IBM NALAIYA THIRAN PROJECT

SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

TEAM ID: PNT2022TMID04297

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1.INTRODUCTION

1.1 Project Overview

The growing population and mass relocation of citizens from urban and semi-urban areas to Smart Cities have resulted in exponential growth in Smart Cities and thereby certain challenges. One of the major challenges Smart Cities are facing is to control, manage and process waste generation on a daily basis. Waste collection and processing at a wider scale is not an easy job. The growing population and resource constraints in waste management activities are the primary reasons, which have made waste management a tough job. To deal with this challenging process, Smart Cities use Smart Waste Management System. This paper has provided an overview of a typical Smart Waste Management system and a review of selected research papers on Smart Waste Management. We tried to identify areas of improvement with existing Smart Waste Management Solutions and proposed an innovative solution called "SmartWMS" for carrying out waste management specifically for Smart Cities. The paper has discussed in detail the architecture and building blocks of the proposed Smart Waste Management System, along with the details of software tools, sensors, and technologies proposed in SmartWMS. The Paper has finally discussed results with respect to the prototype implementation of SmartWMS and also future plans to further improve the iSmartWMS smart waste management system.

IoT based smart waste management system for smart city is a technology for smart cities that uses sensors installed in the trash and garbage bins to notify the city collection service providers to empty the bins. These programs make waste collection more efficient and cost-effective. It also gives a visual appeal in the public spaces ensuring that the bins are emptied before overflowing.With the increase in the waste management initiatives by smart cities, even the urban areas are willing to implement smart waste management programs to improve efficiency and develop a cleaner city.

1.2 Purpose

- Smart waste management technology improves the management of the city services by using in-built sensors where data analytics and technology together notifies the waste collectors, reduces the odor, and enhances the appearance of the bins in public areas. In addition, it helps improve the quality of life of the people.
- A study says that smart sensors reduce the cost of waste collection by 20%. A smart future of waste systems can fetch you a reduction in operational costs and time. More demand for IoT based smart garbage and waste collection bins need to be implemented and managed for a better environment.

2.LITERATURE SURVEY

2.1 Existing problem

1) Smart City Waste Management through ICT and IOT driven

Authors: Dipak.G , P.S.Aithal

Published Month & Year: May 6, 2021

Project Description:

The growing population and mass relocation of citizens from urban and semi-urban areas to Smart Cities have resulted in exponential growth in Smart Cities and thereby certain challenges. One of the major challenges Smart Cities are facing is to control, manage and process waste generation on a daily basis. Waste collection and processing at a wider scale is not an easy job. The growing population and resource constraints in waste management activities are the primary reasons, which have made waste management a tough job. To deal with this challenging process, Smart Cities use Smart Waste Management System. (iSmartWMS).

2) Household Waste Management SystemUsing IoT

Authors: Pushpa Singh , Krishna Kant Singh

Published Year & Month: 16 April 2020

Project Description:

This model discusses the collection and decomposition of waste in thesmart way so that benefitfrom the waste is maximized and the actualwaste is minimized efficiently. This paper focus on the segregation of the waste at two levels: the first level of segregation is on the individual house of thesociety and the second level of segregation is at the society. Author,discuss the recycling of the biodegradable waste for makingcompost. The machine learning technique such as KNN is used to generate an alert message for various combinations of three sensor values like level of bio and non-biodegradable waste, concentration of poisonous gas. The overall impact of this research is in the upliftment of the green technologies by reducingpollutants, conserving, resourcing and reusing the energy throughthe use of technology.

3) Smart Waste Collection System

Authors: Javed Ramzan; Muhammad Wasif Nisar

Published Month & Year: 10 June 2018

Project Description:

This project named smart waste collection is need of today as there is no efficient waste collection system installed in the earth these days this systemis to revolve the waste collection method of the advancing technological 21st century. This system is supported by an android app named “SWC” and firebase real-time data for more efficient user-friendly usage. where’s cloud storage also makes it easier for storage of collection records providing the authorized origination to control manage and audit performance data. To compare several collectors, their configurations, and program behavior, we use an accurate simulator that models all heap objects and the pointers among them, but does not model cache or other memory effects. For object-oriented languages, our results demonstrate that

an older-first collector, which collects older objects before the youngest ones, copies on average much less data than generational collectors. More importantly, we reopen for consideration the question where in the heap and with which policiescopying collectors will achieve their best performance.

4) Smart Garbage Management System

Author: Akshat Mishra, Sushmit Mehta, Vivek Solvande

Published Month & Year :05 January2018

Project Description:

The proposed system monitors the garbage bin. While monitoring the garbage bin it sends the notification to the authority about the level of garbage filled. If the lower authority ignores the notification, the nextnotification goes to the higher authority. The proposed system will help them to actually know that where and when to go to collect the garbage. The proposed system manages the effort to check the area by visiting there. The proposed project is quite helpful for both the Brihan Mumbai Municipal Corporation (BMC) and the citizens in that area by time-to- time interaction between Brihan Mumbai Municipal Corporation (BMC) and the proposed system. Hence the proposed system makes a better way to managegarbage.

2.2 References

1) Smart City Waste Management through ICT and IOT driven
https://www.researchgate.net/publication/351561434_Smart_City_Waste_Management_through_ICT_and_IoT_driven_Solution

2) Household Waste Management SystemUsing IoT
https://www.researchgate.net/publication/340700214_Household_Waste_Management_System_Using_IoT_and_Machine_Learning

3) Smart Waste Collection System
https://www.researchgate.net/publication/344920002_Smart_Waste_Collection_System_BS_Final_Year_Project_Report

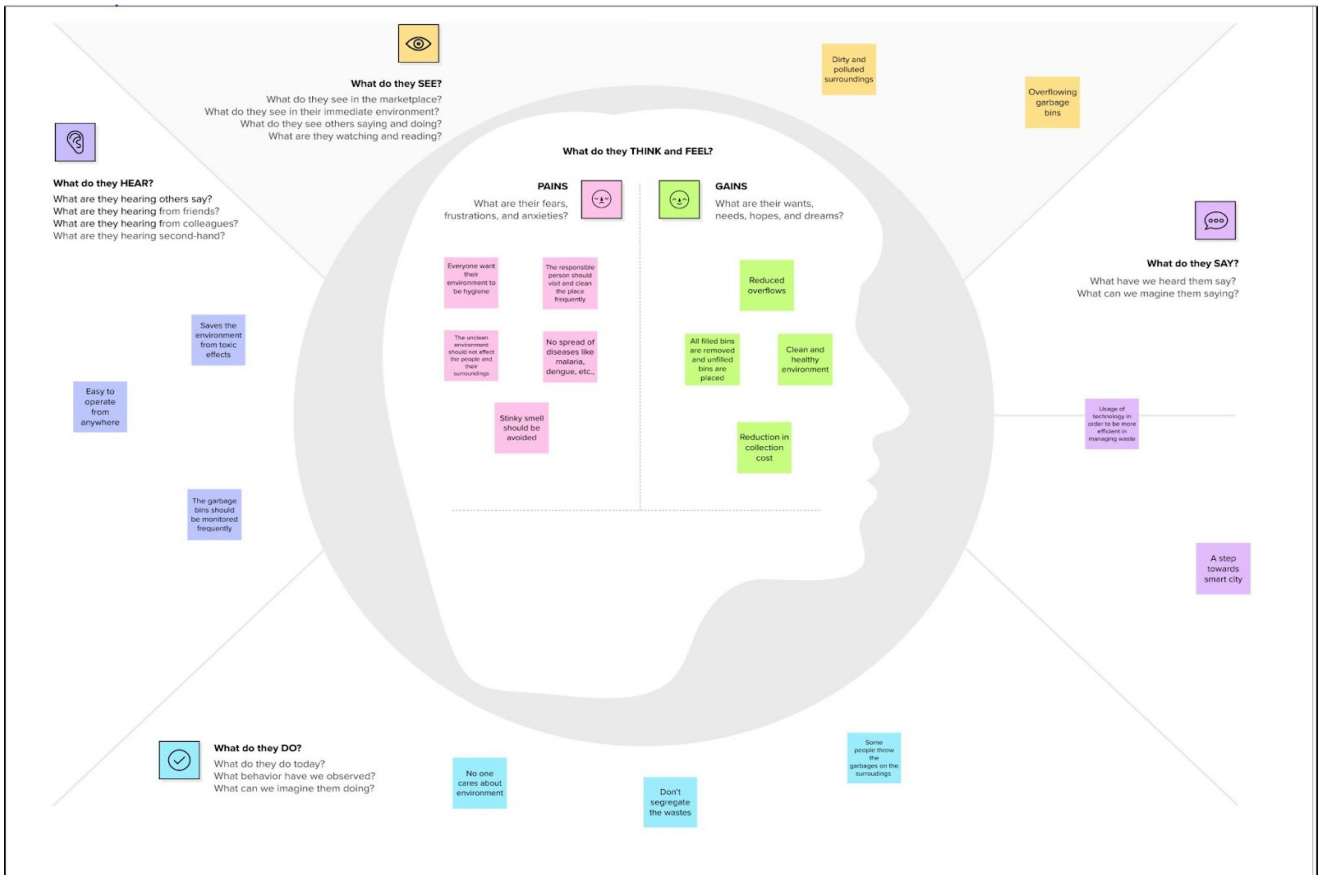
4) Smart Garbage Management System
https://ieeeprojectsmadurai.com/IEEE%202019%20IOT%20BASEPAPERS/27_SMART%20GARBAGE%20DETECTION.pdf

2.3 Problem statement Definition

Smart Cities are rapidly growing and globally set up by various countries for providing world-class services and enjoyable life to their residents. This has attracted many citizens to Smart Cities by leaving their existing cities and hometowns. This has resulted in exponential growth and expansion of Smart Cities at the same time multi-fold problems like an overload on Smart Cities to handle the growing population and to effectively control the waste produced by the huge population, let it be human beings made waste, industrial waste, environmental waste and or medical waste. If a large amount of generated waste is not handled correctly and efficiently, it can generate a hazardous situation and can cause danger to Residents. Also, a shortfall can be possible with some of the necessary items which go to waste after initial use, and if we do not recycle them, such items cost gets increases over time due to shortfall in supply and causes impacting the economy. If we can find out a way to ensure safe and efficient waste management with low cost and low processing time, it will not only help to maintain healthy surroundings but also by recycling reusable waste, it can easily boost the economy and manage the shortfall of necessary items such as paper, footwear, stationery items, tyres, remouldable plastic.

3.IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.2 Ideation & Brainstorming

Brainstorm

Varsha

The sensor values are collected

The collected data is stored and maintained in a cloud platform

Sivapriya

Amount of garbage collected in bins is monitored using sensor

Analyse the sensor data to indicate the municipality

Mahalakshmi

Level of garbage is monitored whether it reached threshold or not

Once the threshold limit is reached, GPS location is sent

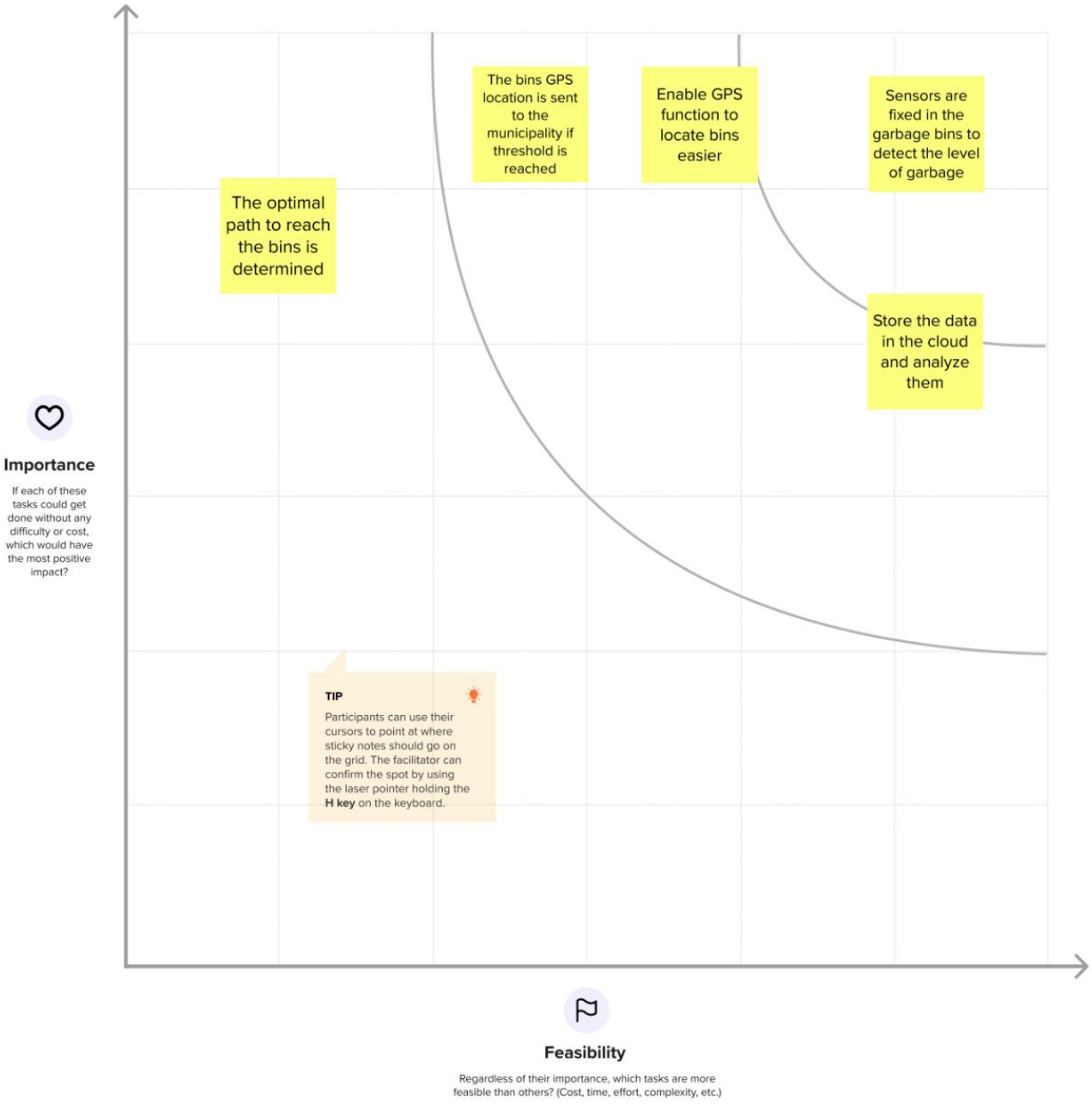
Devadharshini

Nearby truck drivers are intimated to collect the garbage

The optimal path to reach the bins location is analyzed

Group ideas

Prioritize


The bins GPS location is sent to the municipality if threshold is reached
Enable GPS function to locate bins easier
Sensors are fixed in the garbage bins to detect the level of garbage
The optimal path to reach the bins is determined
Store the data in the cloud and analyze them
Importance
If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?
TIP
Participants can use their cursors to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using the laser pointer holding the H key on the keyboard.
Feasibility
Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

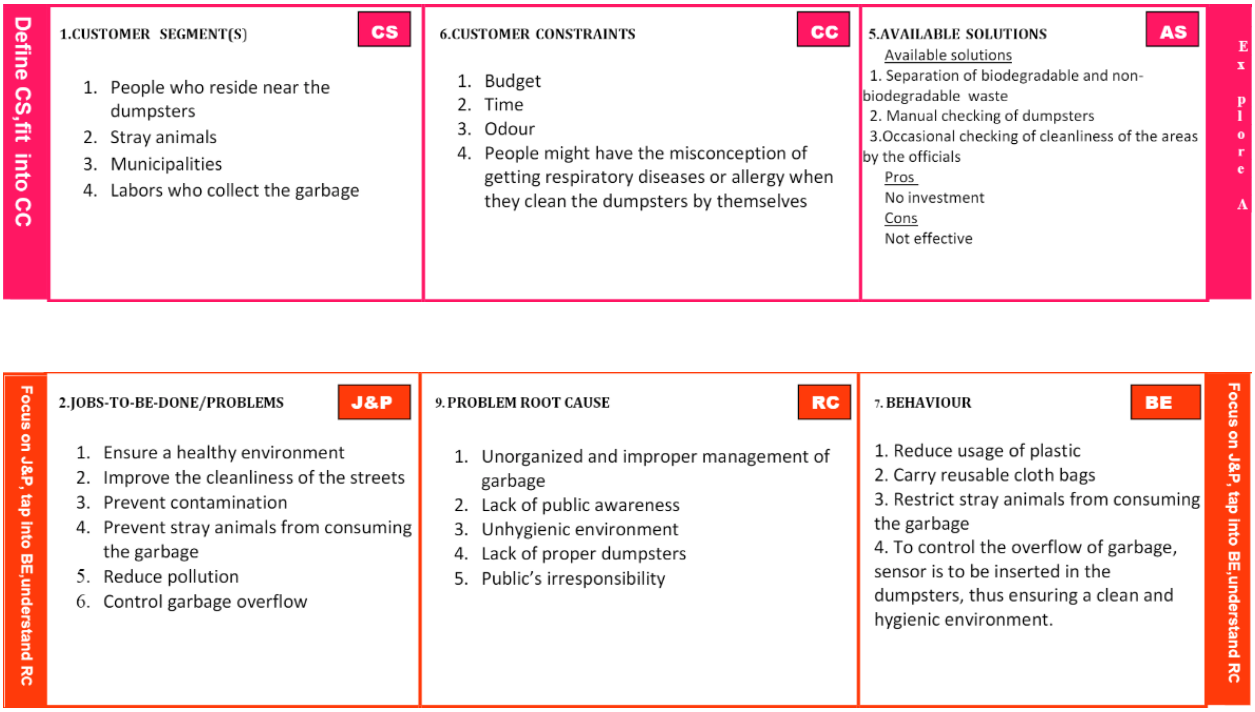
3.3 Proposed Solution

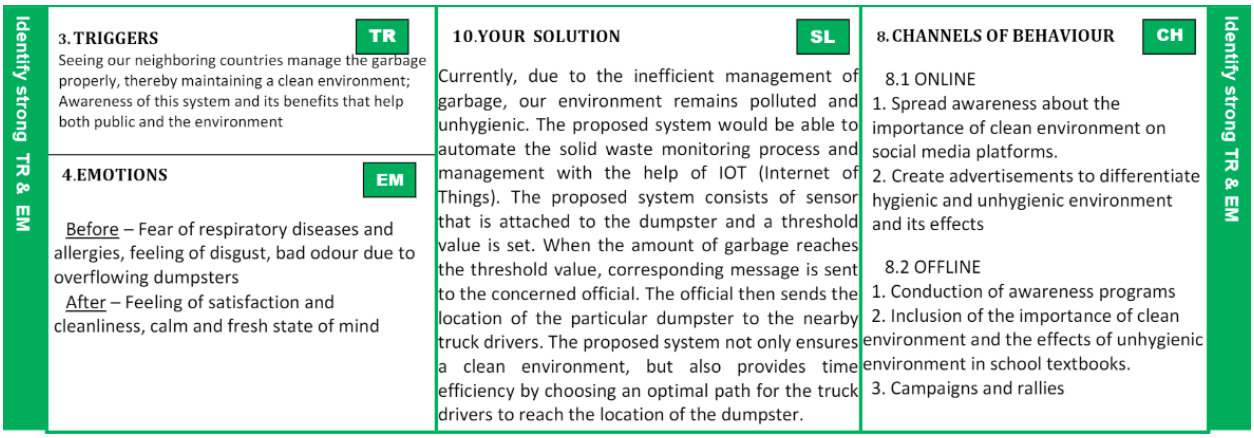
S.No	Parameter	Description
1.	**Problem Statement (Problem to be solved)**	Today big cities around the world are facing a common problem, managing the city waste effectively without making city unclean. Today's waste management systems involve a large number of employees being appointed to attend a certain number of dumpsters. This leads to a very inefficient and unclean system in which some dumpsters are overflowing. Here a smart waste management system is introduced in which each dumpster is embedded in a monitoring system that will notify if the dumpster is full. This system provides an effective solution to the waste management problem.
2.	**Idea / Solution description**	The key objectives of the project are - ● The proposed system would be able to automate the solid waste monitoring process and management with the help of IOT (Internet of Things). ● The proposed system consists of sensor that is attached to the dumpster and a threshold value is set. ● When the amount of garbage reaches the threshold value, corresponding message is sent to the concerned official. The official then sends the location of the particular dumpster to the nearby truck drivers. ● The proposed system not only ensures a clean environment, but also provides time efficiency by choosing an optimal path for the truck drivers to reach he location of the dumpster.

3.	**Novelty / Uniqueness**	• The system immediately acknowledges the officials once the dumpster reaches the threshold value rather than waiting for the dumpster to be filled completely. • It is also periodically monitored. • It also reduces the workload of the workers and is comparatively cost- efficient.
4.	**Social Impact / Customer Satisfaction**	• Ensures a healthy environment. • Improves the cleanliness of the streets. • Prevents contamination and also prevents animals from consuming the garbage. • Reduces pollution.
5.	**Business Model (Revenue Model)**	• Time consumption and cost efficiency is achieved and the garbage collection is performed in an organized way. • It also offers software as a service model to the concerned officials thereby creating revenue from it.

6.	**Scalability of the Solution**	• An efficient IoT- based system is developed for ensuring a clean and healthy environment. • This system can be used to manage the solid waste from small area to big metropolitan cities. • The amount of garbage in any dumpster can be identified quickly with the help of sensor. • It is acknowledged by the officials and the truck drivers are sent there immediately. It also chooses an optimal path for the drivers to reach the dumpster quickly, thereby providing time efficiency.

3.4 Problem solution fit





4.REQUIREMENT ANALYSIS

4.1 Functional requirements

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement(Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Detailed bin invertory	● All monitored binsand stands can be seenon the map, and you can visit them at anytime via the Street View feature from Google. ● Bins or standsare visible on the map as green, orange or red circles. ● You can see bin details in the Dashboard - capacity, waste type, last measurement, GPS location and collection schedule or pick recognition.

FR-2	Real time binmonitoring	● The Dashboard displays real-time data on fill-levels of bins monitored by smart sensors. ● In addition to the % of fill-level, based on the historical data,the tool predicts when the binwill become full, one of the functionalities that are not included even in the best waste management software. ● Sensors recognize picksas well; so you cancheck when the bin was last collected. ● With real-time dataand predictions, youcan eliminate overflowing bins and stop collecting half-empty ones.
FR-3	Expensive bins	● We help you identify bins that drive up your collection costs. The tool calculates a rating for each bin in terms of collection costs. ● The tool considers the average distance depo-bin discharge in the area. The tool assignsbin a rating(1-10) and calculates distance from ● depo-bin discharge.
FR-4	Adjust bin distribution	● Ensure the most optimal distribution of bins. ● Identify areas witheither dense or sparse bindistribution. ● Make sure alltrash types arerepresented within a stand. ● Based on thehistorical data, youcan adjustbin capacity or location wherenecessary.
FR-5	Eliminate unefficient picks	● Eliminate the collection of half-empty bins. ● The sensors recognize picks. ● By using real-time data on fill-levels and

		pickrecognition, we can show you how fullthe bins you collect are.

4.2 Non-functional requirements

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

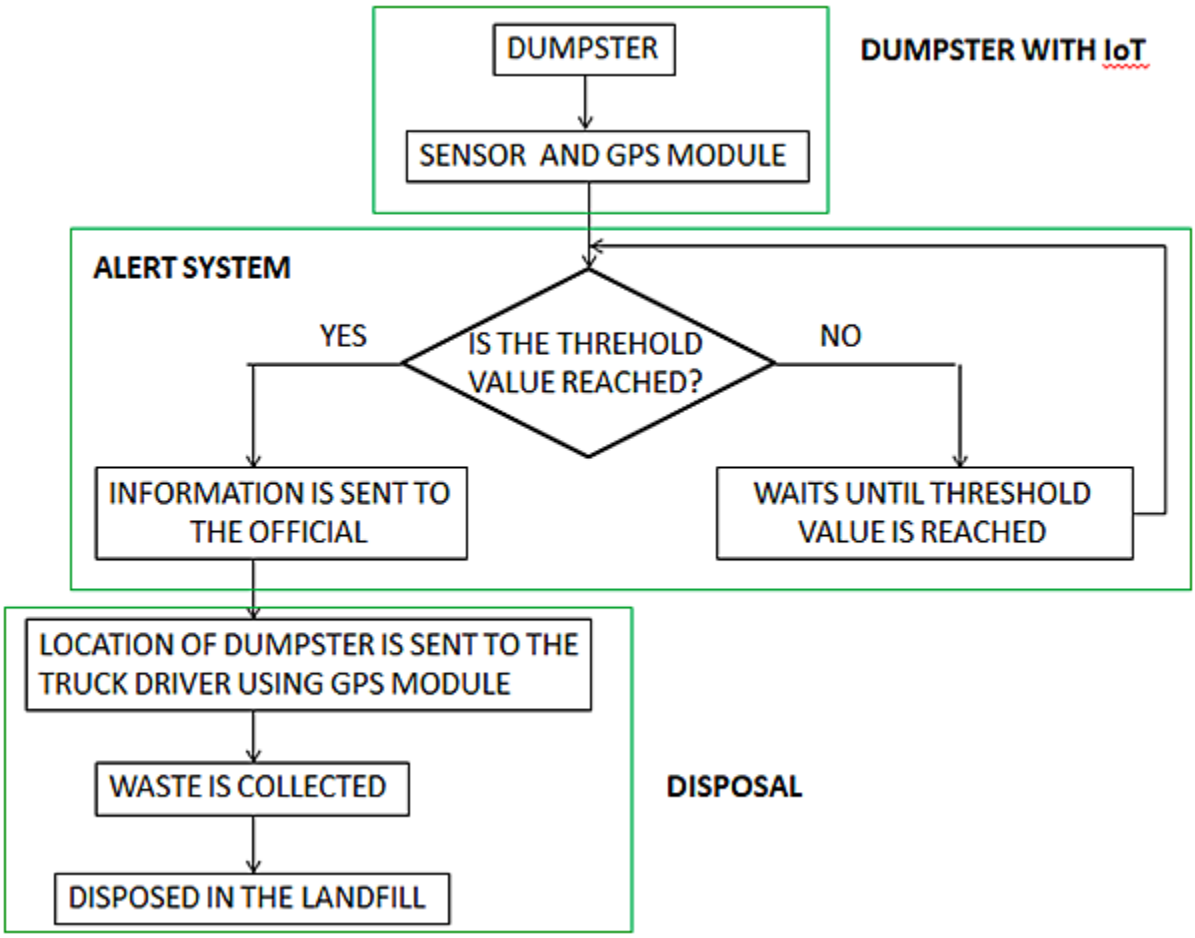
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	● loT device verifies that usability is a special and important perspective to analyzeuser requirements, whichcan further improvethe design quality. ● In the design process with user experience as the core, the analysis of users'product usability can indeed helpdesigners better understand users' potential needs in waste management,behavior and experience.
NFR-2	Security	● Use a reusable bottles. ● Use reusable grocerybags Purchase wisely and recycle. ● Avoid single usefood and drinkcontainers.

NFR-3	Reliability	● Smart waste management is also about creating better working conditions for wastecollectors 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 thatneed servicing.
NFR-4	Performance	● The Smart Sensors use ultrasound technology to measure the fill levels (alongwith other data)in bins several times a day. ● Using a variety of loT networks ((NB-IoT,GPRS), the sensors sendthe data toSensoneo's Smart Waste Management Software System, a powerful cloud-based platform, for data driven daily operations, available also as a wastemanagement app. ● Customers are hence provided data- driven decision making, and optimization of waste collection routes, frequencies, and vehicle loads resulting in route reduction by at least 30%.
NFR-5	Availability	● By developing &deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter.

5.PROJECT DESIGN

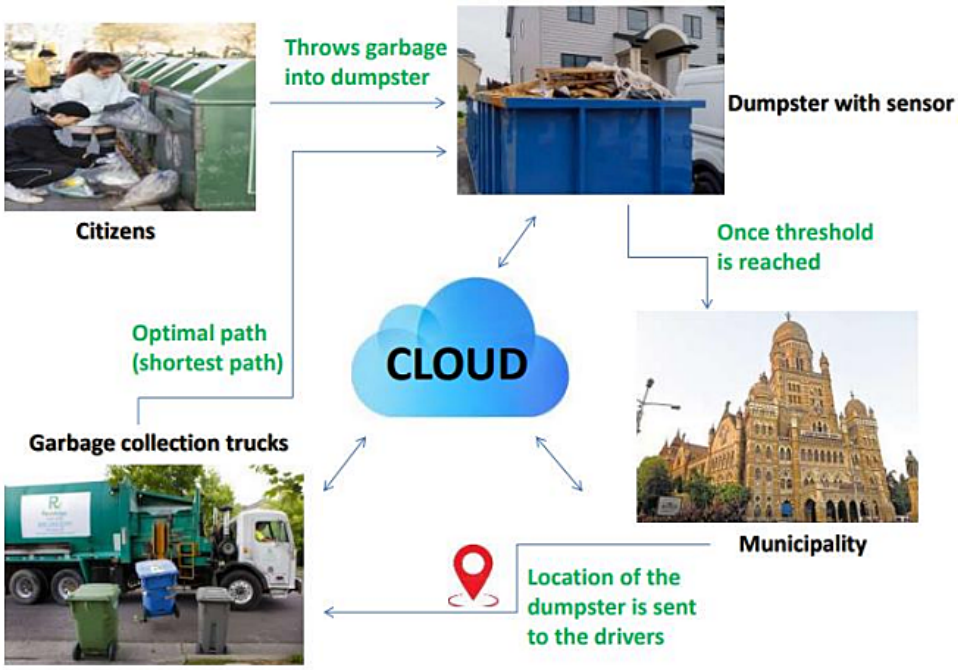
5.1 Data Flow Diagram

A Data Flow Diagram (DFD) is a traditional visualrepresentation of the information flows within a system. A neat and clear DFD can depictthe right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

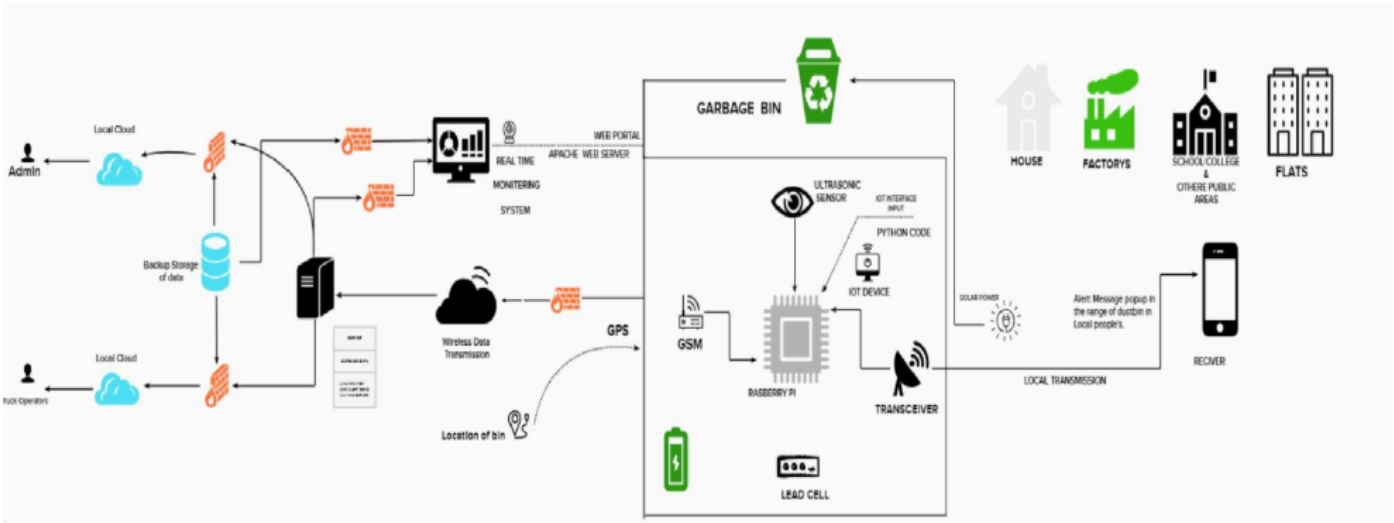


5.2 Solution & Technical Architecture

Solution Architecture



Technical Architecture



5.3 User stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Admin (who manage web server)	Web server login	USN-1	As a admin, I have my user name and password for every worker and co- workers to manage them	I can manage web account and direct workers	High	Sprint-1
Co-admin	Login	USN-2	As a co- admin, I'll manage other monitoring activities like garbage level monitoring, location accuracy, garbage separation and removal of waste within a scheduled time.	I can monitor garbage bins activities.	High	Sprint-2
Customer(Web user)	User	USN-3	Here comes the customer, he/she will have access to mobile apps or login web pages to view progress of bins and to report if any query found.	He/she has the right to make a query if any.	High	Sprint-3
Customer Care Executive	Worker	USN-4	The customer care executive will try to rectify the queries from customers by contacting co-admin. If case of any critical/ emergency situation query can be conveyed to higher authority.	I can attend calls, and respond people, by rectifying the problem.	High	Sprint-4
Truck driver	Worker	USN-5	Here, truck driver is a worker who has particular assignments that he has to report when and where the garbage has been picked according to the daily schedule. And should update the happenings in the given website (webpage login)	I can update my activities onsite when the given task has been completed.	Moderate	Sprint-5

Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	How user interacts with application e.g.Web UI, Mobile App, Chatbot etc.	HTML, CSS, JavaScript / Angular JS /React JS etc.
2.	Application Logic-1	Logic for a process in the application	Python
3.	Application Logic-2	Logic for a process in the application	IBM Watson service
4.	Application Logic-3	Logic for a process in the application	IBM Watson Cloud service
5.	Database	Data Type, Configurations etc.	MySQL,NoSQL
6.	Cloud Database	Database Service on Cloud	IBM Cloudant
7.	File Storage	File storage requirements	Stored Area Network (SANs)
8.	External API-1	Purpose of External API used in the application	Location Tracking
9.	External API-2	Purpose of External API used in the application	Waste Monitoring
10.	Machine Learning Model	Purpose of Machine Learning Model	Object Recognition Model, etc.
11.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: Cloud Server Configuration :	Local, Cloud Foundry, Kubernetes, etc.

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	List the open-source frameworks used	Monitor and clean
2.	Security Implementations	List all the security / access controls implemented, use of firewalls etc.	Encryptions
3.	Scalable Architecture	Justify the scalability of architecture (3 – tier, Micro-services)	To help prevent clean environment
4.	Availability	Justify the availability of application (e.g. use of load balancers, distributed servers etc.)	Available any time
5.	Performance	Design consideration for the performance of the application (number of requests per sec, use of Cache, use of CDN's) etc.	Monitor & dispose the waste

6.PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Product Backlog, Sprint Schedule, and Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a admin, I have my user name and password for every worker and co- workersto manage them	20	High	Varsha S
Sprint-2	Login	USN-2	As a co- admin, I'll manage other monitoring activities like garbage level monitoring, location accuracy, garbage separation and removal of waste within a scheduled time.	20	High	Sivapriya K
Sprint-3	User	USN-3	Here comes the customer, he/she will have access to mobile apps or login web pages to view progress of bins and to report if any query found.	20	High	Devadharshini B
Sprint-4	Worker	USN-4	Here, truck driver is a worker who has particular assignments that he has to report when and where the garbage has been pickedaccording to the daily schedule. And should update the happenings in the given website(webpage login)	20	High	Mahalakshmi B

6.2 Sprint Delivery Schedule

Project Tracker, Velocity & Burndown Chart:

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

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

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

7.CODING & SOLUTIONING

7.1 Feature 1 - Wokwi Simulation

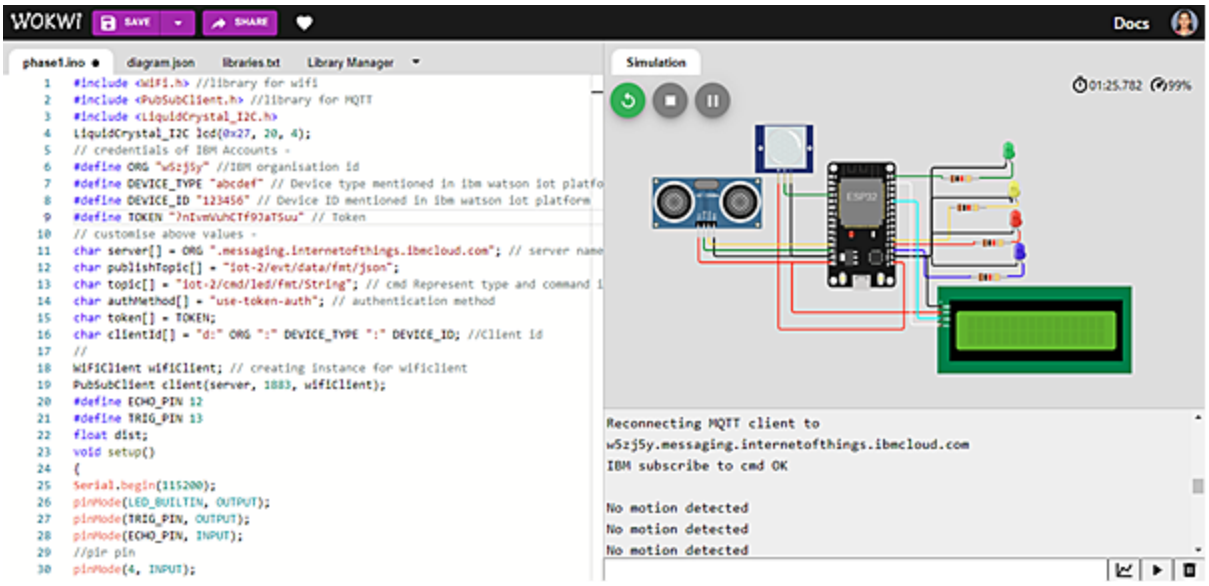
```
#include <WiFi.h>//library for wifi
#include <PubSubClient.h>//library for MQtt
#include "DHT.h"// Library for dht11
#define DHTPIN 15     // what pin we're connected to
#define DHTTYPE DHT22   // define type of sensor DHT 11
#define LED 2
DHT dht (DHTPIN, DHTTYPE);//creating the instance by passing pin and typr of dht connected
 void callback(char* subscribetopic, byte* payload, unsigned int payloadLength);
 //-------credentials of IBM Accounts------
 #define ORG "w5zj5y"//IBM ORGANITION ID
#define DEVICE_TYPE "abcdef"//Device type mentioned in ibm watson IOT Platform
#define DEVICE_ID "123456"//Device ID mentioned in ibm watson IOT Platform
#define TOKEN "?nIvmVuhCTf9JaTSuu"     //Token
```

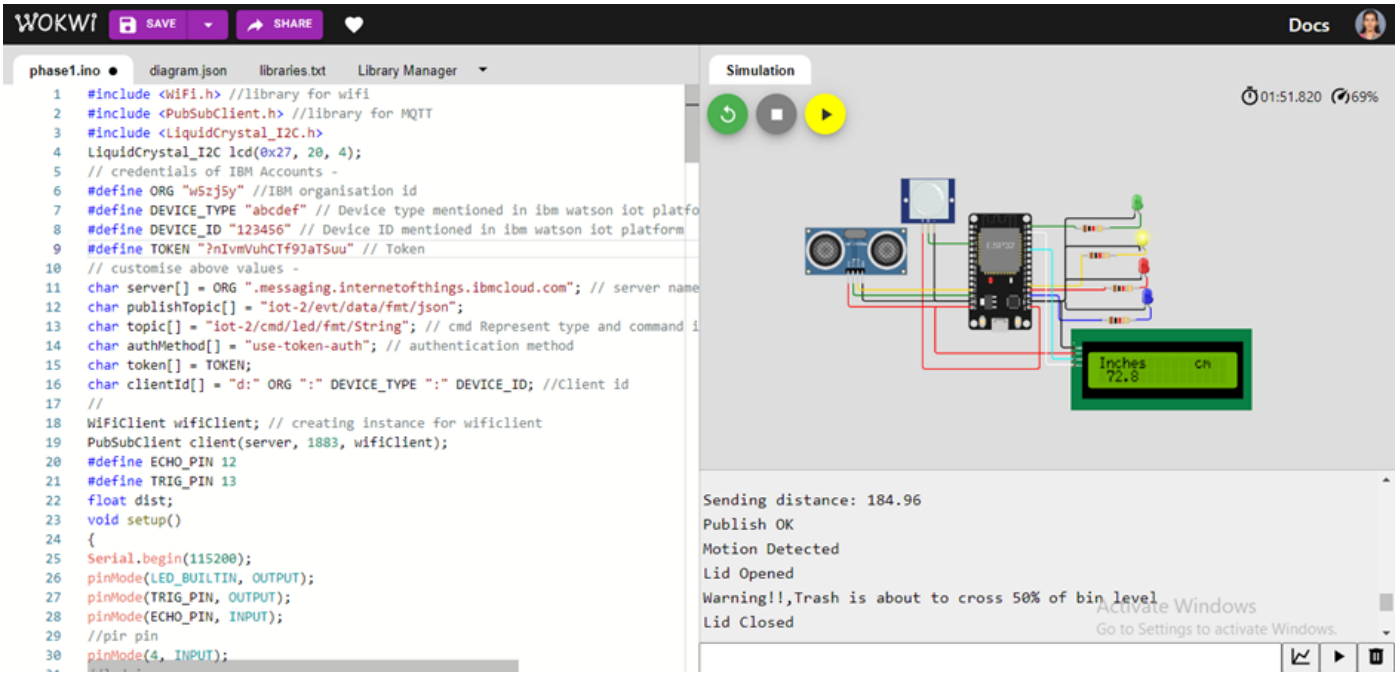
```
String data3;
float h, t;
//-------- Customise the above values --------
char server[] = ORG ".messaging.internetofthings.ibmcloud.com";// Server Name
char publishTopic[] = "iot-2/evt/Data/fmt/json";// topic name and type of event perform and format in which data to be send
char subscribetopic[] = "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);
  dht.begin();
  pinMode(LED,OUTPUT);
  delay(10);
  Serial.println();
  wificonnect();
  mqttconnect();
}
 void loop()// Recursive Function
{
  h = dht.readHumidity();
  t = dht.readTemperature();
  Serial.print("temp:");
  Serial.println(t);
  Serial.print("Humid:");
```

```
  Serial.println(h);

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

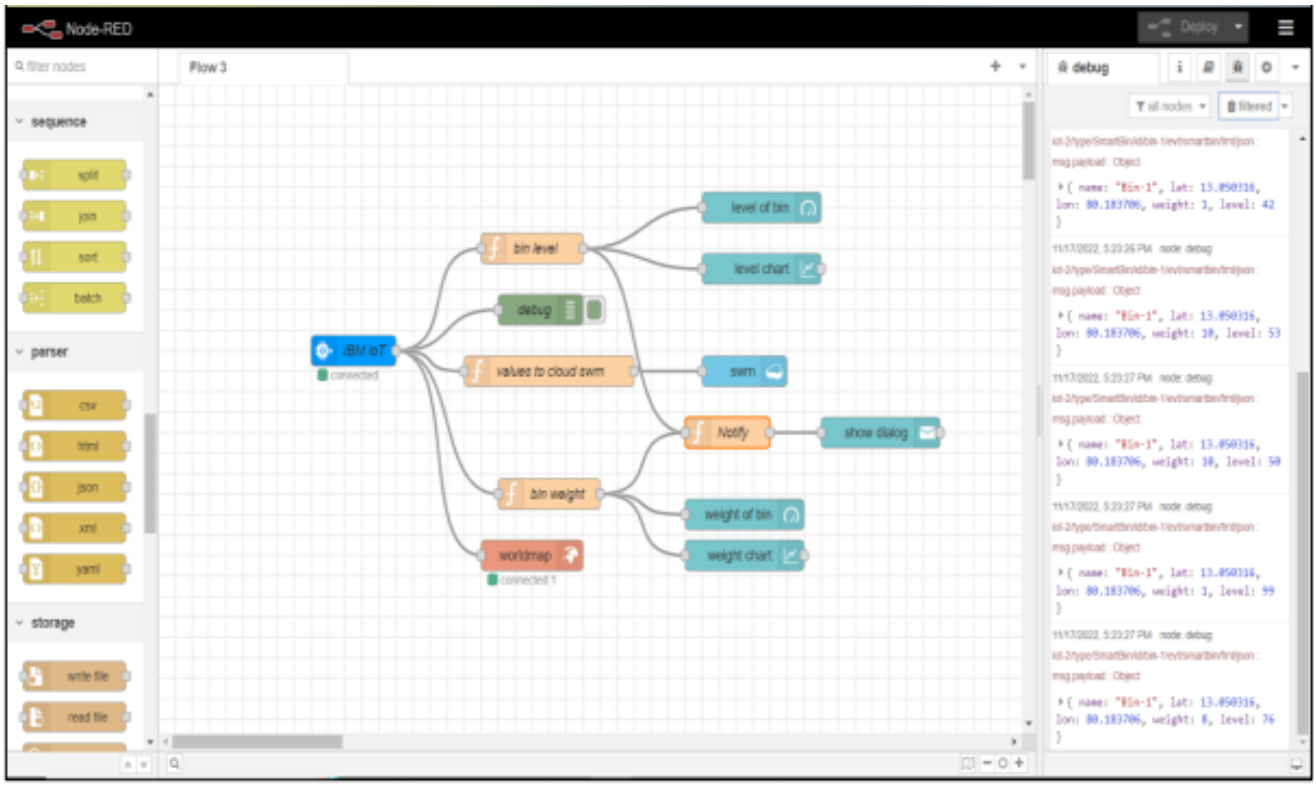


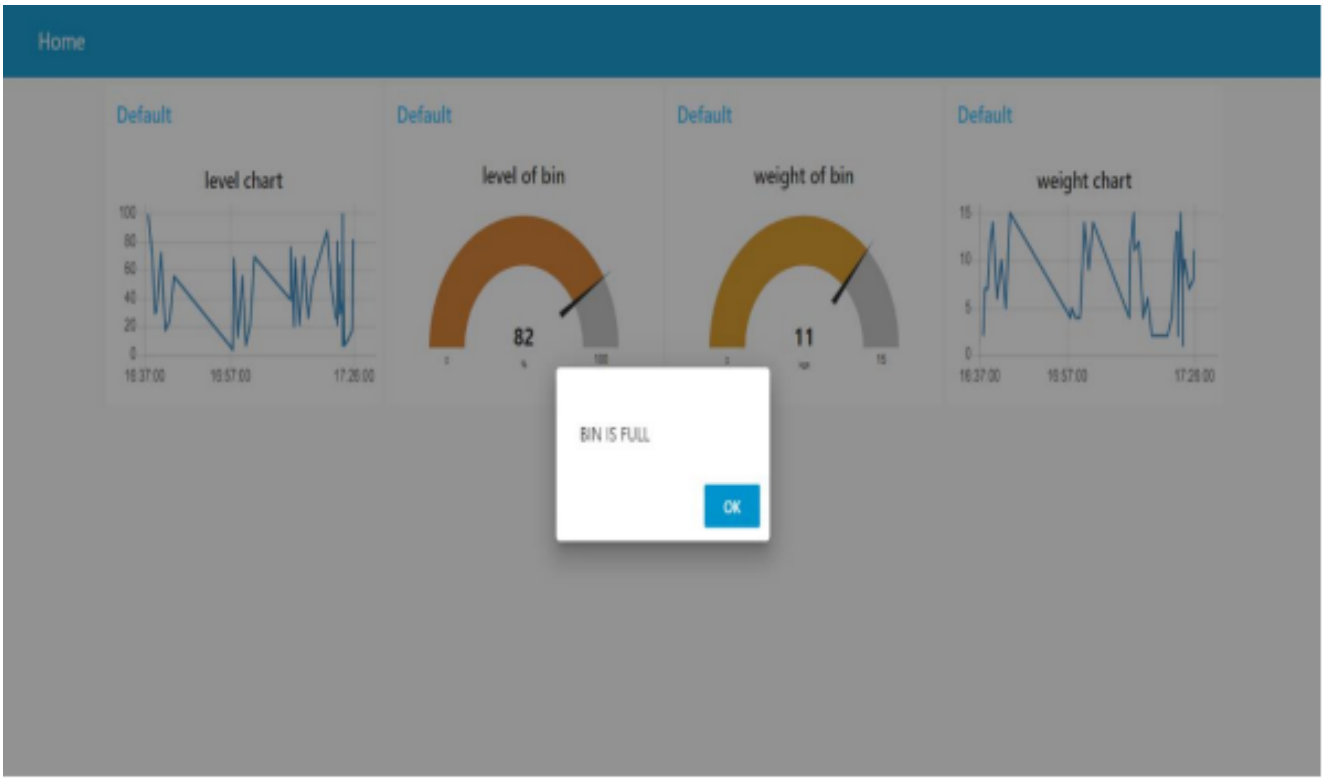


7.2 Feature 2 - Transfer of data from ibm cloud to node-red

```
import wiotp.sdk.device
import time
import random
import collections.abc
try:
```

```
 from collections.abc import MutableMapping
except ImportError:
 from collections import MutableMapping
myConfig = {
"identity": {
"orgId": "gx76pd",
"typeId": "SmartBin",
"deviceId":"bin-1"
},
"auth": {
"token": "ZeskE9*BHtQSqNlICL"
}
}
def myCommandCallback (cmd):
print ("Message received from IBM IoT Platform: %s" % cmd.data['command'])
m=cmd.data['command']
client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)
client.connect()
def pub (data):
client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0,
onPublish=None)
print ("Published data Successfully: %s", myData)
while True:
myData={'name': 'Bin1', 'lat': 13.092677, 'lon': 80.188314}
pub (myData)
time.sleep (3)
client.commandCallback = myCommandCallback
client.disconnect ()
```


Node-RED
Deploy
Flow 3
debug
sequence
split
join
sort
batch
parser
csv
html
json
xml
yaml
storage
write file
read file
IBM IoT
connected
bin level
debug
values to cloud swm
bin weight
worldmap
connected ?
level of bin
level chart
swm
Notify
show dialog
weight of bin
weight chart


Home
Default
level chart
Default
level of bin
82
Default
weight of bin
11
Default
weight chart
BIN IS FULL
OK

8.TESTING

8.1 Test Cases

A test case has components that describe input, action and an expected response, in order to determine if a featureof an application is workingcorrectly. A test case is a set of instructions on “HOW” to validate a particular test objective/target, which when followed will tell us if the expected behaviour of the system is satisfied or not.

Characteristics of a good test case:

a. Accurate: Exacts the purpose.
b. Economical: No unnecessary steps or words.
c. Traceable: Capable of being traced to requirements.
d. Repeatable: Can be used to perform the test over andover.
e. Reusable: Can be reused if necessary.

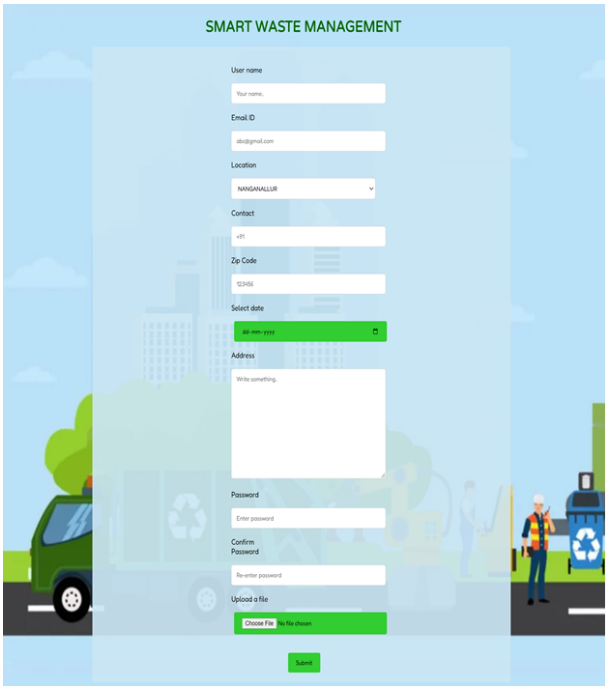
Example:

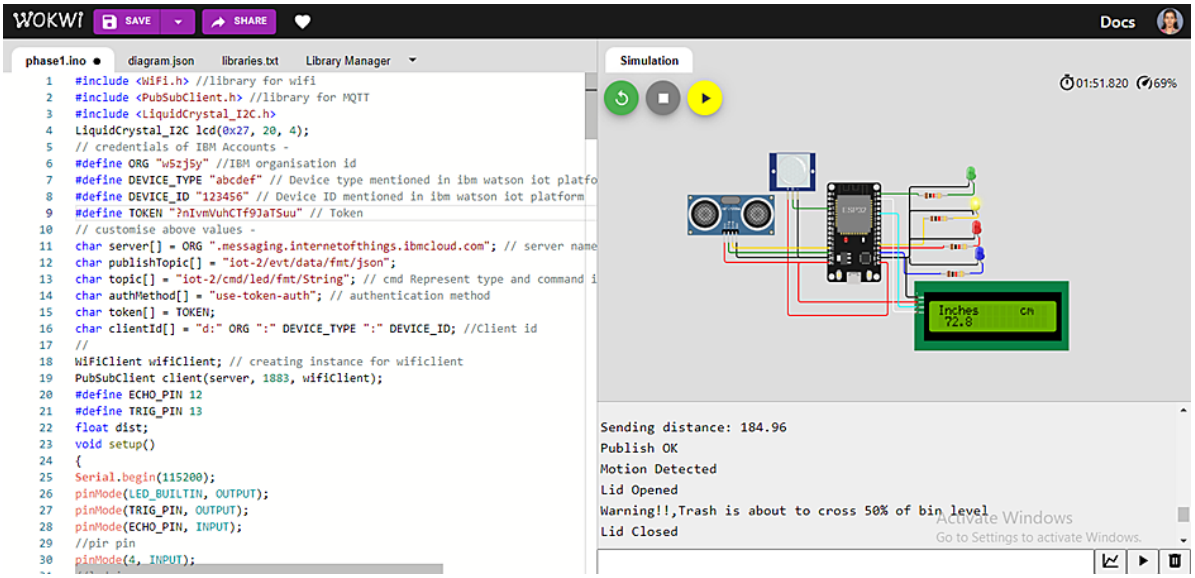
S.NO	Scenario	Input	Expected Output	Actual Output
1	User Login	User name and password	Login	Login success

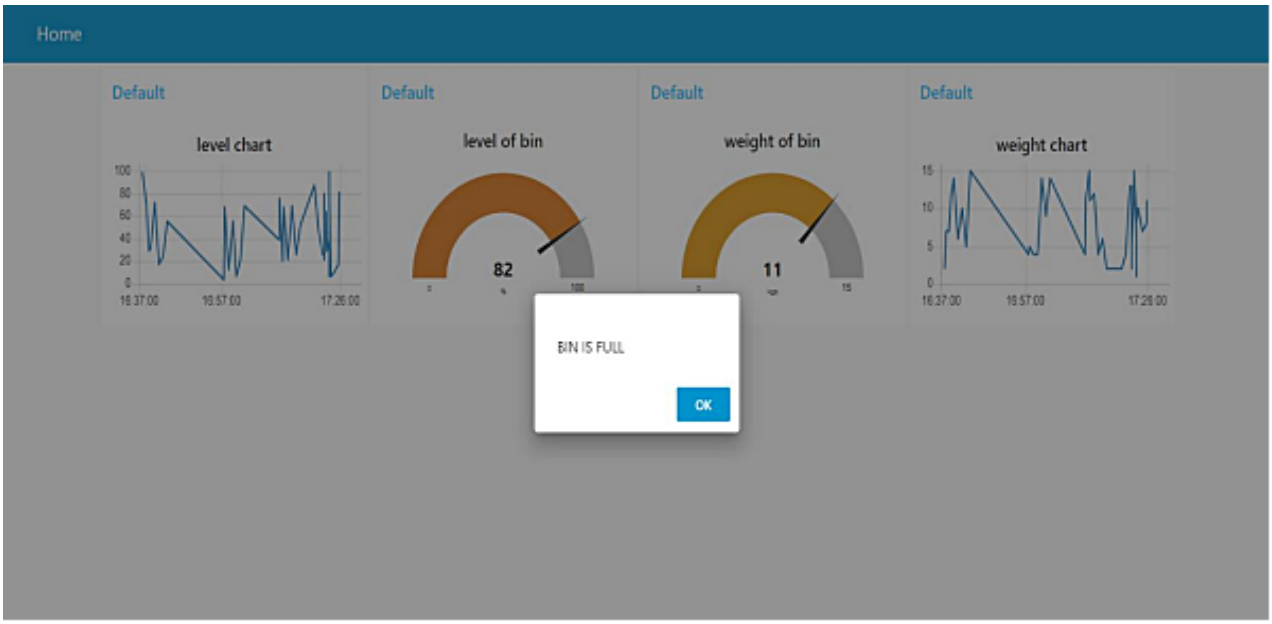
8.2 User Acceptance Testing

This sort of testing is carried out by users, clients, or other authorised bodies to identify the requirements and operational procedures of an application or piece of software. The most crucial stage of testing is acceptance testing since it determines whether or not the customer will accept the application or programme. It could entail the application's U.I., performance, usability, and usefulness. It is also referred to as end-user testing, operational acceptance testing, and useracceptance testing (UAT).

9.RESULTS


SMART WASTE MANAGEMENT
User name
Your name..
Email ID
abc@gmail.com
Location
NANGANALLUR
Contact
+91
Zip Code
123456
Select date
dd-mm-yyyy
Address
Write something..
Password
Enter password
Confirm Password
Re-enter password
Upload a file
Choose File
No file chosen
Submit


WOKWI
SAVE
SHARE
Docs
phase1.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 "w5zj5y" //IBM organisation id
#define DEVICE_TYPE "abcdef" // Device type mentioned in ibm watson iot platfo
#define DEVICE_ID "123456" // Device ID mentioned in ibm watson iot platform
#define TOKEN "?nIvmVuhCTf9JaTSuu" // Token
// customise above values -
char server[] = ORG ".messaging.internetofthings.ibmcloud.com"; // server name
char publishTopic[] = "iot-2/evt/data/fmt/json";
char topic[] = "iot-2/cmd/led/fmt/String"; // cmd Represent type and command i
char authMethod[] = "use-token-auth"; // authentication method
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID; //Client id
//
WiFiClient wifiClient; // creating instance for wificlient
PubSubClient client(server, 1883, wifiClient);
#define ECHO_PIN 12
#define TRIG_PIN 13
float dist;
void setup()
{
Serial.begin(115200);
pinMode(LED_BUILTIN, OUTPUT);
pinMode(TRIG_PIN, OUTPUT);
pinMode(ECHO_PIN, INPUT);
//pir pin
pinMode(4, INPUT);
Simulation
01:51.820
69%
Inches
72.8
cm
Sending distance: 184.96
Publish OK
Motion Detected
Lid Opened
Warning!!,Trash is about to cross 50% of bin level
Lid Closed
Activate Windows
Go to Settings to activate Windows.



10. ADVANTAGES :

The combination of intelligent waste monitoring and trash compaction technologies, smart bins are head and shoulders above traditional garbage bins. Cities installing smart bins can enjoy:

- A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion.
- A reduction in the number of waste bins needed.
- Analytics data to manage collection routes and the placement of bins more effectively.
- Improved environment (i.e. no overflowing bins and less unpleasant odours).

DISADVANTAGES :

By following the traditional ways of waste collection, there comes hindrances like:

- The uneven accumulation of the trash bins means that the waste collection teams

attend to areas where the bins are almost empty while the other areas' trash bins may be overflowing.

- Excessive accumulation of trash that is not emptied in time can lead to health risks to the residents. As a result, they may not prefer to live there, and businesses would not relocate.

11.CONCLUSION

To fulfill the luxurious needs of humans and to save time for the busy world and to give proper service to all without any delay was the main concern which gave an idea for implementing this particular system. The Smart E- Dustbin can be used at public places, educational institutes, corporate world, governmental offices and many more, which serves in user friendly manner and helps in maintaining the world clean and green. The boon part is the end to end communication that it establishes in the real world. This type of communication of course satisfies all the stakeholders. In this project, implementation is done only for a single bin. Integration of many bins each with a unique ID can be done by implementing the principles of IOT and creating database for each bin which can be maintained by using SQL technology and a login webpage is created to ensure authorized entries. Apart from this, dry trash bin and wet trash bin collecting plastic dry waste and biodegradable waste can be installed as there will less complexity for separation and recycling of waste if any. GPS module can be interfaced to each dustbin which sends the status and location of the dustbin, which can be displayed on the GUI maintained by the respective authority of the city. Further the whole system can be made water resistant.

12.FUTURE SCOPE

With increasing population, urbanization and expanding economic activities, Solid waste disposal and management is a challenge in India. Here are some statistics which shows the solid waste management issues in India :

- According to the Central Pollution Control Board of India, the per capita generation of waste has increased from 0.26 kg/day to 0.85 kg/day. Close to 90% of waste is disposed of without proper treatment causing environmental pollution.

- Total of approximately 143,449 MT of municipal waste is generated daily. However, only 35,062 tons of waste is treated.

- A report from MNRE says that waste generation is expected to reach 300 million tons annually by the year 2047.

Multiple factors such as socioeconomic status, commercial activity, increasing population, heterogeneous solid waste type affect how waste is treated and managed in India. Handling, transportation and treatment of waste are the major challenges for municipal authorities as well. Some of them are discussed below.

- Open dumps, burning of waste and lack of landfills are serious concerns as it causes health and environment problems. Health risks such as respiratory diseases, Malaria and Dengue are commonly caused due to waste mismanagement. Also, improper waste disposal mechanism is causing water, soil & air pollution.

- Lack of segregation and collection of waste from the congested localities, the inadequate staff is another challenge in India.

- Using a single bin for mixed waste, weekly collection of waste, uncovered waste carrying vehicles, and lack of land for waste disposal are some other factors responsible for growing waste problem.

13.APPENDIX

Git link - https://github.com/IBM-EPBL/IBM-Project-17187-1659630147

Project demo link - https://www.kapwing.com/videos/6377bfc7280c78001e97d89c