# IOT BASED SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITIAN CITIES

**Team ID:PNT2022TMID033070**

## A PROJECT REPORT

**Submitted by**

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## 1.Introduction

### 1.1 Project Overview

With rapid increase in population, the issues related to sanitation with respect to garbage management are degrading immensely. It creates

unhygienic conditions for the citizens in the nearby surrounding, leading to the spread of infectious diseases and illness. To avoid this problem, IoT based “Smart Waste Management” is the best and trending solution. In the proposed system, public dustbins will be provided with embedded device which helps in real time monitoring of level of garbage in garbage bins. The data regarding the garbage levels will be used to provide optimized route for garbage collecting vans, which will reduce cost associated with fuel. The load sensors will increase efficiency of data related to garbage level and moisture sensors will be used to provide data of waste segregation in a dust bin. The analysis of ceaseless data gathered will help municipality and government authorities to improve plans related to smart waste management with the help of various system generated reports. **1.2 Purpose**

Smart waste management focuses on solving the previously mentioned solid waste management problems using sensors, intelligent monitoring systems, and mobile applications. The first smart waste management solution to make the waste collection process more efficient is sensors. Sensors can measure the fill level of the containers and provide updated information at any time and notify waste management services to empty them when they are full or almost full. These devices help optimize the best possible route containing fully filled containers and create smart schedules for drivers. The selection of the containers also minimizes the need for trash collection staff because their duties are deduced. They can also alert the waste management companies or municipalities if an undesirable incident happens such as sudden temperature rise or displacement of the container by their GPS features.

## 2. Literature survey:

### 2.1 Existing system

Around 80% of waste collections happen at the wrong time. Late waste collections lead to overflowing bins, unsanitary environments, citizen complaints, illegal dumping, and increased cleaning and collection costs. Early waste collections mean unnecessary carbon emissions, more traffic congestion, and higher running costs. The old way of doing waste management is highly inefficient. And in today’s

ever-technological world, an innovative and data-driven approach is the only way forward.

Traditionally, municipalities and waste management companies would operate on a fixed collection route and schedule. This means that waste collection trucks would drive the same collection route and empty every single waste container – even if the waste container did not need emptying. This means high labor and fuel costs – which residents ultimately foot the bill for. This is also an unsustainable way of working - the more vehicles on the road carrying out unnecessary collections means more carbon emissions are released into our planet's atmosphere.

**2.2 Reference**

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

[2] Dr. N. Sathish Kumar, B. Vijayalakshmi, R. Jenifer Prarthana, A .Shankar, (2016 ), "IoT Based Smart Garbage alert system using Arduino UNO ", IEEE

[3] Belal Chowdhury, Morshed U. Chowdhury, (2007) "RFID-based Real-timeSmart Waste Management System", Australasian Telecommunication Networks and Applications Conference, December, Christchurch, New Zealand

[4] Mohd Helmy Abd Wahab, Aeslina Abdul Kadir, Mohd Razali Tomari and Mohamad Hairol Jabbar (2014), "Smart Recycle Bin A Conceptual Approach of Smart Waste Management with Integrated Web based System", IEEE

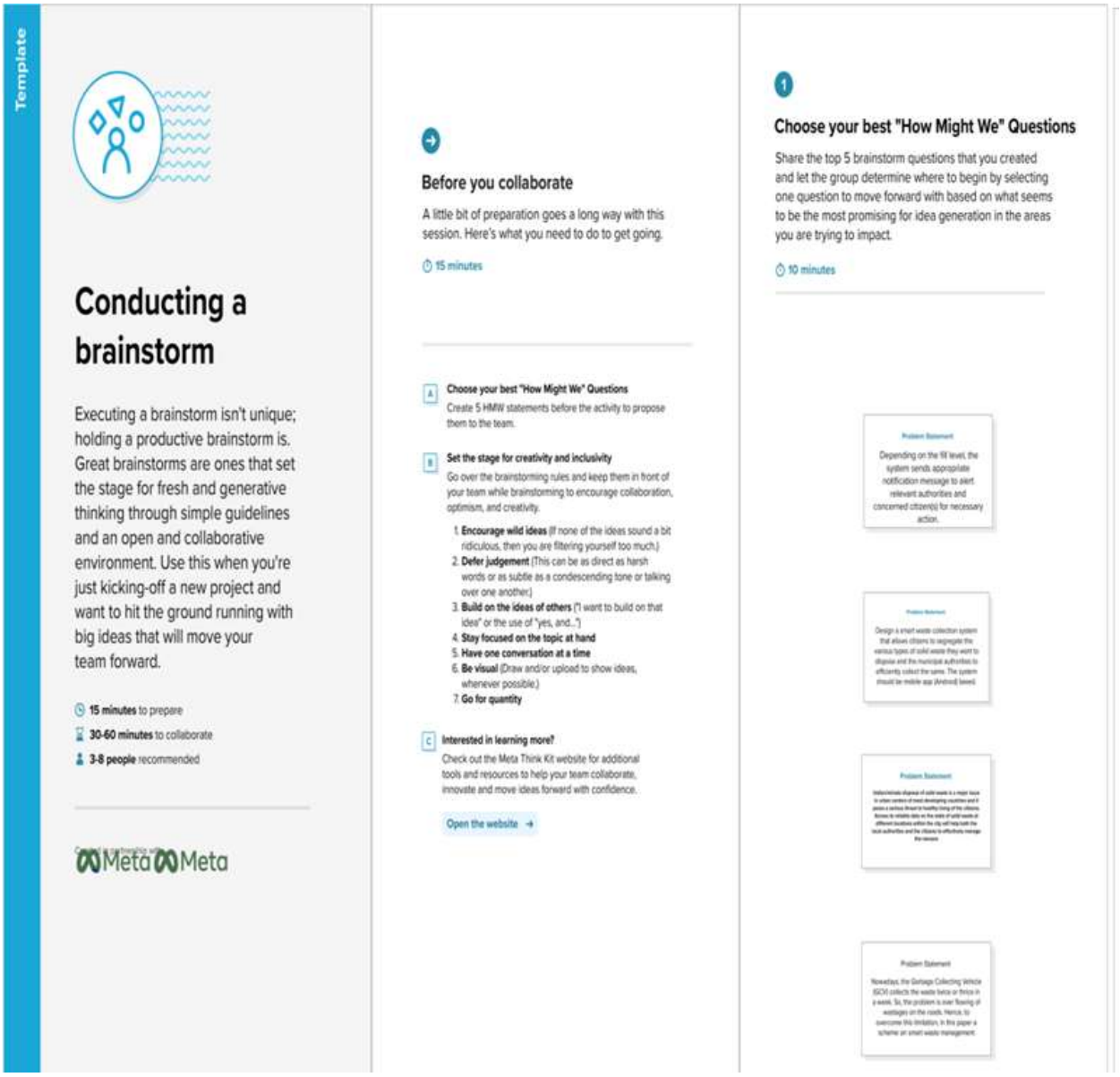
[5] F achmin F olianto, Y ong Sheng Low, Wai Leong Yeow , (2015) "Smartbin: Smart Waste Management System", Tenth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP ) Singapore, 7-9 April, IEEE

[6] Gopal Kirshna Shyam, Sunilkumar S. Manvi, Priyanka Bharti, (2017) " Smart Waste Management using Internet-of- Things (IoT)" Second International Conference On Computing and Communications Technologies(ICCCT'17), IEEE

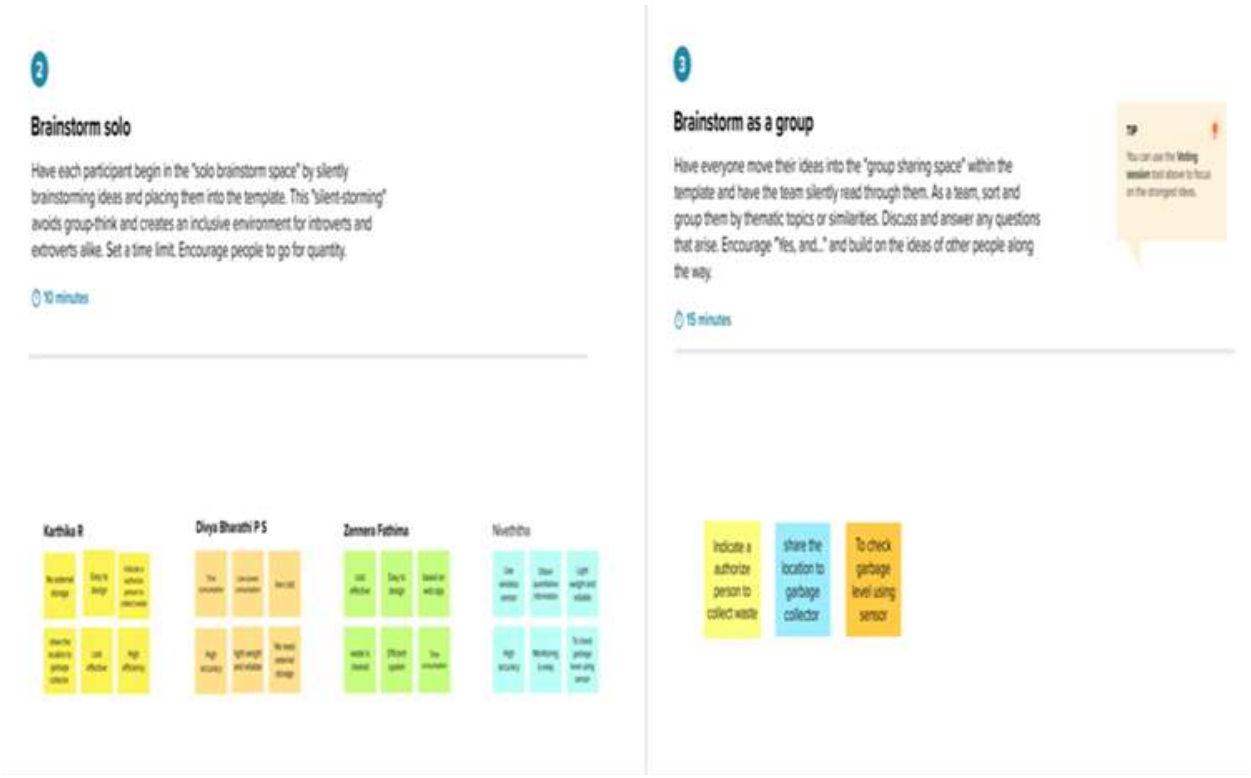
[7] Keerthana B, Sonali M Raghavendran, Kalyani S, Suja P, V.K.G.Kalaiselvi, (2017), “Internet of Bins Trash Management in India “, IEEE
[8] Bharadwaj B, M Kumudha, Gowri Chandra N, Chaithra G, (2017) “Automation of Smart Waste Management Using IoT to Support “Swachh Bharat Abhiyan” – a practical Approach “ IEEE
[9] Shubham Thakker, R.Narayanamoorthi, (2015), “Smart and Wireless Waste Management An innovative way to manage waste and also produce energy” 2nd International Conference on Innovations in Information Embedded and Communication Systems ICIIECS’15 , IEEE
[10] Artemios G. Voyiatzis, John Gialelis, and Dimitrios Karadimas, (2014) “Dynamic Cargo Routing on-the- Go: The Case of Urban Solid Waste Collection” 2 nd IEEE WiMob 2014 international workshop on smart city and ubiquitous computing application , IEEE


## 3.2 Brainstorm & Idea Prioritization Template

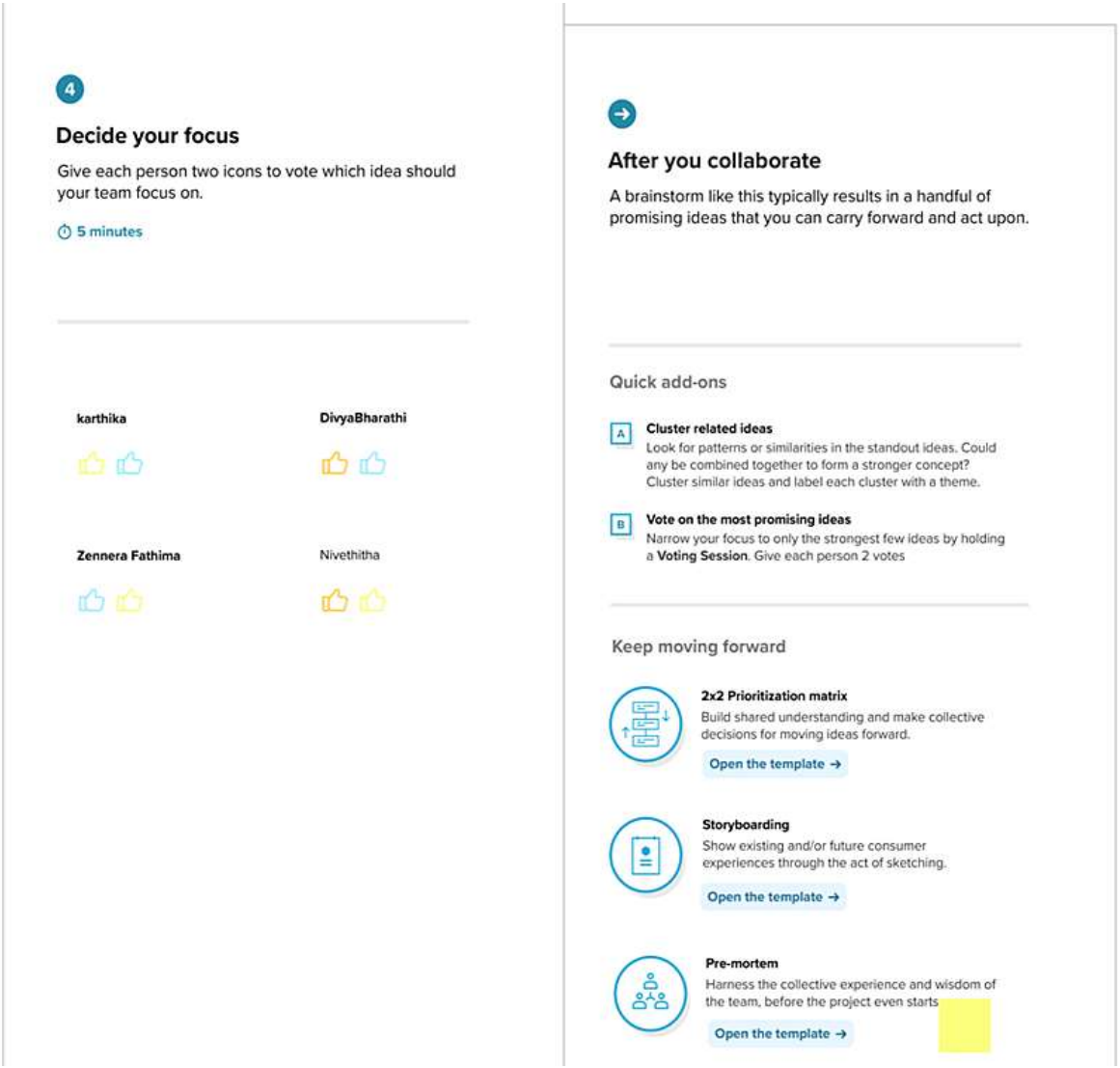
Step-1: Team Gathering, Collaboration and Select the Problem Statement




Step-2: Brainstorm, Idea Listing and Grouping




Step-3: Idea Prioritization




## 3.3.Proposed solution

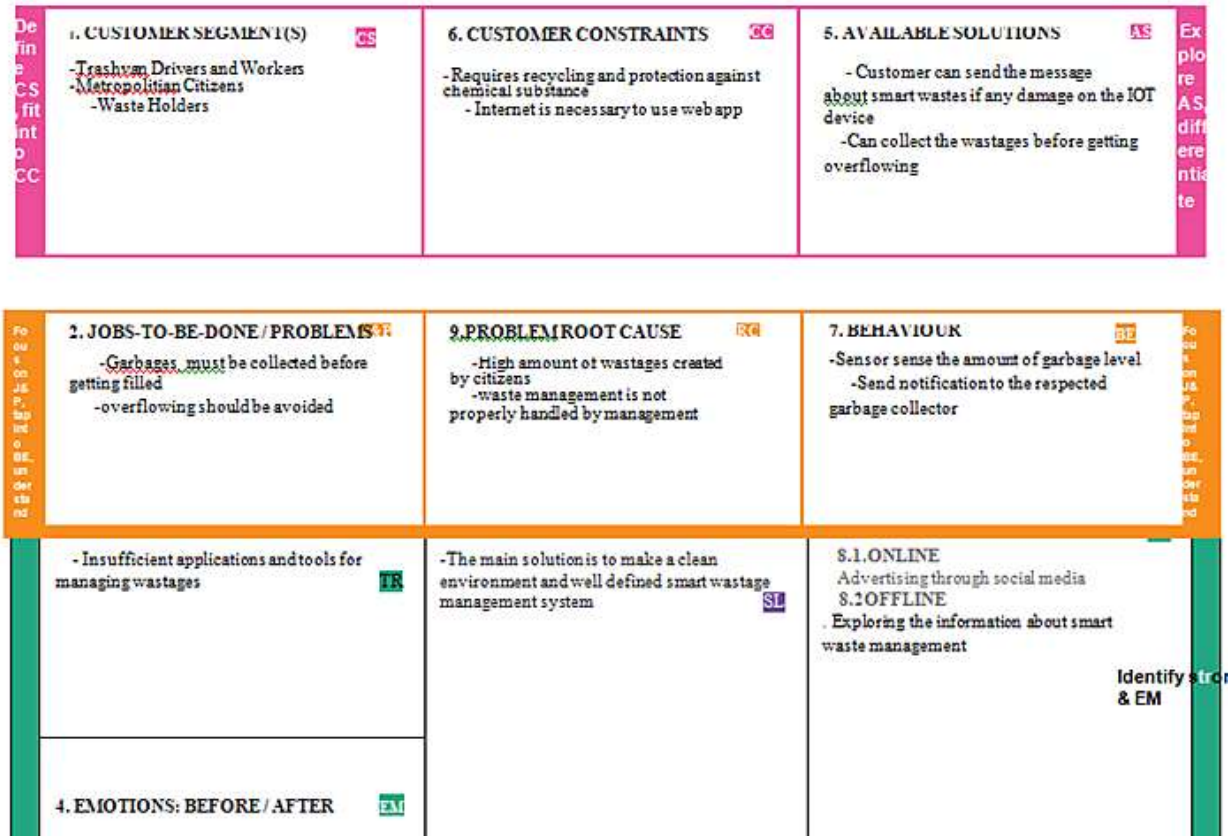
| S.No. | Parameter | Description |
|---|---|---|

| | | |
|---|---|---|
| 1. | Problem Statement (Problem to be solved) | 1. The manual monitoring of wastes in waste bins is a cumbersome process and utilises more human effort, time and cost.<br>2. Irregular disposal of wastes causing trouble to people.<br>3. Foul smell around the place with uncollected wastes or garbage. |
| 2. | Idea / Solution description | 1. This process is achieved by using a ultrasonic sensor to know the levels of garbage bin through cloud connection.<br>2. Creating an app, there by the corporation of a particular locality inside a metropolitan city can check the garbage bins whether they are filled or not. |

| | | |
|---|---|---|
| 3. | Novelty / Uniqueness | 1. Unlike the conventional methods for collecting garbage bins, this method tells us to use the transport only in required places<br>2. To reduce the human-effort and difficulty in monitoring the garbage bins. |
| 4. | Social Impact / Customer Satisfaction | 1. People can experience a clean environment.<br>2. Reduces the human effort involving in the garbage disposal process.<br>3. This idea will be very much beneficial for a city corporation for monitoring the cleanliness of various parts of the city. |
| 5. | Business Model (Revenue Model) | 1. This reduces a huge fuel cost to the city corporations by reducing the unwanted transport expenses to unnecessary places.<br>2. This project aims to support the municipal corporations.<br>3. Provide a clean environment. |

| | | |
|---|---|---|
| 6. | Scalability of the Solution | 1. A huge time is saved from frequent monitoring of garbage bins through human labours.<br>2. It can be updated to automated garbage collection through vehicles.<br>3. There is no need of new establishment of things.<br>4. Already present garbage bins are modified slightly. |

## 3.4 Problem solution fit:




# 4. Requirements

## 4.1 Functional Requirements

| FR No. | Functional Requirement (Epic) | Sub Requirement (Story / Sub-Task) |
|---|---|---|
| FR-1 | Expensive bins | 1. As we are making up bins with sensors and other costly devices , this is somewhat expensive architecture to built.<br>2. And so this requires more security settings as it requires more cost if we need to rebuilt it. |

| | | |
|---|---|---|
| FR-2 | Implementing proper monitoring system | 1. All bins can be seen on the map, and you canvisit them at any time via the Street View feature from Google. Bins are visible on the map as green, orange or red circles.<br>2. You can see bin details in the Dashboard capacity, waste type, last measurement, GPS location and collection schedule or pick recognition. |
| FR-3 | Separation of different kind ofwastes | 1. Separation of different kind of wastes involves people responsibility too and so, proper education needto be provided.<br>2. And bins should be implemented accordingly ineach locations.<br>3. And especially medical wastes should be disposed in a propermanner. |
| FR-4 | Routing the pickup of trash | 1. Route planning for rubbish pickup is semi- automated usingthe tool.<br>2. You are prepared to act and arrange for garbage collection based on the levels of bin fillthat are now present and forecasts ofapproaching capacity.<br>3. To findany discrepancies, compare the planned andactual routes. |

| | | |
|---|---|---|
| FR-5 | Getrid of ineffective picks | 1. Get rid of the collection of half-empty trashcans.<br>2. Picks are recognised by sensors.<br>3. We are able to show you how filled the bins youcollect are by utilizing real-time data on fill- levelsand pick recognition.<br>4. The report details the bin's initial level ofbrimmingness.<br>5. Any picksbelow 80% full thatare inefficient are seenright away. |

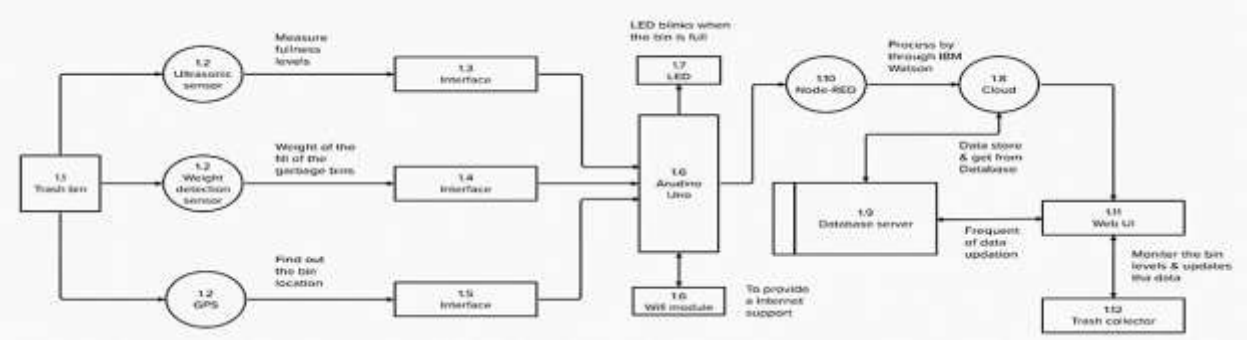
## 4.2 Non-Functional Requirements

| FR No. | Non-Functional Requirement | Description |
|---|---|---|
| NFR-1 | **Usability** | 1. The study of customers' product usability can help designers better understand users'possible demands in waste management, behavior, and experience during the design process, whichplaces a focuson the user experience. |
| NFR-2 | **Security** | 1. Security ensures the level of assurance in data collection, processing and conveying.<br>2. As this is totally depend upon cloudservice we needto make security moreparticularwithout channel crash. |

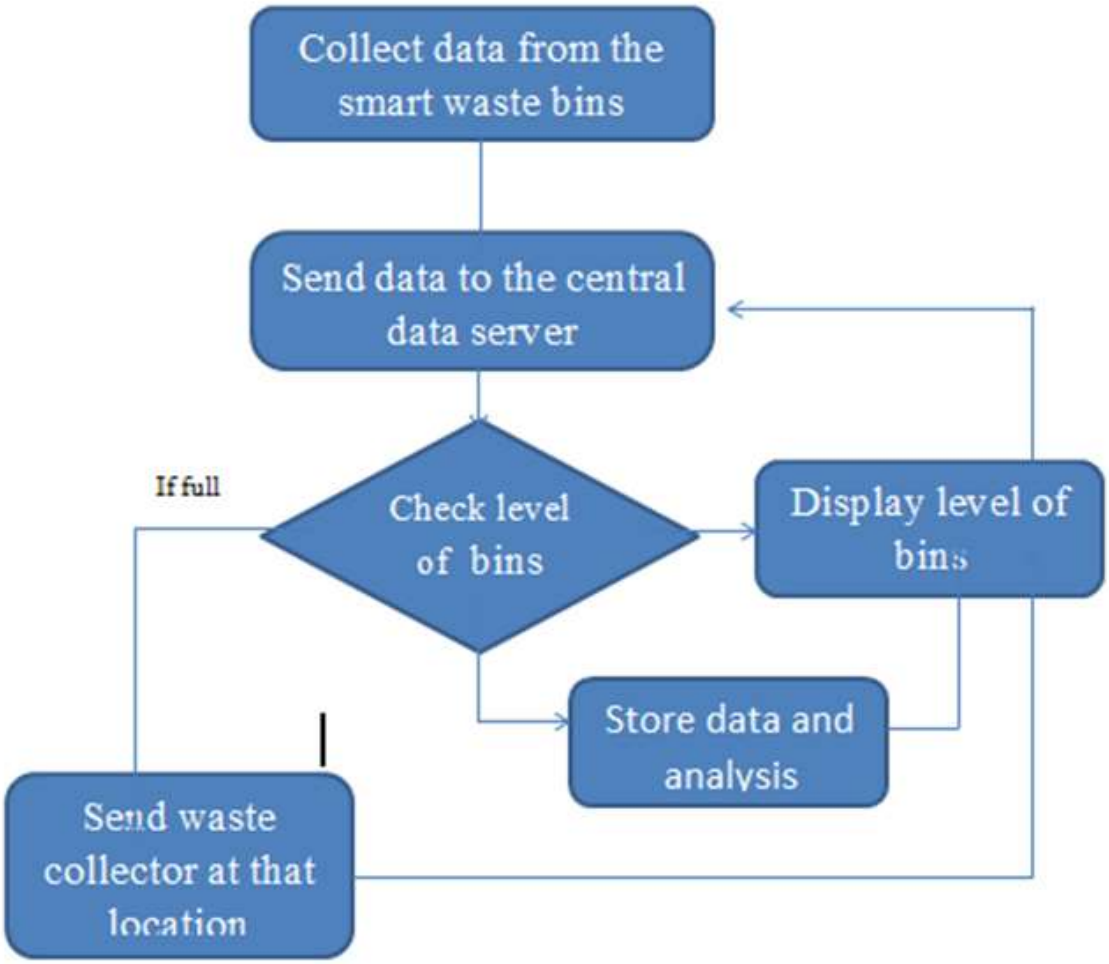
| | | |
|---|---|---|
| NFR-3 | **Reliability** | 1. Creating better working conditions for waste collectors and drivers is another aspect of smart waste management. Waste collectors will use their time more effectively by attending to empty bins that need service rather thandriving the same collection routes. |
| NFR-4 | **Performance** | 1. The system consist of sensors to measure the weightof waste and the level of wasteinside the bin.<br>2. Customers are provided with required datadriven and decision making prototypeswhich would help uses to monitor its performance andencounter their quires. |
| NFR-5 | **Availability** | 1. By creating and implementing durable hardware and gorgeous software, we enablecities, companies, and nations to manage garbage more intelligently. |
| NFR-6 | **Scalability** | 1. We have to customize the number of bins inthe town/city which we are going to monitor 24/7 aweek and collect data.<br>2. Smartwaste management aims to optimizeresource allocation, reduce running costs, and increase the sustainability of waste service.<br>3. Analytics data to manage collection routes and the placement of bins moreeffectively. |

# 5. Project Design

## 5.1 Data Flow Diagram




## 5.2 Solution & Technical Architecture




## 5.3 User Stories

| Use Type | Functional Requirement (Epic) | User Story Number | User Story / Task | Acceptance criteria | Priority | Release |
|---|---|---|---|---|---|---|
| Ad admin | Web server login | USN-1 | As a admin, I have my user name and password foe 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-1 |
| Customer (Web user) | User | USN-3 | Here comes the customer, he/she will have access to mobile apps or login webpages 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-2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cuscustomer | Worker | USN-4 | The customer care executive, will try to rectify the queries from customers by contacting coadmin. If case of any critical/ emergency situation query can be<br>conveyed to higher authority. | I can attend calls and respond people by rectifying the problem. | High | Sprint-4 |
| tdTruck drivdriver | 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<br>happenings in the given website (Webpage login). | I can update my activities on site when the given task has been completed. | Mediu m | Sprint-5 |

# 6.Project Planning and Scheduling

## 6.1 Sprint Planning & Estimation

| Sprint | Functional Requirement (Epic) | UserStory Number | User Story/ Task | Story Points | Priority | Team Members |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Sprint-1 | Registration | USN-1 | As a Administrator, I need to give user id and passcode for ever workers over there in municipality | 10 | High | Nivedhitha.v |
| Sprint-1 | Login | USN-2 | As a Co-Admin, I'll control the waste level by monitoring them vai real time web portal. Once the filling happens, I'll notify trash truck with location of binwith bin ID | 10 | High | Zennera Fathima.K.A |
| Sprint-2 | Dashboard | USN-3 | As a Truck Driver, I'll follow Co-Admin's Instruction to reach the filling bin in short roots and save time | 20 | Low | Karthika.R |
| Sprint-1 | Dashboard | USN-4 | As a Local Garbage Collector, I'II gather all the waste fromthe garbage, load it onto a garbage truck, and deliver it toLandfills | 20 | Mediu m | Karthika.R,Divy a Bharathi.P.S |
| Sprint-1 | Dashboard | USN-5 | As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems | 20 | High | Divya Bharathi.P.S |

## 6.2 Sprint Delivery Scheduling

| Sprint | Total StoryPoints | Duration | Sprint Start Date | Sprint End Date (Planned) | Story Points Completed (as on Planned End Date) | Sprint ReleaseDate (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 Nov2022 | 20 | 05 Nov2022 |
| Sprint-3 | 20 | 6 Days | 07 Nov2022 | 12 Nov2022 | 20 | 12 Nov2022 |
| Sprint-4 | 20 | 6 Days | 14 Nov2022 | 19 Nov2022 | 20 | 19 Nov2022 |

## 7.Coding and Solution

```
#include <LiquidCrystal_I2C.h>
 LiquidCrystal_I2C lcd(0x27, 20, 4);
float cm;
float inches;
#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(34, INPUT);

//ledpins
pinMode(23, OUTPUT); pinMode(22, OUTPUT);
pinMode(21, OUTPUT); pinMode(15, OUTPUT);
```

```
lcd.init(); lcd.backlight(); lcd.setCursor(1, 0); lcd.print("");
}
float readcmCM()
{
digitalWrite(TRIG_PIN, LOW); delayMicroseconds(2); digitalWrite(TRIG_PIN,
HIGH); delayMicroseconds(10); digitalWrite(TRIG_PIN, LOW);
int duration = pulseIn(ECHO_PIN, HIGH); return duration * 0.034 / 2;
}
void loop()
{
        if(digitalRead(34))         //pir motion detection
{
Serial.println("Motion Detected"); Serial.println("Lid Opened"); digitalWrite(10,
HIGH); delay(10000);
Serial.println("Lid Closed");
}
else
{
digitalWrite(10, LOW);
}

if(cm <= 100)       //Bin level detection
{
digitalWrite(21, HIGH);
Serial.println("High Alert!!!,Trash bin is about to be full"); digitalWrite(22, LOW);
digitalWrite(23, LOW);
}
else if(cm > 150 && cm < 250)
{
digitalWrite(22, HIGH);
Serial.println("Warning!!,Trash is about to cross 50% of bin level");
digitalWrite(21, LOW);
digitalWrite(23, LOW);
}
else if(cm > 250 && cm <=400)
{
```

```
digitalWrite(23, HIGH); Serial.println("Bin is available"); digitalWrite(21, LOW);
digitalWrite(22, LOW);
}

float inches = (cm / 2.54);        //print on lcd lcd.setCursor(0,0);
lcd.print("Inches"); lcd.setCursor(4,0); lcd.setCursor(12,0);

lcd.print("cm"); lcd.setCursor(1,1); lcd.print(inches, 1); lcd.setCursor(11,1);
lcd.print(cm, 1); lcd.setCursor(14,1); delay(1000); lcd.clear();

}
```

Diagram.json file

```
{
"version": 1,
"author": "Uri Shaked", "editor": "wokwi", "parts": [
{ "type": "wokwi-esp32-devkit-v1", "id": "esp", "top": 0, "left": 0, "attrs": {} },
{
"type": "wokwi-led",
"id": "led1",
"top": -43.97,
"left": 296.62,
"attrs": { "color": "limegreen" }
},
{
"type": "wokwi-led",
"id": "led2",
"top": 15.48,
"left": 299.36,
"attrs": { "color": "yellow" }
},
{
"type": "wokwi-led",
"id": "led3",
"top": 140.83,
"left": 302.1,
"attrs": { "color": "blue" }
},
```

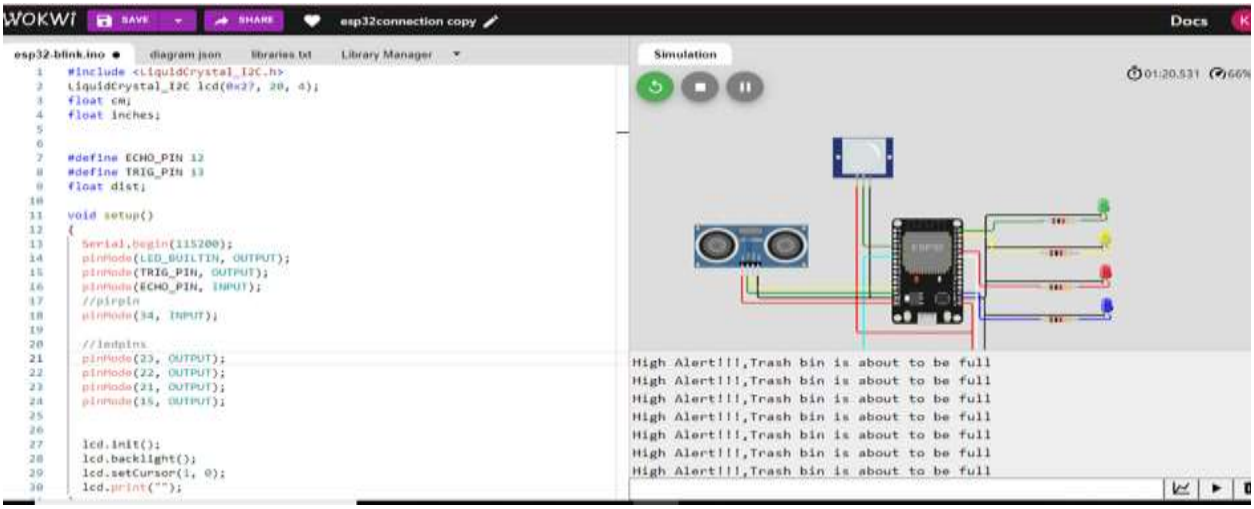
```
{
"type": "wokwi-led",
"id": "led4",
"top": 79.19,
"left": 300.24,
"attrs": { "color": "red" }
},
{
"type": "wokwi-resistor",

"id": "r1",
"top": -3.9,
"left": 224.81,
"attrs": { "value": "1000" }
},
{
"type": "wokwi-resistor", "id": "r2",
"top": 55.55,
"left": 221.42,
"attrs": { "value": "1000" }
},
{
"type": "wokwi-resistor", "id": "r3",
"top": 179.36,
"left": 221.1,
"attrs": { "value": "1000" }
},
{
"type": "wokwi-resistor", "id": "r4",
"top": 119.28,
"left": 220.77,
"attrs": { "value": "1000" }
},
{
"type": "wokwi-lcd1602",
"id": "lcd1",
```

```
"top": 248.08,
"left": 161.61,
"attrs": { "pins": "i2c" }
},
{
"type": "wokwi-hc-sr04",
"id": "ultrasonic1",
"top": 13.99,
"left": -295.33,
"attrs": { "distance": "57" }
},
{
"type": "wokwi-pir-motion-sensor", "id": "pir1",
"top": -147.86,
"left": -88.23,
"attrs": {}
}

],
"connections": [
[ "esp:TX0", "$serialMonitor:RX", "", [] ],
[ "esp:RX0", "$serialMonitor:TX", "", [] ],
[ "led1:A", "r1:2", "green", [ "v0" ] ],
[ "led2:A", "r2:2", "yellow", [ "v0" ] ],
[ "led4:A", "r4:2", "red", [ "v0" ] ],
[ "led3:A", "r3:2", "blue", [ "v0" ] ],
[ "led1:C", "esp:GND.1", "black", [ "v-2.56", "h-170.98", "v116.48" ] ],
[ "led2:C", "esp:GND.1", "black", [ "v-2.24", "h-173.72", "v91.96" ] ],
[ "led4:C", "esp:GND.1", "black", [ "v-3.11", "h-174.6", "v27.59" ] ],
[ "led3:C", "esp:GND.1", "black", [ "v-1.92", "h-177.99", "v-32.18" ] ],
[ "r1:1", "esp:D23", "green", [ "v2.63", "h-71.91", "v19.92" ] ],
[ "r2:1", "esp:D22", "yellow", [ "v-1.65", "h-71.58", "v-30.65" ] ],
[ "r4:1", "esp:D21", "red", [ "v-1.01", "h-89.32", "v-64.37" ] ],
[ "r3:1", "esp:D15", "blue", [ "v0.22", "h-89.65", "v-53.64" ] ],
[ "lcd1:GND", "esp:GND.1", "black", [ "h-26.5", "v-129.82" ] ],
[ "lcd1:VCC", "esp:3V3", "red", [ "h-44.89", "v-131.65" ] ],
```

[ "pir1:VCC", "esp:3V3", "red", [ "v268.96", "h172.77", "v-55.17" ] ], [
"pir1:GND", "esp:GND.2", "black", [ "v0" ] ],
[ "pir1:OUT", "esp:D34", "green", [ "v0" ] ],
[ "esp:D32", "lcd1:SDA", "cyan", [ "h-46.74", "v226.73", "h207.35" ] ],
[ "lcd1:SCL", "esp:D19", "white", [ "h-38.76", "v-0.46" ] ],
[ "ultrasonic1:GND", "esp:GND.2", "black", [ "v0" ] ],
[ "ultrasonic1:ECHO", "esp:D12", "yellow", [ "v0" ] ],
[ "ultrasonic1:TRIG", "esp:D13", "green", [ "v0" ] ],
[ "ultrasonic1:VCC", "esp:VIN", "red", [ "v0" ] ]
]
}
# Wokwi Library List
# See https://docs.wokwi.com/guides/libraries LiquidCrystal I2C
OUTPUT:




# 8.Testing

## 8.1 Test cases

| Component | Test Scenario | Pre-Requisite | Steps To Execute | Test Data | Expected Result | Actual Result |
|---|---|---|---|---|---|---|
| Login page | Verify user is able to log into application with InValid credentials | | Enter invalid username/email in email text box . Enter valid password text box. Click on log in button | username:speed password:123456 | Application should show 'Incorrect email or password ' validation message. | Working as expected |
| Login page | verify user is able to connect with open weather api | | if open weather api was connected it will show connected. | | open weather api will connected | Working as expected |
| Login page | verify user is able to see the temperature and visibility | | click the link the temperature and the visibility will be shown | | if the user click on link the value will be shown otherwise it will not shown | Working as expected |

| | | | NFT - Risk Assessment | | | | | |
|---|---|---|---|---|---|---|---|---|
| S.No | Project Name | Scope/feature | Functional Changes | Hardware Changes | Software Changes | Impact of Downtime | Load/Volume Changes | Risk Score |
| 1 | signs with smart conn | Existing | Low | No Changes | moderate | No downtime | >5 to 10% | GREEN |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

## Performance Testing

| | | | NFT - Risk Assessment | | | | | |
|---|---|---|---|---|---|---|---|---|
| S.No | Project Name | Scope/feature | Functional Changes | Hardware Changes | Software Changes | Impact of Downtime | Load/Volume Changes | Risk Score |
| 1 | signs with smart conn | Existing | Low | No Changes | moderate | No downtime | >5 to 10% | GREEN |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

## 8.2 User Acceptance Testing

## 1.Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the [Signs with smart connectivity for better Waste management 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 howthey were resolved.

| Resolution | Severity1 | Severity2 | Severity3 | Severity4 | Subtotal |
|---|---|---|---|---|---|
| By Design | 10 | 4 | 2 | 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 | 77 |

## Test Case Analysis

| 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 |

# Results

## 9.1 Performance metrics

This project used to measure garbage level and send alert message to trash collector.Reducing waste will not only protect the environment but will also save on costs or reduce expenses for disposal. In the same way, recycling and/or reusing

the waste that is produced benefits the environment by lessening the need to extract resources and lowers the potential for contamination.

## 10.Advantages

It saves time and money by using smart waste collection bins and systems equipped with fill level sensors. As smart transport vehicles go only to the filled containers or bins. It reduces infrastructure, operating and maintenance costs by upto 30%.

1. It decreases traffic flow and consecutively noise due to less air pollution as result of less waste collection vehicles on the roads. This has become possible due to two way communication between smart dustbins and service operators.
2. It keeps our surroundings clean and green and free from bad odour of wastes, emphasizes on healthy environment and keep cities more beautiful.
3. It further reduces manpower requirements to handle the garbage collection process.
4. Applying smart waste management process to the city optimizes management, resources and costs which makes it a "smart city".
5. It helps administration to generate extra revenue by advertisements on smart devices.

## 10.1.Disadvantages

1. Sensor nodes used in the dustbins have limited memory size.
2. It reduces man power requirements which results into increase in unemployments for unskilled people.
3. The trainining has to be provided to the people involved in the smart waste management system.

## 11.Conclusion

1) optimization of the garbage collection process, reduction of labor and resource costs, increase in efficiency and comfort of citizens

2) improvement of the ecological situation in the city

3) increasing environmental awareness and motivation of the citizens;

## 12.Future Scope

There are several future works and improvements for the proposed system, 1. Change the system of user's authentication and atomic lock of bins which would help in securing the bin from any kind of damage or theft. 2. Concept of green-points that would encourage the involvement of the residents or the end users making the idea successful and helping to achieve joined efforts for the waste management and hence fulfilling the idea of Swachch Bharath. 3. Having a case study or data analytics on the type and times the waste is collected on the type of days or season making the bin filling predictable and removing the dependency on electronic components and fixing the coordinates. 4. Improving graphical interfaces for the Server and complete Android applications has possibility of extending the system adding other use cases and applications for smart cities. 5. Moreover, the proposed solution is flexible and decoupled with respect to the determination of optimal number of bins and vehicles or to the algorithm that define the best route for vehicles. Therefore, future works can be made in the study of models that offer the best results in terms of decision-making.

## 13.Appendix

**Source Code**

```
#include <LiquidCrystal_I2C.h>
```

```
 LiquidCrystal_I2C lcd(0x27, 20, 4);
float cm;
float inches;
#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(34, INPUT);

//ledpins
pinMode(23, OUTPUT); pinMode(22, OUTPUT);
pinMode(21, OUTPUT); pinMode(15, OUTPUT);
lcd.init(); lcd.backlight(); lcd.setCursor(1, 0); lcd.print("");
}
float readcmCM()
{
digitalWrite(TRIG_PIN, LOW); delayMicroseconds(2); digitalWrite(TRIG_PIN,
HIGH); delayMicroseconds(10); digitalWrite(TRIG_PIN, LOW);
int duration = pulseIn(ECHO_PIN, HIGH); return duration * 0.034 / 2;
}
void loop()
{
        if(digitalRead(34))         //pir motion detection
{
Serial.println("Motion Detected"); Serial.println("Lid Opened"); digitalWrite(10,
HIGH); delay(10000);
Serial.println("Lid Closed");
}
else
{
digitalWrite(10, LOW);
}

if(cm <= 100)       //Bin level detection
{
```

```
digitalWrite(21, HIGH);
Serial.println("High Alert!!!,Trash bin is about to be full"); digitalWrite(22, LOW);
digitalWrite(23, LOW);
}
else if(cm > 150 && cm < 250)
{
digitalWrite(22, HIGH);
Serial.println("Warning!!,Trash is about to cross 50% of bin level");
digitalWrite(21, LOW);
digitalWrite(23, LOW);
}
else if(cm > 250 && cm <=400)
{
digitalWrite(23, HIGH); Serial.println("Bin is available"); digitalWrite(21, LOW);
digitalWrite(22, LOW);
}

float inches = (cm / 2.54);        //print on lcd lcd.setCursor(0,0);
lcd.print("Inches"); lcd.setCursor(4,0); lcd.setCursor(12,0);

lcd.print("cm"); lcd.setCursor(1,1); lcd.print(inches, 1); lcd.setCursor(11,1);
lcd.print(cm, 1); lcd.setCursor(14,1); delay(1000); lcd.clear();

}
```

Diagram.json file

```
{
"version": 1,
"author": "Uri Shaked", "editor": "wokwi", "parts": [
{ "type": "wokwi-esp32-devkit-v1", "id": "esp", "top": 0, "left": 0, "attrs": {} },
{
"type": "wokwi-led",
"id": "led1",
"top": -43.97,
"left": 296.62,
"attrs": { "color": "limegreen" }
},
{
```

```
"type": "wokwi-led",
"id": "led2",
"top": 15.48,
"left": 299.36,
"attrs": { "color": "yellow" }
},
{
"type": "wokwi-led",
"id": "led3",
"top": 140.83,
"left": 302.1,
"attrs": { "color": "blue" }
},
{
"type": "wokwi-led",
"id": "led4",
"top": 79.19,
"left": 300.24,
"attrs": { "color": "red" }
},
{
"type": "wokwi-resistor",

"id": "r1",
"top": -3.9,
"left": 224.81,
"attrs": { "value": "1000" }
},
{
"type": "wokwi-resistor", "id": "r2",
"top": 55.55,
"left": 221.42,
"attrs": { "value": "1000" }
},
{
"type": "wokwi-resistor", "id": "r3",
```

```
"top": 179.36,
"left": 221.1,
"attrs": { "value": "1000" }
},
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"top": 119.28,
"left": 220.77,
"attrs": { "value": "1000" }
},
{
"type": "wokwi-lcd1602",
"id": "lcd1",
"top": 248.08,
"left": 161.61,
"attrs": { "pins": "i2c" }
},
{
"type": "wokwi-hc-sr04",
"id": "ultrasonic1",
"top": 13.99,
"left": -295.33,
"attrs": { "distance": "57" }
},
{
"type": "wokwi-pir-motion-sensor", "id": "pir1",
"top": -147.86,
"left": -88.23,
"attrs": {}
}

],
"connections": [
[ "esp:TX0", "$serialMonitor:RX", "", [] ],
[ "esp:RX0", "$serialMonitor:TX", "", [] ],
[ "led1:A", "r1:2", "green", [ "v0" ] ],
```

[ "led2:A", "r2:2", "yellow", [ "v0" ] ],
[ "led4:A", "r4:2", "red", [ "v0" ] ],
[ "led3:A", "r3:2", "blue", [ "v0" ] ],
[ "led1:C", "esp:GND.1", "black", [ "v-2.56", "h-170.98", "v116.48" ] ],
[ "led2:C", "esp:GND.1", "black", [ "v-2.24", "h-173.72", "v91.96" ] ],
[ "led4:C", "esp:GND.1", "black", [ "v-3.11", "h-174.6", "v27.59" ] ],
[ "led3:C", "esp:GND.1", "black", [ "v-1.92", "h-177.99", "v-32.18" ] ],
[ "r1:1", "esp:D23", "green", [ "v2.63", "h-71.91", "v19.92" ] ],
[ "r2:1", "esp:D22", "yellow", [ "v-1.65", "h-71.58", "v-30.65" ] ],
[ "r4:1", "esp:D21", "red", [ "v-1.01", "h-89.32", "v-64.37" ] ],
[ "r3:1", "esp:D15", "blue", [ "v0.22", "h-89.65", "v-53.64" ] ],
[ "lcd1:GND", "esp:GND.1", "black", [ "h-26.5", "v-129.82" ] ],
[ "lcd1:VCC", "esp:3V3", "red", [ "h-44.89", "v-131.65" ] ],
[ "pir1:VCC", "esp:3V3", "red", [ "v268.96", "h172.77", "v-55.17" ] ], [
"pir1:GND", "esp:GND.2", "black", [ "v0" ] ],
[ "pir1:OUT", "esp:D34", "green", [ "v0" ] ],
[ "esp:D32", "lcd1:SDA", "cyan", [ "h-46.74", "v226.73", "h207.35" ] ],
[ "lcd1:SCL", "esp:D19", "white", [ "h-38.76", "v-0.46" ] ],
[ "ultrasonic1:GND", "esp:GND.2", "black", [ "v0" ] ],
[ "ultrasonic1:ECHO", "esp:D12", "yellow", [ "v0" ] ],
[ "ultrasonic1:TRIG", "esp:D13", "green", [ "v0" ] ],
[ "ultrasonic1:VCC", "esp:VIN", "red", [ "v0" ] ]
]
}
# Wokwi Library List
# See https://docs.wokwi.com/guides/libraries LiquidCrystal I2C

GitHub Link

https://github.com/IBM-EPBL/IBM-Project-38607-1660383406