Project Report Format

1. **INTRODUCTION**
2. **LITERATURE SURVEY**
   - 2.1. References
   - 2.2. Problem Statement Definition
3. **IDEATION & PROPOSED SOLUTION**
   - 3.1. Empathy Map Canvas
   - 3.2Ideation & Brainstorming
   - 3.3Proposed Solution
   - 3.4Problem Solution fit
4. **REQUIREMENT ANALYSIS**
   - 4.1Functional requirement
   - 4.2Non-Functional requirements
5. **PROJECT DESIGN**
   - 5.1Data Flow Diagrams
   - 5.2Solution & Technical Architecture
   - 5.3User Stories
6. **PROJECT PLANNING & SCHEDULING**
   - 6.1Sprint Planning & Estimation
   - 6.2Sprint Delivery Schedule
   - 6.3Reports from JIRA
7. **CODING & SOLUTIONING (Explain the features added in the project along with code)**
   - 7.1Feature 1
   - 7.2Feature 2
8. **ADVANTAGES & DISADVANTAGES**
9. **CONCLUSION**
10. **FUTURE SCOPE**
11. **APPENDIX**

11.1. Source Code

11.2. GitHub & Project Demo Link

1.INTRODUCTION

I. INTRODUCTION

The smart way of doing things done is the concept behind the smart city's development with less man power and maximum utilization of the technology in the day today life. The use of technologies is very significant towards the development of smart cities. Automation is the key part in the smart cities irrespective of various needs and applications [1]. At places, whether it is a rural or urban area or apartment or multi storey buildings, there occurs the accumulation of wastes. The applicability of a proper waste management system is significant at this point. Rise in urbanization and increase in population matches up to the quantity of solid waste in today's life [2, 3]. Therefore, solid waste management and managing the condition of the waste bins possess a major challenge in metropolitan cities like Chennai, India. Waste bins are part of our lives for decades and mostly the condition of the waste bins is overflowing due to improper waste dumping, collection and management leads in foul smell and unhygienic condition which inherently results in environment pollution.

The old-fashioned method of management of solid waste is an unwieldy and intricate process, which utilizes enormous human effort, valuable time and hefty cost and is not well matched with advancement in technologies. One of the smart ways of monitoring the things is the use of "Internet of Things" (IoT). Through IoT, devices with internet connectivity can be monitored and controlled remotely. We have proposed a waste management system by utilizing the concept of IoT to connect the different dust bins at different locations and also to identify the level of waste in a dust bin through a centralized system. Hence, the concerned persons will be notified about each bin status and there by achieving the removal of wastes in a proper way.

A smart bin for waste management is designed using an Arduino microcontroller, Wi-fi module and sensors to indicate the level of waste, to detect harmful gas and closing of lid thereby giving a solution to collect the waste in proper way [4]. Real time monitoring and collection of solid waste for smart city services is addressed in [5], where each bin is installed with Arduino microcontroller, ultrasonic sensor and Radio Frequency (RF) transmitter on the top of the container which sends signal to the control center through GSM/GPRS when the bin is filled [5].

Smart Garbage Management System is developed and addressed in [6] where, IR sensors embedded on dustbins for waste level detection, GSM 900 modem is used to send waste level data collected by microcontroller, with an additional graphical user interface using MATLAB software. A smart waste management system is proposed by an on-site and real time monitoring of waste as well as a data elaboration through decisional algorithms [7]. An automatic smart waste management system is presented in [8], where smart vehicle system with a local base station and a trash system with smart monitoring & controlling hut having two load sensor and IR proximity sensor were used and addressed.

In [9] a step had been taken to connect the various sensor or actuators in a network through an Access Point (AP) to the cloud and investigated on three different sensor applications. Power consumption, Interference impact and range performance analysis are also evaluated for each application and discussed. Smart community is an emerging application of technological advancement of IoT. Smart community architecture is defined and realized by connecting individual homes through IoT. A similar application of the smart community in Neighborhood Watch and Pervasive Healthcare is presented and challenges involved are also discussed in [10]. A possibility of using Mobile-2-Mobile (M2M) solutions for management of road traffic linking IoT is investigated in [11]. The use of Industrial Wireless Sensor Networks (WSN) in IoT environment is also proposed in [12]. In this work, the design of a smart sensor interface by connecting the sensors in WSN allowing the reconfigurability by reading the data in parallel as well as in real time using ARM Controller is also discussed in detail. Similarly, a smart home control network is developed and evaluated for the smart control of lighting systems in smart homes by using a scalable architecture combining WSN and Power line communications (PLC) technologies. This also results in less radio interference and allows an easy replacement of nodes in a WSN [13].

An IoT-based Smart Garbage system (SGS) is reported in [14] which are operated in Gangnam district, Seoul for a period of one year resulting in the reduction of food waste by 33%. Battery based smart dust bins are connected in wireless mesh network and a router and server is used to transfer the information collected in this work. IoT architecture for optimized waste management in smart cities is also realized in [15], where LoRa LPWAN (Low Power Wide Area Network) technology is used for the transmission of data collected from the microcontroller connected ultrasound sensor nodes.

A Spatial Smart Waste Management System (SWMS) is implemented in Malaysia in order to manage the wastes by giving alerts about the waste level in a bin to the contractor for optimizing the collection routes and penalizes if not collected the garbage on time [16]. A smart recycle bin based on

IoT and Wi-Fi is also introduced based on reduce, reuse and recycle concept. It is like an enforcement system that makes the people to classify the waste for recycling and also used DeviceBit and Blynk applications for real time monitoring [17]. A step is taken towards the detailed analysis of various waste management models and an IoT based reference model is implemented and compared with the existing models to identify the best choice and research challenges [18].

According to the literature found and discussed numerous efforts were made in solid waste management and in IoT. However, the major challenge is to bring together the best method of Solid waste management and the technical advancements of IoT. Therefore, In general, a smart waste monitoring system consists of sensors, transmission medium, waste level data acquisition and collection system and connectivity to the cloud has to be found inside a waste bin for having smartness in the system. Inspired from the literature and the Swachh Bharat initiative of the Government of India, the main objective of this paper is to design and develop an IOT Enabled Smart Waste Bin with Real Time Monitoring for efficient waste management system. The developed system intend to reduce valued human resources effort, time and cost as well as to protect the environment and healthy living of the people with the help of Modern technologies such as cloud system, Wi-Fi, ultrasonic ranger sensor, capacitive action.

II. METHODOLOGY

Inspired from the literature and as a preliminary study, design of a smart waste bin is presented in this section. This section also describes the use of different sensors, actuators and controllers associated with the design of the smart bin. The waste level detection using the capacitance method is also presented. Further, a smart waste management system utilizing the designed smart bins is also addressed as a proposed system using the recent technical advancements of automation and the Internet of Things (IoT).

A. Design of Smart Dust Bin

Figure 1 shows the block diagram of a smart waste bin, where the smartness is achieved by having ultrasonic sensors, capacitive sensors, microcontrollers, servo motors, NodeMcU and integrating to form a complete autonomous system. The waste level inside the bin is determined by estimating the distance between the bottom of the bin and the lid using ultrasonic sensor. In addition to this, the level of waste is also estimated by using

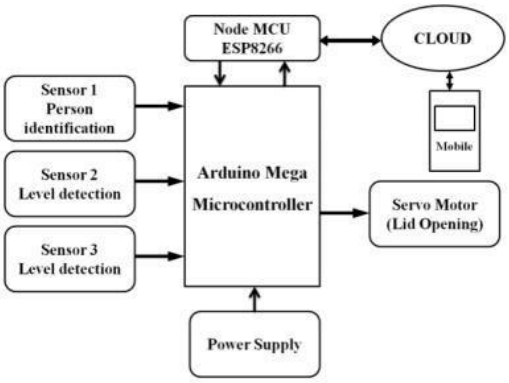


Fig. 1. Block diagram of Smart Dust Bin.

Change in capacitance principle by having parallel plates inside the bin. The sensors are connected with the controller and the levels are continuously recorded in the cloud. When the waste level exceeds the threshold value, which is set according to the dimension of the bin, the controller alerts the responsible municipal persons or the sanitary inspector with the bins ID, bin location and the bin level. An automated opening and closing of the bin lid is also incorporated by having another ultrasonic sensor, which opens the lid of the bin whenever it perceives a person nearby to the bin. A power supply unit provides a necessary power to the operation of the bin. Once the bin is emptied and serviced, it returns to the default operation.

A commonly used cylindrical plastic trash bin with the dimension of 30x20x60cm with lid is used to develop the smart bin. As shown in figure 1, the smart bin uses two SRF 04 ultrasonic transceivers for the detection of waste level and to perceive the motion of a person nearby bin respectively. The ultrasonic sensors are operated with the frequency of 40 KHz and the time of flight method is utilized to estimate the level of waste inside the bin and also to estimate the motion of the person when he falls inside the threshold value of 30cm. Ultrasonic sensor 1 is mounted facing the bottom of the bin, which measures the level of waste inside the bin with the threshold of 25%, 50%, 75% and 90% of the bin depth of 60cm. Similarly, ultrasonic sensor 2 used to detect the motion of the person is mounted at the top of the bin facing outside. TowerPro MG995 Metal Gear Servo Motor with 180° operation is used as the actuator for opening and closing the lid of the bin whenever the sensor perceives the nearby motion of the person. The lid closes automatically when the person moves away from the threshold distance. A rechargeable Lithium Polymer (LiPo) battery of 2200mAh, 11.1V is used as a power supply to the entire system. Entire electronic system is mounted within a weather proof casing and fixed in the trash bin.

An Atmega2560+NodeMCU ESP8266 microcontroller with 32 Mb (megabits) of flash memory, working on arduino development environment is used as a controller to integrate the sensors, actuators and communication devices to provide the necessary actions required by the smart bin. The advantage of using this controller is that the all of the modules can work together or each separately, eliminating the interface issues, when compared to the other arduino controller used in the literatures. NodeMcU is used as the communication device which connects the system with the IoT cloud by broadcasting the level of waste in bin, status of the bin along with the bin ID and location. Further, it also broadcasts the alert signal to the sanitation inspector or central municipal server whenever the bin exceeds the 90% threshold level limits. Universal Datagram Protocol (UDP) is used as the communication standard by the system, with the maximum packet size of 255 bytes. However, only 40 bytes are used as a packet size out of which 8 bytes are used as UDP header and remaining 32 bytes for data to effectively communicate the status information to the cloud as shown in Figure 2. The data byte consists of Bin ID, Location with Latitude and Longitude information, Bin Level, Status and Power level.

Source Port	Destination	Length	Check sum	Bin ID	Empty	Location	Empty	Check sum	Bin Level	Empty	Bin Status	Power level
2	2	2	2	2	4	8	4	2	4	4	2	2
UDP Header (8 bytes)				UDP DATA (32 bytes)								

Fig. 2. Universal Datagram Protocol (UDP) packet.

As mentioned in the previous section, the entire process is developed in Arduino IDE. Figure 3 shows the flowchart of the arduino program where the motion detection and level measurement is executed in parallel.

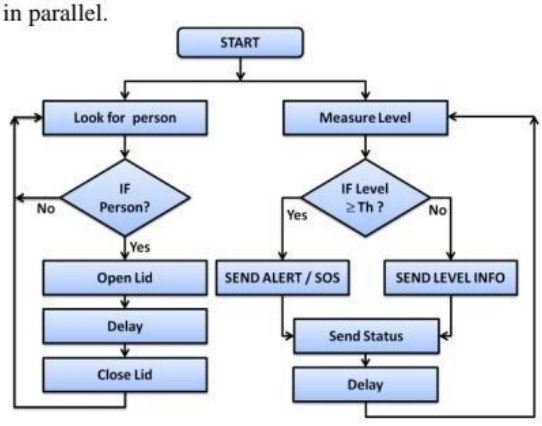


Fig. 3. Software flowchart of Smart Waste Bin

In order to have efficient communication method as per UDP protocol each bin is identified by dedicated IP address configured in the NodeMcU and updates the information of the bin to the cloud for predetermined minutes establishing the connection with the cloud using polling strategy. Polling strategy is utilized to route the data efficiently to the cloud, since the NodeMcU has limited memory and energy constrained, thereby reducing communication overload. As the data are logged into the IoT cloud, the level and status of the bins along with the alerts are monitored using the blynk mobile app installed in the sanitation inspector and the centralized municipal server. Once the bins are serviced and the wastes are removed, the system returns back to the original state.

B. Parallel Plate Capacitor based detection of waste level.

Most of the design for smart waste bin found in the literature uses ultrasonic sensors to detect the level of waste in the bin which were very similar to the technique discussed in the previous sections and as mentioned in figure 4 (a). However, this level detection is prone to errors while opening the lid of the waste bin due to the motion of the person near the bin to dump the trash. The lid opening causes the sensor to move away from the sensing field of view as depicted in figure 4 (b), and provides faulty data to the cloud and a municipal sanitary inspector. In order to avoid such errors, the level of waste detection is achieved using a simple parallel plate capacitance principle as given in figure 4. Two copper plates of dimension 50cm x 5cm x 0.3cm is used as the electrodes and mounted opposite to each other, in the wall of the bin as shown in figure 4. These plates are with the cross sectional area of 250cm^2 and separated with the distance of 18cm, with the initial capacitance value of 1.22 pF by general capacitance equation given as equation 1, considering the permittivity of free space and air as the dielectric medium between the plates assuming there are no wastes in the bin.

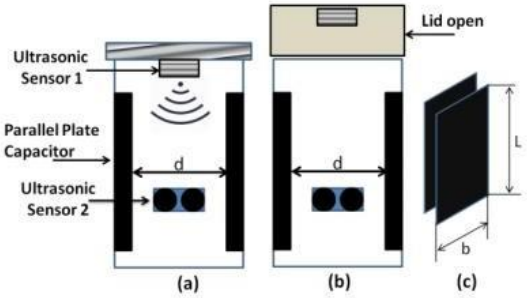


Fig. 4. (a) Smart bin with lid closed and parallel plates (b) Bin with lid open and position of sensor (c) Parallel plates as capacitors

$$C = \varepsilon_r \varepsilon_0 \frac{A}{d} \quad (1)$$

Where,
'C' is the capacitance between the parallel plates,
'ε_o' is the permittivity of the free space which is 8.854×10^{-12}
'ε_r' is the relative permittivity or dielectric constant of the material between the plates,
'A' is the cross sectional area of the plates
'd' is the separation distance between the plates.

As the wastes are dumped in the bin the, the waste / trash acts as a dielectric medium between the plates and the capacitance between the plates changes due to the changes in the relative permittivity (ε_r) of the material. As a result, this change in capacitance value is correlated to the level of waste inside the bin.

Figure 5 shows a signal conditioning circuit developed to convert the change in capacitance value to electric signal which could be read by the microcontroller for further processing. This circuit consists of two stages where the first stage is the sensing and transduction stage in which the capacitance is converted into the electrical signal by measuring the voltage drop across the capacitor which is given by equation 2.

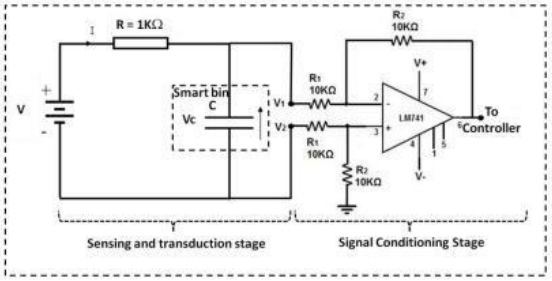


Fig. 5. Sensing, transduction and signal conditioning circuit used to convert capacitance into electrical signal

$$V_C = V\left(1 - e^{-t/RC}\right) \quad (2)$$

Where,
'V' is the applied voltage
'Vc' is the voltage drop across the capacitor
'R' is the resistance value
'C' is the capacitance of the parallel plates,
't' is the elapsed time.

As the change in capacitance due to change in the level of dielectric constant, is very small, the voltage drop across the capacitance is also very small, which has to be amplified so that the microcontroller can read the electrical values. Therefore, the second stage of the signal conditioning circuit has a differential amplifier designed using op-Amp LM741/OP07, with appropriate gain values. Hence, the voltage across the capacitor is amplified and fed to the micro controller for the detection of trash level in the bin. This method of detection of waste level is simple and cost effective when compare to the use of ultrasonic sensors

III. EXPERIMENTS AND RESULTS

Design and development of an IoT enabled smart waste bin using parallel plate capacitance and ultrasonic sensor based level detection is presented and discussed in the previous section. Series of experiments were carried out to measure the performance of the waste bin. Experiments were conducted by establishing a cloud linking the waste bins with the local area network in our centre at Hindustan Institute of Technology and Science. Experiments are conducted using plastic bottles and paper as trash. The change in capacitance is estimated to be 4.6pF, when the bin is full of plastic bottles as trash and 2.2 pF for the full bin with paper as trash. Figure 6 shows the value of capacitance obtained theoretically as well as experimentally for different levels of the bin. The statuses of the bins are monitored using the blynk app, running in the mobile phone.

Figure 7, depicts the qualitative results of the statuses of the bin monitored using blynk app. The level of waste in the bin is represented by traffic lights in the app where red indicates the fullness of the bin, green indicates the 25% level and yellow indicates the 50% level. It could be observed from figure 5, that whenever a motion is detected near to the bin, the bin lid opens automatically and the level of the bin is detected, communicated to the cloud and displayed in the app effectively.

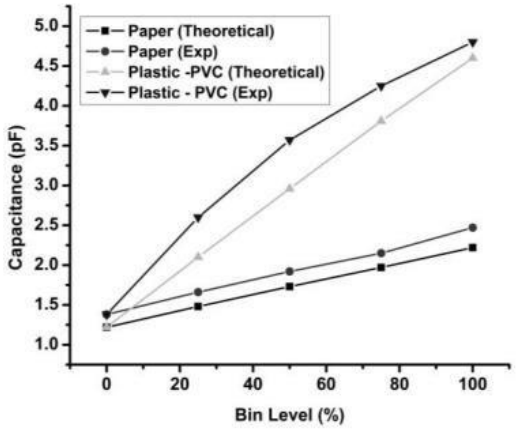


Fig. 6. Capacitance values for different bin levels for paper and plastic-PVC as trash.

IV. PROPOSED SYSTEM

Figure 8 shows the general architecture which uses the cluster of smart waste bins connected through IoT in the outdoor environment as mentioned in the previous sections. It uses a GPS, GSM/GPRS modules instead of the NodeMcu's to

communicate the status of the smart waste bins enabling the effective waste management system,

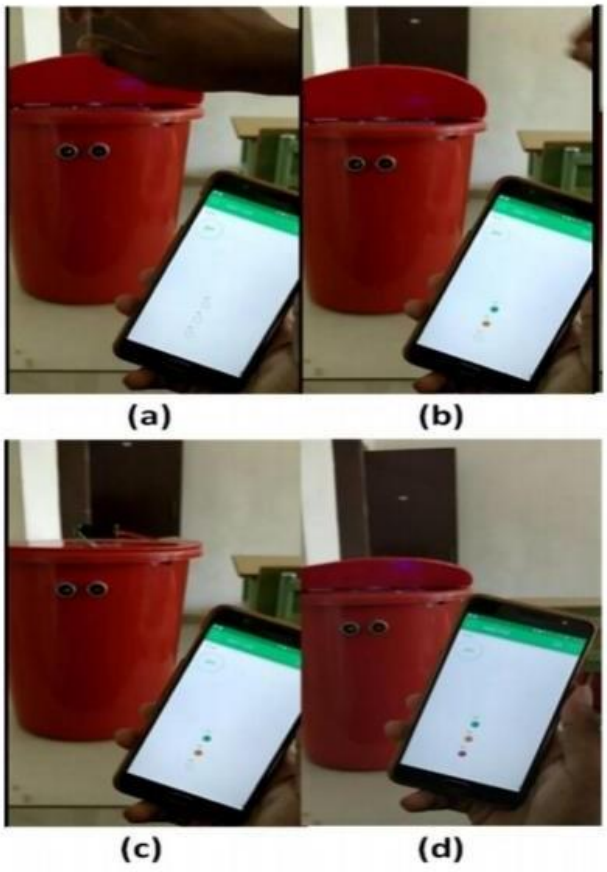


Fig. 7. (a) Detection of motion and opening of lid with bin empty, (b) bin is 50% full and lid open, (c) bin is 50% full and lid is in closed condition when motion is not detected (d) Alert due to the bin is with full of waste.

Fig. 8. Architecture of the waste management system using smart waste bins and IoT.

Which is planned to be implemented in our Hindustan Institute of Technology and Science campus. Figure 9 depicts our proposed architecture similar to the one illustrated in figure 6. The major difference is that the smartness of the waste bin is improved by adding the mobility for the bins to move from its location through following guide lines to the common waste management dump yard rather than indicating to the sanitary worker to service it.

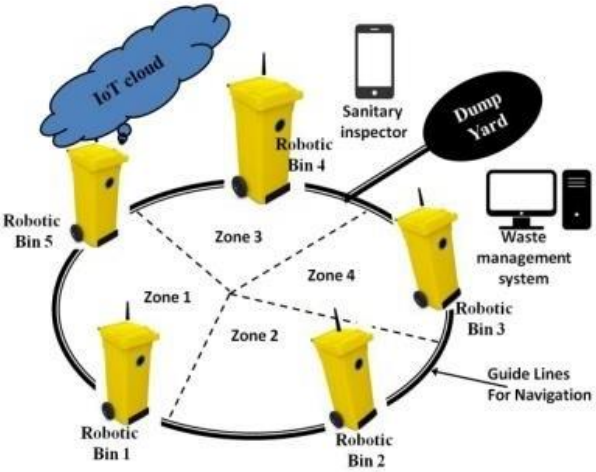


Fig. 9. Architecture of the indoor waste management system using robotic smart waste bins and IoT.

Therefore, the proposed system could be considered as a robotic smart waste bin, where the bins could mobilize, localize its location; communicate its status to the cloud. During the bins are serviced at the dump yard, spare bins could automatically replace the serviced bins enhancing the effectiveness of the system. This concept is proposed due to the evolution of the smart buildings and smart homes in recent times and it could be a potential technical advancement in the area of waste management systems and IoT.

V. Conclusion

In most of the metro cities globally poses a challenge on effective waste solid waste management and maintenance of the waste bins. In this work an IOT enabled Smart Waste Bin with real time monitoring is designed and presented. In addition to the waste level measurement by using ultrasonic sensors, a sensing mechanism based on simple parallel plate capacitance is also developed and presented. Experimental investigations are carried out where the waste level of the smart bins is measured using the parallel plate capacitance and ultrasonic sensors and the statuses of the bins are communicated to the cloud effectively. The results prove the efficiency of the designed smart bins qualitatively. A smart waste management system incorporating robotic smart bins, where the smart bin has the mobility to move to the waste dockyard by localizing itself in the environment, is also proposed in this work. This system could find an application in smart buildings where the waste management could be practiced autonomously in a smarter way. Our future work is to investigate the performance of the proposed traditional and robotic waste management system in outdoor and indoor environment respectively in our Institutional campus.

2. LITERATURE SURVAY

2.1. References:

TITLE	AUTHOR	OBJECTIVE
"Solid-waste management | Britannica.com."	J. A. Nathanson	Solid waste management (SWM) is the process of collecting, handling, and disposing of no longer in use solid objects that are discarded**.**
"Municipal solid waste management in Malaysia: Practices and challenges,"	L. A. Manaf, M. A. A. Samah, and N. I. M. Zukki	In today's world, typical solid waste management includes large outdoor waste bins, waste pickup trucks, and scheduled pickup routine by the related party.
Mohd Helmy Abd Wahab, Aeslina Abdul Kadir, Mohd Razali Tomari and Mohamad Hairol Jabbar	"Smart Recycle Bin A Conceptual Approach of Smart Waste Management with Integrated Web based System", IEEE.	proposed a garbage storing up framework that is adjusted having data gathering structure subject to the arranging of pictures taken and GSM module.Survey on waste management and monitoring system based on IoT and study on previous papers related to IoT. Abdullah et al.

"SMART GARBAGE BIN,"	J. A. SHAHABDEEN	explain that solid waste is categorized into three categories, each is handled by different authorities. the smart waste bins are integrated with several sensors (e.g., proximity sensor, weight sensor, temperature sensor, etc.). Example of working smart waste bin is produced by ZAN Compute Inc. called Smart Garbage Bin, as patented by Shahabdeen.
"Cloud- based Smart Waste Management for Smart Cities", IEEE.	Mohammad Aazam, Marc St-Hilaire, Chung-Horng Lung, Ioannis Lambadaris	provides the idea of sensors-based waste bins, capable of notifying waste level status. An automatic waste bin and make use of cloudcomputing paradigm to evolve a more robust and effective smart waste management mechanism. proposed a Smart Recycle Bin that caters for recycling glass, paper, aluminum can and plastic products. It automatically evaluates the value of the wastes thrown accordingly and provide 3R card. The recycle system enables collection of points for performing a disposal activity into designated recycle bins. Such system encourages recycling activities by allowing the points to be redeemable for products or services. The system records the data related to the disposeactivities,disposedmaterial,identification of the user and points collected by the user.Prajakta et al.

2.2.Problem Statement:

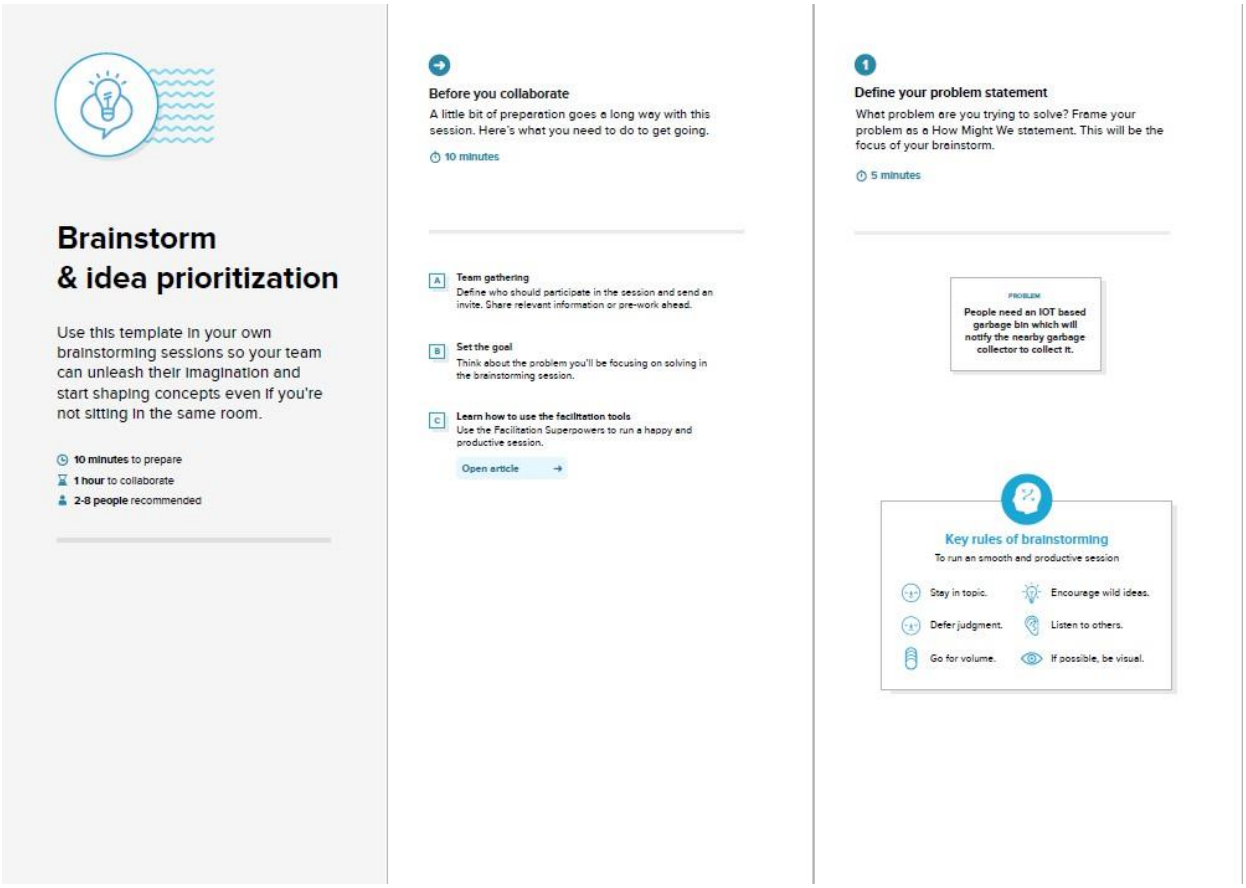
Problem Statement (PS)	**I am (Customer)**	**I'm trying to**	**But**	**Because**	**Which makes me feel**
Filled Dustbins are not notified	Common People	Create Clean Environment	Dustbins are filled	Improper management of dustbins	Irresponsible
Notification of filled cans are not received properly	Garbage Scavengers	Collect garbage at time	Information about filled dustbins are not received	No proper system to send notification	Improper System

3.IDEATION AND PROPOSED SOLUTION

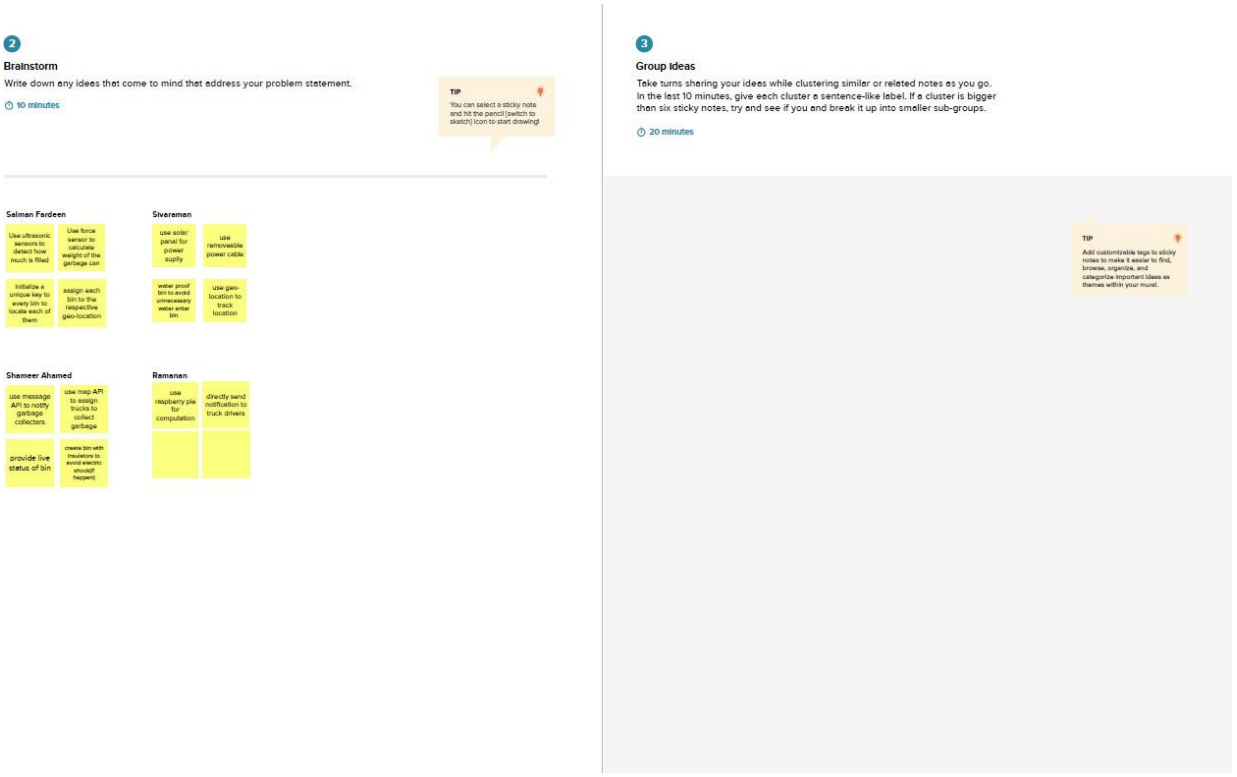
3.1.Empathy Map

3.2.Ideation & Brainstorming

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



Step-2: Brainstorm, Idea Listing and Grouping



Salman Fardeen:

- Use ultrasonic sensors to detect how much is filled.
- Use force sensor to calculate weight of the garbage can.
- Initialize a unique key to every bin to locate each of them
- assign each bin to the respective geo-location

Sivaraman:

- use solar panel for power supply
- use removeable power cable
- water proof bin to avoid unnecessary water enter bin
- use geolocation to track location

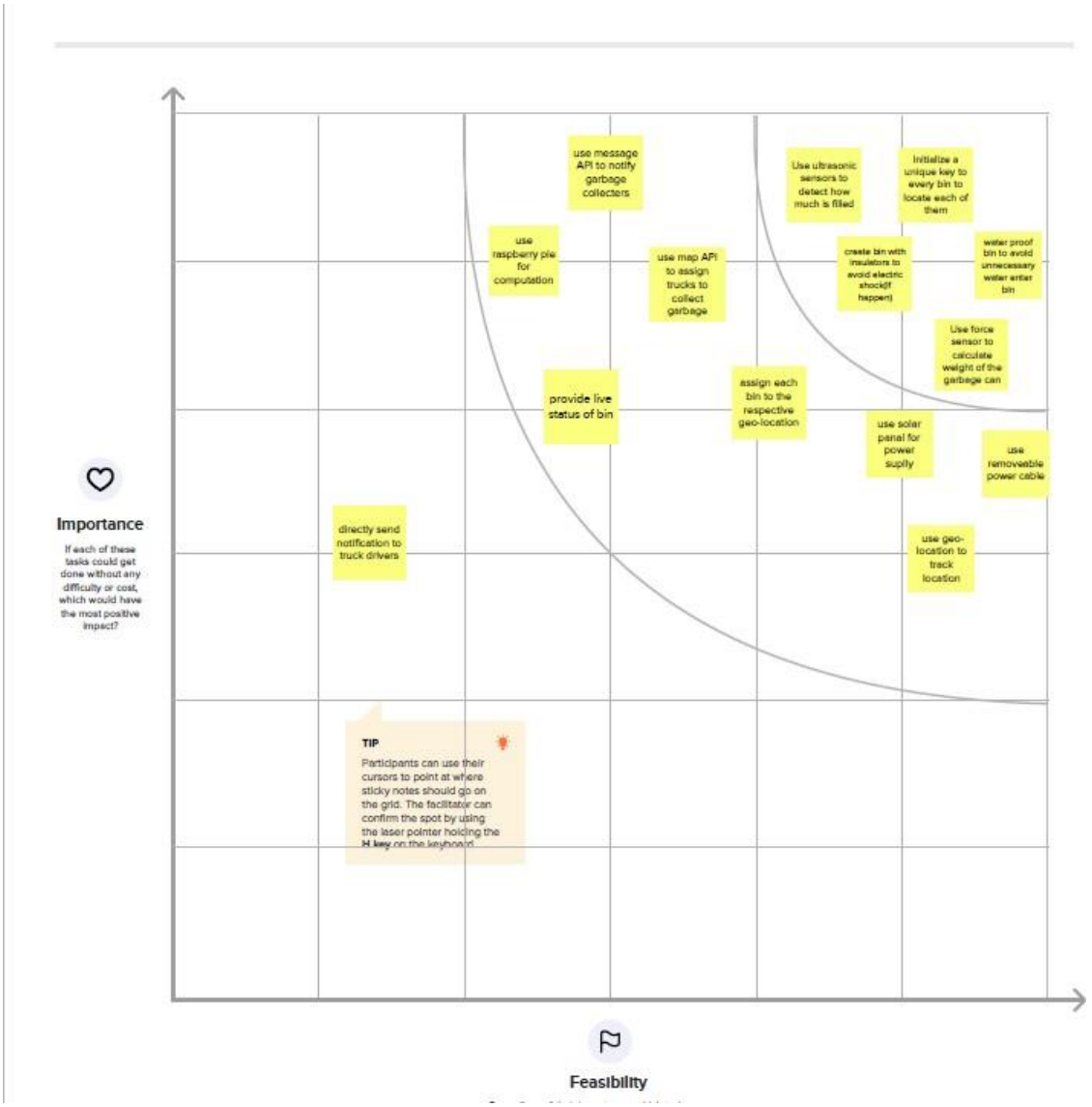
Shameer Ahamed:

- use message API to notify Garbage collectors
- assign use map API to trucks to collect garbage
- provide live status of bin
- create bin with insulators to avoid electric shock(If happen)

Ramanan:

- Use raspberry pie for computation
- directly send notification to truck drivers

Step-3: Idea Prioritization



3.3.Proposed Solution Template

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	➢ Filled garbage cans are unnoticed by the scavengers, who collect them. ➢ Improper maintenance and staffing in garbage collection sector
2.	Idea / Solution description	➢ Creating an IOT based garbage can, which can check whether the cans are filled ➢ It also sends the live status of bins to the respective garbage collection centre.
3.	Novelty / Uniqueness	This idea makes this garbage collection in a computerized way, which is unique when compared to the previous versions of the system.
4.	Social Impact / Customer Satisfaction	In case of social impact, this is completely done for the sake of common people, who suffer from improper disposal of wastes in their residence. If this comes to regular use, this creates a satisfaction to common people.
5.	Business Model (Revenue Model)	Power supply can be taken using a solar panel. So, there won't be any expense other than the initial can's cost. In case of revenue, this is a project done for public welfare, so if revenue is needed, we could get some it through government for maintaining these things
6.	Scalability of the Solution	In this regard, smart city design has been increasingly studied and discussed around the world to solve this problem. Following this approach, this paper presented an efficient IoT-based and real-time waste management model for improving the living environment in cities, focused on a citizen perspective. The proposed system uses sensor and communication technologies where waste data is collected from the smart bin, in real-time, and then transmitted to an online platform where citizens can access and check the availability of the compartments scattered around a city.

3.4.Problem Solution Fit

4.Requirement Analysis

4.1.Functional Requirements:

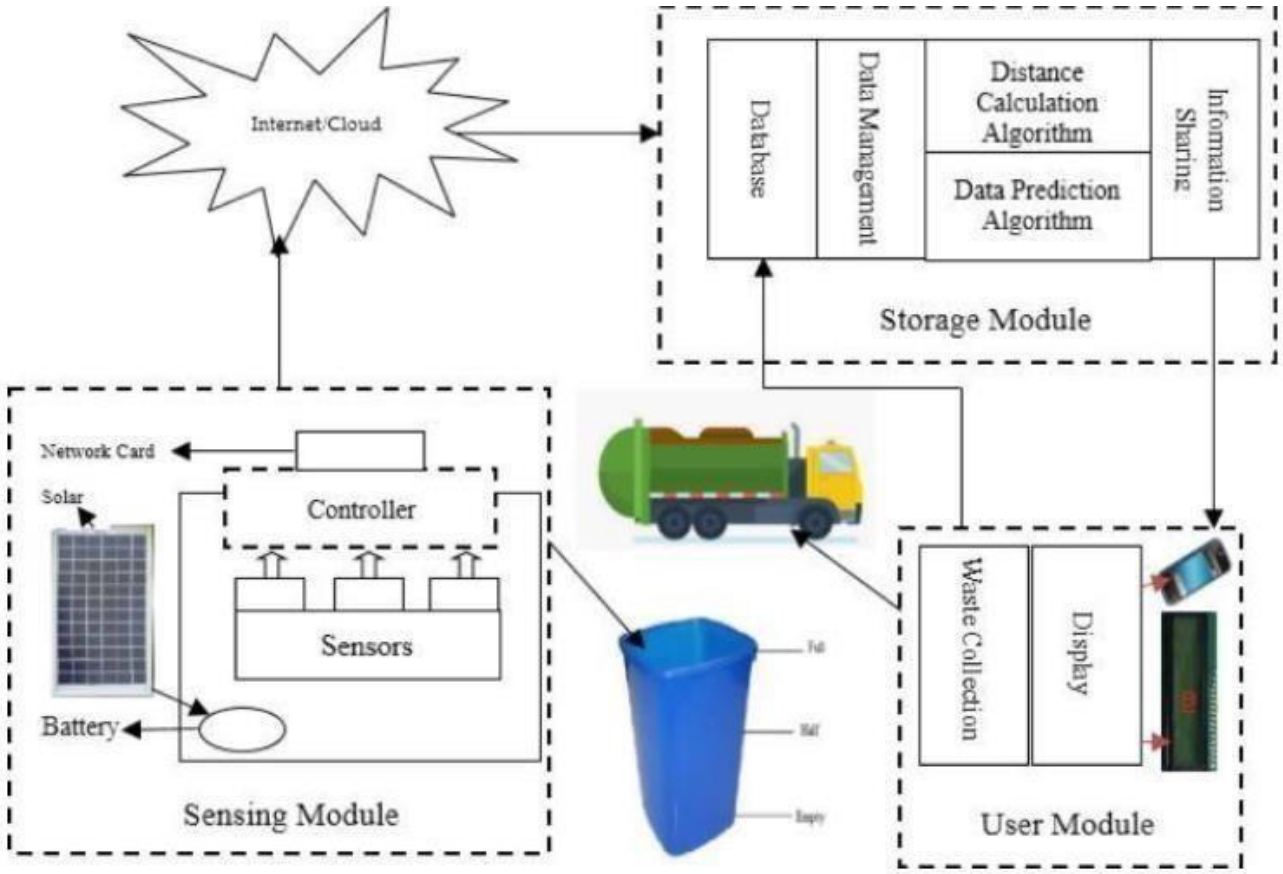
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Assign each dustbin a unique ID	Each dustbin must have unique ID for proper mapping of dustbins
FR-2	Geolocation of every Smart Dustbin	Location of each dustbin must be mapped to the ID of the dustbins
FR-3	Live status of each dustbin	Status or how much dustbin is filled should be monitored by the Collectors
FR-4	Notify filled dustbin to cloud	If the dustbin is filled for around 90-95%, then it must be entered in the cloud
FR-5	Notify to the collectors	If an entry is done in the cloud, it must be notified to the garbage collectors
FR-6	Tracking system in trucks	Trucks must have the tracking system to find a short and easy path for the truck drivers, in order to make efficient garbage collection
FR-7	Change of dustbins	If dustbin is damage or has some technical flaws, it must be changed and new dustbin ID must be entered in the cloud for the respective geo-location

4.2.Non-functional Requirements:

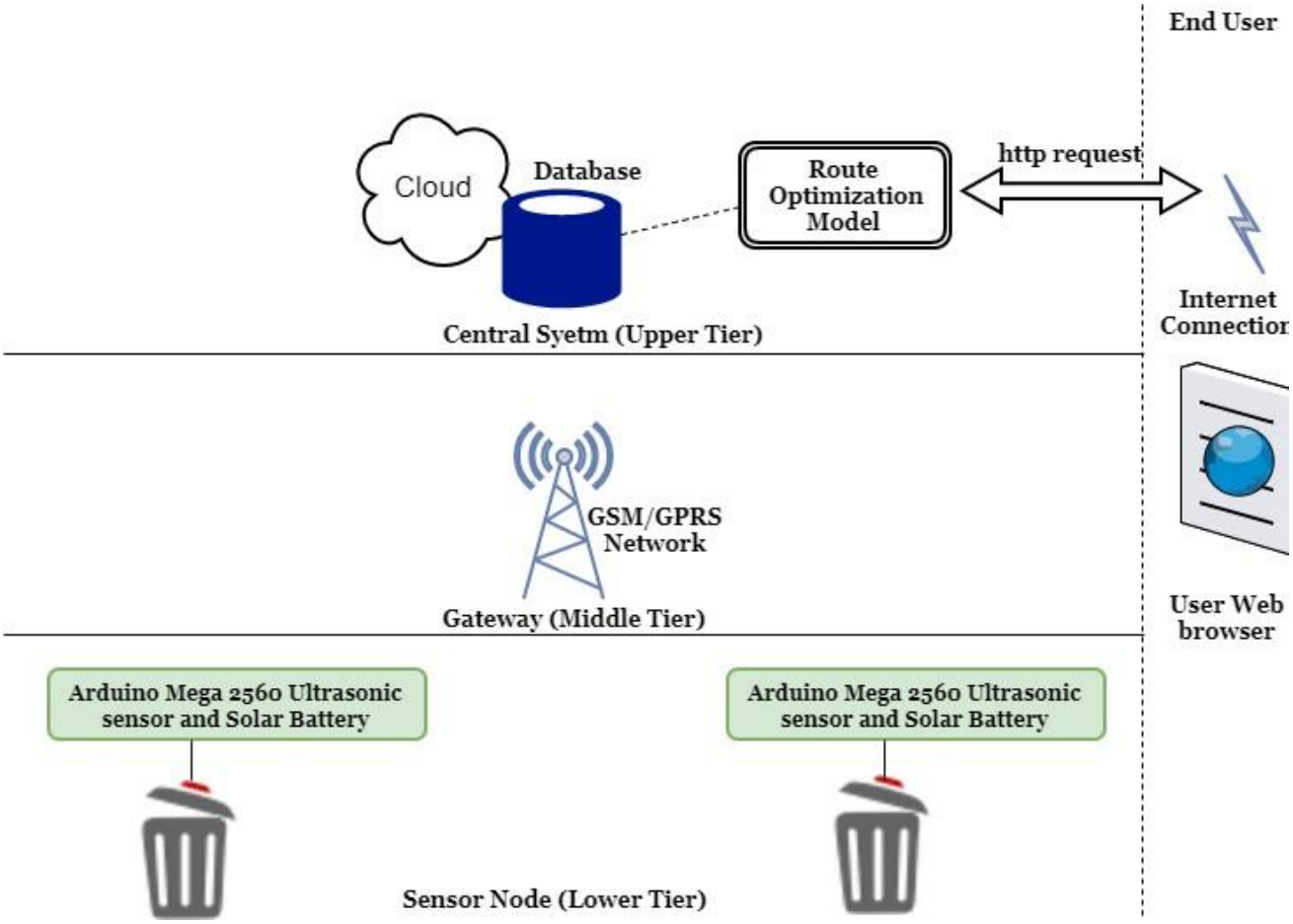
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	This technology will be and can be used on the daily basis, in order to have clean and green environment
NFR-2	**Security**	This application need not be more secure as it does not contain any private information, but has many security precautions
NFR-3	**Reliability**	This is most reliable in the current situation as garbage is being increased day by day
NFR-4	**Performance**	Customers have provided data-driven decision making, optimisation of waste collection routes, frequency and vehicle loads resulting in route reduction
NFR-5	**Availability**	By developing & deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter.
NFR-6	**Scalability**	Using smart waste bins reduce the number of bins inside town , cities coz we able to monitor the garbage 24/7 more cost effect and scalability when we moves to smarter.

5.Project Design

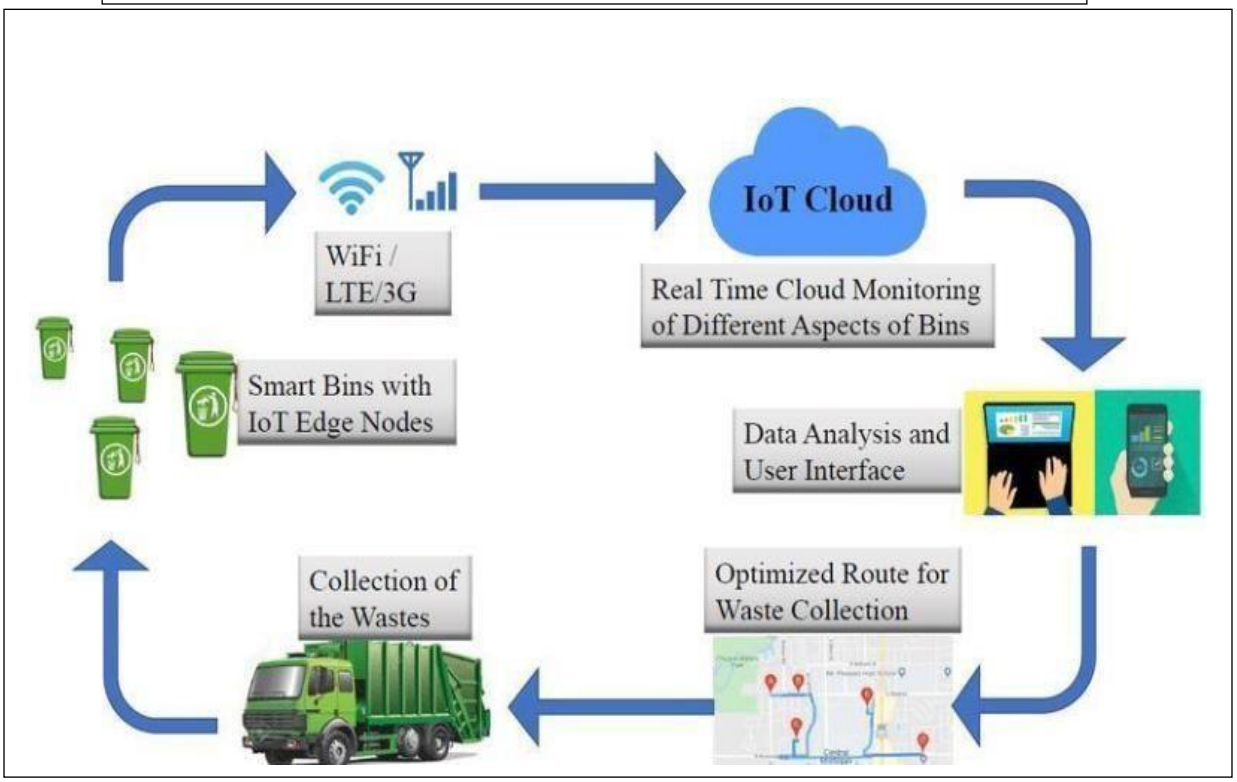
5.1.Data Flow Diagram:



5.2.Solution and Technical Architecture:



Solution Architecture



5.3.User Stories

User Stories

Use the below template to list all the user stories for the product.

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 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-2
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-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 on site when the given task has been completed.	Moderate	Sprint-5

6.PROJECT PLANNING AND SCHEDULING

6.1.Sprint Planning & Estimation:

Sprint	Functiona Requireme nt (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Sub-Admin Login	USN-1	As a Regional admin, I can login by entering theID number, password.	20	High	Ramanan
Sprint-2	User Registration	USN-2	As a user, I will login using the vehicle number,and password.	20	High	Sivaraman
Sprint-3	Dashboard	USN-3	As a admin, I can view the status of each bin inthis module. The information is fetched using the API from the IBM cloud.	20	High	Salman Fardeen
Sprint-4	Tracking	USN-4	As a Truck Driver, I can track the dustbin that isfilled in my area so that I can navigate to that dustbin to collect the garbage	20	High	Salman Fardeen
Sprint-5	Dashboard	USN-5	As a regional admin, I can check whether the processes are undergone without any problems	20	Low	Shame er Aham ed

6.2.Sprint Delivery Schedule:

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	26 Oct 2022	01 Nov 2022	20	01 Nov 2022
Sprint-2	20	6 Days	02 Oct 2022	08 Nov 2022	20	08 Nov 2022
Sprint-3	20	6 Days	09 Nov 2022	15 Nov 2022	20	15 Nov 2022
Sprint-4	20	6 Days	16 Nov 2022	22 Nov 2022	20	22 Nov 2022
Sprint-5	20	6 Days	22 Nov 2022	28 Nov 2022	20	28 Nov 2022

7.CODING & SOLUTION

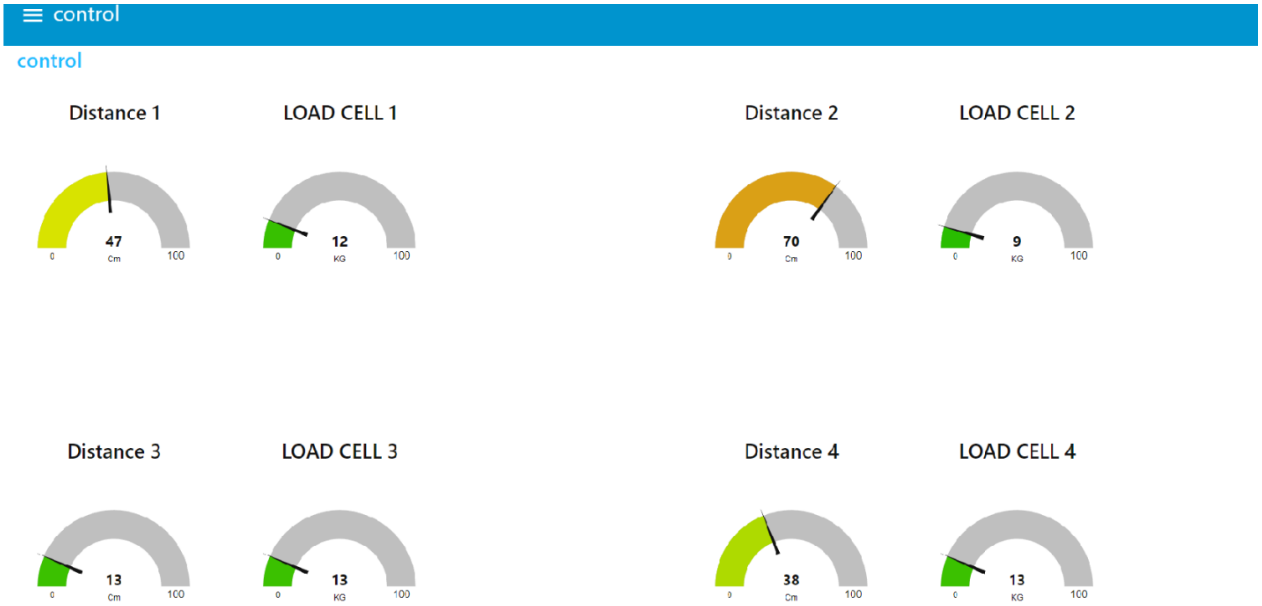
7.1. Feature 1 : Accurate Status of weight and filled data

CODE:

```
#include <WiFi.h>
#include <WiFiClient.h>
#include <PubSubClient.h>
#include <Arduino.h>
#include "soc/rtc.h"
#include "HX711.h"
#define SOUND_SPEED 0.034
#define CM_TO_INCH 0.393701

HX711 scale;

const char* ssid = "Wokwi-GUEST";
const char* password = "";
const int LOADCELL_DOUT_PIN = 16;
const int LOADCELL_SCK_PIN = 4;
#define DHTPIN 4
const int trigPin = 5;
const int echoPin = 18;
#define DHTTYPE DHT22
#define ORG "le341f"
#define DEVICE_TYPE "ESP32"
#define DEVICE_ID "24.0A.C4.00.01.10"
#define TOKEN "7fY18u!4egPRI&_t)U"
long duration;
float distanceCm;
float distanceInch;

char server[] = ORG ".messaging.internetofthings.ibmcloud.com";
char pubTopic1[] = "iot-2/evt/status1/fmt/json";
char pubTopic2[] = "iot-2/evt/status2/fmt/json";
char authMethod[] = "use-token-auth";
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;

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

void setup() {
   Serial.begin(115200);
   Serial.println();
   Serial.print("Connecting to ");
   Serial.print(ssid);
   WiFi.begin(ssid, password);
   while (WiFi.status() != WL_CONNECTED) {
     delay(500);
     Serial.print(".");
   }
```

```
    Serial.println("");

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

    if (!client.connected()) {
       Serial.print("Reconnecting client to ");
       Serial.println(server);
       while (!client.connect(clientId, authMethod, token)) {
          Serial.print(".");
          delay(500);
       }
       Serial.println("Bluemix connected");
    }
    Serial.begin(115200); // Starts the serial communication
    pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
    pinMode(echoPin, INPUT);
    // rtc_clk_cpu_freq_get(RTC_CPU_FREQ_80M);
    scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
}

long lastMsg = 0;
void loop() {
    digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distanceCm = duration * SOUND_SPEED/2;
  Serial.print("Distance (cm): ");
  Serial.println(distanceCm);
  delay(1000);

    client.loop();
    long now = millis();
    if (now - lastMsg > 3000) {
       lastMsg = now;
       int num = (rand() % (100));
       Serial.println(num);
       String payload = "{\"d\":{\"Name\":\"" DEVICE_ID "\"";
            payload += ",\"distance\":";
            payload += distanceCm;
            payload += ",\"Weight\":";
            payload += num;
            payload += "}}";
       Serial.print("Sending payload: ");
       Serial.println(payload);

       if (client.publish(pubTopic1, (char*) payload.c_str())) {
          Serial.println("Publish ok");
       } else {
          Serial.println("Publish failed");
       }
    }}
```

7.2. Feature 2 : Data is clearly displayed using node red



8. ADVANTAGE AND DISADVANTAGE

8.1.Advantages:

1. This practice is highly lucrative:

- The Journal of Waste management says that the revenues generated by the waste management would top by $60 million by 2018. But, there are only a few people who sincerely consider this as an industry into various facets of waste management like recycling and reusing, and reap the benefits.

2. Keeps the environment clean and fresh:

- Perhaps, the greatest advantage of waste management is keeping the environment fresh and neat. These waste disposal units also make the people go disease-free as all the resultant wastes are properly disposed and taken care of.

3. Saves the Earth and conserves energy:

- This characteristic of waste management includes specifically the recycling aspect. As recycling of waste helps in reducing the cutting down of trees. This cutting of trees is mainly done for the production of paper.

4. Reduces environmental pollution:

- Waste management if done in a proper manner not only eliminates the surrounding waste but also will reduce the intensity of the greenhouse gases like methane, carbon monoxide which is emitted from the wastes accumulated.

5. Waste management will help you earn money:

- Right from old and used bottles to tin cans and e-wastes, all kinds of wastes are collected and paid. These wastes are then segregated according to the extent of pollution they cause to the environment and these wastes are recycled accordingly for various purposes.

6. Creates employment:

- You may even ask how come this is possible? But in all the facets of waste management, a huge amount of labor is needed. Right from the collection to the final step of segregation, every phase needs manpower and ultimately a large number of employment opportunities get opened up.

8.2.Disadvantages:

1. The process is not always cost-effective:

- Yes, though it may pay cash to the contributors, the truth is this process needs a lot of money, time and land to set up a plant and run. As the amount of waste that is being contributed to the waste product unit increases, so are the number of plants that process these resources.

2. The resultant product has a short life:

- This is also true since the resulting recycled product cannot be expected to have a durable quality. As the product itself has its origin from the remains of the other trashed waste products and heaps of partially used ones.

3. The sites are often dangerous:

- As the waste management sites include the landfills to recycling units under its aegis, these sites are highly susceptible to fungal and bacterial growth thereby leading to various diseases.

4. The practices are not done uniformly:

- Still, a large scale of these waste management practices are done only as a small scale process and is mostly confined to residential homes, schools, and colleges and is not practiced in a uniform manner in large industries and conglomerates.

5. Waste management can cause more problems:

- Though waste management creates employment, it only has the ability to produce low-quality jobs. These jobs include right from sorting the garbage collector to the intensive and laborious jobs that are needed in the factories and outlets.

9.Conclusion

- One of the essential components of a smart city is a Clean and Green Environment and the crux of it is a Smart, Intelligent, and Connected Waste Management System. In Espha, I have developed a System where the Waste bins are equipped with a Compactor and a Bin Level Detection System.
- Mostly the Garbage bins are Underutilized, if the waste is compressed regularly it could lead to significantly higher storage of waste in the same volume of Bin, leading to lesser numbers of pickup turns and improved efficiency. For the same we can incorporate a solar based compactor which works on Linear Actuator Principle would work on the inputs from the Arduino Board.

Sensors and Actuators Involved:

- Ultrasonic (HC-SR04) or IR Sensors are used to identify bin levels.

Switch along with Servo motor to trigger the Linear Actuator for Compacting the Waste bin.

- Arduino and ESP8266(ESP-01) or NodeMCU.
- Other Sensors like Air Quality sensors can be used to identify Foul smells which will also be used to predict pickup schedules based on Anomalies.

Technical Details:

- The Bin level data has been integrated with Thing speak IOT cloud, for reporting and analysis.
- I also have a great User Interface to view the route mapping, placement of Bins in the City etc.

Hardware Side:

- At Hardware Side, I have employed an Ultrasonic Sensor to know the fill % of the dustbin and upload it to cloud. Further, data is uploaded to channel only if there is significant change.
- On the basis of this Fill %, we can also run compactor, fill % is more than 45-55%. However, I wasn't able to implement this here.
- We can employ two or more HC-SR04 and take average instead of one sensor in order to avoid false alarms due to non-uniformity.
- I have assigned bin Id to each smart bin. So, we can manage the bins easily, and save the cost of a GPS sensor (around 1000 Rs.).

10.FUTURE SCOPE

- Global Smart Waste Management System Market Size, Status and Forecast 2025" report provides the newest industry data and industry future trends, allowing you to identify the products and end users driving Revenue growth and profitability. The industry report lists the leading competitors and provides the insights strategic industry Analysis of the key factors influencing the market.

- The report spread across 94 pages is an overview of the Global Smart Waste Management System Market Size, Status and Forecast 2025. The Global Smart Waste Management System Market is projected to grow at a healthy growth rate from 2018 to 2025 according to new research. The study focuses on market trends, leading players, supply chain trends, technological innovations, key developments, and future strategies.

- Analytics and Reporting Solutions provide Advanced Analytics and help in managing data generated by the sensors. It is expected to hold the largest share of the Smart Waste Management System Market by solution. The solution includes components such as advanced analytics, data management, and dashboards & platforms. The huge flow of data and the need for environment protection are the major driving forces for the growth of analytics and reporting solutions in the Smart Waste Management System Market.

- A complete analysis of the competitive landscape of the Global Smart Waste Management System Market is provided in the report. This section includes company profiles of market key players. The profiles include contact information, gross, capacity, product details of each firm, price, and cost. This report investigates new project feasibility with a purpose of enlightening new entrants about the possibilities in this market. In this report, thorough SWOT analysis & investment analysis is provided which forecasts imminent opportunities for the Smart Waste Management System Market players.

11.APPENDIX

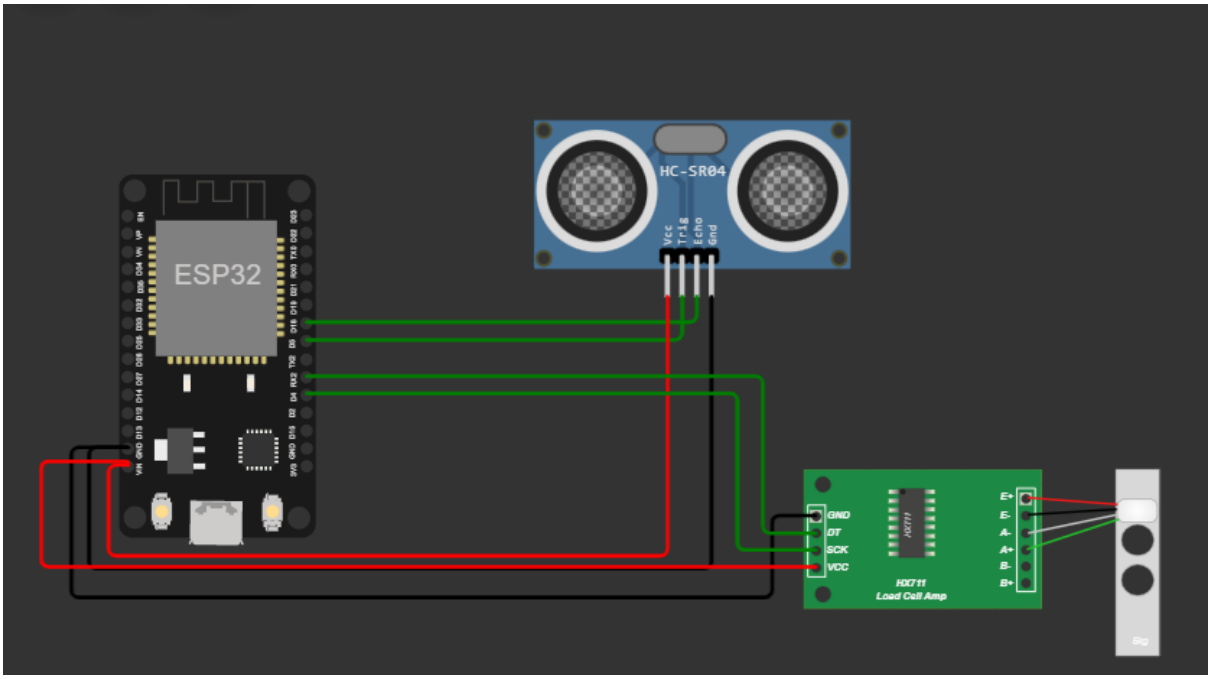
11.1. Source Code:

ESP32:

```
#include <WiFi.h>
#include <WiFiClient.h>
#include <PubSubClient.h>
#include <Arduino.h>
#include "soc/rtc.h"
#include "HX711.h"
#define SOUND_SPEED 0.034
#define CM_TO_INCH 0.393701

HX711 scale;

const char* ssid = "Wokwi-GUEST";
const char* password = "";
const int LOADCELL_DOUT_PIN = 16;
const int LOADCELL_SCK_PIN = 4;
#define DHTPIN 4
const int trigPin = 5;
const int echoPin = 18;
#define DHTTYPE DHT22
#define ORG "le341f"
#define DEVICE_TYPE "ESP32"
#define DEVICE_ID "24.0A.C4.00.01.10"
#define TOKEN "7fY18u!4egPRI&_t)U"
long duration;
float distanceCm;
float distanceInch;

char server[] = ORG ".messaging.internetofthings.ibmcloud.com";
char pubTopic1[] = "iot-2/evt/status1/fmt/json";
char pubTopic2[] = "iot-2/evt/status2/fmt/json";
char authMethod[] = "use-token-auth";
```

```
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;

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

void setup() {
   Serial.begin(115200);
   Serial.println();
   Serial.print("Connecting to ");
   Serial.print(ssid);
   WiFi.begin(ssid, password);
   while (WiFi.status() != WL_CONNECTED) {
     delay(500);
     Serial.print(".");
   }
   Serial.println("");

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

   if (!client.connected()) {
      Serial.print("Reconnecting client to ");
      Serial.println(server);
      while (!client.connect(clientId, authMethod, token)) {
         Serial.print(".");
         delay(500);
      }
      Serial.println("Bluemix connected");
   }
   Serial.begin(115200); // Starts the serial communication
   pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
   pinMode(echoPin, INPUT);
   // rtc_clk_cpu_freq_get(RTC_CPU_FREQ_80M);
   scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
}
```

```
long lastMsg = 0;
void loop() {
   digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distanceCm = duration * SOUND_SPEED/2;
  Serial.print("Quantity: ");
  Serial.println(distanceCm/10);
  delay(1000);

   client.loop();
   long now = millis();
   if (now - lastMsg > 3000) {
      lastMsg = now;
      int num = (rand() % (100));
      Serial.println(num);
      String payload = "{\"d\":{\"Name\":\"" DEVICE_ID "\"";
           payload += ",\"distance\":";
           payload += distanceCm;
           payload += ",\"Weight\":";
           payload += num;
           payload += "}}";
      Serial.print("Sending payload: ");
      Serial.println(payload);

      if (client.publish(pubTopic1, (char*) payload.c_str())) {
         Serial.println("Publish ok");
      } else {
         Serial.println("Publish failed");
      }
   }
}
```



11.2. Github and Project demo Link:

Github : https://github.com/IBM-EPBL/IBM-Project-33175-1660215673

Demo Link: https://vimeo.com/772689086