PROJECT REPORT

Smart Waste Management System For Metropolitan Cities

Submitted by

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CHAPTER 1

INTRODUCTION

a. PROJECT OVERVIEW

A growing trend in computing is the “Internet of Things” (abbreviated as: IoT) – devices connected to the internet (and/or to other devices) which interact with the physical world by gathering, processing, and sharing data. IoT devices are also referred to as connected devices or as smart devices.

Smart Waste Management Systems can help reduce excess spending and ensure a more intelligent budget in addition to optimising operating planning. Furthermore, they serve as a model for environmentally friendly trash management.

b. PURPOSE

Smart waste management is distinguished by the use of technology to improve waste management efficiency. This not only allows trash collectors to design more effective routes for emptying the bins, but it also reduces the likelihood of any bin remaining full for more than a week.

All of the data collected by the bin is sent here so that it can be used to benefit trash management. When a bin is full, it is immediately placed on the path. The pickup service may thus easily drive the most effective route. They don't have to check on bins which are not yet full and can immediately empty those that are. This lowered the likelihood of excess rubbish being dumped on the roadway, as well as the quantity of greenhouse gases emitted by the vehicles.

CHAPTER 2

LITERATURE SURVEY

a. EXISTING PROBLEM

The problem statement intends to create a desktop application for managing the waste using IOT technology. Every day people generate a growing amount of rubbish and pollution. We dispose of this at home or wherever we are, usually in garbage cans inside or on the street.

The traditional waste management system consists of waste pickup trucks and their drivers that follow a predetermined route without checking the fullness level of the containers. Because this technology cannot detect container fullness, half-full containers can be emptied while pre-filled containers must wait until the next collection period. Furthermore, because drivers collect empty bins, the system's predefined collection routes waste time, increase fuel consumption, and overuse resources.

b. REFERENCES

S.NO	PAPER	AUTHOR	YEAR	METHOD AND ALGORITHM
1.	Real-time smart garbage bin mechanism for solid waste management in smart cities	N.S Raghava, Dominic Abuga	2021	The main focus of this paper is to suggest novel methods of solid waste management and the associated control mechanism for smart cities coherently making a Smart Garbage Bin Mechanism(SGBM). The decision-based algorithms would sense

				the waste-data through a wireless sensor network (WSN). The architecture had three modules, namely the control station, smart garbage bin and gatewa
2.	IoT-Based Smart Waste Bin Monitoring and Municipal Solid Waste Management System for Smart Cities	Muhammad Irfan, Abdullah Saeed Al wadie and Adam Glowacz	2020	The researchers have adopted various methods and techniques to resolve these issues, specifcally, the solid waste management [12]. In [13–15], the capacity, weight, temperature, humidity and chemical sensors are used for solid waste monitoring and collection. In [15], author (s) have presented a municipal solid waste management platform for recycling collection information with the help of IT technology
3.	Smart waste management using Iot and Block chain technology	Manish Lamichhane	2017	The purpose of experimentation , a simulation of SGB is used which is based on the assumptions that the SGB calculates the weight of waste using similar methods. This kind of SGB can be suitable for deployment to real world of TAG in real world. Sorting at source enhances the

				quality of waste generated significantly.
4.	Monitoring the smart garbage bin filling status: an iot application towards waste management	Sirisha Yerraboina, Nallapaneni Manoj Kumar, K Parimala, N. Aruna Jyothi	2018	Microcontroller using the ZigBee methodology was proposed for the garbage bin application. With this, a prototype was developed for making the collection process to be easier by spotting the filled or yet to spill over of the bins from any particular area. The proposed ZigBee based methodology was used for the information exchange between the garbage bins and sensor elements
5.	IOT Based Smart Garbage alert system using Arduino UNO	Dr.n.Sathishkumar, b.Vijayalakshmi, r.Jeniferprarthana, a.Shankar	2020	Technique is to store an identical serial number that recognizes a person or object on a microchip that is committed to an antenna. The combination of antenna and microchip are combinedly referred to as "RFID transponder" or "RFID tag" and it
6.	A Serverless IoT	Eyhab Al-Masri, Ibrahim Diabate, Richa Jain, Ming	2018	The data collected by the smart bins' camera module and sensors is sent to an analytics unit.

	Architecture for Smart Waste Management Systems	Hoi Lam and Swetha Reddy		The analytics unit examines captures images of disposed substances and is able to process them to detect possible violations.
7.	An Internet of Things Based Smart Waste Management System Using LoRa and Tensorflow Deep Learning Model	Hatem rmili, Mohammad tariqul islam , md. Rashedul islam	2020	A deep learning method such as a convolutional neural network allows for the extraction of unique features from the image and then classifies them into each class with high accuracy. the pre-trained object detection model is trained using images of waste as a training dataset.

C. PROBLEM STATEMENT DEFINITION

IoT solutions for solid waste management problems offer municipalities data intelligence and real-time insights. In that regard, the fill patterns of specific containers can be identified by historical data and managed accordingly in the long term. In addition to hardware solutions, mobile applications are used to overcome the challenges in the regular waste management system, such as keeping track of the drivers while they are operating on the field.

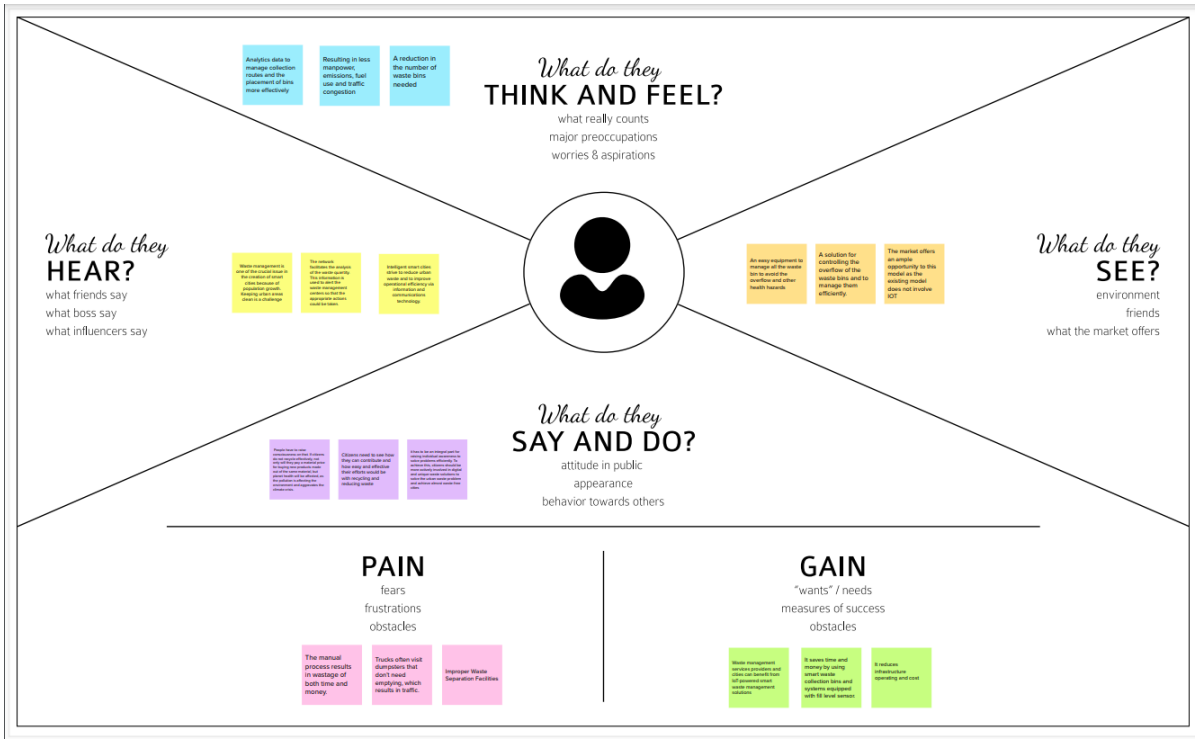
Municipalities benefit from data intelligence and real-time insights provided by IoT solutions for solid waste management issues. In this sense, historical data

can be used to identify certain container fill trends and manage them in the long run. In addition to hardware solutions, mobile applications are utilised to tackle issues in the traditional waste management system, such as tracking drivers while they are on the road.

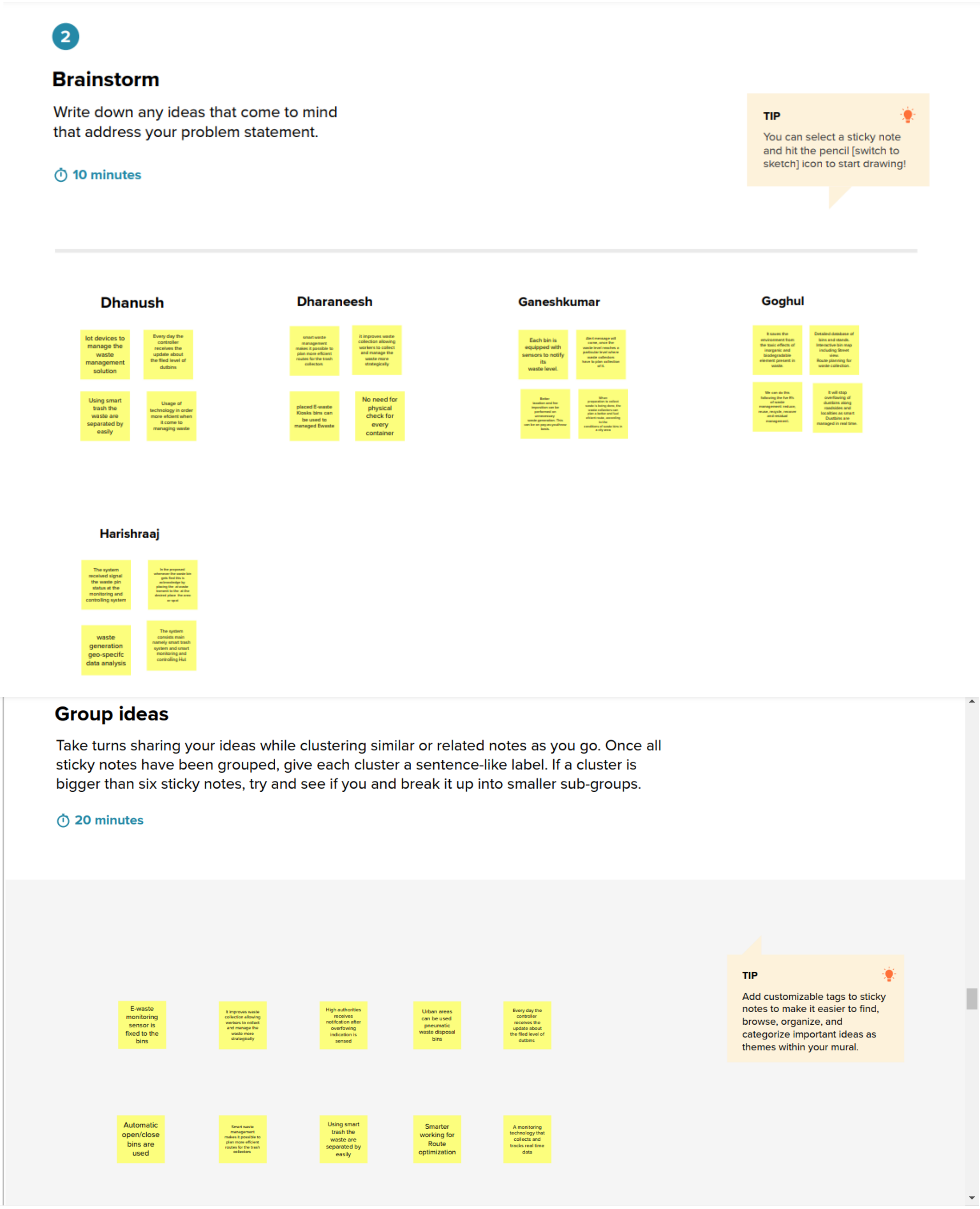
CHAPTER 3

IDEATION AND PROPOSED SOLUTION

a. EMPATHY MAP CANVAS



b. IDEATION & BRAINSTORMING



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

Importance

If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?

TIP

Participants can use their cursors to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using the laser pointer holding the **H key** on the keyboard.

Feasibility

Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

3.3 PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Solid waste disposal is a major problem for both residents of metropolitan regions and urban centres in the majority of developing nations.
2.	Idea / Solution description	The proposed idea is to detect garbage levels in bins and getting the weight of the garbage in the bin. In order to address these issues An idea called "smart bin" has been put out, and it combines software and hardware technology. By providing a GPS position from the device, we can use the web application to see where each bin is located. This makes it easier for the designated person to come and collect the trash.
3.	Novelty / Uniqueness	Utilize a load sensor to estimate the weights. The data are transmitted to the sensor known as Node MCU by the load sensor, which forecasts the precise value. In addition, we continue to offer client assistance once product setup is complete, including both on-site and remote support based on customer needs.

4.	Social Impact / Customer Satisfaction	Reduces the fuel usage and route optimization when emptying trash all around the city. It leads to spend less time and money. We can guarantee that everyone is in good health. Everywhere throughout the cities, cleanliness is maintained.
5.	Business Model (Revenue Model)	It promotes a healthy environment, maintains the environment clean and green, eliminates the smell of garbage, and keeps cities looking more attractive. lowering the number of people needed to manage garbage collection. The city administration will be able to generate reports, exercise control over the budget, limit waste, and get a broad awareness of the situation. It is possible to detect and improve driver routes, fill patterns, lower operating costs, and schedules using past data gathered by sensors and databases. It is more practical to collect garbage effectively using remote monitoring and IoTbased waste bins. Additionally, it lowers fuel and route costs.

6.	Scalability of the Solution	In any large city, this initiative will be quite successful at controlling garbage. Here, a priority system is implemented in place of more traditional periodic collection techniques to ensure that the city is always clean and free of overflowing dumpsters.

3.4 PROBLEM SOLUTION FIT

Problem-solution fit is a term used to describe the point validating that the base problem resulting in a business idea really exists and the proposed solution actually solves that problem.

Purpose:

1. **Validate that the problem exists:** When you validate your problem hypothesis using real-world data and feedback. That is, you gather information from real users to determine whether or not they care about the pain point you're trying to solve.
2. **Validate that your solution solves the problem:** When you validate that the target audience appreciates the value your solution delivers to them.

Project Title: Smart Waste Management System For Metropolitan Cities **Project Design Phase-I - Solution Fit Template** **Team ID:** PNT2022TMID04344

Define CS, fit into CC

1. CUSTOMER SEGMENT(S) CS

Municipality and Local authorities of Metropolitan cities of India.
(Mumbai, Delhi, Chennai, Banglore, Kolkata etc.)

6. CUSTOMER CONSTRAINTS CC

Lack of proper waste management technology within budget
-concerns relating to the maintenance if such a technology is employed

5. AVAILABLE SOLUTIONS AS

Routine collection of garbage from the trash bins by the trucks each morning. If the garbage bins are not filled it will be a waste of manpower, fuel and time. If waste collection is scheduled less frequently it will lead to overflowing waste and polluting the environment.

Explore AS, differentiate

Focus on J&P, tap into BE, understand RC

2. JOBS-TO-BE-DONE / PROBLEMS J&P

The fixed routine for waste collection is inefficient as the average citizen may not dispose the same amount of waste everyday leading to overflowing bins and no proper communication channel to alert the municipality of this issue and schedule pick-ups.

9. PROBLEM ROOT CAUSE RC

-Alarming generation of waste due to population growth and urbanization.
-There is no way for us to know when the garbage cans are full
-This leads to overflowing of the garbage cans and unhygienic environment

7. BEHAVIOUR BE

b-People wait for the garbage to be cleared by the trucks until next day
-There is no direct way to contact the truck drivers for the people.

Focus on J&P, tap into BE, understand RC

Identify strong TR & EM

3. TRIGGERS TR

People want to make their environment cleaner and also prevent the spread of health hazards in their community

Waste tend to decay faster, and if not carefully managed, decomposition can lead to bad odour

Piled up waste also serves as a breeding place for mosquitos and other insects.

4. EMOTIONS: BEFORE / AFTER EM

The people of the community feel irritated to see their environment completely polluted and also at the same time are unable to take any actions to clean the garbage. This garbage cans also get filled up fast due to the tremendous increase in waste generation. They have to wait for the truck drivers to arrive the next day to empty the garbage cans.

Once the trash is removed people feel much relieved and can continue on their daily activities like taking a walk, jogging or cycling without having to worry about the smell of garbage.

10. YOUR SOLUTION SL

A Web app is built where the level of the garbage cans, its weight and location are monitored. Sensors are fitted in the garbage bins and the required data is collected and acquired from it. The real-time monitoring system indicates when the bin is full and alerts the authorized person to empty the bin

8. CHANNELS of BEHAVIOUR CH

8.1 ONLINE
What kind of actions do customers take online? Extract online channels from #7
The customer might complain about waste piling up on online forums, share pictures and videos on social media to raise awareness
8.2 OFFLINE
What kind of actions do customers take offline? Extract offline channels from #7and use them for customer development.
File complaints to local authority, invite press to write about this issue or may employ private waste disposal company to clear the garbage.

Identify strong TR & EM

CHAPTER 4

REQUIREMENT ANALYSIS

a. FUNCTIONAL REQUIREMENTS

Functional requirements may involve calculations, technical details, data manipulation and processing, and other specific functionality that define what a system is supposed to accomplish. The following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Detailed bin inventory.	Bins that can be visited at any time via street view and are shown on maps with GPS location. Maps show bins as different coloured circles. The garbage can's capacity, recyclable or nonrecyclable waste, waste measurement, GPS location, and pick recognition are all visible in the dashboard.
FR-2	Bin Monitoring	Waste that is placed in bins is observed by sensors. The tool forecasts when the bin will fill based on the prior data. Every action is recognised by intelligent sensors. As a result, it will examine the most recent data gathered. We can stop bins from overflowing by using real-time data and predictions.

FR-3	Expensive bins	It aids in the identification of bins that raise collection expenses. The tool rates each bin according to how much it will cost to gather the contents.
FR-4	Eliminates unefficient picks	1.The sensor recognize picks.
		2.By the data filled on the bin, pick recognition, we can show how full the bins you collect are. 3.Eliminates the collection of empty bins.
FR-5	Adjust bin distribution	1. We must first make sure that the bins are distributed in the best possible way. 2. Shows where the distribution of bins is dense or sparse. 3. We can modify the position or capacity of the bins based on historical data.
FR-6	Waste collection routes.	We are prepared to respond and schedule based on the level of bin filling that is now being experienced and the anticipated capacity. To find any discrepancies, we must compare the routes that were planned and those that were taken.

4.2 NON FUNCTIONAL REQUIREMENTS

Non-functional requirement (NFR) is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours. The following are the non-functional requirements of the proposed solution.

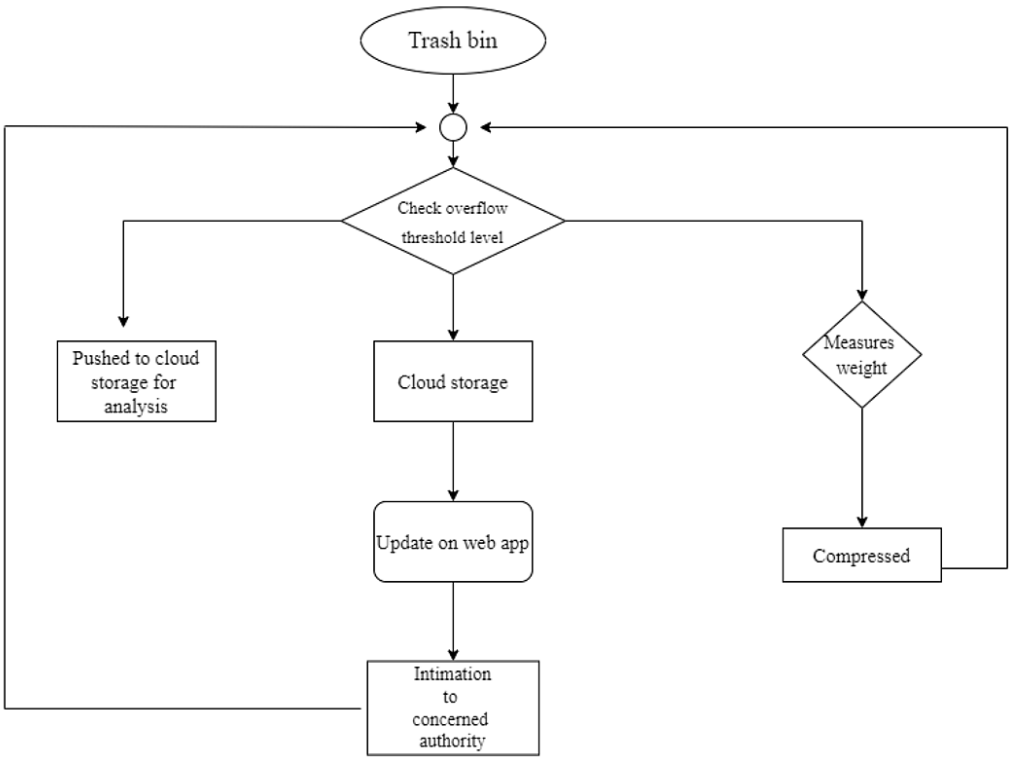
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	We are prepared to respond and schedule based on the level of bin filling that is now being experienced and the anticipated capacity. To find any discrepancies, we must compare the routes that were planned and those that were taken.
NFR-2	**Security**	1.Use reusable and recyclable bottles 2.Avoid non-recyclable plastic container. 3.Use reusable bags
NFR-3	**Reliability**	This project (Smart waste management system) is all about creating better work
		experience for waste collectors and drivers. Waste collector will spend their time more efficiently instead of driving the same collection routes and servicing empty bins.
NFR-4	**Performance**	For data-driven daily operations and available garbage, the sensors transfer the data to smart waste management software system, a cloud platform, using a variety of IoT networks. Users are given access to data-driven decision making, and garbage collection route optimization is reduced by at least 35%.

NFR-5	**Availability**	We enable cities and nations to manage garbage more intelligently by creating robust hardware and software.
NFR-6	**Scalability**	By using smart bins, we can monitor the garbage whenever we want at a lower cost and with greater scalability. This helps cities and urban regions utilise less bins.

CHAPTER 5

PROJECT DESIGN

a. DATA FLOW DIAGRAM



b. SOLUTION & TECHNICAL ARCHITECTURE

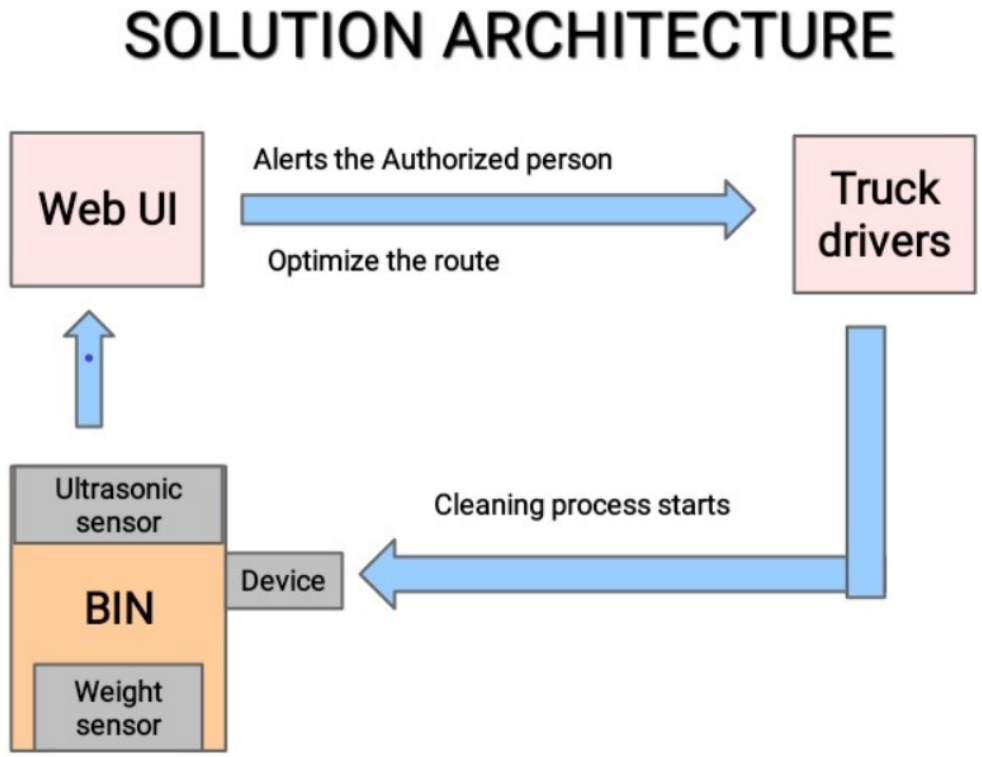


Table-1 : Components & Technologies

S.No	Component	Description	Technology
1.	User Interface	Dynamic web application to show the status of bin and its location	HTML,CSS,JavaScript.
2.	Application Logic-1	Logic for IR sensor data.	C++ / Python
3.	Application Logic-2	Logic for ultra sonic sensor data.	C++ / Python
4.	Application Logic-3	Logic for a Weight sensor data.	C++ / Python
5.	Cloud Database	Database Service on Cloud	IBM Watson IOT platform,Cloudant DB
6.	File Storage	File storage requirements	IBM Object Storage
7.	External API-1	To locate the smart bins .	API maps
8.	Infrastructure (Server / Cloud)	Application deployment on users system /Retrieve data form cloud	Local system, Cloud..

Table-2: Application and characteristics

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Micro web framework, Written in Python	Flask
2.	Security Implementations	Provides Security rules to allow asses to data	Fire base, fire walls
3.	Scalable Architecture	New features can be added	Node RED
4.	Availability	Web application can be accessed from any where.	IBM Watson IOT platform, HTML, CSS, JavaScript
5.	Performance	Provides real time data to web application which uses cloud platform and alerts garbage collector. All truck drivers can access the application at same time	Cloudant DB IBM Watson IOT platform

5.1 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)	Login	USN-1	As an Admin, I gave user id and password for ever workers and manage them.	I can manage web account /dashboard	Medium	Sprint-2
Co Admin	Login	USN-2	As a Co Admin, I'll manage garbage level monitor if garbage get filling alert I will post location and garbage id to trash truck	I can manage garbage monitoring	High	Sprint-1
Truck Driver	Login	USN-3	As Truck Driver, I'll follow the route send by Co Admin to reach the filled garbage.	I can drive to reach the garbage filled route in shortest route given	Medium	Sprint-2
Local Garbage Collector	Login	USN-4	As a Waste Collector, I'll collect all the trash from garbage and load into garbage truck and send them to landfill	I can collect trash and pulled to truck and send off	Medium	Sprint-2
Municipality	Login	USN-5	As a Municipality, I'll check the process are happening in discipline manner without any issues.	I can manage all these process going good	High	Sprint-1

CHAPTER 6

PROJECT PLANNING AND SCHEDULING

a. SPRINT PLANNING AND ESTIMATION

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Login / Sign Up	USN - 1	User can signup using their email and password and confirm the details.	10	High	GOGHUL S
Sprint-1		USN - 2	A confirmation mail is sent to the user.	10	High	
Sprint-2	Login	USN - 3	User can login using login credentials and is authenticated.	20	Medium	GANESHKUMAR S
Sprint-3	Dashboard Area	USN - 4	User can view the previous login activities of the account and updates.	10	Medium	DHARANEESH KT
Sprint-4	Search Location	USN - 5	User can search for the bins available around the location.	10	Low	HARISHRAAJ S
Sprint-4	Issues / Results	USN - 6	User can post their grievances related to the bins and gets the results of bin status around the location from IBM Cloud.	10	High	DHANUSH P

b. SPRINT DELIVERY SCHEDULE

SPRINT	Total story points	Duration	Sprint start date	Sprint end date	Story points completed	Sprint release date
SPRINT-1	20	4 days	26 Oct 2022	30 Oct 2022	20	30 Oct 2022
SPRINT-2	20	4 days	1 Nov 2022	05 Nov 2022	20	05 Nov2022
SPRINT-3	20	4 days	07 Nov 2022	11 Nov 2022	20	11 Nov2022
SPRINT-4	20	4 days	14 Nov 2022	17 Nov 2022	20	17 Nov2022

CHAPTER 7

CODING & SOLUTIONING

7.1 Feature 1

One of the major feature of our proposed solution is to identify the trash level of the garbage bins. All of the data acquired by the bin is transferred here to be used in garbage management. When a bin is full, it is placed on the path right away. As a result, the pickup service can easily drive the most efficient route. They don't have to check on empty bins and can instantly empty ones that are. This reduced the possibility of litter being deposited on the road as well as the amount of greenhouse gases released by the vehicles.

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

      //------------------------ credentials of IBM Accounts ----------
---------------------

      #define ORG "ede5q6"                              // IBM organisation
id
      #define DEVICE_TYPE "MyTesting"                   // Device type
mentioned in ibm watson iot platform
      #define DEVICE_ID "12345"                 // Device ID mentioned in
ibm watson iot platform
      #define TOKEN "lrTLbr*22xoKqc)Wko"            // Token

      //------------------------ customise above values ---------------
---------------------------------------

      char server[] = ORG ".messaging.internetofthings.ibmcloud.com";
// server name
      char publishTopic[] = "iot-2/evt/data/fmt/json";
// topic name and type of event perform and format in which data to be
send
      char topic[] = "iot-2/cmd/led/fmt/String";
```

```
// cmd Represent type and command is test format of strings
      char authMethod[] = "use-token-auth";
// authentication method
      char token[] = TOKEN;
      char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;
//Client id

      //-------------------------------------------------------------------
-----------------------------------------------------

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

      #define ECHO_PIN 12
      #define TRIG_PIN 13
      float dist;

      void setup()
      {
        Serial.begin(115200);
        pinMode(LED_BUILTIN, OUTPUT);
        pinMode(TRIG_PIN, OUTPUT);
        pinMode(ECHO_PIN, INPUT);
        //pir pin
        pinMode(4, INPUT);

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


        lcd.init();
        lcd.backlight();
        lcd.setCursor(1, 0);
        lcd.print("");
        wifiConnect();
        mqttConnect();
      }

      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;
  return 300;
}

void loop()
 {

lcd.clear();

  publishData();
  delay(500);
  if (!client.loop())
    {
      mqttConnect();                                    //
function call to connect to IBM
    }
}


/* ---------------------------------retrieving to cloud----------
-----------------------------------------*/

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);
                }
              initManagedDevice();
              Serial.println();
            }
        }
      void initManagedDevice()
        {
          if (client.subscribe(topic))
            {
              Serial.println("IBM subscribe to cmd OK");
            }
          else
            {
              Serial.println("subscribe to cmd FAILED");
            }
        }
      void publishData()
      {
        float cm = readcmCM();

         if(digitalRead(34))                                    //pir
motion detection
         {
           Serial.println("Motion Detected");
           Serial.println("Lid Opened");
           digitalWrite(15, HIGH);

         }
         else
         {
           digitalWrite(15, LOW);
         }

       if(digitalRead(34)== true)
       {
         if(cm <= 100)
//Bin level detection
         {
           digitalWrite(2, HIGH);
           Serial.println("High Alert!!!,Trash bin is about to be
full");
           Serial.println("Lid Closed");
           lcd.print("Full! Don't use");
```

```
          delay(2000);
          lcd.clear();
          digitalWrite(4, LOW);
          digitalWrite(23, LOW);
        }
        else if(cm > 150 && cm < 250)
        {
          digitalWrite(4, HIGH);
          Serial.println("Warning!!,Trash is about to cross 50% of bin
level");
          digitalWrite(2, LOW);
          digitalWrite(23, LOW);
        }
        else if(cm > 250 && cm <=400)
        {
          digitalWrite(23, HIGH);
          Serial.println("Bin is available");
          digitalWrite(2,LOW);
          digitalWrite(4, LOW);
        }
          delay(10000);
          Serial.println("Lid Closed");
       }
       else
       {
         Serial.println("No motion detected");
       }




        if(cm <= 100)
      {
      digitalWrite(21,HIGH);
      // String payload = "{\"HighAlert !Trash bin is about to be
full\":\"";
      // payload += cm;
      // payload += "\" }";
      String payload="{\"data\":";
      payload+="\"HighAlert !Trash bin is about to be full\"";
      payload+="," "\"gap\":";
      payload+=cm;
      payload+="}";
      Serial.print("\n");
      Serial.print("Sending payload: ");
```

```
      Serial.println(payload);

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

      if(cm > 150 && cm < 250)
      {
      digitalWrite(22,HIGH);
      String payload="{\"data\":";
      payload+="\"warning! Trash is about to cross 50% of bin
level\"";
      payload+="," "\"gap\":";
      payload+=cm;
      payload+="}";
      // String payload="";
      // // String payload = "{\"warning! Trash is about to cross 50%
of bin leve\":\"";
      // payload += cm;
      // payload += "\" }";
      Serial.print("\n");
      Serial.print("Sending distance: ");
      Serial.println(cm);
      if(client.publish(publishTopic, (char*) payload.c_str()))
      {
      Serial.println("Publish OK");
      }
      else
      {
      Serial.println("Publish FAILED");
      }
      }
      ////////////////////////////

      if(cm > 250 && cm <=400)
      {
      digitalWrite(21,HIGH);

      // String data="Bin is available";
      // float gap=cm;
      // String payload="{\Data"
```

```
      // String data="{\"data\":\"Bin is available\" ,";
      // String payload = "\"load\":\"";
      String payload="{\"data\":";
      payload+="\"Trash is in low level(Space available)\"";
      payload+="," "\"gap\":";
      payload+=cm;
      payload+="}";
      // payload += cm;
      // payload += "\" }";
      // data+=payload;
      Serial.print("\n");
      Serial.print("Sending payload: ");
      Serial.println(payload);

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

        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



      {
        "version": 1,
```

```
        "author": "ganesh Kumar",
        "editor": "wokwi",
        "parts": [
          { "type": "wokwi-esp32-devkit-v1", "id": "esp", "top": 76,
"left": 19.31, "attrs": {} },
          {
            "type": "wokwi-hc-sr04",
            "id": "ultrasonic1",
            "top": -16.86806233723958,
            "left": -148.66666666666669,
            "attrs": {}
          },
          {
            "type": "wokwi-pir-motion-sensor",
            "id": "pir1",
            "top": -25.33,
            "left": 367.47,
            "attrs": {}
          },
          {
            "type": "wokwi-lcd1602",
            "id": "lcd1",
            "top": 122.59,
            "left": 454.48,
            "attrs": { "pins": "i2c" }
          },
          {
            "type": "wokwi-led",
            "id": "led1",
            "top": 28.02,
            "left": 211.04,
            "attrs": { "color": "limegreen" }
          },
          {
            "type": "wokwi-resistor",
            "id": "r1",
            "top": 76.14,
            "left": 152.31,
```

```
      "attrs": { "value": "1000" }
    },
    {
      "type": "wokwi-led",
      "id": "led2",
      "top": 53.99,
      "left": 259.59,
      "attrs": { "color": "yellow" }
    },
    {
      "type": "wokwi-resistor",
      "id": "r2",
      "top": 175.42,
      "left": 147.07,
      "attrs": { "value": "1000" }
    },
    {
      "type": "wokwi-led",
      "id": "led3",
      "top": 330.14,
      "left": 277.16,
      "attrs": { "color": "red" }
    },
    {
      "type": "wokwi-resistor",
      "id": "r3",
      "top": 315.38,
      "left": 199.1,
      "attrs": { "value": "1000" }
    },
    {
      "type": "wokwi-led",
      "id": "led4",
      "top": 291.12,
      "left": 316.19,
      "attrs": { "color": "blue" }
    },
    {
```

```
            "type": "wokwi-resistor",
            "id": "r4",
            "top": 255.49,
            "left": 236.26,
            "attrs": { "value": "1000" }
          }
        ],
        "connections": [
          [ "esp:TX0", "$serialMonitor:RX", "", [] ],
          [ "esp:RX0", "$serialMonitor:TX", "", [] ],
          [ "ultrasonic1:VCC", "esp:VIN", "red", [ "v39.24", "h42.88",
"v6" ] ],
          [ "ultrasonic1:GND", "esp:GND.2", "black", [ "v0" ] ],
          [ "ultrasonic1:ECHO", "esp:D12", "green", [ "v0" ] ],
          [ "ultrasonic1:TRIG", "esp:D13", "cyan", [ "v0" ] ],
          [ "pir1:VCC", "esp:3V3", "red", [ "v0" ] ],
          [ "lcd1:SCL", "esp:D22", "blue", [ "h-5.67", "v-201.1" ] ],
          [ "pir1:GND", "esp:GND.2", "black", [ "v20.74", "h84.02",
"v-128", "h-368.67", "v151.33" ] ],
          [ "pir1:OUT", "esp:D34", "green", [ "v36.07", "h112.81", "v-
116.67", "h-376.67" ] ],
          [ "lcd1:SDA", "esp:D21", "magenta", [ "h-28.61", "v-51.54" ]
],
          [ "esp:VIN", "lcd1:VCC", "red", [ "h311.3", "v-61.84",
"h0.82" ] ],
          [ "lcd1:GND", "esp:GND.1", "black", [ "h-14.75", "v122.42",
"h-206.35", "v-57.91" ] ],
          [ "led1:C", "esp:GND.1", "black", [ "v106.72", "h0.28", "v-
4.08" ] ],
          [ "led1:A", "r1:2", "green", [ "v0" ] ],
          [ "r1:1", "esp:D23", "green", [ "v0" ] ],
          [ "esp:RX2", "r2:1", "green", [ "h0" ] ],
          [ "r2:2", "led2:C", "green", [ "v-1.37", "h56.81" ] ],
          [ "led2:A", "esp:GND.1", "black", [ "v0" ] ],
          [ "led3:A", "r3:2", "green", [ "v47.79", "h-31.84" ] ],
          [ "r3:1", "esp:D2", "green", [ "v0" ] ],
          [ "led3:C", "esp:GND.1", "black", [ "v11.93", "h-135.76" ]
],
```

```
          [ "led4:A", "r4:2", "green", [ "v15.09", "h-19.18", "v-
82.28", "h-3.16" ] ],
          [ "r4:1", "esp:D15", "green", [ "v0" ] ],
          [ "led4:C", "esp:GND.1", "black", [ "v34.07", "h27.74", "v-
71.73", "h-222.57", "v-67.51" ] ]
        ]
      }
```

7.2 Feature 2

Municipalities gain from IoT systems' data intelligence and real-time insight into solid waste management concerns. In this manner, historical data can't utilised to identify and control certain container fill trends in the long run.

Location of the bins can be identified preciesly. Mobile applications, in addition to hardware solutions, are used to address challenges in the traditional waste management system, such as tracking drivers while they a on the road.

```
#IBM Watson IOT Platform
#pip install wiotp-sdk
import wiotp.sdk.device
import time
import random
myConfig = {
    "identity": {
        "orgId": "ede5q6",
        "typeId": "Locator",
        "deviceId":"54321"
    },
    "auth": {
        "token": "-DO!)E9jNUw7gpC57O"
    }
}

def myCommandCallback(cmd):
```

```
    print("Message received from IBM IoT Platform: %s" % cmd.data['command'])
    m=cmd.data['command']

client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)
client.connect()

while True:
    city = "London"
    lat = 34.8976508
    long = 67.9764532

    data = {'name':city, 'lat':lat, 'lon':long}
    client.publishEvent(eventId="Active", msgFormat="json", data=data, qos=0,
onPublish=None)
    print("Data Updated to IBM Platform: ", data)
    time.sleep(3)
client.disconnect()
```

CHAPTER 8

TESTING

TEST CASES

HP_TC_003	Functional	Home Page	Check if usercan can see the bin level.	The input image should be uploaded to the application successfully	Working as expected	PASS
HP_TC_004	Functional	Home Page	Check if user can view loaction	The application should not allow user to select a non image file	User is able to upload any file	FAIL
HP_TC_005	Functional	Home Page	Check if the page reloads automatically	The page shouldredirect to theresults page	Working as expected	PASS

BE_TC_001	Functional	Backend	Check if allvthe routes are working properly
M_TC_001	Functional	Model	Check if the model can handle various map sizes

M_TC_002	Function al	Model	Check if themodel predicts thedigit
M_TC_003	Function al	Model	Check if the model can handle complex input image
RP_TC_0 01	UI	Home Page	Verify UI elements inhome Page
RP_TC_0 02	UI	Home Page	Check if the map is displayed properly
RP_TC_0 03	UI	Result Page	Check if theresult is displayed properly
RP_TC_0 04	UI	Result Page	Check if the details are displayed properly

a. USER ACCEPTANCE TESTING

i. DEFECT ANALYSIS

Resolution	Severi	Severi	Severi

	ty 1	ty 2	ty 3
By Design	1	0	1
Duplicate	0	0	0
External	0	0	2
Fixed	4	1	0
Not Reproduced	0	0	0
Skipped	0	0	0
Won't Fix	1	0	1
Total	6	1	4

ii. TEST CASE ANALYSIS

Section	Total Cases	Not Tested	Fail	
Client Application	10	0	3	
Security	2	0	1	
Performance	3	0	1	
Exception Reporting	2	0	0	

CHAPTER 9

RESULTS

As was previously described, the IBM cloud, IOT platform, and node red platform were used to develop and successfully deploy the IoT device for smart waste management. All of the problem statements described above are resolved by using this device. It cuts down on budget for bigger firms and will be used for budget spending that is efficient. Consequently, there is also less pollution.

i.

CHAPTER 10

ADVANTAGES & DISADVANTAGES

ADVANTAGES

1. Reduction in Collection Cost
2. No Missed Pickups
3. Reduced Overflows
4. Waste Generation Analysis
5. CO_2 Emission Reduction

DISADVANTAGES

6. System requires a greater number of waste bins for separate waste collection as per population in the city.
7. This results into high initial cost due to expensive smart dustbins compare to other methods.
8. Sensor nodes used in the dustbins have limited memory size

CHAPTER 11

CONCLUSION

A Smart Waste Management system that is more effective than the one in use now is achievable by using sensors to monitor the filling of bins. Our conception of a "smart waste management system" focuses on monitoring waste management, offering intelligent technology for waste systems, eliminating human intervention, minimizing human time and effort, and producing a healthy and trash-free environment. The suggested approach can be implemented in smart cities where residents have busy schedules that provide little time for garbage management. If desired, the bins might be put into place in a metropolis where a sizable container would be able to hold enough solid trash for a single unit. The police might be high.

CHAPTER 12

FUTURE SCOPE

There are several future works and improvements for the proposed system, including the following:

• Change the system of user authentication and atomic lock of bins, which would aid inprotecting the bin from damage or theft.

• The concept of green points would encourage the involvement of residents or end users, making the idea successful and aiding in the achievement of collaborative waste management efforts, thus fulfilling the idea of Swachh Bharath.

• Having case study or data analytics on the type and times waste is collected on differentdays or seasons, making bin filling predictable and removing the reliance on electronic components, and fixing the coordinates.

• Improving the Server's and Android's graphical interfaces

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APPENDIX

GITHUB

https://github.com/IBM-EPBL/IBM-Project-34816-1660277369h

PROJECT DEMO

https://node-red-izmpc-2022-11-16.eu-gb.mybluemix.net/