Smart Waste Management System For Metropolitan Cities

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SUBMITTED BY

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CHAPTER 1

INTRODUCTION

1.1 PROJECT OVERVIEW

This project aims to design and implement a combination of IoT and Application Development based Waste Management Systems. The combination of IoT and Application Development has plenty of applications such as home security systems, payment technologies, intruder recognition systems, etc. This research utilizes the application for Waste Management. The kit consists of hardware and software parts. The hardware part comprises a sensor unit, which detects the volume of waste present in the bin, a weight-detecting garbage system, a GPS locator, and a GSM module to communicate with a mobile device. The software part uses Python codes and C codes.

1.2 PURPOSE

The purpose of this project is a small step to Reduce Air, Water, and Soil Pollution. The world faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment, and disposal. It is a matter of health safety. Tuberculosis, pneumonia, diarrhoea, tetanus, whooping cough, etc. are other common diseases spread due to improper waste management. The toxic wastes can lead to different kinds of pollution - air, water, and soil. Our current systems cannot cope with the volumes of waste generated by an increasingly urban population and this has a huge impact on the environment and public health. It reduces manual labour, increases sustainable development, and reduces common health issues related to improper waste management techniques.

CHAPTER 2

LITERATURE SURVEY

2.1 EXISTING PROBLEM

Waste management plays a crucial role these days. As environmental concerns grow, wastes are to be properly managed and recycled. Improper management will lead to air pollution, and soil erosion may even affect human health. Lisa Safer, et al. enhance the point about the health impacts of incineration, landfill, composting, land spreading sewage sludge, and sewage discharges. A step to reduce the risks is the proposed work of waste management using IoT. Gopal Krishna Shyam, et al. submitted a work that utilizes sensors and uses an IoT algorithm that can read, collect, and transmit a huge volume of data over the Internet. These data, when put into a Spatio-temporal context and processed by intelligent and optimized algorithms, can be dynamically handled by waste collection processes. The published work by Tran Anh Khoa et al put forth a low-cost IoT architecture that efficiently achieves waste management by predicting the probability of the waste level in trash bins, using machine learning and graph theory, and determining the shortest path of waste collection. It also examines the data transfer on the LoRa module and demonstrates the advantages of the system, which is implemented through a simple circuit designed with low cost, ease of use, and replaceability. "Challenges and Opportunities of Waste Management in IoT-Enabled Smart Cities: A Survey" by Theodoros Anagnostopoulos, et al. gives detailed information on various aspects of IoT in waste management. With the above references, this project proposes a Smart Waste Management System For Metropolitan Cities that detects the level of Garbage in bins, and the weight of the garbage in the bin and alerts the authorized person to empty the bin whenever the bins are full. With further advancements, the Garbage level of the bins can be monitored through a Web App through which we can view the location of every bin by sending GPS location from the device.

2.2 REFERENCES

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[2] Kurre, Vishesh Kumar. "Smart Garbage Collection Bin overflows Indicator using IOT." International Research Journal of Engineering and Technology (IRJET) (2016).

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[5] Kumar, S. Vinoth, T. Senthil Kumaran, A. Krishna Kumar, and MahanteshMathapati. "Smart garbage monitoring and clearance system using internet of things." IEEE Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials, (2017).

[6] Swati Dewangan,IoT- Enabled Intelligent Solid Waste Management System for Smart City: A Survey, ISSN NO : 2249-7455

[7] Amoo OM, Fangbale RL (2013). Renewable municipal solid waste pathways for energy generation and sustainable development in the Nigerian context. International Journal of Energy and Environmental Engineering, 4(1): 42.J.H. Chuang. Potential-Based Approach for Shape Matching and Recognition. Pattern Recognition,

2.3 PROBLEM STATEMENT DEFINITION

Waste management in metropolitan cities faces numerous challenges. The main problem faced by the metropolitan cities are detecting the garbage level weather it filled or not and also we need to measure the weight of the garbage bin. Then alerts the authorized person to empty the bin whenever the bins are full. We need to develop a web application to monitor the status of the bins remotely at anywhere. The application should provide the location of the every bin connected in the application with the help of global positioning system (GPS). The indication of the bins and the location of the every bin should be provided by web applications simultaneously.

CHAPTER 3

IDEATION & PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS
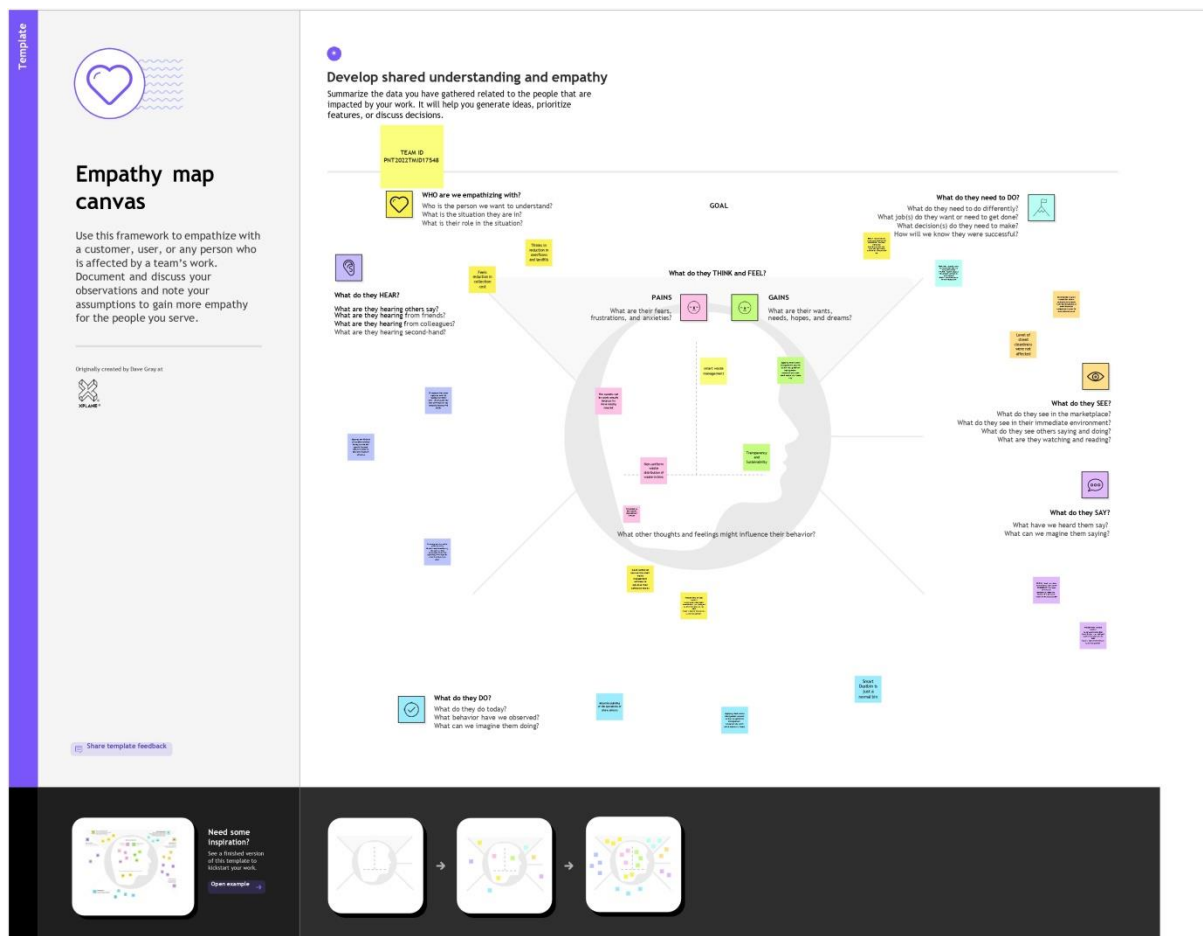
3.2 IDEATION & PROCESSIING

8

Brainstorm

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

⏱ 10 minutes

TIP
You can select a sticky note and hit the pencil [switch to sketch] icon to start drawing!

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

⏱ 20 minutes

AHIESH SUJO

The proposed system would be able to use IOT to automate the monitoring of solid waste collection overall.

Balaabhileesh

Waste generation analysis to understand cities usages

Adding an ultrasonic sensor to gauge bin level

When bins fill, the designated individual receives an alarm message.

Aravindhan

Load cell at the base of the bins

Activate GPS to make bin location easier

Gowrisankar

IoT gadget recive power supply from solar panels

Analyzing trash creation to comprehend urban utilisation

Waste segregation could be added.

Dustbin damage can also be monitored

If a waste slip out it will be detected.

Collection of the daily waste are calculated

TIP
Add customizable tags to sticky notes to make it easier to find, browse, organize, and categorize important ideas as themes within your mural.

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3.3 PROPOSED SOLUTION

S. No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Waste management in metropolitan cities faces numerous challenges. The main problem faced by the metropolitan cities are detecting the garbage level weather it filled or not and also we need to measure the weight of the garbage bin. Then alerts the authorized person to empty the bin whenever the bins are full. We need to develop a web application to monitor the status of the bins remotely at anywhere. The application should provide the location of the every bin connected in the application with the help of global positioning system (GPS).The indication of the bins and the location of the every bin should be provided by web applications simultaneously.
2.	Idea / Solution description	Smart waste management is characterized by the usage of technology in order to be more efficient when it comes to managing waste. 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 being full for over a week.
3.	Novelty / Uniqueness	A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion.
4.	Social Impact / Customer Satisfaction	Reducing waste will not only protect the environment but will also save on costs or reduce expenses for disposal. In the same way, recycling and/or reusing the waste that is produced benefits the environment by lessening the need to extract resources and lowers the potential for contamination.
5.	Business Model (Revenue Model)	Waste Management generates revenue through the provision of various waste management and disposal services and recycling solutions to residential, commercial, industrial, and municipal clients. The Company derives its revenue in the form of various fees associated with its service offerings.
6.	Scalability of the Solution	As the product is offered with subscription service , further development in both software and hardware can be made

3.4 PROBLEM SOLUTION FIT

CUSTOMER SEGMENT Government and Industries	**CUSTOMER CONSTRAINTS** • Difficulty in garbage level indication • insufficient Technology	**AVAILABLE SOLUTION** • Sharing location of bin to the sanitary worker via notification from the application. • It also contains information such as level and weight of the bin
JOBS-TO-BE-DONE / PROBLEMS • Need to know the exact location of the garbage bins • Need to know the level and the weight of the garbage bins	**PROBLEM ROOT CAUSE** The level of garbage bins cannot be identified by the sanitary workers.As a result , the overflow of garbage occurs which results in disturbance for both sanitary workers and residents living nearby.	**BEHAVIOUR** Focus in web application can help to indicate the garbage status and to point the location of the bins
TRIGGERS Garbage bins overflow leads to unhealthy society and give discomfort to the sanitary workers BEFORE : Insecurity,illness,fear AFTER : Secured living,relief,unburden	**YOUR SOLUTION** Implementation of ultrasonic sensor and weight sensor to the garbage bins and by connecting bins to internet we can point the exact location on the website.	**CHANNELS of BEHAVIOUR** ONLINE : Information will be conveyed to avoid the overflow of garbage bin. OFFLINE : With the information of location of garbage sanitary workers will take necessary actions.

CHAPTER 4

REQUIRMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENT

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail Registration through LinkedIn
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Detailed bin inventory	All monitored bins and stands can be seen on the map,and you can visit them at any time via the Street View feature from Google. Bins or stands are visible on the map as green, orange or red circles. You can see bin details in the Dashboard – capacity, waste type, last measurement, GPS location and collection schedule or pick recognition
FR-4	Real time bin monitoring	The Dashboard displays real-time data on fill-levels of bins monitored by smart sensors. In addition to the % of fill-level, based on the historical data, the tool predicts when the bin will become full, one of the functionalities that are not included even in the best waste management software.. Sensors recognize picks as well;so you can check when the bin was last collected. With real-time data and predictions, you can eliminate the overflowing bins and stop collecting half-empty ones
FR-5	Eliminate inefficient picks	Eliminate the collection of half-empty bins. The sensors recognize picks. By using real-time data on fill-levels andpick recognition, we can show you how full the bins youcollect are. The report shows how full the bin was when picked. You immediately see any inefficient picks below 80% full.
FR-6	Plan waste collection routes	The tool semi-automates waste collection route planning. Based on current bin fill-levels and predictions of reaching full capacity, you are ready to respond and schedule waste collection. You can compare planned vs. executed routes to identify any inconsistencies.

4.2 NON-FUNCTIONAL REQUIREMENTS

Non-functional Requirements:

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

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	IoT device verifies that usability is a special and important perspective to analyze user requirements, which can further improve the design quality. In the design process with user experience as the core, the analysis of users' product usability can indeed help designers better understand users' potential needs in waste management, behavior and experience
NFR-2	**Security**	Use a reusable bottles Use reusable grocery bags Purchase wisely and recycle Avoid single use food and drink containers
NFR-3	**Reliability**	Smart waste management is also about creating better working conditions for waste collectors and drivers. Instead of driving the same collection routesand servicing empty bins, waste collectors will spendtheir time more efficiently, taking care of bins that need servicing.
NFR-4	**Performance**	The Smart Sensors use ultrasound technology to measure the fill levels (along with other data) in bins several times a day. Using a variety of IoT networks ((NB-Io T, GPRS), the sensors send the data to Smart Waste Management Software System, a powerful cloud-based platform, for data driven daily operations, available also as a waste management app. Customers are hence provided data-driven decision making, and optimization of waste collection routes, frequencies, and vehicle loads resulting in route reduction by at least 30%.
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.

CHAPTER 5

PROJECT DESIGN

5.1 Project Design Phase-II Data Flow Diagram & User Stories
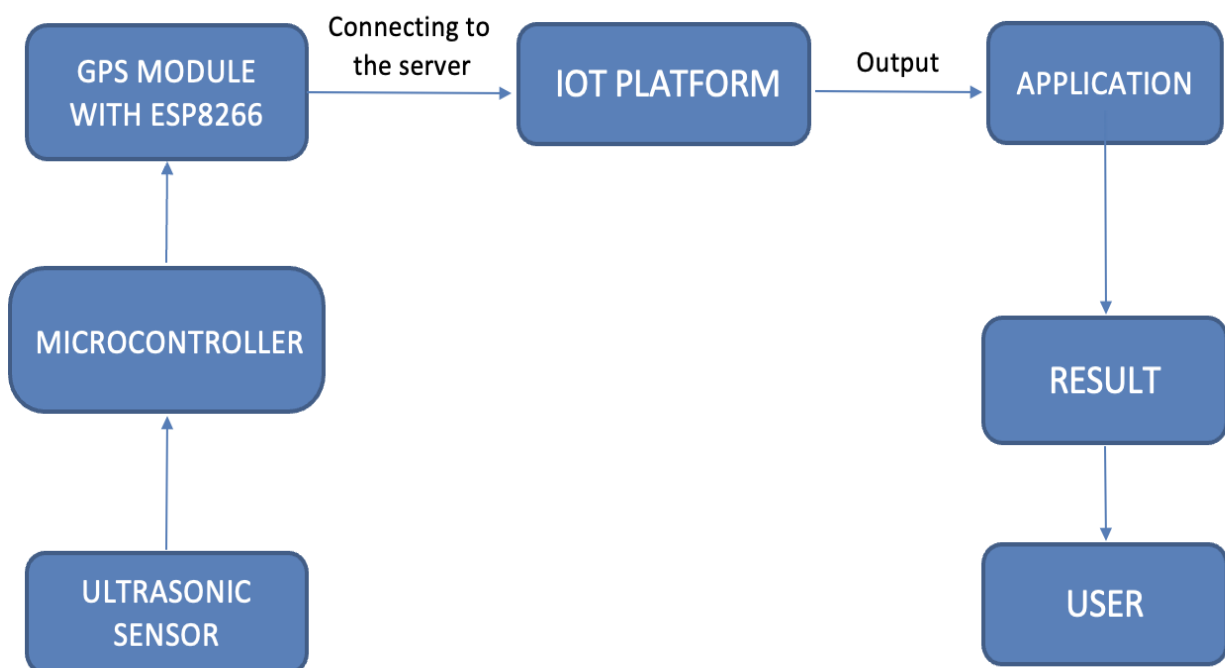
5.2 SOLUTION ARCHITECTURE
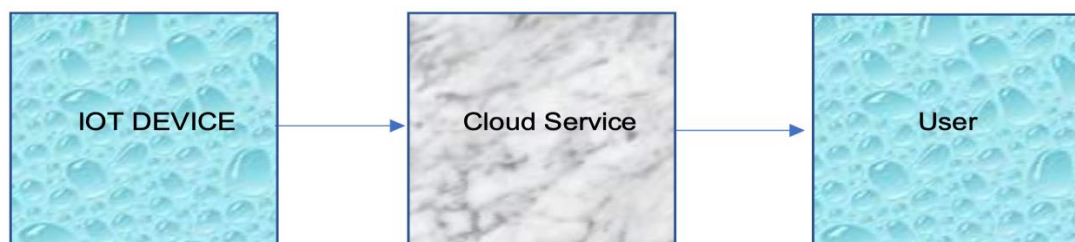
SOLUTION ARCHITECTURE

Design

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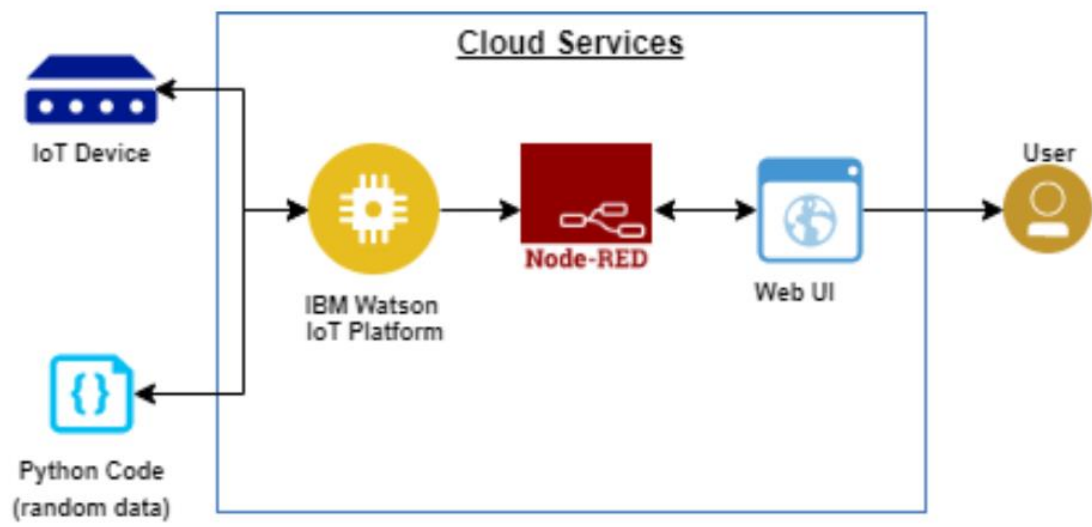- Getting the weight of the garbage in the bin.
- Alerts the authorized person to empty the bin whenever the bins are full.
- Garbage level of the bins can be monitored through a web App.
- We can view the location of every bin in the web application by sending GPS location from the device.

Software and system required:

- Python IDLE
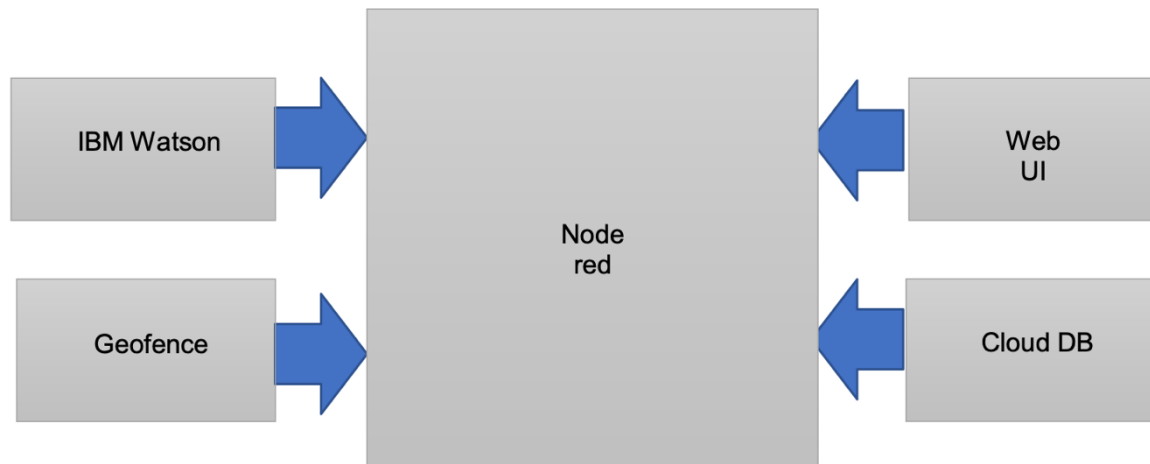- 4GB processor and OS-Windows/Linux/MAC

Block diagram:

Cloud Services

IoT Device

IBM Watson IoT Platform

Node-RED

Web UI

User

Python Code (random data)

IOT Device

ULTRASONIC SENSOR → RASPBERRY PI ← GPS/GSM

Cloud service:

5.3 USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Web user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can able to access the status the status every bin in the city	High	Sprint-1
Customer (Cloud user)	Access	USN-2	As a user, I can access database of the garbage bin	I can receive confirmation email & click confirm	High	Sprint-2
Customer Care Executive	Gmail account	USN 3	As a user, I can register for the application through Gmail	I can register and access the model	Medium	Sprint-1
Administrator	Login	USN 4	As a Admin, I can log into the application by entering email & password	I can access the garbage database directly	High	Sprint-1
Customer (User)	Internet Facility	USN 5	As a user I can give input to the model through the website	I can get location and status of the bin	High	Sprint-2
Customer (User)	Laptop or Computer or Mobile	USN 6	As a user I can view the pictorial garbage status and able to view the location of the bin in a maps	I can insights on garbage status	High	Sprint-2

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CHAPTER 6

PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	Literature survey on the selected project & gathering information by referring the, technical papers,research publications etc.	12 SEPTEMBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements	24 SEPTEMBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	25 SEPTEMBER 2022
Proposed Solution	Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc.	23 SEPTEMBER 2022
Problem Solution Fit	Prepare problem - solution fit document.	02 OCTOBER 2022
Solution Architecture	Prepare solution architecture document.	03 OCTOBER 2022

6.2 Sprint Delivery Schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Login	USN-1	As an Administrator, I need to give user id and pass code for every worker over there in municipality	10	High	Ahiesh Sujo I S
Sprint-2	Login	USN-2	As a Co-Admin, I will control the waste levelby monitoring them via real time web portal.Once the filling happens, I will notify trash truck with location of bin with bin ID	10	High	Balaabhileesh T S R
Sprint-3	Dashboard	USN-3	As a Truck Driver, I'll follow Co-Admin's Instruction to reach the filling bin in short rootsand save time	20	Low	Gowrisankar R
Sprint-4	Dashboard	USN-4	As a Local Garbage Collector, I'll gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills and I'll make sure everything is proceeding as planned andwithout any problems	20	Medium	Aravindhan P R

Project Tracker, Velocity & Burndown Chart:

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	5 Days	26 Oct 2022	28 Oct 2022	20	28 Oct 2022
Sprint-2	20	5 Days	2 Nov 2022	06 Nov 2022	20	06 Nov 2022
Sprint-3	20	5 Days	07 Nov 2022	15 Nov 2022	20	15 Nov 2022
Sprint-4	20	5 Days	13 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

$$_{18}AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

CHAPTER 7

CODING & SOLUTION

7.1 Feature 1

- IOT DEVICE

- WOKWI SOFTWARE

- IOT WATSON PLATFORM

- NODE RED

- WEB UI

- CLOUDANT DB

7.2 Feature 2

- REGISTRATION

- LOGIN

- VERIFICATION

- SELECT THE CITY

- DISPLAY THE STATUS OF BIN

- ADD QUERY

7.3. DATA BASE SCHEME

```
labl_0 = Label(base, text="Registration form",width=20,font=("bold",

20))

labl_0.place(x=90,y=53)

lb1= Label(base, text="Enter Name", width=10, font=("arial",12))

lb1.place(x=20, y=120)

en1= Entry(base) en1.place(x=200, y=120)

lb3= Label(base, text="Enter Email", width=10, font=("arial",12))

lb3.place(x=19, y=160)

en3= Entry(base) en3.place(x=200, y=160)

lb4= Label(base, text="Contact Number", width=13,font=("arial",12))

lb4.place(x=19, y=200)

en4= Entry(base) en4.place(x=200, y=200)

lb5= Label(base, text="Select Gender", width=15, font=("arial",12))

lb5.place(x=5, y=240)

var = IntVar()

Radiobutton(base, text="Male", padx=5,variable=var,

value=1).place(x=180, y=240)

Radiobutton(base, text="Female", padx =10,variable=var,

value=2).place(x=240,y=240)
```

```python
Radiobutton(base, text="others", padx=15, variable=var,
value=3).place(x=310,y=240)

list_of_cntry = ("United States", "India", "Nepal", "Germany") cv =
StringVar()

drplist= OptionMenu(base, cv, *list_of_cntry) drplist.config(width=15)

cv.set("United States")

lb2= Label(base, text="Select Country", width=13,font=("arial",12))

lb2.place(x=14,y=280)

drplist.place(x=200, y=275)

lb6= Label(base, text="Enter Password", width=13,font=("arial",12))

lb6.place(x=19, y=320)

en6= Entry(base, show='*') en6.place(x=200, y=320)

lb7= Label(base, text="Re-Enter Password", width=15,font=("arial",12))

lb7.place(x=21, y=360)

en7 =Entry(base, show='*') en7.place(x=200, y=360)Button(base,
text="Register", width=10).place(x=200,y=400) base.mainloop()

 def generateOTP() :

# Declare a digits variable # which stores all digits digits = "0123456789"

OTP = ""

# length of password can be changed # by changing value in range

for i in range(4) :

OTP += digits[math.floor(random.random() * 10)] return OTP
```

```python
# Driver code

if     name  == "  main  " :

print("OTP of 4 digits:", generateOTP()) digits="0123456789"

OTP=""

for i in range(6): OTP+=digits[math.floor(random.random()*10)]

otp = OTP + " is your OTP" msg= otp

s = smtplib.SMTP('smtp.gmail.com', 587) s.starttls()

s.login("Your Gmail Account", "You app password") emailid =

input("Enter your email: ")

 s.sendmail('&&&&&&&&&',emailid,msg) a = input("Enter Your

OTP >>: ")

if a == OTP: print("Verified")

else:

print("Please Check your OTP again")
```
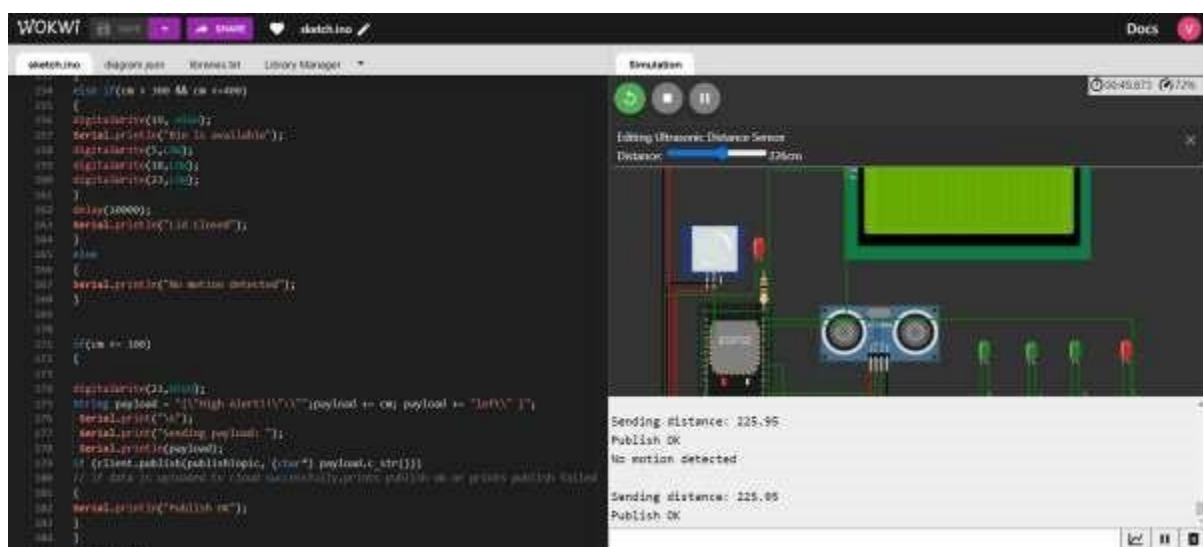
CHAPTER 8

TESTING

8.1 Test Cases

| S NO	TEST CASE	FEATURE	STEPS TO EXECUTE	EXPECTED RESULT	ACTUAL RESULT	EXECUTED BY
1	FUNCTIONAL	LOGIN	LOGIN TO EXECUTE BY FILLING THE DETAILS	CORRECT LOGIN CREDENTIALS	WORKING AS EXPECTED	Ahiesh Sujo I S
2	FUNCTIONAL	REGISTRATION	REGISTRATION THROUGH FORMS	REGISTRATION FORM TO BE FILLED AND DISPLAYED	WORKING AS EXPECTED	Ahiesh Sujo I S
3	FUNCTIONAL	WOKWI	TO DEVELOP THE IOT DEVICE AND CODE THE IOT DEVICE	SENSE THE DATA	WORKING AS EXPECTED	Aravindhan P R
4	FUNCTIONAL	IBM WATSON	PUSH THE SENSED DATA FROM WOKWI	SENSED DATA IN IBM WATSON	WORKING AS EXPECTED	Balaabhileesh T S R
5	FUNCTIONAL	NODE RED	TO CONNECT WITH THE IBM WATSON AND THEN COLLECT THE SENSED DATA AND DISPLAY IN NODE RED DASHBOARD	VISUAL REPRESENTATION OF SENSED DATA IN NODE RED DASHBOARD	WORKING AS EXPECTED	Ahiesh Sujo I S, Gowrisankar
6	TESTING	TEST THE ENTIRE WORK	TO CHECK ALL THE MENTIONED TESTCASE ARE WORKING PROPERLY	TEST CASE ARE WOKING PROPERLY	WORKING AS EXPECTED	Balaabhileesh T S R, Gowirsankar

CHAPTER 9

RESULTS

9.1Perfomance Metrics

- ## IOT DEVICE SIMULATION IN WOKWI SOFTWARE

- ## SENSED THE DATA VISUALIZATION IN IBM WATSON
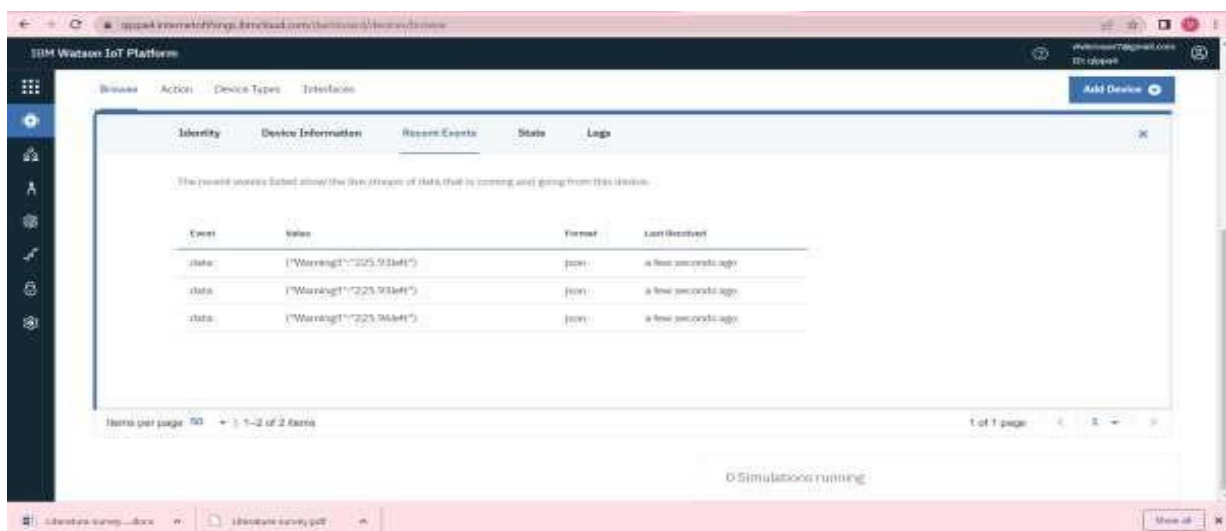
- **NODE RED CONNCETIONS**

- **VISUALIZATION OF SENSED DATA IN NODE RED DASHBOARD**

- **SAMPLE OF OUR WEBPAGE UI**
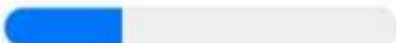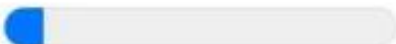
CHAPTER 10

ADVANTAGES & DISADVANTAGES

Advantages

The advantage of using this system is that it overcomes the health and environmental hazards of improper waste management processes to a certain extent. This cannot be the only solution but one of the solutions to sustainable development. The use of solar panels to produce the required energy can be of great use as it is not a renewable resource, but it powers the sensor for detection and the IoT Devices present in the Truck for real-time GPS Tracker. This system is cheap and very efficient. The door - to door collection also helps the differently abled to manage the waste properly. The utilization of simple everyday gadgets makes it easy to understand for the customers to completely use the product. Anyone from age 5-90 can use the product. This is not the restriction that is mentioned but the ease and comfort of the app for all ages. One of the main advantages is that awareness is created among the users. They come to know about the anthropocentric character that degrades the environment to a great level and in turn affects health. This acts as a change or at least a motivation to a certain extent to support, love and care for mother Earth which has done everything to satisfy our needs and all we do is degrade it. But it's time we repay it, help her and stop the antagonist's torture, and live happily.

Disadvantages

If something has a lot of positive effects there would be something negative. Nothing can be perfect or in an ideal condition. All we can do is satisfy a certain level and make it more advantageous than considering the disadvantages. One of these kinds is the adaptation to the new technology would take a lot of time to get accustomed to as a daily life habit. Another disadvantage is considering security. Well-secured information for the user will cost a lot and would make the project a more reliable one, as the user's personal information is collected, it is the owner's responsibility or the creator's responsibility to make it with a desirable or highly secured system. Considering the high competition in this market, the initial cost would be high. Investing in a good cause makes us satisfied. Investing in a profitable system makes us innovate more but the drawback is that in the initial stages a very high amount is expected or compelled to be spent to market or advertise the product.

CHAPTER 11

CONCLUSION

A proper waste management system is essential for sustainable development. This would be a small step towards a developing nation overcoming the limitations of waste management. This step secures us from the environmental and health hazards that are being induced as a slow poison is interrelated. The technology in this period of the 21st century refines us and the surroundings to a better persona and a better place to live. It is the time when we have to bring in change and portray respect, love and care toward the beings that have helped us for our survival. There is a solution. And, this Project is just one very small part of it.

CHAPTER 12

FUTURE SCOPE

A proper waste management system is essential for sustainable development. This would be a small step towards a developing nation overcoming the limitations of waste management. This step secures us from the environmental and health hazards that are being induced as a slow poison is interrelated. The technology in this period of the 21st century refines us and the surroundings to a better persona and a better place to live. It is the time when we have to bring in change and portray respect, love and care toward the beings that have helped us for our survival. There is a solution. And, this Project is just one very small part of it.

CHAPTER 13

APPENDIX

SOURCE CODE

- Code for IoT device in Wokwi

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2); // I2C address 0x3F, 16 column and 2 rows
int trigPin = 9;   // TRIG pin
int echoPin = 8;   // ECHO pin
float duration_us, distance_cm,distance;
void setup() {
 lcd.init();            // initialize the lcd
 lcd.backlight();
 pinMode(7,OUTPUT);
 pinMode(6,OUTPUT);
 pinMode(5,OUTPUT);
 pinMode(4,OUTPUT);      // open the backlight
 pinMode(trigPin, OUTPUT); // config trigger pin to output mode
 pinMode(echoPin, INPUT); // config echo pin to input mode
}
void loop() {
 // generate 10-microsecond pulse to TRIG pin
 digitalWrite(trigPin, HIGH);
 delayMicroseconds(10);
 digitalWrite(trigPin, LOW);
 // measure duration of pulse from ECHO pin
 duration_us = pulseIn(echoPin, HIGH);
 // calculate the distance
 distance_cm = 0.017 * duration_us;
```

```
distance=400-distance_cm;
lcd.clear();
 lcd.setCursor(0, 0); // start to print at the first row
lcd.print("waste level: ");
lcd.print(distance);
digitalWrite(6,HIGH);
digitalWrite(7,LOW);
digitalWrite(5,LOW);
digitalWrite(4,LOW);
if(distance>=175)
{
  digitalWrite(5,HIGH);
  digitalWrite(6,LOW);
  digitalWrite(7,LOW);
  digitalWrite(4,LOW);
}
if(distance>=275)
{
  digitalWrite(4,HIGH);
  digitalWrite(6,LOW);
  digitalWrite(5,LOW);
  digitalWrite(7,LOW);
}
if(distance>=375)
{
  digitalWrite(7,HIGH);
  digitalWrite(6,LOW);
  digitalWrite(5,LOW);
  digitalWrite(4,LOW);
}

 delay(500);
}
```

- Code for connecting to IoT Watson

```
#include <LiquidCrystal_I2C.h>
#include <WiFi.h>
#include <PubSubClient.h>
#include<WiFiClient.h>
LiquidCrystal_I2C lcd(0x27, 20, 4); // I2C address 0x3F, 16 column and 2 rows


int trigPin = 2;    // TRIG pin
int echoPin = 15;    // ECHO pin


#define ORG "qippa4"
#define DEVICE_TYPE "Esp32"
#define DEVICE_ID "Waste"
#define TOKEN "C72(GeQy)UPSVtHdUw"
char server[] = ORG ".messaging.internetofthings.ibmcloud.com"; // server name
char publishTopic[] = "iot-2/evt/data/fmt/json";
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 wifi
PubSubClient client(server, 1883, wifiClient);


void setup() {
 lcd.init();           // initialize the lcd
 lcd.backlight();
 pinMode(5,OUTPUT);
 pinMode(18,OUTPUT);
 pinMode(19,OUTPUT);
 pinMode(23,OUTPUT);
```

```
  pinMode(34,INPUT);

  pinMode(14,OUTPUT);

  // open the backlight

  pinMode(trigPin, OUTPUT); // config trigger pin to output mode

  pinMode(echoPin, INPUT);

  Serial.begin(115200);

  wifiConnect();

  mqttConnect();
// config echo pin to input mode

}


float readcmCM()

{

digitalWrite(trigPin, LOW);

delayMicroseconds(2);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);

int duration = pulseIn(echoPin, HIGH);

return duration * 0.034 / 2;

}


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))

{

Serial.println("Motion Detected"); Serial.println("Lid Opened"); digitalWrite(14, HIGH);


}

else

{

digitalWrite(14, LOW);

} //PIR motion detection



if(digitalRead(34))

{

if(cm <= 100)

//Bin level detection

{

digitalWrite(23, 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(18,LOW);
```

```
digitalWrite(19,LOW);

digitalWrite(5,LOW);

}

else if(cm > 100 && cm < 200)

{

digitalWrite(5, HIGH);

Serial.println("Warning!!,Trash is about to cross 75% of bin level");

digitalWrite(18,LOW);

digitalWrite(19,LOW);

digitalWrite(23,LOW);

}

else if(cm > 200 && cm < 300)

{

digitalWrite(18, HIGH);

Serial.println("Warning!!,Trash is about to cross 50% of bin level");

digitalWrite(5,LOW);

digitalWrite(19,LOW);

digitalWrite(23,LOW);

}

else if(cm > 300 && cm <=400)

{

digitalWrite(19, HIGH);

Serial.println("Bin is available");

digitalWrite(5,LOW);

digitalWrite(18,LOW);

digitalWrite(23,LOW);

}

delay(10000);

Serial.println("Lid Closed");

}

else

{

Serial.println("No motion detected");

}
```

```
if(cm <= 100)
{


            digitalWrite(21,HIGH);

            String payload = "{\"High Alert!!\":\"";payload += cm; payload += "left\" }";

             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 or prints publish failed

            {

            Serial.println("Publish OK");

            }

            }

            if(cm <= 250)

            {

            digitalWrite(22,HIGH);

             String payload = "{\"Warning!!\":\"";payload+= cm; payload += "left\" }";

            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");

  }

  }


  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();

}
```

- Code for login page

```html
<html>

<head>

<meta name="viewport" content="width=device-width, initial-scale=1">

<style>

body {font-family: Arial, Helvetica, sans-serif;}


/* Full-width input fields */

input[type=text], input[type=password] {

  width: 100%;

  padding: 12px 20px;

  margin: 8px 0;

  display: inline-block;

  border: 1px solid #ccc;

  box-sizing: border-box;

}


/* Set a style for all buttons */

button {

  background-color: #04AA6D;

  color: white;

  padding: 14px 20px;

  margin: 8px 0;

  border: none;

  cursor: pointer;

  width: 100%;
```

```css
}

button:hover {

  opacity: 0.8;

}


/* Extra styles for the cancel button */

.cancelbtn {

  width: auto;

  padding: 10px 18px;

  background-color: #f44336;

}

/* Center the image and position the close button */

.imgcontainer {

  text-align: center;

  margin: 24px 0 12px 0;

  position: relative;

}


img.avatar {

  width: 40%;

  border-radius: 10%;

}


.container {

  padding: 16px;

}
```

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```css
span.psw {

  float: right;

  padding-top: 16px;

}


/* The Modal (background) */

.modal {

  display: none; /* Hidden by default */

  position: fixed; /* Stay in place */

  z-index: 1; /* Sit on top */

  left: 0;

  top: 0;

  width: 100%; /* Full width */

  height: 100%; /* Full height */

  overflow: auto; /* Enable scroll if needed */

  background-color: rgb(0,0,0); /* Fallback color */

  background-color: rgba(0,0,0,0.4); /* Black w/ opacity */

  padding-top: 60px;

}


/* Modal Content/Box */

.modal-content {

  background-color: #fefefe;

  margin: 5% auto 15% auto; /* 5% from the top, 15% from the bottom and centered */

  border: 1px solid #888;

  width: 80%; /* Could be more or less, depending on screen size */

}

/* The Close Button (x) */
```

```css
.close {

 position: absolute;

 right: 25px;

 top: 0;

 color: #000;

 font-size: 35px;

 font-weight: bold;

}


.close:hover,

.close:focus {

 color: red;

 cursor: pointer;

}


/* Add Zoom Animation */
.animate {

 -webkit-animation: animatezoom 0.6s;

 animation: animatezoom 0.6s

}


@-webkit-keyframes animatezoom {

 from {-webkit-transform: scale(0)}

 to {-webkit-transform: scale(1)}

}


@keyframes animatezoom {

 from {transform: scale(0)}
```

```css
    to {transform: scale(1)}
  }


  /* Change styles for span and cancel button on extra small screens */
  @media screen and (max-width: 300px) {
   span.psw {
     display: block;
     float: none;
   }
   .cancelbtn {
     width: 100%;
   }


  }
  </style>
</head>
```

```html
  <body style="text-align: center;">


  <h1 style="padding-top: 200px; text-align: center;">Smart Waste Management System
For Metropolitan Cities</h1>


  <button                  onclick="document.getElementById('id01').style.display='block'"
style="width:auto; ">Login</button>


  <div id="id01" class="modal">


   <form  class="modal-content animate" method="post">
    <div class="imgcontainer">
```

```html
        <span  onclick="document.getElementById('id01').style.display='none'"  class="close"
title="Close Modal">&times;</span>
        <img src="goLogo.jpg" alt="Avatar" class="avatar">
      </div>


      <div class="container">
        <label for="uname"><b>Username</b></label>
        <input   id="frm1"   type="text"   placeholder="Enter   Username"   name="uname"
required>


        <label for="psw"><b>Password</b></label>
        <input type="password" placeholder="Enter Password" name="psw" required>



        <button     style="color:     black"     onclick="window.location.href=('district.html')"
type="submit">signin</button>
        <label>
          <input type="checkbox" checked="checked" name="remember"> Remember me
        </label>
      </div>


      <div class="container" style="background-color:#f1f1f1">
        <button                                                                 type="button"
onclick="document.getElementById('id01').style.display='none'"
class="cancelbtn">Cancel</button>
        <span class="psw">Forgot <a href="#">password?</a></span>
      </div>
    </form>
```

```
        </div>

<p style="text-align: center;font-size: 10px; color: #04AA6D;">Reuse, Recycle, and Reduce

the waste for a better future !</p>

    <script>


    function myFunction() {

      var x = document.getElementById("frm1");

      var text = "";

      var i;

      for (i = 0; i < x.length ;i++) {

        text += x.elements[i].value + "<br>";

      }

      document.getElementById("demo").innerHTML = text;


    }

    // Get the modal action_page.php

    var modal = document.getElementById('id01');


    // When the user clicks anywhere outside of the modal, close it

    window.onclick = function(event) {

      if (event.target == modal) {

        modal.style.display = "none";

      }

    }

    </script>


    </body>

</html>
```

- Code of Coimbatore district

```html
<!DOCTYPE html>

<html>

<head>

<meta name="viewport" content="width=device-width, initial-scale=1">

<style>

body {font-family: Arial, Helvetica, sans-serif;}


/* Full-width input fields */

input[type=text], input[type=password] {

  width: 100%;

  padding: 12px 20px;

  margin: 8px 0;

  display: inline-block;

  border: 1px solid #ccc;

  box-sizing: border-box;

}


/* Set a style for all buttons */

button {

  background-color: #04AA6D;

  color: white;

  padding: 14px 20px;

  margin: 8px 0;

  border: none;

  cursor: pointer;

  width: 100%;
```

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button:hover {

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  text-align: center;

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  position: relative;

}



img.avatar {

  width: 40%;

  border-radius: 10%;

}



.container {

  padding: 16px;

}
```

```css
span.psw {

  float: right;

  padding-top: 16px;

}


/* The Modal (background) */

.modal {

  display: none; /* Hidden by default */

  position: fixed; /* Stay in place */

  z-index: 1; /* Sit on top */

  left: 0;

  top: 0;

  width: 100%; /* Full width */

  height: 100%; /* Full height */

  overflow: auto; /* Enable scroll if needed */

  background-color: rgb(0,0,0); /* Fallback color */

  background-color: rgba(0,0,0,0.4); /* Black w/ opacity */

  padding-top: 60px;

}


/* Modal Content/Box */

.modal-content {

  background-color: #fefefe;

  margin: 5% auto 15% auto; /* 5% from the top, 15% from the bottom and centered */

  border: 1px solid #888;

  width: 80%; /* Could be more or less, depending on screen size */

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```css
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.animate {

 -webkit-animation: animatezoom 0.6s;

 animation: animatezoom 0.6s

}


@-webkit-keyframes animatezoom {

 from {-webkit-transform: scale(0)}

 to {-webkit-transform: scale(1)}

}
```

```
@keyframes animatezoom {

  from {transform: scale(0)}

  to {transform: scale(1)}

}


/* Change styles for span and cancel button on extra small screens */

@media screen and (max-width: 300px) {

  span.psw {

    display: block;

    float: none;

  }

  .cancelbtn {

    width: 100%;

  }


}

</style>

</head>

<body style="text-align: center;">


<h1 style="padding-top: 200px; text-align: center;">Smart Waste Management System For Metropolitan Cities</h1>


<button                  onclick="document.getElementById('id01').style.display='block'" style="width:auto; ">Login</button>


<div id="id01" class="modal">
```

```html
<form class="modal-content animate" method="post">

<div class="imgcontainer">

<span onclick="document.getElementById('id01').style.display='none'" class="close"
title="Close Modal">&times;</span>

<img src="goLogo.jpg" alt="Avatar" class="avatar">

</div>


<div class="container">

<label for="uname"><b>Username</b></label>

<input id="frm1" type="text" placeholder="Enter Username" name="uname"
required>


<label for="psw"><b>Password</b></label>

<input type="password" placeholder="Enter Password" name="psw" required>


<button style="color: black" onclick="window.location.href=('district.html')"
type="submit">signin</button>

<label>

<input type="checkbox" checked="checked" name="remember"> Remember me

</label>

</div>


<div class="container" style="background-color:#f1f1f1">

<button                                                                type="button"
onclick="document.getElementById('id01').style.display='none'"

class="cancelbtn">Cancel</button>

<span class="psw">Forgot <a href="#">password?</a></span>
```

```
      </div>

      </form>

    </div>

    <p style="text-align: center;font-size: 10px; color: #04AA6D;">Reuse, Recycle, and
Reduce the waste for a better future !</p>

    <script>

    function myFunction() {

     var x = document.getElementById("frm1");

     var text = "";

     var i;

     for (i = 0; i < x.length ;i++) {

      text += x.elements[i].value + "<br>";

     } document.getElementById("demo").innerHTML = text;

     }

    // Get the modal action_page.php

    var modal = document.getElementById('id01');


    // When the user clicks anywhere outside of the modal, close it

    window.onclick = function(event) {

      if (event.target == modal) {

         modal.style.display = "none";

      }

    }

    </script>


    </body>

</html
```

GitHub Link:

https://github.com/IBM-EPBL/IBM-Project-43876-1660720195