 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 locationand status of the bin displayed to the admin.

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

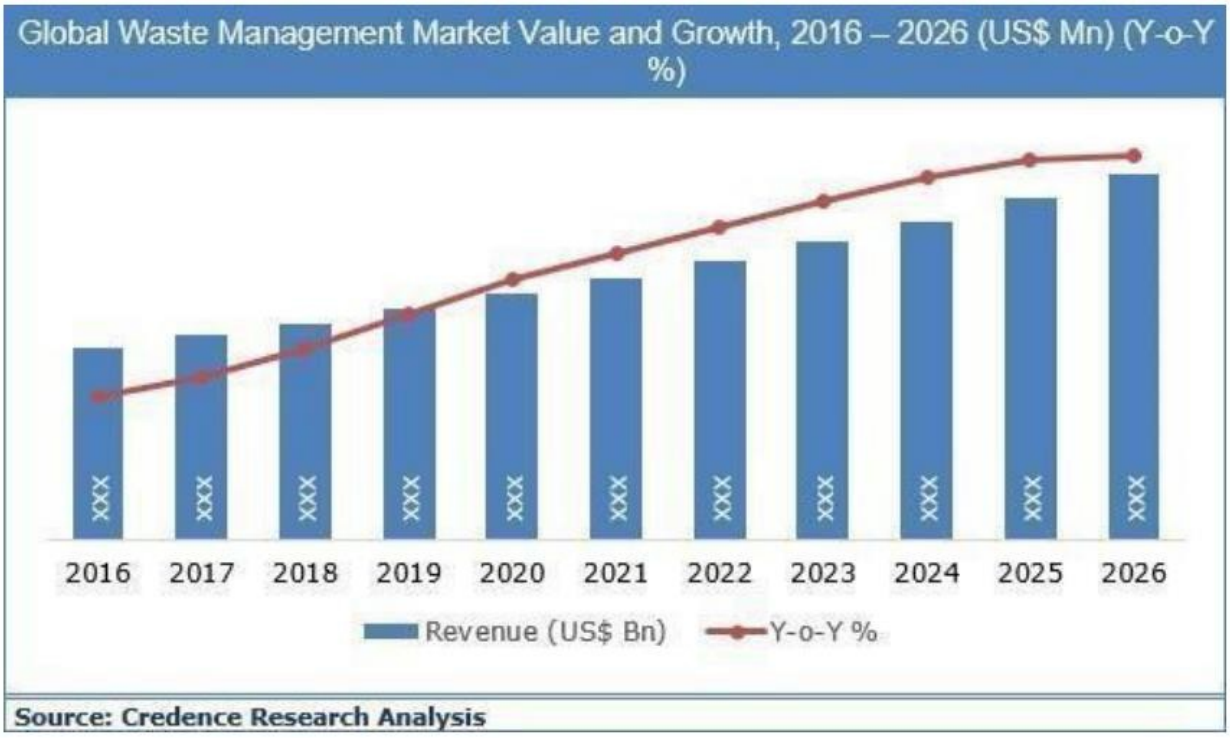
3. TEST CASE ANALYSIS

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

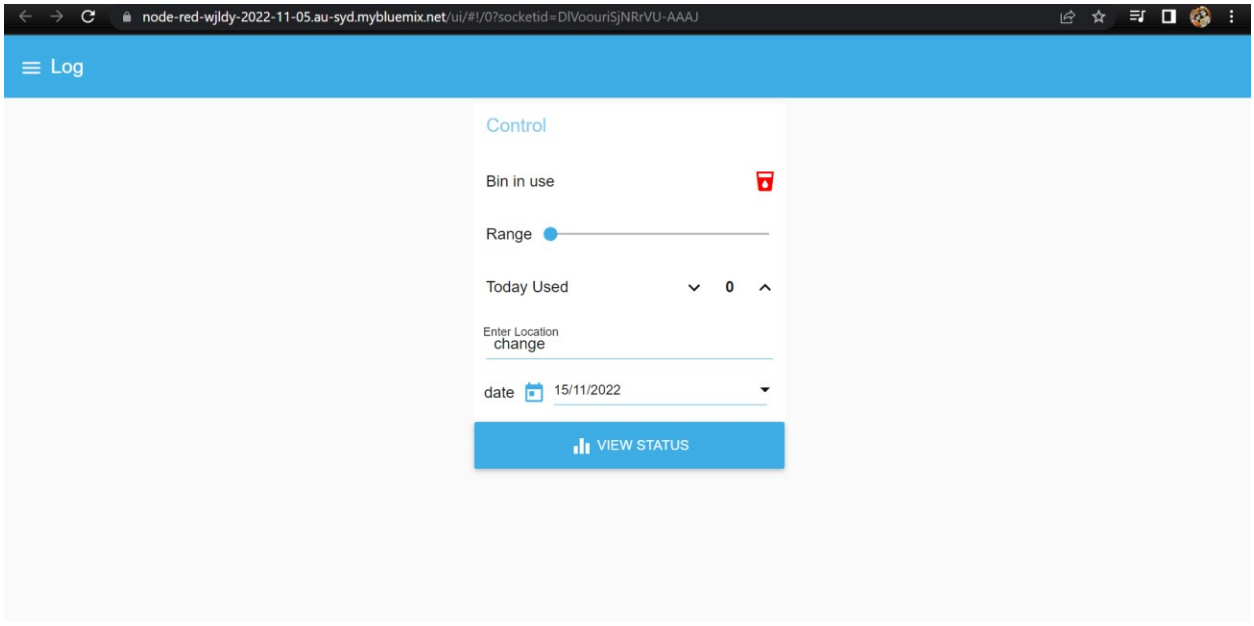
Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	51	0	0	51
Security	2	0	0	2
Outsource Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

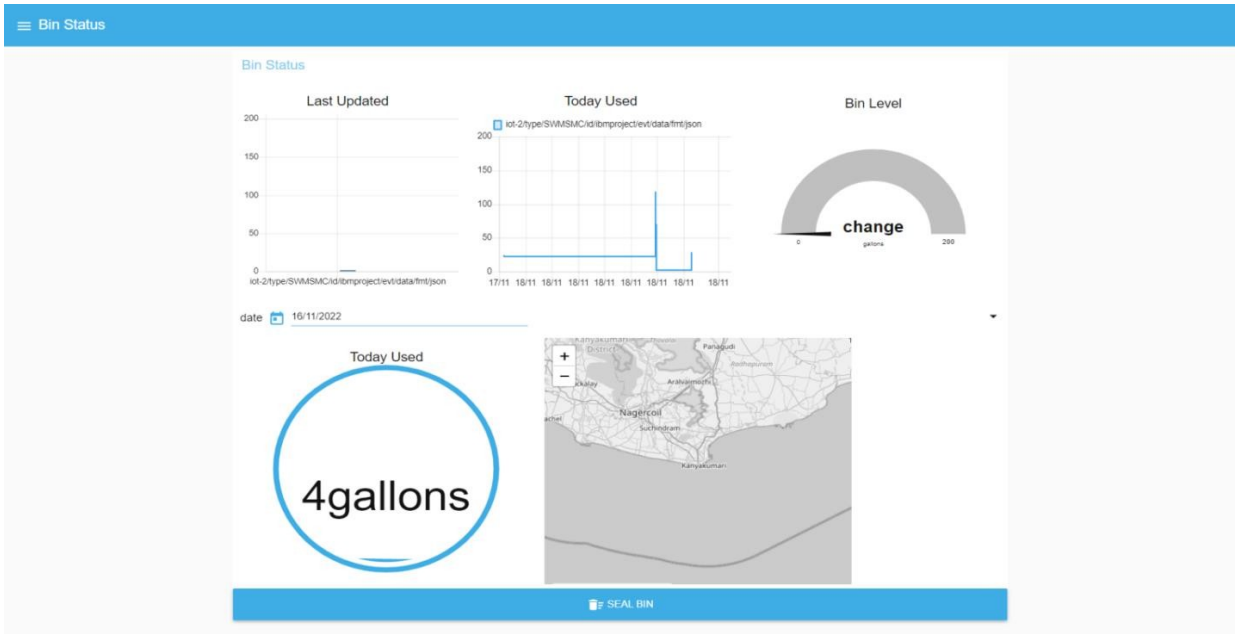
9. RESULTS

Performance Metrics



9.2 . Admin Web UI





10. ADVANTAGES AND DISADVANTAGES

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

14. 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.

13.1. Source code

```
#include <WiFi.h>               // library for wifi
#include <PubSubClient.h>   // library for
MQTT#include <LiquidCrystal_I2C.h>
#include    <mjson.h>
LiquidCrystal_I2C
lcd(0x27, 20, 4);

//                  credentials of IBM Accounts

#define ORG "9gbe4w"      // IBM organisation id
#define DEVICE_TYPE "SWMSMC"      //  Device  type
mentioned in ibm watson iot platform#define DEVICE_ID
"ibmproject"                  // Device ID mentioned in ibm
watson  iot  platform  #define  TOKEN  "sUNA41tG6-
Pq)0rk5X"                     // Token

//                  customise above values

char                server[]                =                ORG
".messaging.internetofthings.ibmcloud.com";      //  server
namechar publishTopic[] = "iot-2/evt/data/fmt/json";
 //  topic  name  and  type  of  event  perform  and
format in which data to be sendchar 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
wificlientPubSubClient client(server, 1883, wifiClient);

#define ECHO_PIN 12
#define
TRIG_PIN
13float dist;
String data3;
bool
SealBin     =
true;     void
setup()
{
  Serial.begin(1152
  00);
  pinMode(LED_B
  UILTIN,
  OUTPUT);
  pinMode(TRIG_P
  IN,     OUTPUT);
  pinMode(ECHO_
  PIN, INPUT);
  //pir       pin
  pinMode(3
  4, INPUT);

  //ledpins
  pinMode(23
  , OUTPUT);
  pinMode(2,
  OUTPUT);
  pinMode(4,
  OUTPUT);
  pinMode(15
  , OUTPUT);
```

```
  lcd.init();
  lcd.backligh
  t();
  lcd.setCurso
  r(1,          0);
  lcd.print("");
  wifiConnect
  ();
  mqttConnect
  ();
}

float readcmCM()
{
  digitalWrite(TRI
  G_PIN,      LOW);
  delayMicrosecond
  s(2);
  digitalWrite(TRI
  G_PIN,     HIGH);
  delayMicrosecond
  s(10);
  digitalWrite(TRI
  G_PIN, LOW);
  int           duration           =
  pulseIn(ECHO_PIN,
  HIGH); return   duration   *
  0.034 / 2;
}

void loop()
```

```
 {

  lcd.clear();

  publish
  Data();
  delay(50
  0);
  if (!client.loop())
    {
      mqttConnect();                    // function call to connect to IBM
    }
}

/*                              retrieving to cloud                                */

void wifiConnect()
{
  Serial.print("Connecti
  ng          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("Motio
    n              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("Li
  d          Closed");
  lcd.print("Full!
  Don't          use");
  delay(2000);
```

```
  lcd.clear();
  digitalWrite(
  4,       LOW);
  digitalWrite(
  23, LOW);
 }
 else if(cm > 100 && cm < 180)
 {
  digitalWrite(4, HIGH);
  Serial.println("Warning!!,Trash is about to cross
  50% of bin level");digitalWrite(2, LOW);
  digitalWrite(23, LOW);

 }
 else if(cm > 180)
 {
  digitalWrite(23,
  HIGH);
  Serial.println("Bin   is
  available");
  digitalWrite(2,LOW);
  digitalWrite(4,
  LOW);

 }
  delay(10000);
  Serial.println("Lid Closed");
}
else
{
  Serial.println("No
  motion       detected");
  digitalWrite(2,  LOW);
  digitalWrite(15,
  LOW);  digitalWrite(4,
  LOW);
  digitalWrite(23,
  LOW);
```

```
 }

}
  else
  {
    digitalWrite(15, LOW);

  }


  if(cm <= 100)
{
digitalWrite(21,HIGH);
String      payload      =
"{\"High_Alert\":";
payload += cm;
payload    +=    "    }";
Serial.print("\n");
Serial.print("Sending
payload:                 ");
Serial.println(payloa
d);

if (client.publish(publishTopic, (char*) payload.c_str()))        //      if      data      is
uploaded to cloud successfully,prints publish okelse prints publish failed
{
Serial.println("Publish OK");
}
}
else if(cm <= 180)
{
digitalWrite(22,HIGH);
String     payload     =
"{\"Warning\":";
payload += cm ;
payload    +=    "    }";
Serial.print("\n");
Serial.print("Sending
```

```
payload:                  ");
Serial.println(payloa
d);
if(client.publish(publishTopic, (char*) payload.c_str()))
{
Serial.println("Publish OK");
}
else
{
Serial.println("Publish FAILED");
}
```

```
}
  else if(cm > 180)
  {
  digitalWrite(2
  3,HIGH);
  String
  payload      =
  "{";   payload
  += cm;
  payload   +=   "   }";
  Serial.print("\n");
  Serial.print("Sending
  payload:              ");
  Serial.println(payloa
  d);

  if (client.publish(publishTopic, (char*) payload.c_str()))      // if data is
  uploaded to cloud successfully,prints publish okelse prints publish failed
  {
  Serial.println("Publish OK");
  }

  }

   float inches = (cm / 2.54);                  //print
   on lcdlcd.setCursor(0,0);
   lcd.print("Inc
   hes");
   lcd.setCursor
   (4,0);
   lcd.setCursor
   (12,0);
   lcd.print("cm
   ");
   lcd.setCursor
   (1,1);
```

```
  lcd.print(inc
  hes,          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=="\"Seal
        Bin\"")
        {
          SealBin = true;

        }


        }

  data3="";
}
```

13.2 . GITHUB LINK

LINK : https://github.com/IBM-EPBL/IBM-Project-39181-1660399380

VIDEO DEMO LINK:

https://drive.google.com/file/d/1peaICp7TE2ZeZH1Mgd87SlGZCWTphrMF/view?usp=sharing