

# PROJECT REPORT

## SMART WASTE MANAGEMENT FOR METROPOLITAN CITIES

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# 1. INTRODUCTION

## 1.1 Project Overview

Project Name : **Smart Waste Management System For Metropolitan Cities.**

Category : **Internet Of Things.**

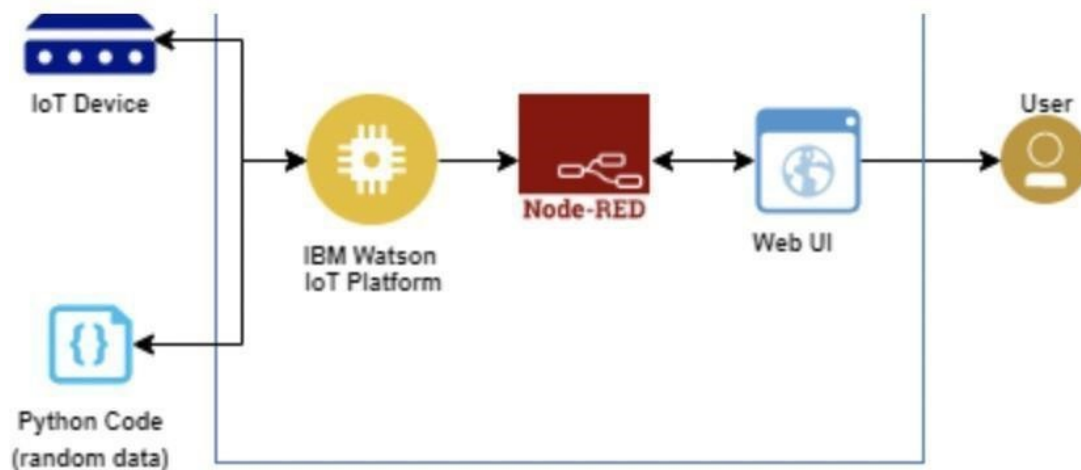
### Project Description:

1. Garbage level detection in bins.
2. Getting the weight of the garbage in the bin.
3. Alerts the authorized person to empty the bin whenever the bins are full.
4. Garbage level of the bins can be monitored through a web App.
5. We can view the location of every bin in the web application by sending GPS location from the device.

### Skills Required:

Python, IoT Cloud Platform, IBM Cloud, Node-RED, IBM IoT Platform, IBM Node-red, IBM Cloudant DB

### Technical Architecture :



## **1.2 Purpose**

The main objective of the project is to manage the waste using iot platform efficiently. In the proposed system, we intimate the garbage collector about the garbage level before overflowing.

Smart city waste management technology allows workers to empty bins before they become overflowing with trash or recycling, and before infestation becomes an issue. Smart waste sensors can also alert garbage collectors when bins develop unpleasant smells which can then be treated to eliminate odors. Smart waste management control lots of problems which disturbs the society in pollution and diseases.

### **Main objectives:**

1. Reduce human intervention
2. Using technology to automate waste management
3. Save time and cost
4. Helps to prevent diseases due to garbage dumps
5. Clean cities and healthy environment

## **2. LITERATURE SURVEY**

### **2.1 Existing problem**

The traditional way of manually monitoring the wastes in waste bins is a complex and utilizes more human effort, time and cost. Manual waste management causes missed pickups, overflowing bins. This will cause hygiene problems and in order to overcome all these problems, we are proposing the smart waste management system which helps in them anagement of waste without human interaction in order to maintain a clean environment.

## 2.2 References

### Paper 1:

A Survey on Garbage Collection and Monitoring System for Smart cities using IOT

**Publisher:** Dept of Computer Engineering, Terna Engineering College, Nerul, Navi

Mumbai **Reference:** <https://www.irjet.net/archives/V5/i2/IRJET-V5I2118.pdf>

### Paper 2:

IOT enabled solid waste management in smart cities

**Publisher:** S. Vishnu 1 , S. R. Jino Ramson 1,2,3,\* , Samson Senith 4 , Theodoros Anagnostopoulos 5 , Adnan M. Abu-Mahfouz 6 , Xiaozhe Fan 2 , S. Srinivasan 3 and A. Alfred Kirubaraj 4

**Reference:** <https://www.mdpi.com/2624-6511/4/3/53/pdf>

### Paper 3:

IOT enabled intelligent solid waste management system for smart city

### **Publisher:**

<https://www.semanticscholar.org/paper/IoT-Enabled-Intelligent-Solid-Waste-Management-for-De-wangan/6fbe2679732dbcff5132ed75114137e00dcc53beisher>

**Reference:** <https://www.irjet.net/archives/V5/i2/IRJET-V5I2118.pdf>

## 2.3 Problem Statement Definition

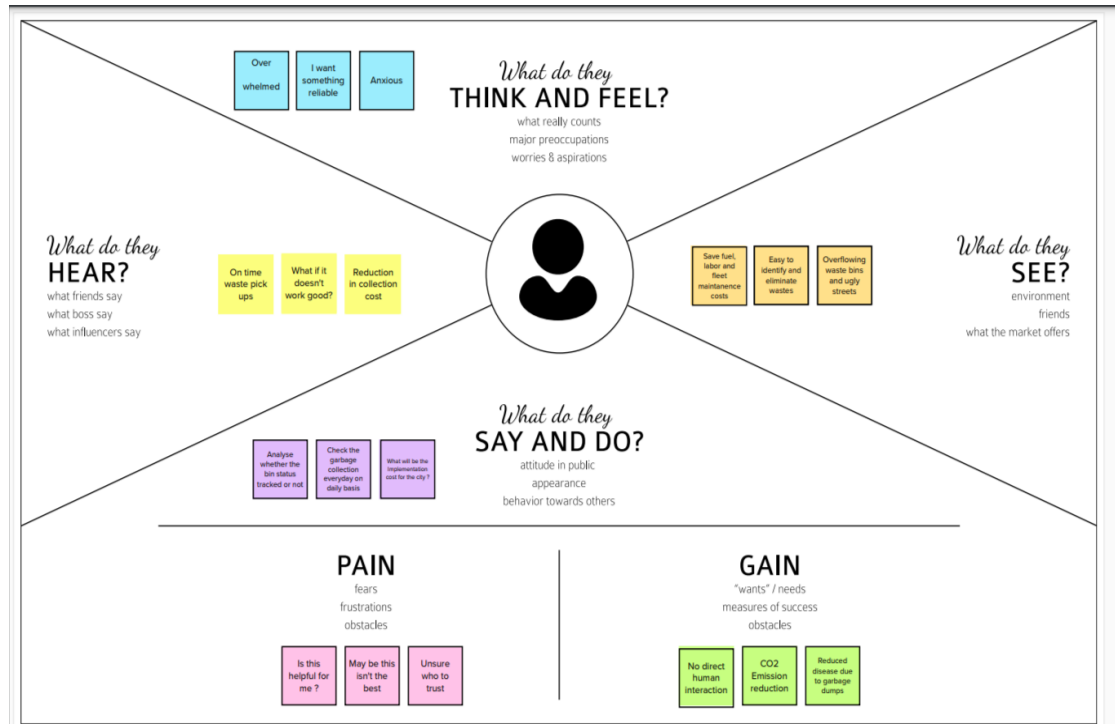
A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion. A reduction in the number of waste bins needed. Analytics data to manage collection routes and the placement of bins more effectively.

Theme: Internet of Things

Technologies: LoRa, Smart Mesh, RF, WiFi

### 3. IDEATION & PROPOSED SOLUTION

#### 3.1 Empathy Map Canvas



#### 3.2 Ideation & Brainstorming

**1 Define your problem statement**

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

🕒 5 minutes

PROBLEM

How might we protect the environment through effective waste management?

**2 Brainstorm**

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

🕒 10 minutes

**Vaishnavi**

We can get dustbins locations in city		Ask people about timing for waste pick up
Dustbin filling level is to be monitored		Make a reliable system

**Anju Jessica**

Access location of dustbins from their body	Notify using message	Ugly roads due to garbage
		Mixed garbage pickups

**Paul keins**

Reduce diseases by cleaning garbage	Get location of dustbin	Inform dustbin collectors

**Selva murugan**

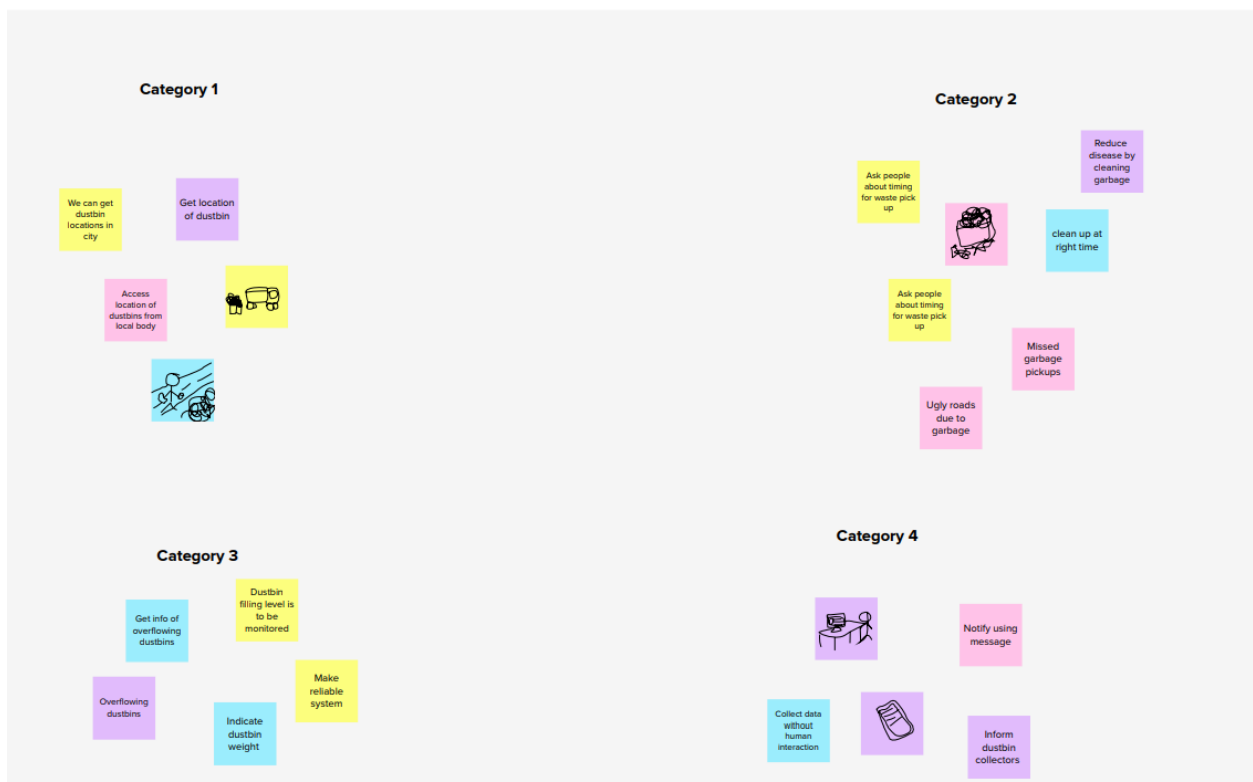
Get info of overflowing dustbins	clean up at night time	

3

### Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. In the last 10 minutes, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you can break it up into smaller sub-groups.

🕒 20 minutes



4

### Prioritize

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

20 minutes

**Category 2**

Ask people about timing for waste pick-up

Reduce clutter by cleaning garbage

clean up at right time

Ask people about timing for waste pick-up

Missed garbage pickups

Light roads due to garbage

**Category 4**

Notify using message

Inform dustbin collectors

Make relative system

Missed garbage pickups

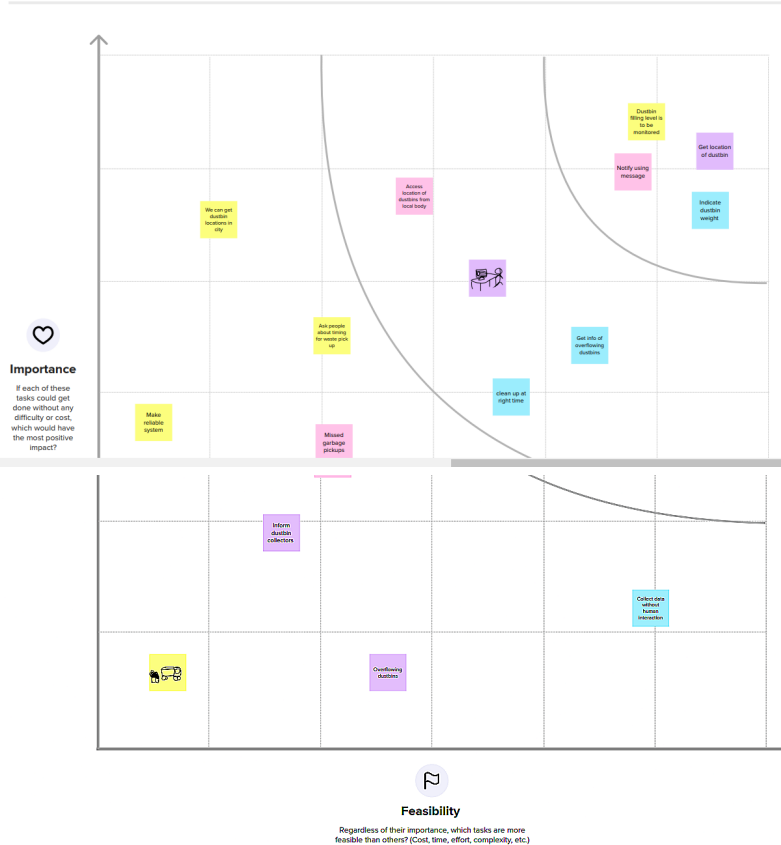
clean up at right time

Get info of overflowing dustbins

Indicate dustbin weight

Get location of dustbin

Double string level is to be monitored



After you  
You can  
member

Quick

A Shu  
Shu  
the

B Exp  
Exp  
em

Keep m



Shar



### 3.3 Proposed Solution

S.No	Parameter	Description
1.	Problem Statement	India faces major environmental challenges associated with waste generation and lacking waste collection, transport, treatment, and disposal. conventional systems in India can't manage the volumes of waste generated, and this impacts the surroundings and public health.
2.	Idea/Solution description	A Web application is built where the location of garbage bins, their weight, and the level of the waste collected are monitored. Sensors are fitted in the garbage bins and the required data is collected and acquired from them. The real-time monitoring system indicates when the bin is full and alerts the authorized person to empty the bin.
3.	Novelty/Uniqueness	This project introduces a way to sort out problems like missed pickups and overflowing garbage bins. This prevents the wastage of labor costs, fuel costs, and time.
4.	Social Impact / Customer Satisfaction	Provides healthy Environment Improves hygiene because of timely waste collection Clean cities can be achieved Control the level of pollution and gases
5.	Business Model (Revenue Model)	The software can be offered as a Service model to the Government. The revenue can be generated by charging the customers for the provision of services from waste management to safe disposal and recycling.
6.	Scalability of the Solution	The proposed solution uses sensors where the information about garbage bins can be collected in real-time. Communication technologies enable the authorized person to check data online.

### 3.4 Problem Solution fit

**Problem-Solution fit canvas 2.0**

Smart waste management for metropolitan cities

TEAM ID : PNT2022TMID20530

Define CS, fit into CC	<b>1. CUSTOMER SEGMENT(S)</b> Who is your customer? I.e. working parents of 0-5 y.o. kids	<b>6. CUSTOMER CONSTRAINTS</b> What constraints prevent your customers from taking action or limit their choices of solutions? I.e. spending power, budget, no cash, network connection, available devices.	<b>5. AVAILABLE SOLUTIONS</b> Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? I.e. pen and paper is an alternative to digital notetaking.	Explore AS, differentiate
	<ul style="list-style-type: none"> <li>Municipality and</li> <li>Local authorities of Metropolitan cities of India</li> </ul>	<ul style="list-style-type: none"> <li>Lack of proper waste management technology within budget</li> <li>A robust cloud service to analyze and process the data acquired from the garbage bins</li> </ul>	<ul style="list-style-type: none"> <li>Collection of garbage from the trash bins by the trucks in fixed routine.</li> <li>If the garbage bins are not filled it will be a waste of manpower, fuel and time.</li> </ul>	
Focus on J&P, tap into BE, understand RC	<b>2. JOBS-TO-BE-DONE / PROBLEMS</b> Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.	<b>9. PROBLEM ROOT CAUSE</b> What is the real reason that this problem exists? What is the back story behind the need to do this job? I.e. customers have to do it because of the change in regulations.	<b>7. BEHAVIOUR</b> What does your customer do to address the problem and get the job done? I.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (I.e. Greenpeace)	Focus on J&P, tap into BE, understand RC
	<p>The fixed routine for waste collection is inefficient as the average citizen may not dispose of the same amount of waste every day leading to overflowing bins and no proper communication channel to alert the municipality of this issue and schedule pick-ups.</p>	<ul style="list-style-type: none"> <li>Alarming generation of waste due to population growth and urbanization.</li> <li>There is no way for us to know when the garbage cans are full.</li> <li>This leads to overflowing of garbage cans and an unhygienic environment.</li> </ul>	<ul style="list-style-type: none"> <li>People wait for the garbage to be cleared by the trucks until the next day.</li> <li>There is no direct way to contact the truck drivers for the people.</li> </ul>	
Identify strong TR & EM	<b>3. TRIGGERS</b> What triggers customers to act? I.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.	<b>10. YOUR SOLUTION</b> If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality. If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.	<b>8. CHANNELS of BEHAVIOUR</b> <b>8.1 ONLINE</b> What kind of actions do customers take online? Extract online channels from #7	Extract online & offline CH of BE
	<ul style="list-style-type: none"> <li>News about disease-causing mosquitoes in uncleaned garbage bins.</li> <li>Garbage dumps lead to bad odor.</li> </ul>	<p>A Web application is developed in which data of garbage bins collected are monitored.</p> <p>Sensors are used to collect the required data.</p> <p>The real-time monitoring system indicates whether the bin is full or not and alerts the authorized person to empty the bin.</p>	<b>8.2 OFFLINE</b> What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.	
	<b>4. EMOTIONS: BEFORE / AFTER</b> How do customers feel when they face a problem or a job and afterwards? I.e. lost, insecure > confident, in control - use it in your communication strategy & design.		Customers must complain the government online with uploading pictures of their uncleaned garbage bins and its consequences.	
	People feel disgusting when seeing uncleaned garbage dumps. People feel relieved after cleaning garbage at right time.		Customers must complain to the local authority by writing a letter about waste maintenance. Also can go to a private waste cleaning authority for help.	

Problem-Solution fit canvas is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 license  
 Created by Daria Nepriakhina / Amaltama.com

**AMALTAMA**

## 4. REQUIREMENT ANALYSIS

### 4.1 Functional requirement

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Download the application through online registration
FR-2	User Confirmation	Confirmation via E-mail Confirmation via OTP using the phone number
FR-3	Cloud	Sensor details are updated and stored in the cloud database.
FR-4	Notifier	Notification should send automatically to the registered mail or phone when bins are filled
FR-5	Sensor	Garbage bins are fitted with sensors that will monitor the wastage level.

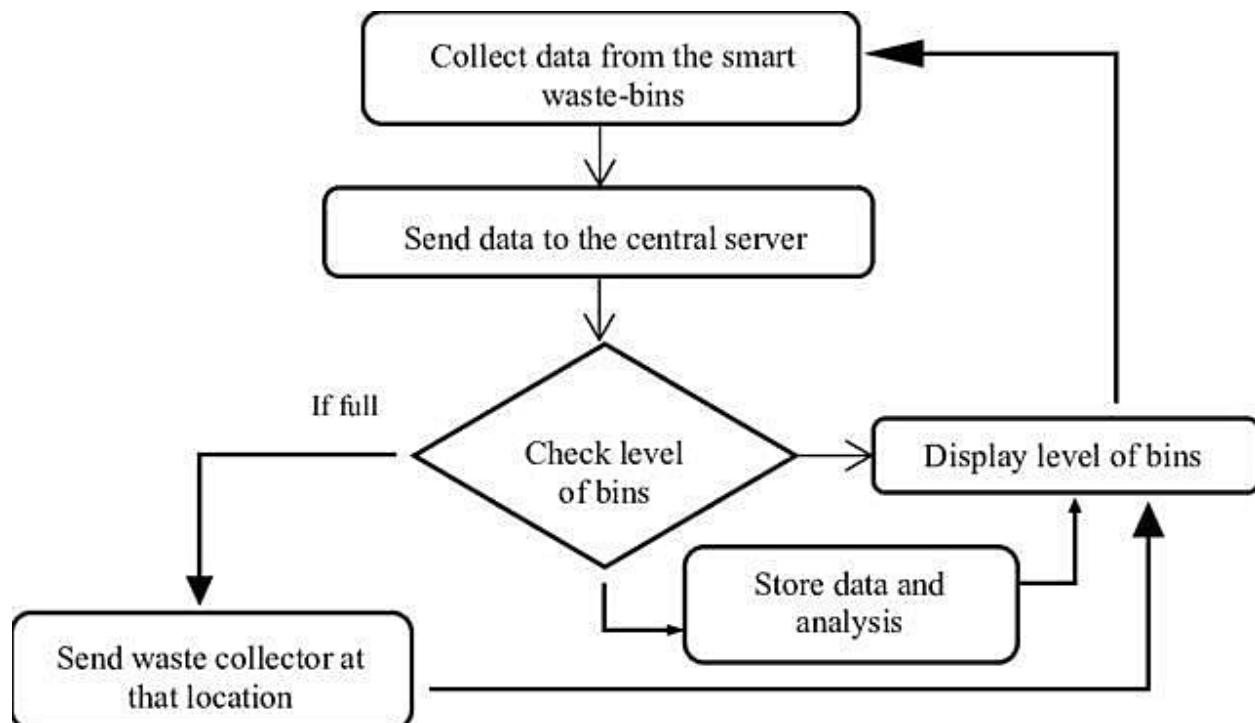
## 4.2 Non-Functional requirements

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	It will stop the overflowing of dustbins along roadsides and localities as smart bins are managed in real time.
NFR-2	Reliability	Details are maintained in the cloud.
NFR-3	Performance	It provides a clean environment
NFR-4	Availability	This method is available for all urban people in smart city
NFR-5	Scalability	Maintaining garbage bin monitoring and providing guiding service based on the database.

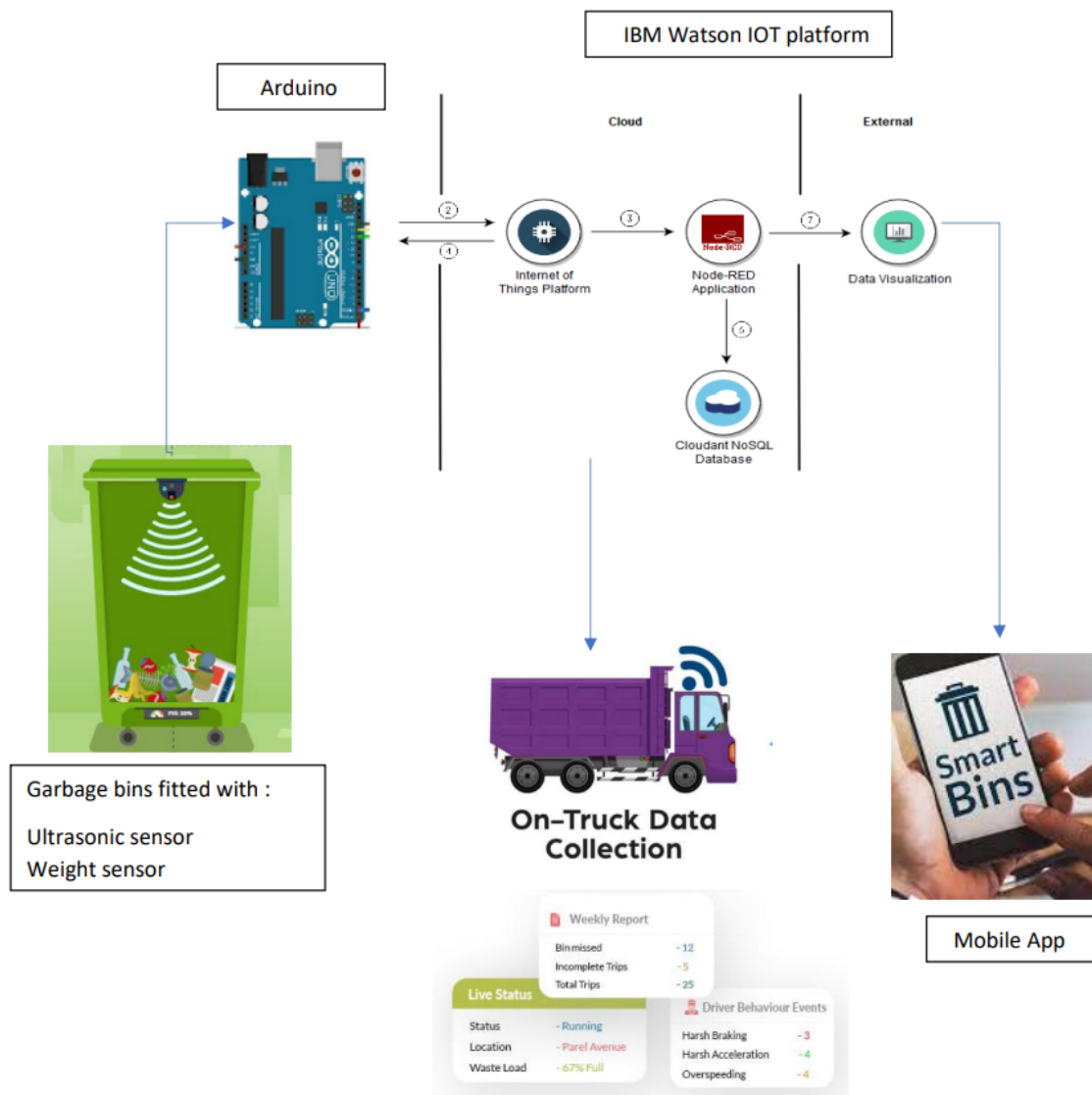
## 5. PROJECT DESIGN

### 5.1 Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the 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



### 5.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can download the application	I can view the data sent by the hardware	High	Sprint-3
Customer (web user)	Registration	USN-1	As a user, I can view the application web page	I can view the data sent by the hardware	High	Sprint-3
Customer (Data types)	Data viewing	USN-1	As a user, I can view garbage level monitoring	Data from the hardware	High	Sprint-1
		USN-2	As a user, I can view the level of wastage	Data from the hardware	High	Sprint-1
		USN-3	As a user, I can view the level of dustbin is detected	Data from the hardware	High	Sprint-1
Customer	Actions	USN-1	As a user, I can receive notification that appears on the phone	I receive notification	Medium	Sprint-2
		USN-1	As a user, I need sensor Access which connected to mobile	Based on the sensor the level of the garbage will monitor	Medium	Sprint-2
Administrator	Storage	USN-1	As an administrator, I can store the data	All the data are stored in a cloud database	High	Sprint-4

## 6. PROJECT PLANNING & SCHEDULING

### 6.1 Sprint Planning & Estimation

Title	Description	Details
<b>Literature Survey &amp; Information Gathering</b>	Literature survey on the selected project & gathering information by referring the, technical papers, research publication etc .	28 SEPTEMBER 2022
<b>Prepare Empathy Map</b>	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem Statements.	24 SEPTEMBER 2022
<b>Ideation</b>	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	25 SEPTEMBER 2022
<b>Proposed Solution</b>	Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc.	23 SEPTEMBER 2022
<b>Problem Solution Fit</b>	Prepare problem - solution fit Document.	30 SEPTEMBER 2022
<b>Solution Architecture</b>	Prepare solution architecture Document.	28 SEPTEMBER 2022
<b>Customer Journey</b>	Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit).	20 OCTOBER 2022
<b>Functional Requirements</b>	Prepare the functional requirement document.	08 OCTOBER 2022
<b>Data Flow Diagrams</b>	Draw the data flow diagrams and submit for review.	09 OCTOBER 2022

<b>Technology Architecture</b>	Prepare the technology architecture diagram.	10 OCTOBER 2022
<b>Prepare Milestone &amp; Activity List</b>	Prepare the milestones & activity list of the project.	22 OCTOBER 2022
<b>Project Development - Delivery of Sprint-1, 2, 3 &amp; 4</b>	Develop & submit the developed code by testing it.	IN PROGRESS

## 6.2 Sprint Delivery Schedule

<b>Sprint</b>	<b>Functional Requirement (Epic)</b>	<b>User Story Number</b>	<b>User Story / Task</b>	<b>Story Points</b>	<b>Priority</b>	<b>Team Members</b>
Sprint-1	Login	USN-1	As an Administrator, I need to give a user id and passcode to every workers over there in the municipality	2	High	Vaishnavi Anju Jessica Paul keins Selva Murugan
Sprint-1	Login	USN-2	As a Co-Admin, I'll control the waste level by monitoring them via a real-time web portal. Once the filling happens, I'll notify the trash truck with the location of the bin with bin ID	2	High	Vaishnavi Anju Jessica Paul keins Selva Murugan
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	2	High	Vaishnavi Anju Jessica Paul keins Selva Murugan
Sprint-3	Dashboard	USN-4	As a Local Garbage Collector, I'll gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills	2	High	Vaishnavi Anju Jessica Paul keins Selva Murugan
Sprint-4	Dashboard	USN-5	As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems	2	High	Vaishnavi Anju Jessica Paul keins Selva Murugan

## 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

## 7. CODING & SOLUTIONING

### 7.1 Feature 1

```
#include <cstdlib>
#include <time.h>
#include <WiFi.h>
#include <PubSubClient.h>
```

```
#define ORG "evd8ss"
#define DEVICE_TYPE "raspberrypi"
#define DEVICE_ID "1234"
#define TOKEN "12345678"
#define speed 0.034
```

```
char server[] = ORG ".messaging.internetofthings.ibmcloud.com";
char publishTopic[] = "iot-
2/evt/data/fmt/json";
char authMethod[] = "use-token-auth";
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;
```

```
WiFiClient wifiClient;
PubSubClient client(server, 1883, wifiClient);
```



```
int weight = 0;
```

```
String location = "Coimbatore";
```

```
String status = "";
```

```
void setup() {
```

```
    Serial.begin(99900);
```

```
    wifiConnect();
```

```
    mqttConnect();
```

```
}
```

```
void loop() {
```

```
    srand(time(0));
```

```
    //initial
```

```
    variable    int p;
```

```
    weight = random(0,80);
```

```
    if(weight > 0 && weight < 25){
```

```
        p = 0;
```

```
    }
```

```
    else if(weight > 25 && weight < 50){
```

```
        p = 1;
```

```
    }
```

```
else{
```

```
    p =
```

```
    2;
```

```
}
```

```
    //set a quality status
```

```

    switch (p) {
case 0:
status = "Low";
break; case 1:
    status =
"Half";
break; case
2:    status =
"Full";
break;
    }

```

//Obviously the output.It is like json format 'cause it will help us for future sprints

```

String payload = "{"; payload+="\"Weight
\":"; payload+=weight; payload+=",";
payload+="\"Loaction\":"; payload+="Coimbatore";
payload+=",";
payload+="\"Status\":"+"\""+status+"\""}";
Serial.println(payload);

```

```

if(client.publish(publishTopic, (char*) payload.c_str()))
{
    Serial.println("Publish OK");
}
else{
    Serial.println("Publish failed");
}
delay(1000);

```

```

if (!client.loop())
{
    mqttConnect();
}

```

```
}
```

```
void wifiConnect()
```

```
{
```

```
  Serial.print("Connecting to ");
```

```
  Serial.print("Wifi");
```

```
  WiFi.begin("Wokwi-GUEST", "", 6);
```

```
  while (WiFi.status() != WL_CONNECTED)
```

```
  {
```

```
    delay(500);
```

```
    Serial.print(".");
```

```
  }
```

```
  Serial.print("WiFi connected, IP address: ");
```

```
  Serial.println(WiFi.localIP());
```

```
}
```

```
void mqttConnect()
```

```
{
```

```
  if (!client.connected())
```

```
  {
```

```
    Serial.print("Reconnecting MQTT client to ");
```

```
  Serial.println(server);
```

```
    while (!client.connect(clientId, authMethod, token))
```

```
    {
```

```
      Serial.print(".");
```

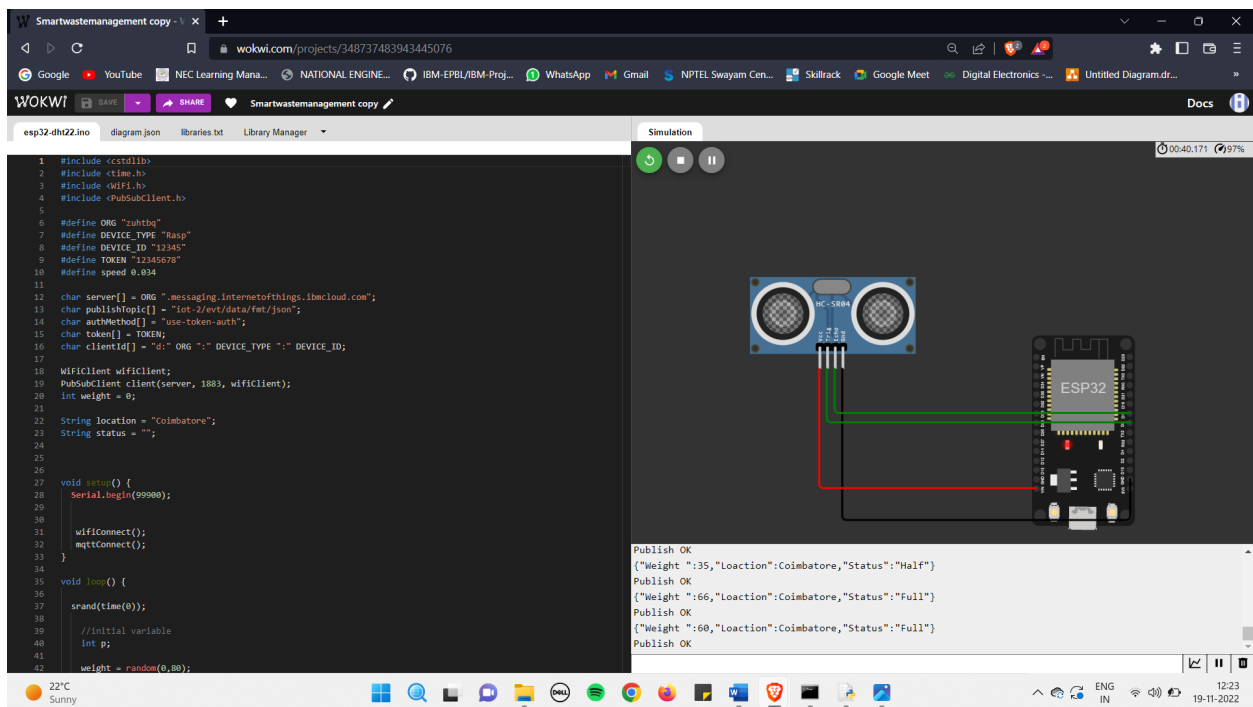
```
    delay(500);
```

```
    }
```

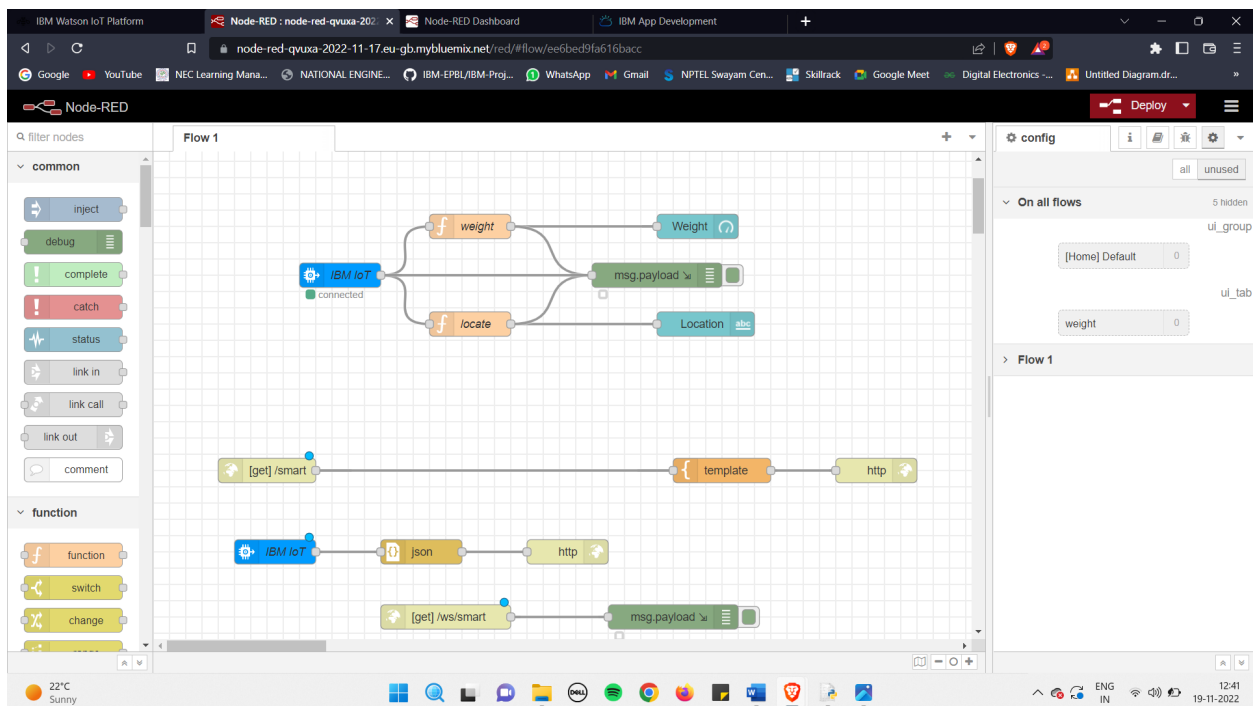
```
    Serial.println();
```

```
  }
```

```
}
```



## 7.2 Node red

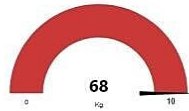


## Smart Waste Management Initiation

### Driver Button

Location  
**Coimbatore**

Weight



### Message To Driver

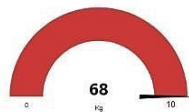
Over Weight Please Collect The Garbage

## Smart Waste Management Initiation

### Driver Button

Location  
**Coimbatore**

Weight



### Driver Update

GARBAGE COLLECTED

## **8. TESTING**

### **8.1 Test Cases**

#### **TEST CASE 1:**

WEIGHT: 0 KG

STATUS: NOT FILLED, DUSTBIN IS EMPTY

#### **TEST CASE 2:**

WEIGHT: 10KG

STATUS: 20% FILLED, NOT READY TO DISPOSE

#### **TEST CASE 3:**

WEIGHT: 20KG

STATUS: 40% FILLED, NOT READY TO DISPOSE

#### **TEST CASE 4:**

WEIGHT: 30KG

STATUS: 60% FILLED, NOT READY TO DISPOSE

#### **TEST CASE 5:**

WEIGHT: 45KG

STATUS: 90% FILLED, READY TO DISPOSE

## **9. RESULTS**

### **9.1 Performance Metrics**

Total MSW Generated = Total tons Recycled + Total tons Recovered + Total tons Disposed  
MSW = Municipal Solid Waste (does not include industrial, special and demolition wastes)

## **10. ADVANTAGES & DISADVANTAGES**

### **ADVANTAGES:**

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.

### **DISADVANTAGES:**

Misunderstanding of the operations of smart sensors

Non-optimized truck routes

## 11. CONCLUSION

Monitoring the garbage bins through sensors, it is possible to achieve a more efficient system than the manual method. The project “Smart waste management system”, mainly concentrates on providing a smart technology for waste system without human intervention, reducing human time and effort and which results in healthy and waste ridden environment. The proposed idea can be implemented for smart cities where the residents would be busy enough and wouldn’t have enough time for managing waste. The bins can be implemented in a city if desired where there would be a large bin that can have the capacity to accumulate the waste of solid type for a single apartment. The cost could be distributed among the residents leading to cheaper service provision.

## 12. FUTURE SCOPE

Waste management in future includes improvement in monitoring systems, data collection, and advancements based on new upcoming technologies.

## 13. APPENDIX

**Source Code :** <https://wokwi.com/projects/348737483943445076>

**GitHub:** <https://github.com/IBM-EPBL/IBM-Project-33561-1660222837>

**Project Demo Link:** <https://github.com/IBM-EPBL/IBM-Project-33561-1660222837/blob/main/Final%20Deliverables/Demo%20link.mp4>