SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES

PNT2022TMID30690

Project Report Format

1. **INTRODUCTION**
   - 1.1 Project Overview
   - 1.2 Purpose
2. **LITERATURE SURVEY**
   - 2.1 Existing problem
   - 2.2 References
   - 2.3 Problem Statement Definition
3. **IDEATION & PROPOSED SOLUTION**
   - 3.1 Empathy Map Canvas
   - 3.2 Ideation & Brainstorming
   - 3.3 Proposed Solution
   - 3.4 Problem Solution fit
4. **REQUIREMENT ANALYSIS**
   - 4.1 Functional requirement
   - 4.2 Non-Functional requirements
5. **PROJECT DESIGN**
   - 5.1 Data Flow Diagrams
   - 5.2 Solution & Technical Architecture
   - 5.3 User Stories
6. **PROJECT PLANNING & SCHEDULING**
   - 6.1 Sprint Planning & Estimation
   - 6.2 Sprint Delivery Schedule
   - 6.3 Reports from JIRA
7. **CODING & SOLUTIONING (Explain the features added in the project along with code)**
   - 7.1 Feature 1
   - 7.2 Feature 2
   - 7.3 Database Schema (if Applicable)
8. **TESTING**
   - 8.1 Test Cases
   - 8.2 User Acceptance Testing
9. **RESULTS**
   - 9.1 Performance Metrics
10. **ADVANTAGES & DISADVANTAGES**
11. **CONCLUSION**
12. **FUTURE SCOPE**
13. **APPENDIX**

    Source Code

    GitHub & Project Demo Link

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

PROJECT REPORT

1. INTRODUCTION

Project Overview

IOT is bringing revolution to almost every aspect of our lives by changing how we do things. The use of Smart IOT devices is on the rise with all the industries heavily investing in IOT. The main aims of investing in IoT are to improve operations efficiency, improve product quality, and reduce the costs of production.

Purpose

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, and increase the sustainability of waste services

2. LITERATURE SURVEY

Existing problem

The waste management in metropolitan cities has serious environmental impacts like water pollution, methane emissions, and soil degradation. The average density of Indian municipal waste at the point of collection varies from 400 to 600 kg per cubic meter. At the landfill site, however, the density is much higher because of compaction and putrefaction. Waste incineration (including Waste to Energy) and other thermal processes are local sources of air pollution, constituting additional health risk factors to city dwellers, who often already have to cope with serious air contamination issues. Ecosystems vary widely from location to location. However, one of the most outsize consequences of our global waste problem manifests itself in relation to our marine life and waterways. Simply put, it affects the people

who depend on the ocean for their livelihoods.

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

Challenges:

1) No segregation at source
2) Incorrect/inadequate segregation techniques
3) Slow adoption of in-house composting
4) Lack of monitoring in housing societies
5) Tips for achieving 100% waste segregation
6) Problems faced by the government with respect to housing societies
7) Key approaches for housing societies to manage waste better

References

[1] K N Fallavi; V Ravi Kumar; B M Chaithra (2017) Smart waste management using Internet of Things: A survey , *IEEExplore*

[2] Inna Sosunova and Jari Porras (Member, IEEE) 18 July 2022. IoT-Enabled Smart Waste Management Systems for Smart Cities: A Systematic Review. *Ieee Access.*

[3] Saurabh Pargaien; Amrita Verma Pargaien; Dikendra Verma; Vatsala Sah; Neeraj Pandey(2021). Smart Waste Collection Monitoring System using IoT. *IEEExplore*

Problem Statement Definition

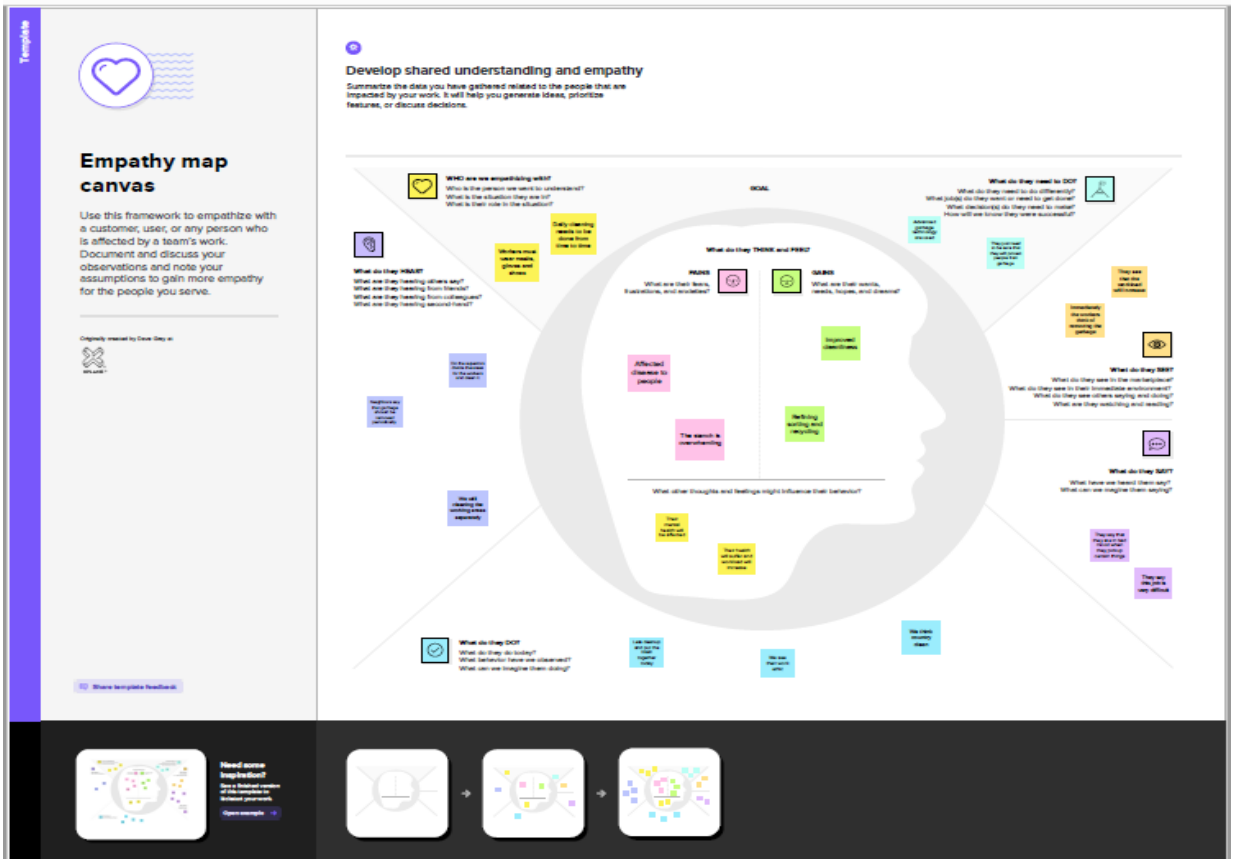
A big challenge in the urban cities is solid waste management. The garbage collecting authority in traditional waste management system doesn't know about the level of garbage in dustbin, if the dust bins gets full by garbage then it gets overflowed as well as spelled out from the dustbin leading to unhygienic condition in cities. People throw garbage on that dustbin which is already overflowed. Sometimes due to unclean garbage bins bad smell arises also toxic and unhygienic gases are produced which is way to support to the air pollution and to some harmful diseases which are easily spreadable. It is very bad look of the city. Use of traditional system result in inefficient and time and money spending system.

3. IDEATION & PROPOSED SOLUTION

Empathy map Canvas

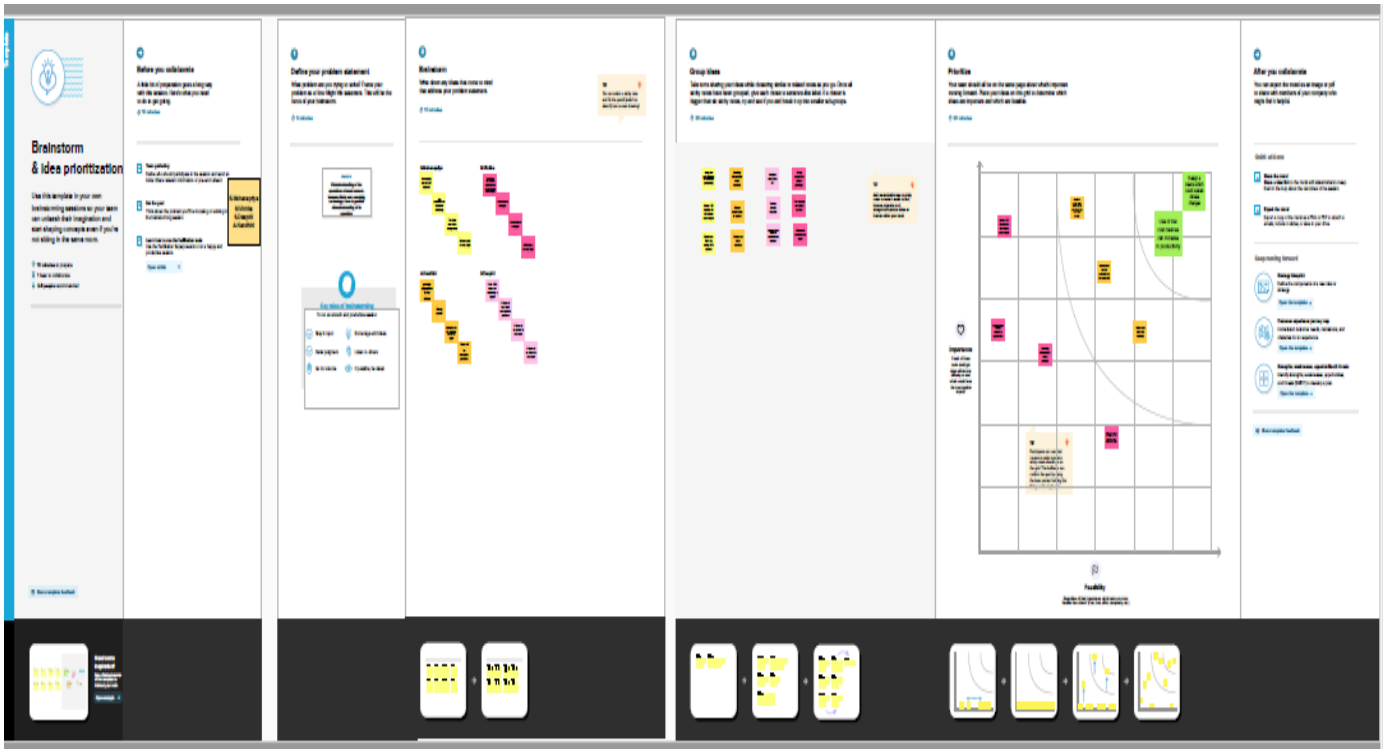
An empathy map is a collaborative tool teams can use to gain a deeper insight into their customers. Much like a user persona, an empathy map can represent a group of users, such as a customer segment. The empathy map was originally created by Dave Gray and has gained much popularity within the agile community.

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690



Ideation & Brainstorming

Ideation is the process where you generate ideas and solutions through sessions such as Sketching, Prototyping, Brainstorming, Brainwriting, Worst Possible Idea, and a wealth of other ideation techniques.



SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	A historical backlog of waste services for, especially, urban informal areas, tribal areas and rural formal areas. Although 61%10 of all South African households had access to kerbside domestic waste collection services in 2007, this access remains highly skewed in favour of more affluent and urban communities. Inadequate waste services lead to unpleasant living conditions and a polluted, unhealthy environment.
2.	Idea / Solution description	The Proposed system consists of main subsystems namely Smart Trash System(STS) and Smart Monitoring and Controlling Hut(SMCH). In the proposed system, whenever the waste bin gets filled this is acknowledged by placing the circuit at the waste bin, which transmits it to the receiver at the desired place in the area or spot.
3.	Novelty / Uniqueness	In mega cities due to comparatively more population along with the rapid urbanization the collection of garbage is becoming a big task. Waste management is a matter of concern, equal involvement of the Government and the citizens is a must to manage and overcome waste management issues.
4.	Social Impact / Customer Satisfaction	Public and social health are paramount not only to individual governments in the world, but the United Nations (UN) as well. The world body, in a bid to achieve the Millennium Development Goals (MDGs), encourages governments to implement social intervention programs that lead to improvement in basic services for health, education, water and sanitation. In September 2015, Heads of State and Governments adopted the 2030 Agenda for Sustainable Development which includes the 17 Sustainable Development Goals (SDGs). The SDGs builds on the success of the MDGs. The Goal 6 of the SDGs is to ensure availability and sustainable management of water and sanitation.
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	Sensoneo's smart waste management solution empowers cities to manage and battle ever-growing volumes of urban and municipal waste. The growing volumes of waste are largely caused by two factors: large-scale urbanization and industry growth. The modern lifestyle around the globe produces much more waste per citizen than only a decade ago. The United Nations projects 66% of the world´s population will live in cities by 2050. To sustain all these factors, problems and challenges, cities need a sophisticated and efficient tool to manage waste, monitor bins with sensors, and optimize capacity and collection routes.

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

Problem Statement

An inefficient waste management may create serious environmental impacts like infectious diseases, land and water pollution, and climate changes. In this design smart waste management is used for proper disposal and efficient collection of waste by using a Web application.

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

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.

Problem Solution Fit

PROBLEM	SOLUTION
Customer segments?	1.Make clean India 2.Keep the city clean 3.Fleet management platform 4.Automatic sensor based operation with zero manual invention. 5.The protection of the environment & the health of populations.
Customer constraints?	1.Recycling might be inexpensive. 2. More energy consumption and pollution. 3.Insufficient data collection.
Available solutions	Based on IOT technology, smart waste management aims to optimize resource allocation, reduce running costs, and increases the sustainability of waste services.
Behaviour	Ai-based smart waste bin, designed for public places, enabling them to Monitor and Manage.
Problem root cause	The greatest problem regarding waste management in developing countries begins at the very starting point of the process. Due to lack of proper systems for disposal and collections, wastes & garbage's end up in the roads and surrounding. According to a report from Google research, the amount of waste generation in 2010 was around 20,000 tons per day, and it is estimated that by 2025 the amount will be no less than around 47000 tons per day.with the existing methods of collecting and disposal it is near impossible to manage such amount of waste in the future as around 30% of waste end up on the roads and public places due to ineffective disposing & collecting methods.
Triggers	1. AI recycling robots & solar-power trash compactor 2 Smart waste bins 3. Digitally improvement cities 4. Motivate & influence people to follow proper waste disposal.

4. REQUIREMENT ANALYSIS

4.1 Functional Requirements:

Taking sensor reading from the Sensor Circuit • Pushing the data to a MySQL database. Retrieving information from database for Calculation garbage bin which fulfils the condition for garbage collection.

Example: Collect garbage from bins whose level is over 80% of bin.

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	User verification	Theusershould receiveaverification e-mailwhichthey have to confirm to complete the registration.
FR-4	Authentication	Thedata insidethedeviceisneedtobeauthenticated toensuretheprivacy oftheusers.
FR-5	Legal Requirements	ProperMedicalCertificate isproducedtoensurethe integrityoftheusers.
FR-6	Database	Information of the location area will be stored in the database.

4.2Non-functional Requirements:

The project requires a user interface for monitoring and manually intervening (if required) in the efficient and timely collection of garbage from the selected Garbage bins.

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

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	It can be widely used in metropolitan cities with time management.
NFR-2	**Security**	stored We are using login for the admin and the information will be in IBM cloud
NFR-3	**Reliability**	It will be reliable that it can update with very time period so that the accuracy will be good
NFR-4	**Performance**	It will be perform fast and secure even at the lower bandwidth.
NFR-5	**Availability**	Smart Waste Management System will be available in every Metropolitan Cities
NFR-6	**Scalability**	It is scalable that we are going to use data in kb so that the quite amount of storage is satisfied.

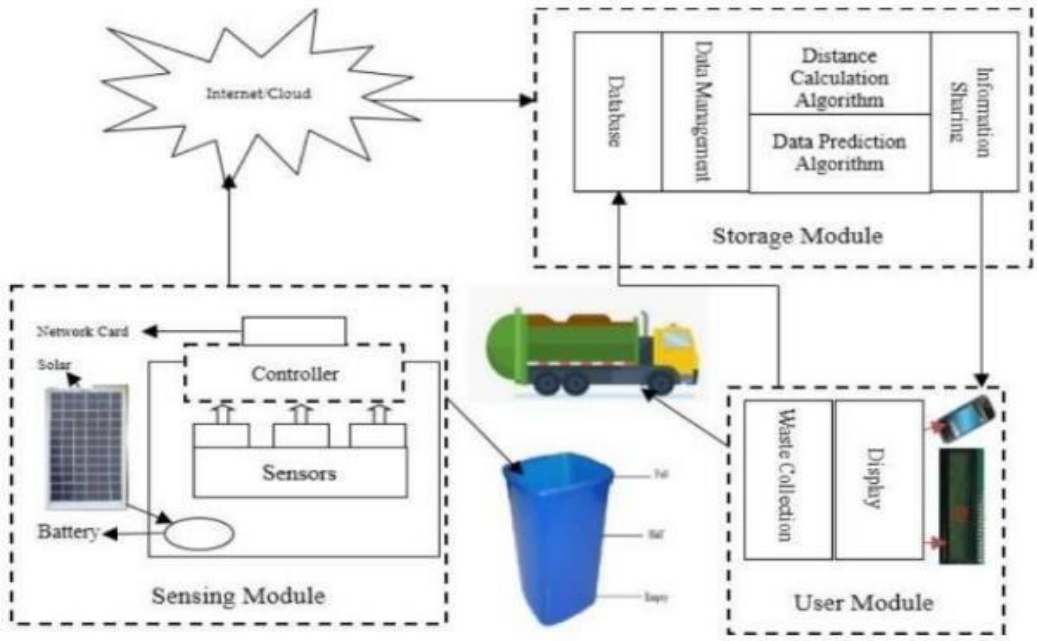
.

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

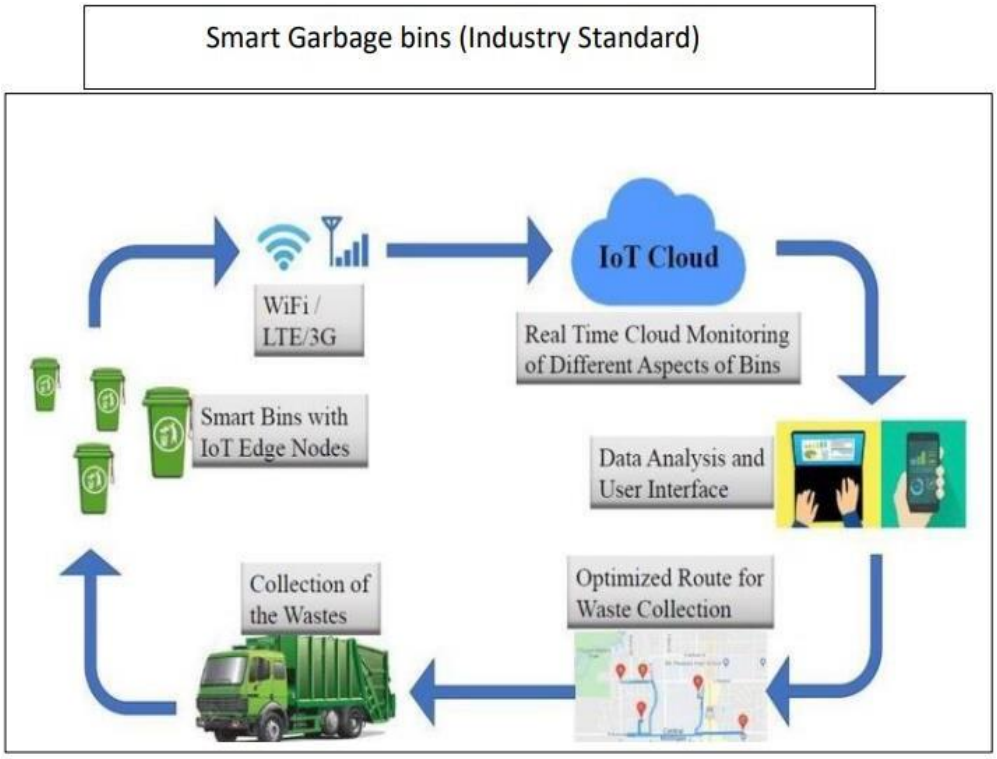
5. PROJECT DESIGN

Data 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 requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690



- The different parameters garbage level, gps, garbage weight, and then humidity are sensed usingdifferent sensors and obtained value is stored in the IBM cloud.

- Arduino UNO is used as a processing Unit that process the data obtained from the sensors andwhether data from the weather API.

- NODE-RED is used as a programming tool to write the hardware, software, and APIs. The MQTTprotocol is followed for the communication.

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

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:

- Discover the finest technological solution to address current company issues..
- Describe the software's design, features, functionality, and other elements to the project's stakeholders..
- Specify the features, stages of development, and requirements for the solution.
- Offer guidelines for how the solution is created, managed, and delivered.

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

Example - Solution Architecture Diagram

Example - Solution Architecture Diagram:

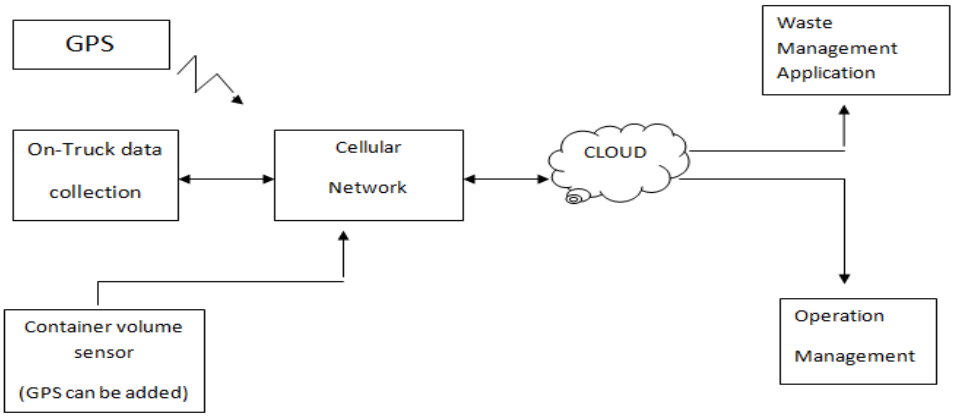


Figure 1: Architecture and data flow of the smart waste management application

User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
		USN-3	As a user, I can register for the application through Facebook	I can register & access the dashboard with Facebook Login	Low	Sprint-2
		USN-4	As a user, I can register for the application through Gmail		Medium	Sprint-1
	Login	USN-5	As a user, I can log into the application by entering email & password		High	Sprint-1
	Dashboard					
Customer (Web user)						
Customer Care Executive						
Administrator						

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

6. PROJECT PLANNING & SCHEDULING

Sprint Planning & Estimation

Product Backlog, Sprint Schedule, and Estimation

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	Literature survey on the selected project & gathering information by referring the, technical papers,research publications etc.	29 AUGUST 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements	6 SEPTEMBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	12 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.	24 SEPTEMBER 2022
Solution Architecture	Prepare solution architecture document.	30 SEPTEMBER 2022

SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

Sprint Delivery Schedule

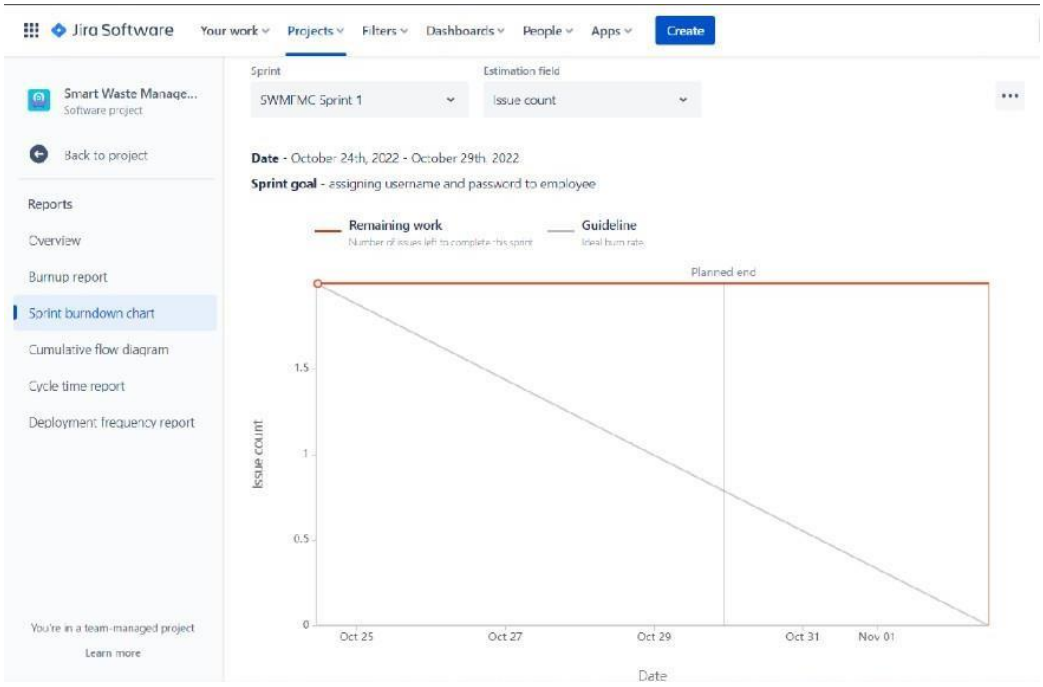
Project Tracker, Velocity & Burndown Chart

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

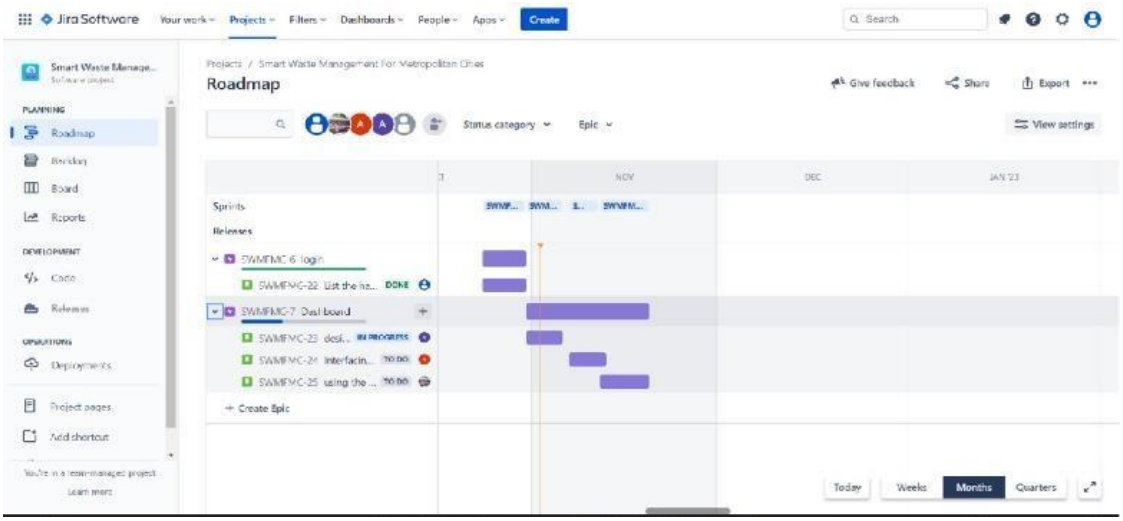
Velocity:
Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

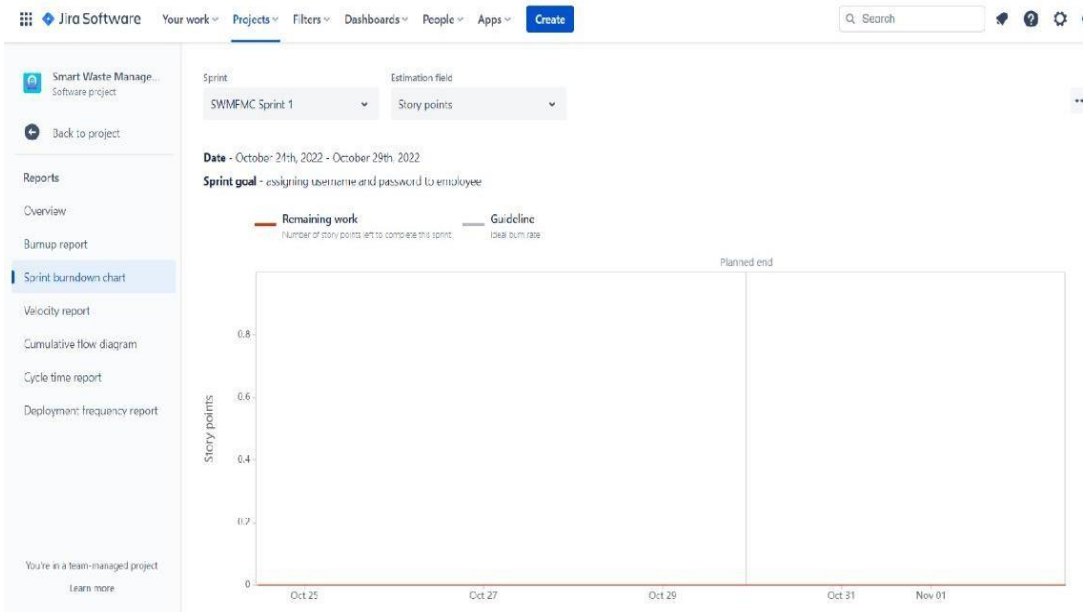
$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

Reports from JIRA



SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

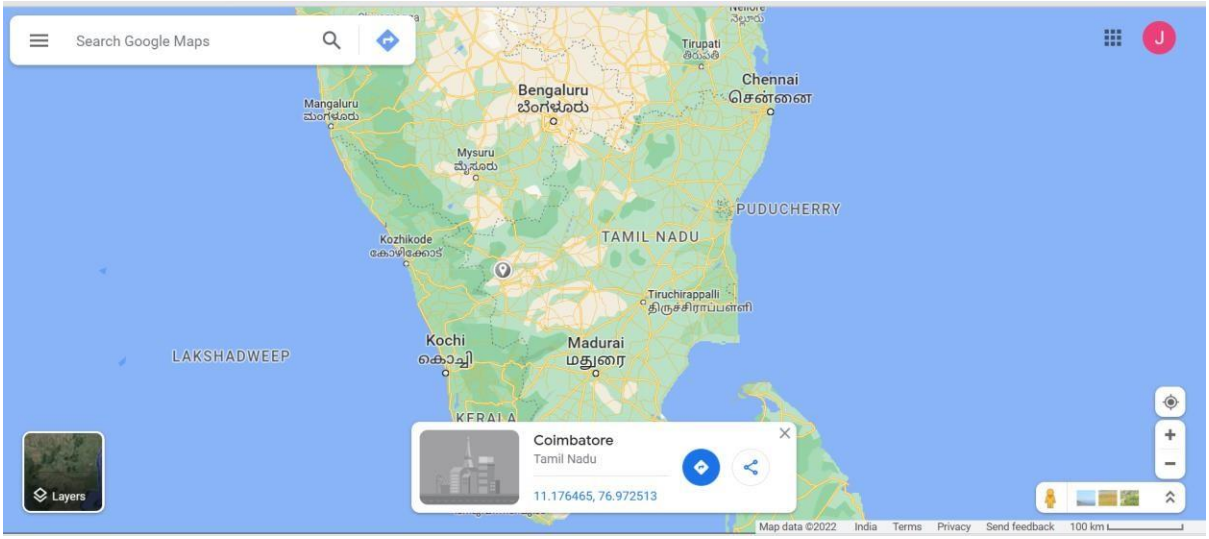




SMART WASTEMANAGEMENT SYSTEM FOR METROPOLITAN CITIES
PNT2022TMID30690

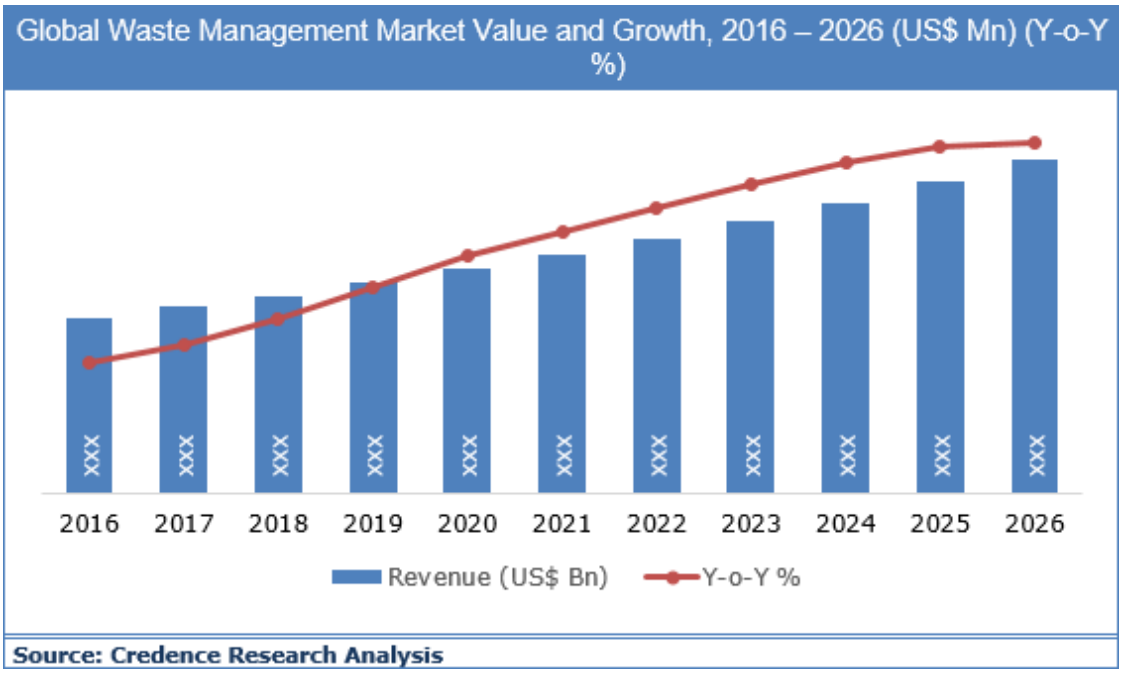
7. CODING & SOLUTIONING

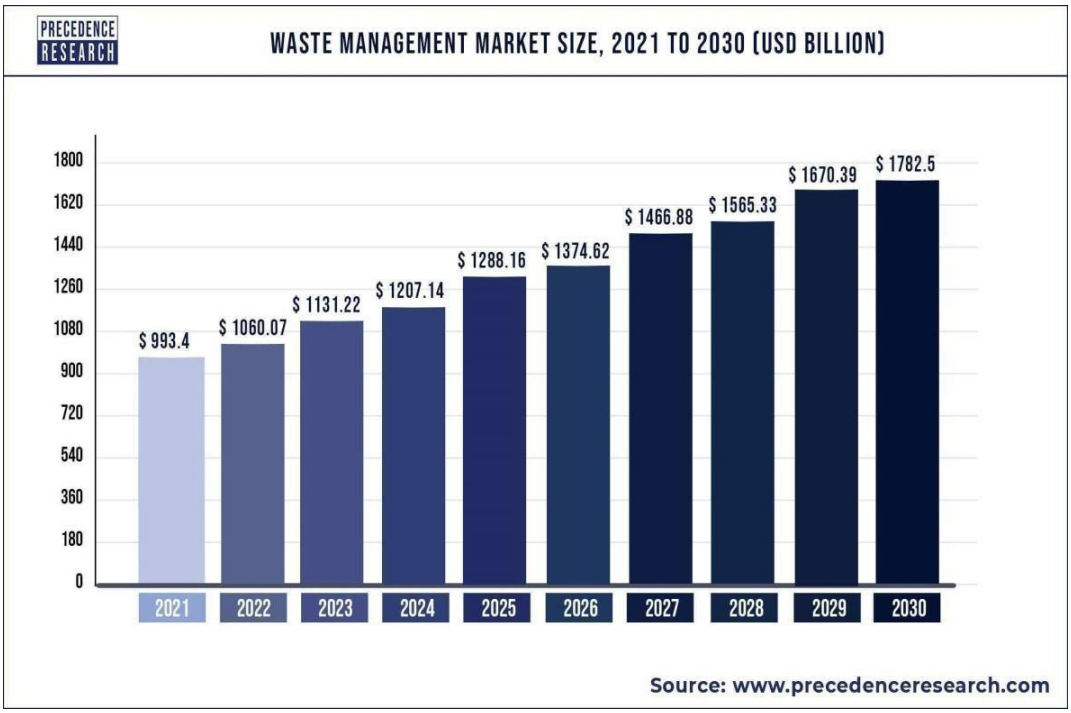
Feature



8. RESULTS

Performance Metrics





9. ADVANTAGES & DISADVANTAGES

Advantages

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

Disadvantages

- Setting up the sensor
- Non-optimized truck routes
- Non-uniform waste distribution of waste in bins

10. CONCLUSION

This proposed system, integrates different sensing and communication technologies to monitor real time bin information. This system is good enough to carry out practically as it helps to collect the garbage from the garbage bins on time before the garbage overflows from that bin which can possess threat to the health of the people leaving in nearby area. This project can avoid such situations of overflowed dustbin and the message can be sent directly to the cleaning vehicle instead of the contractor's office (Authority). In Smart system design main is Development of web portal and applications for city administration, municipal staff and public.

11. FUTURE SCOPE

Total of approximately 143,449 MT of municipal waste is generated daily. However, only 35,062 tons of waste is treated. A report from MNRE says that waste generation is expected to reach 300 million tons annually by the year 2047. There are four tiers to waste management to reduce its environmental impact: pollution prevention and source reduction; reuse or redistribution of unwanted, surplus materials; treatment, reclamation, and recycling of materials within the waste; and disposal through incineration, treatment, or land burial.

12. APPENDIX

Source Code

```
import time
import sys
import ibmiotf.application
import ibmiotf.device
import random
```

```
#Provide your IBM Watson Device Credentials


organization = "8wd932"
deviceType = "Node_Mcu"
deviceId = "123456789"
authMethod = "token"
authToken = "123456789"


# Initialize GPIO


def myCommandCallback(cmd):
    print("Command received: %s" % cmd.data['command'])
    status=cmd.data['command']
    if status =="lighton":
        print("led in on")
    else :
        print ("led is off")


try:
 deviceOptions = {"org": organization, "type": deviceType, "id": deviceId, "auth-method":
authMethod, "auth-token": authToken}
 deviceCli = ibmiotf.device.Client(deviceOptions)
 #.....


except Exception as e:
 print("Caught exception connecting device: %s" % str(e))
 sys.exit()


#Connect and send a datapoint "hello" with value "world" into the cloud as an event of type "greeting"
10 times
deviceCli.connect()


while True:
        #Get Sensor Data from DHT11
```

```
time.sleep(5)
ult_son=random.randint(
0,80)
weight=random.randint(
0,100)
lat = round(random.uniform(11.03, 11.50), 6)
long = round(random.uniform(76.80,
76.90), 6)gps = str(lat) + str(',') +
str(long)
data = {'Ultrasonic' : ult_son, 'Weight' : weight , 'GPS'
: gps}#print data
def myOnPublishCallback():
   print ("Published Ultrasonic = %s Cm" %ult_son, "Weight:%s kg" %weight, "GPS: %s"
%gps)success= deviceCli.publishEvent("IoTSensor", "json", data,
                qos=0,
on_publish=myOnPublishCall
back)if not success:
   print("Not connected to
IoTF")time.sleep(1)
deviceCli.commandCallback =

myCommandCallback# Disconnect the device and

application from the cloud deviceCli.disconnect()
```

GitHub & Project Demo Link

https://github.com/IBM-EPBL/IBM-Project-18144-1659679848

https://www.kapwing.com/videos/6379913a879e360117ba902e