SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

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IBM NAALAIYATHIRAN GUIDED PROJECT REPORT

Submitted by

ADARSH G	**[711719106701]**
CHRISTINA AISHVARYA B	**[711719106702]**
MELVIN S	**[711719106025]**
NITHISH B K	**[711719106100]**

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ANNA UNIVERSITY: CHENNAI 600025

BONAFIDE CERTIFICATE

Certified that this guided project report **"SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES"** is the bonafide work of **"ADARSH G, CHRISTINAAISHVARYA B, MELVIN S, NITHISH B K"** who carried out the project work under my supervision.

SIGNATURE

Ms. R. SATHYABAMA

MENTOR

Department of Electronics and Communication Engineering

SIGNATURE

Mr. K. SIVA PRAKASH

EVALUATOR

Department of Electronics and Communication Engineering

SIGNATURE

Dr. C. VENKATESH

HoD

Department of Electronics and communication Engineering

SIGNATURE

Dr. S. K. MYDHILI

SPOC

Department of Electronics and Communication Engineering

Submitted for the semester end review examination held on ……

Internal Examiner

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ABSTRACT

With the increasing population and industrialization of nations throughout the globe, waste has become a great concern for all of us. Over years, researchers figured that only waste management is not enough for its proper treatment and disposal techniques to preserve our environment and keeping it clean in this era of globalization. With the help of technology researchers have, introduced IoT based Smart Waste Management solutions and initiatives that ensures reduced amount of time and energy required to provide waste management services and reduce the amount of waste generated. Unfortunately, developing countries are not being able to implement those existing solutions due to many factors like socio-economic environment. Therefore, in this research we have concentrated our thought on developing a smart IoT based waste management system for developing countries like INDIA that will ensure proper disposal, collection, transportation and recycling of household waste with the minimum amount of resources being available.

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LIST OF ABBREVIATIONS

GSM	Global System for Mobile communication
GPS	Global positioning System Internet of Things
IoT	Internet of Things
POPs	Persistent Organic Pollutants

CHAPTER 1

INTRODUCTION

1.1 PROJECT OVERVIEW:

Our waste generation is constantly growing to form a global garbage crisis. Even though we indulge in creating a more sustainable and greener, we still fail to handle our waste generation and management. Combining technology support with a vision of social, economic and environmental sustainability is the best way out of this problem. It is done in the following manner. The smart bin system undergoes a thorough system check and battery level monitoring in order to function efficiently. If the battery level is found to be low, it has to be recharged immediately, else it can proceed to the next step. The threshold level levels of the bin are indicated my multiple sensors attached to bin. If the garbage exceeds the level, then an alert message is sent to the garbage collectors as well as to the municipality or area administration. The area in which garbage is found to overflow is allocated to respective garbage collectors in the form of messages through GSM system. Once the waste bin is emptied, an information update is sent to the municipality and server is updated. This is howthe waste from bins can be efficiently handled and managed using technology which in turn keeps the environment clean and healthy.

1.2PURPOSE:

We amalgamate technology along with waste management in order to effectively create a safe and a hygienic environment. Smart waste management is about using technology and data to create a more efficient waste industry. Based on IoT (Internet of Things) technology, smart waste management aims to optimize resource allocation, reduce running costs. This makes it possible to plan more efficient routes for the trash collectors who empty the bins, but also lowers the chance of any bin beingfull for over a week. This makes them well aware of the existing garbagelevel and instigate them whenever the bins reach the threshold level.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. Thus, smart waste management providesus with the most optimal way of managing the waste in an efficient manner using technology.

CHAPTER 2

LITERATURE SURVEY

2.1 EXISTING PROBLEM

Waste management has become an alarming challenge in local towns and cities across the world. Often the local area bins are overflowing and the municipalities are not aware of it. This affects the residents of that particular area in numerous ways starting from bad odour to unhygienic and unsafe surroundings. Poor waste management - ranging from non-existing collection systems to ineffective disposal -causes air pollution, water and soil contamination. Open and unsanitary areas contribute to contamination of drinking water and can cause infection and transmit diseases. Toxic components such as Persistent Organic Pollutants (POPs) pose particularly significant risks to human health and the environment as theyaccumulate through the food chain. Animals eating contaminated plants have higher doses ofcontaminants than if they were directly exposed. Precipitation or surface water seeping through waste will absorb hazardous components from landfills, agricultural areas, feedlots, etc. and carry them into surface and groundwater. Contaminated groundwater also poses a great health risk, as it is often used for drinking, bathing and recreation, as well as in agricultural and industrial activities. Landfills and waste transfer stations can attract various pests (insects, rodents, gulls, etc.) that look for food from waste. These pests can spread diseases through viruses and bacteria (i.e., salmonella and e-coli), which are a risk to human health.

2.2 SURVEY OF SMART WASTE MANAGEMENT SYSTEM

S.NO	TITLE OF THE PROJECT	ADVANTAGES	DISADVANTAGES	RESULT
1	IOT Enabled Smart Waste Bin with Real Time Monitoring for efficient waste management in Metropolitan Cities	The capacitance sensor in the bin continuously monitors the level of the bin in real time and communicates to the central cloud where the bins are connected.	The resultant product has a short life.	Such smart bins are connected to the cloud, where the bin status is communicated, recorded and monitored by the local bodies through and android app or a centralized server
2	IoT-Enabled Solid Waste Management in Smart Cities	The development and validation of a hybrid network architecture approach to efficiently manage trash bins in public places.	The sites are often dangerous	Residential areas of cities were discussed in this paper.
3	IoT Based Smart Garbage System.	The design of the smart dustbin includes a single by ultrasonic sensor which configured with Arduino Uno with this research it is sending SMS to the Municipal Council that particular dustbin is to overflow	High initial cost due to expensive smart dustbins compare to other methods	It is sending SMS to the Municipal Council that particular dustbin is to overflow

4	An IoT enabled Smart Garbage Management System for Smart Cities – Indian Scenario	This system is basically useful for small scale industries.	The resultant product has a short life and Power consumption.	Every dustbin has its own Id and database. Database show the list of bins with their Id and exact location.
5	A Survey on Garbage Collection and Monitoring System for Smart cities using IOT	Cost Reduction and resource optimization And Intelligent management of the services in the city.	Sensor nodes used in the dustbins have limited memory size.	This paper introduces you to the use of IoT on one such area, that is, Garbage Detection in smart ways using IoT and see how this can also be a major part of developing a city into a smart city.
6	Iot Based Waste Monitoring System using Raspberry Pi Kit	The system makes use of Raspberry Pi for sending data over Node-RED cloud	Process is not always cost efficient.	Node-RED is a visual tool for wiring the Internet of Things (IOT) that can be run on a Raspberry Pi and allows for rapid prototyping of this project.
7	Implementation of Automatic Waste Management System Using IOT & Android for Smart Cities.	It helps administration to generate extra revenue by advertisements on smart devices	System requires more number of waste bins for separate waste collection as per population in the city.	That dustbins will be connected to a central system.

Table 2.1 Survey of Smart Waste Management System

2.3 PROBLEM STATEMENT TABLE

Problem Statement (PS)	**I am (Customer)**	**I am trying to**	**But**	**Because**	**Which makes me feel**
PS-1	Council	Monitor the waste in my city	I have not much effective system for monitoring	Because of high cost	unhygienic
PS-2	Council	Manage the waste in mycity	I have not much effective System for managing	Because of more time consuming	unsafe

Table 2.2 Representing the Problem Statement Phase

CHAPTER 3

IDEATION & PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behavior and attitudes. It is a useful tool to helps teams better understand their users. Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user's perspective along with his or her goals and challenges.

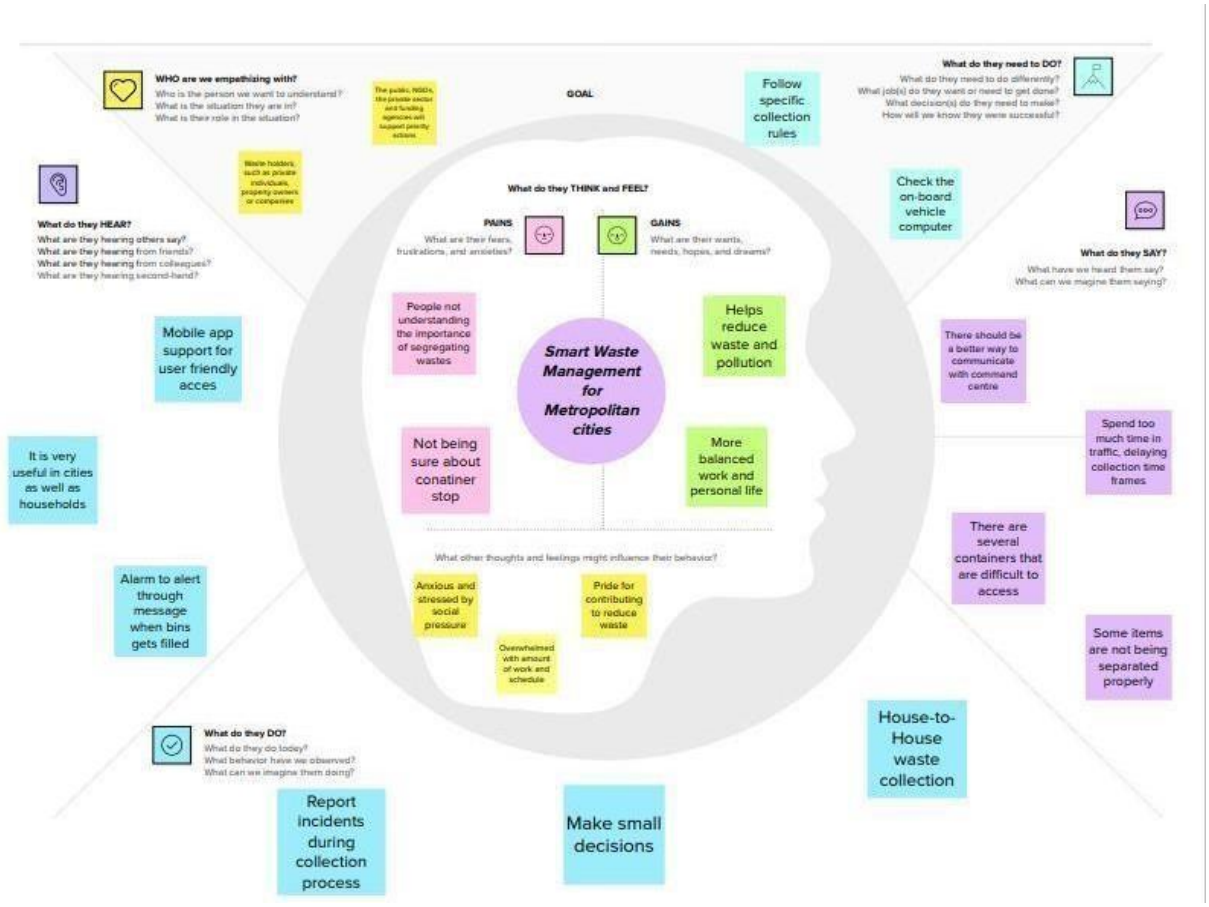

Fig.3.1 Screenshot of Empathy Map

3.2 IDEATION & BRAINSTORMING

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate, helping each other develop a rich amount of creative solutions.

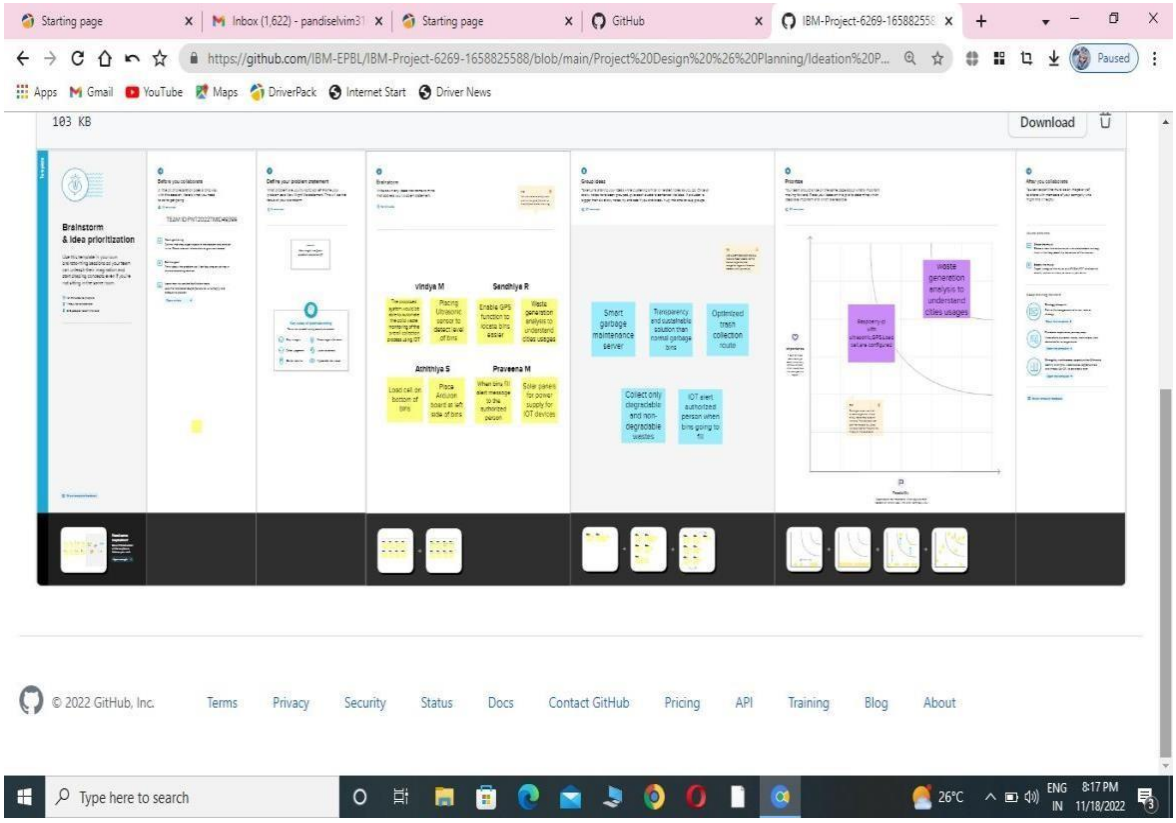

Fig.3.2 Screenshot of Ideation & Brainstorming

3.3 PROPOSED SOLUTION

SI No.	Parameter	Description
1	Problem Statement (Problem to besolved)	Detecting the level of garbage and informing the garbage collectors through a proper communication channel about the garbage level and alerts them to collect it at a specified time efficiently.
2	Idea / Solution description	By using fill level sensors, we can detect the garbage level. Improving the communication channel using proper technology like WiMAX. Using GPS for tracking the location of bin and sorting out the short routes.
3	Novelty / Uniqueness	By using IoT, GPS and GSM like technologieswhich if properly used in the establishment of this project helps to detect the garbage level and intimating about it to the authorityand initiating them to collect the garbage on time.
4	Social Impact / Customer Satisfaction	It keeps our surroundings clean and green and free from bad odour of wastes, emphasizes on healthy environment. Reduces air pollution
5.	Business Model (Revenue Model)	Smart waste management system is an innovative and effective step to analyze the production of waste annually and it helps to find the ways to reduce the factors which increases the waste produced.

6.	Scalability of the Solution	Smart waste management can attain its scalability by still more advancement in IoT and using many sensors to detect its accurate level accurately. Its implementation can be enhanced by using 5G type of technology for faster communication. AI recycling robots can be used in the nearer future.

Table 3.1 Proposed solution

3.4 PROBLEM SOLUTION FIT:

A complex process with numerous sub- processes, solution architecture connects business issues withtechnological solutions. the objectives are to find the best technological solution to address current company issues. Describe to the project & stakeholders the software's & structure, distinction, behavior, and other features. Define the solution's requirements and concern development stages, and features. Specifications on how the solution is defined, maintained, and delivered should be provided.

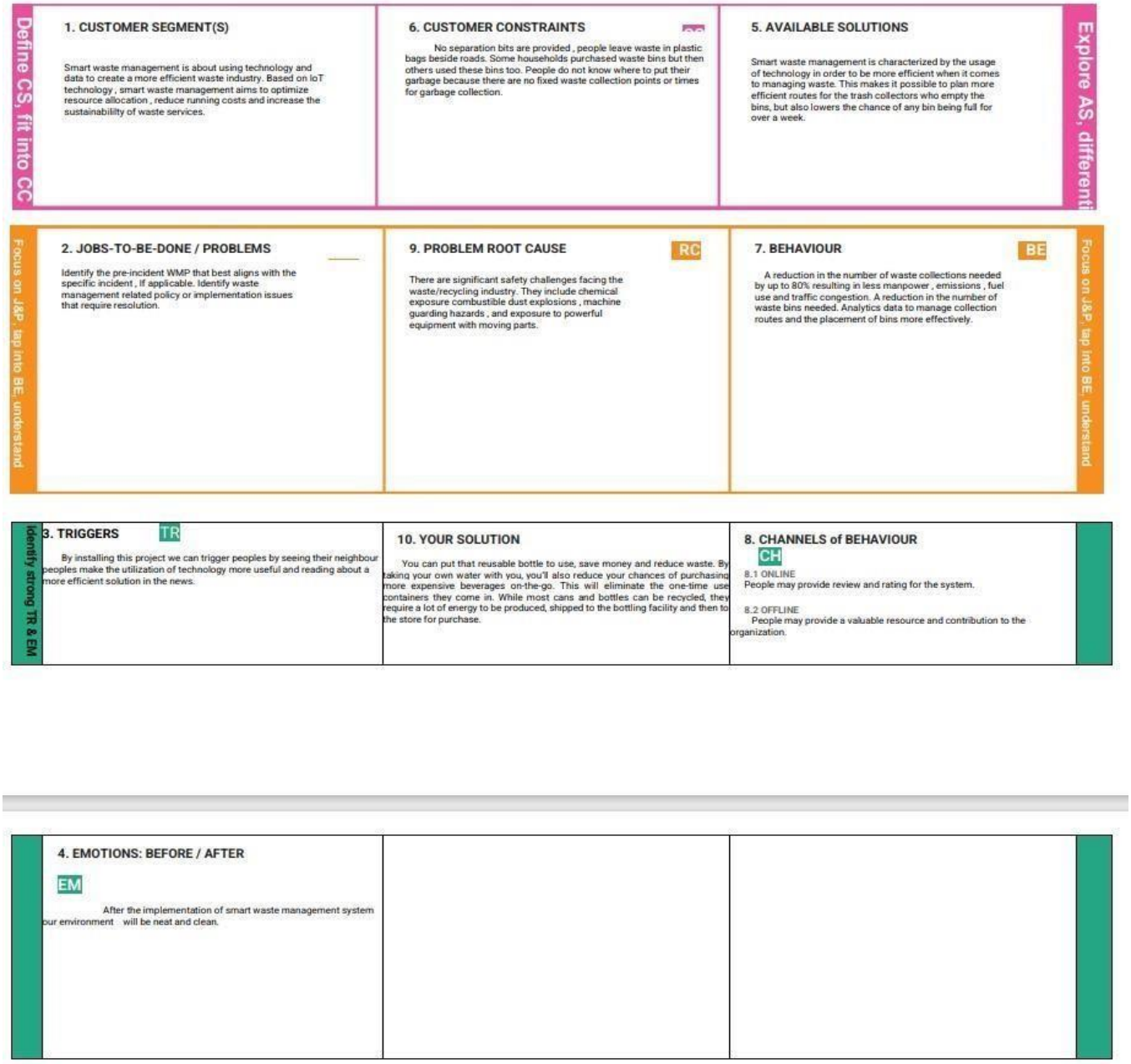

Fig.3.3 Screenshot of Problem Solution Fit

CHAPTER 4

REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENT

Following are the functional requirements of the proposed solution:

FR No.	Functional Requirement(Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Real time bin monitoring.	The Dashboard shows statistics on the amount of fill in bins as it is being tracked by smart sensors. The application also forecasts when the bin will fill up based on past data in addition to the percentage offill level, which is one of the features that even the finest waste management software lacks. As picks are also recognized by the sensors, you candetermine when the bin was last emptied. You can get rid of the overflowing bins and cease collecting half-empty ones using real-time data and forecasts.
FR-2	Eliminate inefficient picks.	Get rid of the collection of half-empty trash cans. Picks are recognized by sensors. We can demonstrate to you how full the bins you collect are using real-time data on fill-levels and pick recognition.
FR-3	Plan waste collection routes.	Route planning for rubbish pickup is semiautomated using the tool. You are prepared toact and arrange for garbage collection based on thelevels of bin fill that are now present and forecasts of approaching capacity. To find any discrepancies, compare the planned and actual paths.

FR-4	Adjust bin distribution.	Ensure the best possible bin distribution. Determine which regions have a dense or sparse distribution of bins. Ensure that each form of waste has a representative stand. You can make any required adjustments to bin position or capacity based on past data.
FR-5	Expensive bins.	We assist you in locating containers that increase collection prices. The tool determines a collection cost rating for each bin. The tool takes local average depo-bin discharge into account. The tool determines the distance from depo-bin discharge and rates bins (1–10).
FR-6	Detailed bin inventory.	On the map, you can see every monitored bin and stand, and you can use Google Street View at any time to visit them. On the map, bins or stands appear as green, orange, or red circles. The Dashboard displays information about each bin, including its capacity, trash kind, most recent measurement, GPS position, and pick-up schedule.

Table 4.1 Functional Requirement

4.2 NON-FUNCTIONAL REQUIREMENTS

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

FR No.	NON-FUNCTIONAL REQUIREMENT	DESCRIPTION
NFR-1	**Usability**	Usability is a unique and significant perspective to examine user needs, which may further enhance the design quality, according to IoT devices. Analyzing how well people interact with a product may help designers better understand customers' prospective demands for waste management, behavior, and experience in the design process when user experience is at the Centre.
NFR-2	**Security**	Utilize recyclable bottles. Utilize reusable shopping bags. Spend responsibly and recycle Eat and drink in limited-use containers.
NFR-3	**Reliability**	Creating improved working conditions for garbage collectors and drivers is another aspect of smart waste management. Waste collectors will use their time more effectively by attending to bins that require service rather than travelling the same collection routes and servicingempty bins.
NFR-4	**Performance**	The Smart Sensors assess the fill levels in bins (along with other data) numerous times each day using ultrasonic technology. The sensors feed data to Senone's Smart Waste Management Software System, a robust cloud-based platform with data driven daily operations and a waste management app, using a variety of IoT networks (NB-IoT, GPRS). As a consequence, customers receive data-driven decision-making services, and garbage collection routes, frequency, and truck loads are optimized, resulting in at least a 30% decrease in route length.

NFR-5	**Availability**	By creating and implementing robust hardware and gorgeous software, we enable cities, companies, and nations to manage garbage more intelligently.
NFR-6	**Scalability**	Using smart trash bins allows us to scale up and monitor the rubbish more efficiently while also reducing the number of bins needed in towns and cities.

Table 4.2 Non-Functional Requirement

CHAPTER 5

PROJECT DESIGN

5.1DATA FLOW DIAGRAMS:

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored A smart waste management platform uses analytics to translate the data gather in your **bins into actionable insights to help you improve your waste services.** You can receive data on metric such as:

- The first test conducted is the situation where the garbage bin is empty or its garbage level is very low

- Then, the bin is filled with more garbage until its level has surpassed the first threshold **value, which is set to 80% then the first warning SMS is being sent, as depicted**
- The first notification SMS sent by the system, once the waste reaches the level of 85% full
- The second notification SMS sent by the system, indicating that bin is at least 95% full and **the garbage needs to be collected immediately**

- Locations prone to overflow
- The number of bins needed to avoid overflowing waste
- The number of collection services that could be saved
- The amount of fuel that could be saved
- The driving distance that could be saved

DATA FLOW DIAGRAM

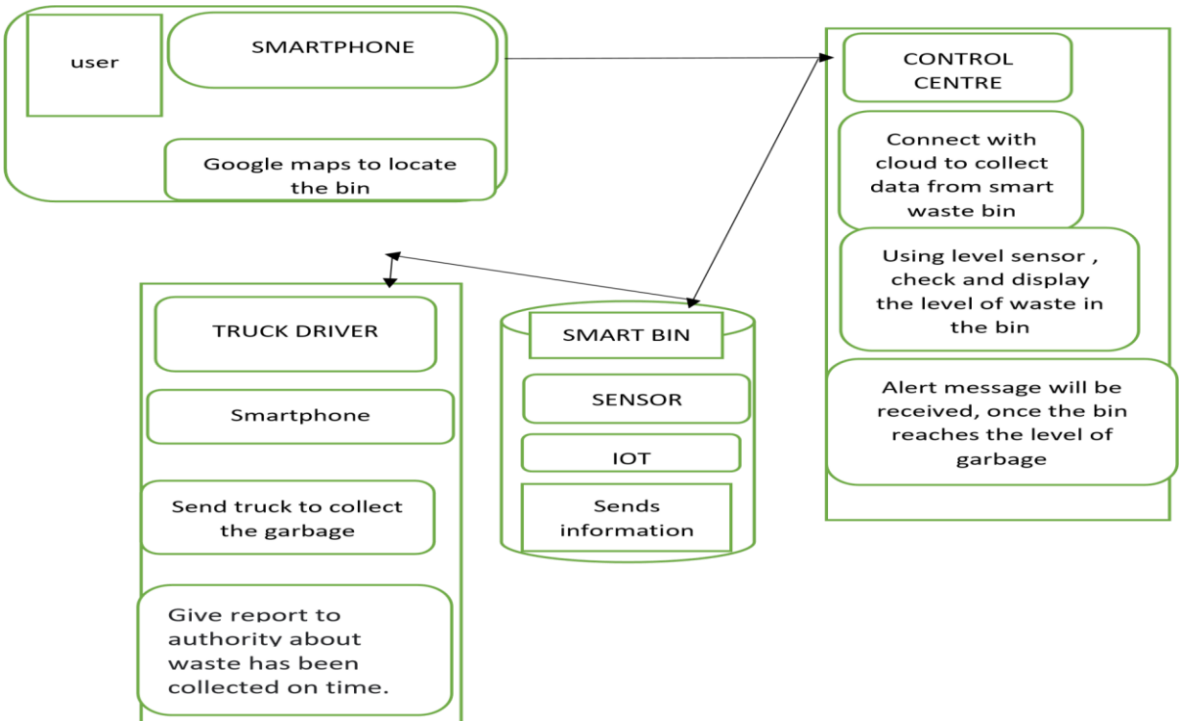

Fig 5.1 Screenshot of Data Flow Diagram

5.2 SOLUTION & TECHNICAL ARCHITECTURE:

Solution architecture is a complex process with many sub-processes that bridges the gap between business problems and technology solutions. Its goals are to: Find the best tech solution to solve existing business problems. Describe the structure, characteristics, behavior, and other aspects of the software to project stakeholders. Define features, development phases, and solution requirements. Provide specifications according to which the solution is defined, managed, and delivered.

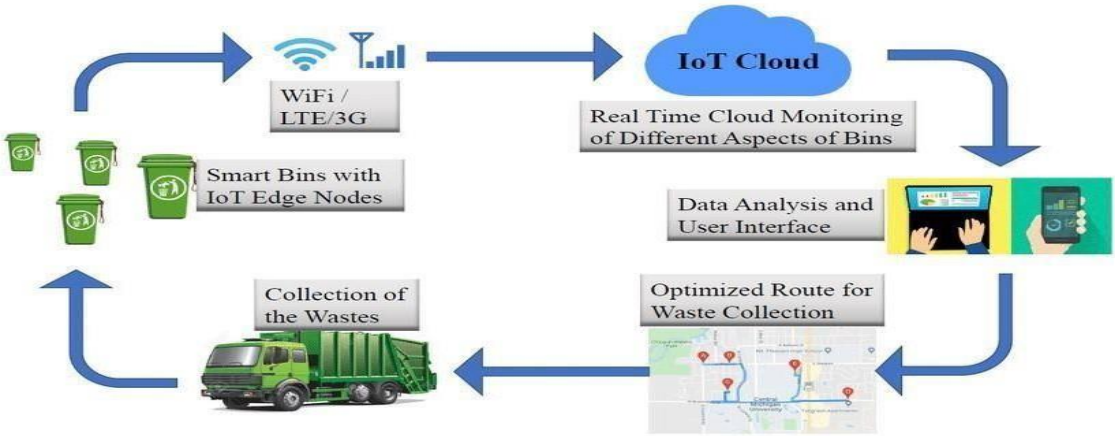

Fig 5.2 Screenshot of Technical Architecture

5.3 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	Login	USN-1	As an administrator, I assigned user name sandpasswords to each employee and managedthem.	I can control myonline account and dashboard.	Medium	Sprint-1
Co-Admin	Login	USN-2	As a Co-Admin, I'll control the waste level monitor. If a garbage filling alert occurs, I will notify the trash truck of the location and rubbish ID.	I can handlethe waste collection .	High	Sprint-1
Truck Driver	Login	USN-3	As a Truck Driver, I'll follow Co Admin's instruction to reach the filled garbage.	I can take the shortest path toreach the waste filled route specified.	Medium	Sprint-2
Local Garbage Collector	Login	USN-4	As a Local Garbage Collector, I'II gather allthe waste from the garbage, load it onto a garbage truck, and deliver it to Landfills	I can collect the trach, pullit to the truck, and send itout.	Medium	Sprint-3
Municipality officer	Login	USN-5	As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems.	All of these processes areundermy control.	High	Sprint-4

Table 5.1 User Stories

CHAPTER 6

PROJECT PLANNING & SCHEDULING

6.1 SPRINT PLANNING & ESTIMATION:

PHASE	TITLE	DESCRIPTION
Ideation Phase	Literature Survey & Information Gathering	Literature survey on the selected project & gatheringinformation by referring the,technical papers, research publications etc.
	Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements
	Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based onthe feasibility & importance.
Phase-1	Proposed Solution	Prepare the proposed solution document, which includes thenovelty, feasibility of idea, business model, social impact,scalability of solution, etc.
	Problem Solution Fit	Prepare problem - solution fitdocument.
	Solution Architecture	Prepare solution architecturedocument.
Phase-2	Customer Journey	Prepare the customer journey mapsto understand the user interactions & experiences with the application(entry to exit).
	Functional Requirement	Prepare the functional and Nonfunctional requirementdocument.
	Data Flow Diagrams	Draw the data flow diagrams andsubmit for review.
	Technology Architecture	Prepare the technology architecturediagram.
Project planning phase	Prepare Milestone & ActivityList	Prepare the milestones & activitylist of the project.
Project developmen tphase	Project Development - Delivery of Sprint-1, 2, 3 & 4	Develop & submit the developedcode by testing it.

Table 6.1 Sprint Planning

6.2 SPRINT DELIVERY SCHEDULE:

Sprint	Functional Requirement (Epic)	Task	Story points	Priority	Team Member
Sprint-1	Registration	As a team lead, I can enroll for the project by entering my email passwordand within that I can enter my team and I will receive confirmation email once, I have enrolled for the project with team id and along with team members name.	2	High	Christina Aishvarya B
Sprint-2	Login	As a team member, I can login to the IBM portal by entering email& password	2	High	Adarsh G
Sprint-2	Login	As a team member, I can login to the IBM portal by entering email & password.	1	Medium	Melvin S
Sprint-2	Login	As a team member, I can login to the IBM portal by entering email & password.	1	Medium	Nithish B K

Table 6.2 Sprint Delivery Schedule

Sprint	Total story points	Duration	Sprint Start Date	Sprint EndDate (Planned)	Story Points Completed (Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	22 Oct 2022	27 Oct 2022	20	06 Nov 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	30	07 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	49	08 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	50	09 Nov 2022

Table 6.3 Sprint Delivery

CHAPTER 7

CODING & SOLUTIONING

7.1 WOKWI CODE FOR SENSOR TRANSMISSION

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

//..... credentials of IBM Accounts.....

#define ORG "9gbe4w"       // IBM organisation id
#define DEVICE_TYPE "SWMSMC"// Device type mentioned in
ibm watson iot platform #define DEVICE_ID "ibmproject"
                           // Device ID mentioned in ibm
watson iot platform #define TOKEN "sUNA41tG6-Pq)0rk5X"
                           // 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;
String data3;
bool SealBin
= true; void
```

```
setup()
{
 Serial.begin(1152
 00);
 pinMode(LED_BUILT
 IN, OUTPUT);
 pinMode(TRIG_PIN,
 OUTPUT);
 pinMode(ECHO_PIN,
 INPUT);
 //pir pin
 pinMode(34,
 INPUT);

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

 lcd.init();
 lcd.backligh
 t();
 lcd.setCurso
 r(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;
}
void loop()
 {

 lcd.clear();

 publishD
 ata();
 delay(50
 0);
 if (!client.loop())
  {
   mqttConnect();                // function call to connect to IBM
  }
}

/*                        retrieving to cloud
                        */ void wifiConnect()
{
 Serial.print("Connecti
 ng 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.prin
      t(".");
      delay(500);
     }
    initManagedDevice();
    Serial.println();
   }
 }
```

```
void initManagedDevice()
 {
  if (client.subscribe(topic))
void publishData()
{
 float cm = readcmCM();

 if(digitalRead(34))            //pir motion detection
 {
  Serial.println("Moti
  on Detected");
  Serial.println("Lid
  Opened");
  digitalWrite(15,
  HIGH);
if(digitalRead(34)== true)
{
 if(cm <= 100)                        //Bin level detection
 {
  digitalWrite(2, HIGH);
  Serial.println("High Alert!!!,Trash bin is about to be full");
  !!,Trash is about to cross 50% of bin level");
  digitalWrite(2, LOW);
  digitalWrite(23, LOW);

 }
 else if(cm > 180)
 {
  digitalWrite(23,
  HIGH);
  Serial.println("Bin
  is available");
  digitalWrite(2,LOW);
  digitalWrite(4,
  LOW);

 }
  delay(10000);
  Serial.println("Lid Closed");
  }Serial.println("
  Lid     Closed");
  lcd.print("Full!
  Don't      use");
  delay(2000);
  lcd.clear();
  digitalWrite(
  4, LOW);
  digitalWrite(
  23, LOW);
 }
 else if(cm > 100 && cm < 180)
```

```
   {
    digitalWrite(4, HIGH);
   Serial.println("Warning
   else
   {
    Serial.println("No
    motion detected");
    digitalWrite(2, LOW);
    digitalWrite(15,
    LOW); digitalWrite(4,
    LOW);
    digitalWrite(23,
    LOW);
   }
  }
   else
   {
    digitalWrite(15, LOW);
}
   if(cm <= 100)
  {
  digitalWrite(21,HIGH);
  String payload =
  "{\"High_Alert\":";
  payload += cm;
  payload += " }";
  Serial.print("\n");
  Serial.print("Sendin
  g payload: ");
  Serial.println(paylo
  ad);

  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");
  }
  }
  else if(cm <= 180)
  {
  digitalWrite(22,HIGH);
  String payload =
  "{\"Warning\":";
  payload += cm ;
  payload += " }";
  Serial.print("\n");
  Serial.print("Sendin
  g payload: ");
  Serial.println(paylo
  ad);
  if(client.publish(publishTopic, (char*) payload.c_str()))
```

```
{
Serial.println("Publish OK");
}
Else
{
Serial.println("Publish FAILED");
}
}
else if(cm > 180)
{
digitalWrite(
23,HIGH);
String
payload =
"{"; payload
+= cm;
payload += " }";
Serial.print("\n");
Serial.print("Sendin
g payload: ");
Serial.println(paylo
ad);

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("I
 nches");
 lcd.setCurso
 r(4,0);
 lcd.setCurso
 r(12,0);
 lcd.print("c
 m");
 lcd.setCurso
 r(1,1);
 lcd.print(in
 ches, 1);
 lcd.setCurso
 r(11,1);
 lcd.print(cm
 , 1);
 lcd.setCurso
 r(14,1);
```

```
 delay(1000);
 lcd.clear();
}

//handles commands from user side

void callback(char* subscribetopic, byte* payload, unsigned int payloadLength)
{

 Serial.print("callback invoked for topic: ");
 Serial.println(subscribetopic);
 for (int i = 0; i < payloadLength; i++) {

  data3 += (char)payload[i];
 }
 Serial.println("data: "+ data3);

 const char *s =(char*)
 data3.c_str(); double
 pincode = 0;

     const
     char
     *buf; int
     len;

     if (mjson_find(s, strlen(s), "$.command", &buf, &len))  // And print it
     {

      String

      command(buf,len);

      if(command=="\"SealBi

      n\"")
      {
       SealBin = true;


      }
      }
 data3="";
```

7.2FEATURE 1- LOCATION TRACKER:

Another solid part of the prototype is its alerting system. While the sensing elements are responsiblefor sensing the dustbins.

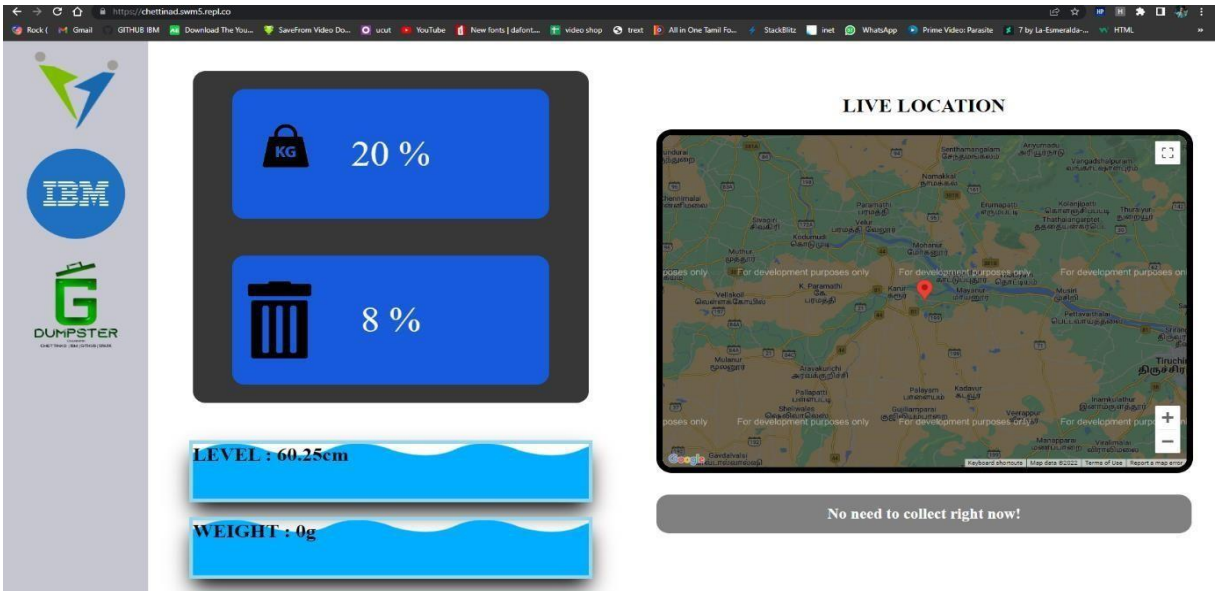

Fig 7.1 Screenshot of location Tracker

7.3FEATURE 2- LIVE UPDATE ON COLLECTED DATA:

Live updating on collected data of smart waste management system.

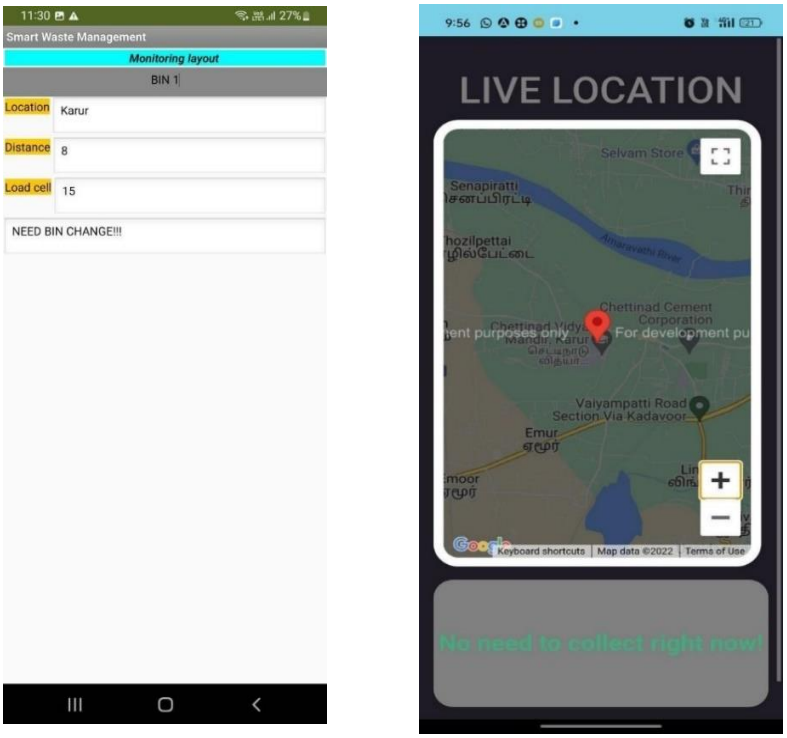

Fig 7.2 Screenshot of Live Update on Collected Data

CHAPTER 8

TESTING

8.1 TESTCASES

Maximum Size of Bin: 200 cm Safe limit: below 100 cm

Minimum threshold limit of bin: 100 cm

Maximum threshold limit of bin: 180 cm

S.no	**Bin Level (cm filled)**	**Bin Status**	**Location**
1	45	Safe	Kanyakumari
2	78	Safe	Coimbatore
3	112	Warning	Trichy
4	169	Warning	Chennai
5	186	Warning	Ooty
6	193	High Alert	Tirunelveli
8	0	Safe	Chengalpattu
9	35	Safe	Madurai
10	101	Warning	Salem
11	132	Warning	Thanjavore
12	158	Warning	Vellore
13	93	High Alert	Erode

Table 8.1 Bin level detection

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[ProductName] 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 how they were resolved

Resolution	Severity1	Severity 2	Severity 3	Severity 4	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	7

Table.8.2 Defect Analysis

8.2.1. TEST CASE ANALYSIS

This report shows the number of test cases that have passed, failed, and untested

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

Table 8.3 Test Case Analysis

CHAPTER 9

RESULTS

9.1 PERFORMANCE METRICS:

Performance metrics are defined as figures and data representative of an organization's actions, abilities, and overall quality.

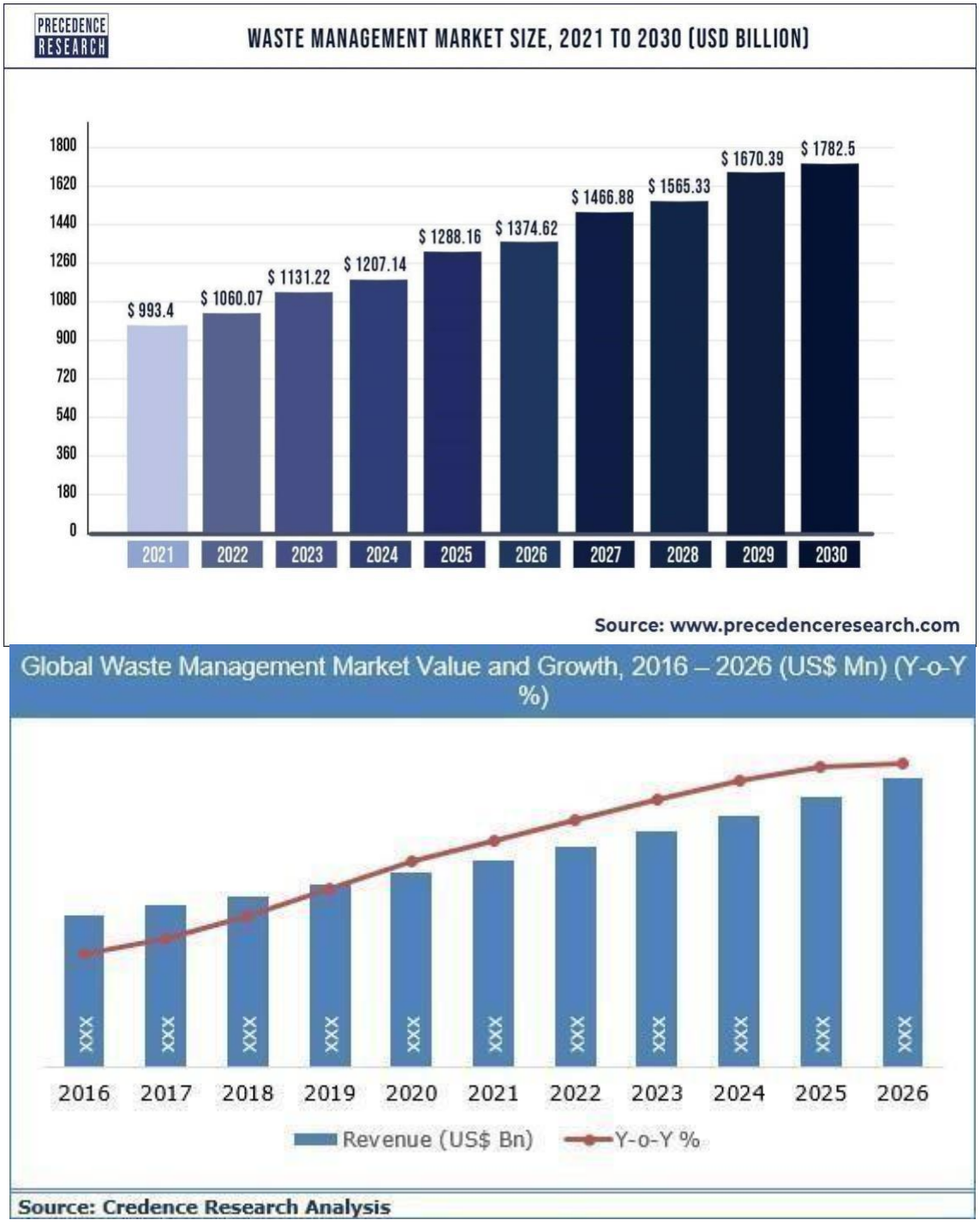

Fig 9.1 Screenshot of Performance Metrics

CHAPTER 10

ADVANTAGES & DISADVANTAGES

10.1 ADVANTAGES:

- Reduction in Collection Cost
- No Missed Pickups
- Reduced Overflows
- Waste Generation Analysis
- CO2 Emission Reduction

10.2 DISADVANTAGES

System requires a greater number of waste bins for separate waste collection as perpopulation in the city and this results into high initial cost due to expensive smart dustbins compare to othermethods. 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 nowis achievable by using sensors to monitor the filling of bins. Our conception of a "smart wastemanagement 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 price might be high.

CHAPTER 12

FUTURE SCOPE

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

1. Change the system of user authentication and atomic lock of bins, which would aid inprotecting the bin from damage or theft.
2. 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.
3. 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.
4. Improving the Server's and Android's graphical interfaces

CHAPTER 13

APPENDLX

13.1 SOURCE CODE

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

//            credentials of IBM Accounts

#define ORG "9gbe4w"  // IBM organisation id
#define DEVICE_TYPE "SWMSMC" // Device type
mentioned in ibm watson iot platform #define
DEVICE_ID "ibmproject"  // Device ID mentioned
in ibm watson iot platform #define TOKEN
"sUNA41tG6-Pq)0rk5X"  // 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";
 //
authenticati
on 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;
String data3;
bool
SealBin =
true; void
setup()
{
 Serial.begin(1
 15200);
 pinMode(LED_BU
 ILTIN,
 OUTPUT);
 pinMode(TRIG_P
 IN, OUTPUT);
 pinMode(ECHO_P
 IN, INPUT);
 //pir pin
 pinMode(3
 4,
 INPUT);

 //ledpins
 pinMode(2
 3,
 OUTPUT);
 pinMode(2
 ,
 OUTPUT);
 pinMode(4
 ,
 OUTPUT);
 pinMode(1
```

```
 5,
 OUTPUT);

 lcd.init()
 ;
 lcd.backli
 ght();
 lcd.setCur
 sor(1, 0);
 lcd.print(
 "");
 wifiConnec
 t();
 mqttConnec
 t();
}
float readcmCM()
{
 digitalWrite(T
 RIG_PIN, LOW);
 delayMicroseco
 nds(2);
 digitalWrite(T
 RIG_PIN,
 HIGH);
 delayMicroseco
 nds(10);
 digitalWrite(T
 RIG_PIN, LOW);
 int duration =
 pulseIn(ECHO_PIN,
 HIGH); return duration
 * 0.034 / 2;
}
void loop()
```

```
{
 lcd.clear();
 publish
 Data();
 delay(5
 00);
 if (!client.loop())
  {
   mqttConnect();           // function call to connect to IBM
  }
}

/*                  retrieving to cloud                    */

void wifiConnect()
{
 Serial.print("Conn
 ecting 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.pr
      int(".");
      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("M
  otion Detected");
  Serial.println("L
  id Opened");
  digitalWrite(15,
  HIGH);


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("Ful
  l!       Don't
  use");
  delay(2000);
```

```
 lcd.clear(
 );
 digitalWri
 te(4,
 LOW);
 digitalWri
 te(23,
 LOW);
}
else if(cm > 100 && cm < 180)
{
 digitalWrite(4, HIGH);
 Serial.println("Warning!!,Trash is
 about to cross 50% of bin level");
 digitalWrite(2, LOW);
 digitalWrite(23, LOW);

}
else if(cm > 180)
{
 digitalWrite(23,
 HIGH);
 Serial.println("B
 in is
 available");
 digitalWrite(2,LO
 W);
 digitalWrite(4,
 LOW);

}
 delay(10000);
 Serial.println("Lid Closed");
}
else
{
 Serial.println("No
 motion detected");
 digitalWrite(2,
 LOW);
 digitalWrite(15,
 LOW);
 digitalWrite(4,
 LOW);
```

```
  digitalWrite(23,
  LOW);
 }

}
 else
 {
  digitalWrite(15, LOW);

 }


 if(cm <= 100)
{
digitalWrite(21,HIGH);
String payload =
"{\"High_Alert\":"
; payload += cm;
payload += " }";
Serial.print("\n"
);
Serial.print("Sen
ding payload: ");
Serial.println(pa
yload);

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");
}
}
else if(cm <= 180)
{
digitalWrite(22,HIGH);
String payload =
"{\"Warning\":";
payload += cm ;
payload += " }";
Serial.print("\n"
);
Serial.print("Sen
ding payload: ");
```

```
}
 else if(cm > 180)
 {
 digitalWrite(2
 3,HIGH);
 String payload
 = "{"; payload
 += cm;
 payload += " }";
 Serial.print("\n");
 Serial.print("Sendin
 g payload: ");
 Serial.println(paylo
 ad);

 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("In
  ches");
  lcd.setCursor
  (4,0);
  lcd.setCursor
  (12,0);
  lcd.print("cm
  ");
  lcd.setCursor
  (1,1);
  lcd.print(inc
  hes, 1);
  lcd.setCursor
  (11,1);
  lcd.p``rint(c
  m, 1);
  lcd.setCursor
  (14,1);
  delay(1000);
  lcd.clear();
 }

 //handles commands from user side

 void callback(char* subscribetopic, byte* payload, unsigned int payloadLength)
 {
```

```
 Serial.print("callback invoked for topic: ");
 Serial.println(subscribetopic);
 for (int i = 0; i < payloadLength; i++) {

  data3 += (char)payload[i];
 }
 Serial.println("data: "+ data3);

 const char *s
 =(char*)
 data3.c_str(); double
 pincode = 0;


    const char
    *buf; int
    len;

    if (mjson_find(s, strlen(s), "$.command", &buf, &len))  // And print it
    {
     String
     command(buf,len);
     if(command=="\"SealBi
     n\"")
     {
      SealBin = true;

     }


     }

 data3="";
}
```

13.2 GITHUB AND PROJECT DEMO LINK

13.2.1 GITHUB LINK

https://github.com/IBM-EPBL/IBM-Project-17696-1659675309

13.2.2 PROJECT DEMO LINK

https://drive.google.com/file/d/1ehmJ125JvldzIOrD5QwUxa3SaUrl6_o_/view

CHAPTER 14

REFERENCE

[1] A. Godfrey, R. Conway, D. Meagher, G. ÓLaighin,2008, “Direct measurement of human movement by accelerometry”, doi:10. 1016/j.medengphy.2008.09.005, Medical Engineering Physics, vol.30, no.10, pp. 1364-1386,

[2] Gagandeep Singh Kukreja, Atulya Alok, Anil Kumar Reddy, Ruban Nersisson, October 2020, “IOT based foot neuropathy analysis and remote monitoring of foot pressure and temperature” DOI:10.1109/ICCS49678.2020.9277004,

[3] C. Agurto, S. Barriga, M. Burge and P. Soliz, "Characterization of diabetic peripheral neuropathy in infrared video sequences using independent component analysis," 2015 IEEE, DOI:10.1109/MLSP.2015.7324362, vol:13

[4] T. Bernard, C. D'Elia, R. Kabadi and N. Wong, "An early detection system for foot ulceration in diabetic patients," 2009 IEEE 35th Annual Northeast Bioengineering Conference, 2009, DOI:10.1109/NEBC.2009.4967797, vol.13, issue no:06.

[5] Hyun Lee, Kyungseo Park, Byoungyong Lee, Jae Sung Choi, Ramez Elmasri, “Issues in data fusion in healthcare monitoring”, 2008, DOI: 10.1145/1389586. 1389590, vol.13, issue.no:06.

[6] Sophini subramaniam, sumit majumder, abu ilius faisal and M. Jamal deen , “INSOLE BASED SYSTEM FOR HEALTH monitoring”, doi:http://doi.org/ 10.3390/s2, 2022,vol.22,issue.no:22

[7] Rachel C. King, emma villeneuve, ruth J. White, R. Simon sherratt, william holderbaum,william S. Harwina,"application of data fusion techniques and technologies for wearable health monitoring”,2016,doi:10.1016/ jmedengphy.2016.12.01

[8] R. A. Corpin et al., "Prediction of diabetic peripheral neuropathy (DPN) using plantar pressure analysis and learning models," 2019 IEEE, pp. 1-6, doi: 10.1109 /hnicem48295.2019.9072889.vol.13, issue. No: 06.

[9] Fahmida haque 1, mamun b. I. Reaz, muhammad e, h. Chowdhury, fazida h. Hashim 1, norhana arsad , sawal h. M. ALI "diabetic sensorimotor polyneuropathy severity classification using adaptive neuro fuzzy inference system”,doi:10.1109/ access.2020.3048742,vol.09.

[10] Komori, hiroya; watanabe, kouhei; tsuichihara, satoki; takemura, hiroshi; imai, mieko; haraguchi, mikiko; chou, shengpu, “screening system for diabetes peripheral neuropathy using foot plantar images on different hardness floor” ,2019 IEEE - screening system for diabetes peripheral neuropathy using foot plantar images on different hardness floor.