SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITIAN CITIES

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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**.

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*

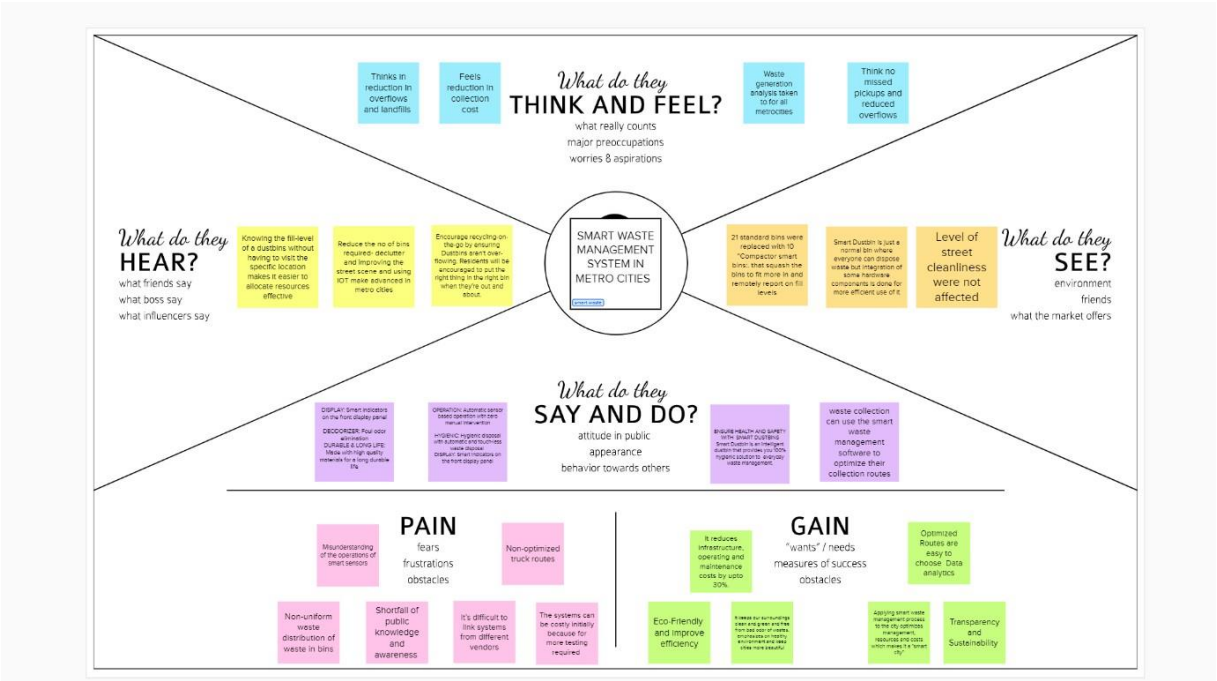
Problem Statement Definition

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

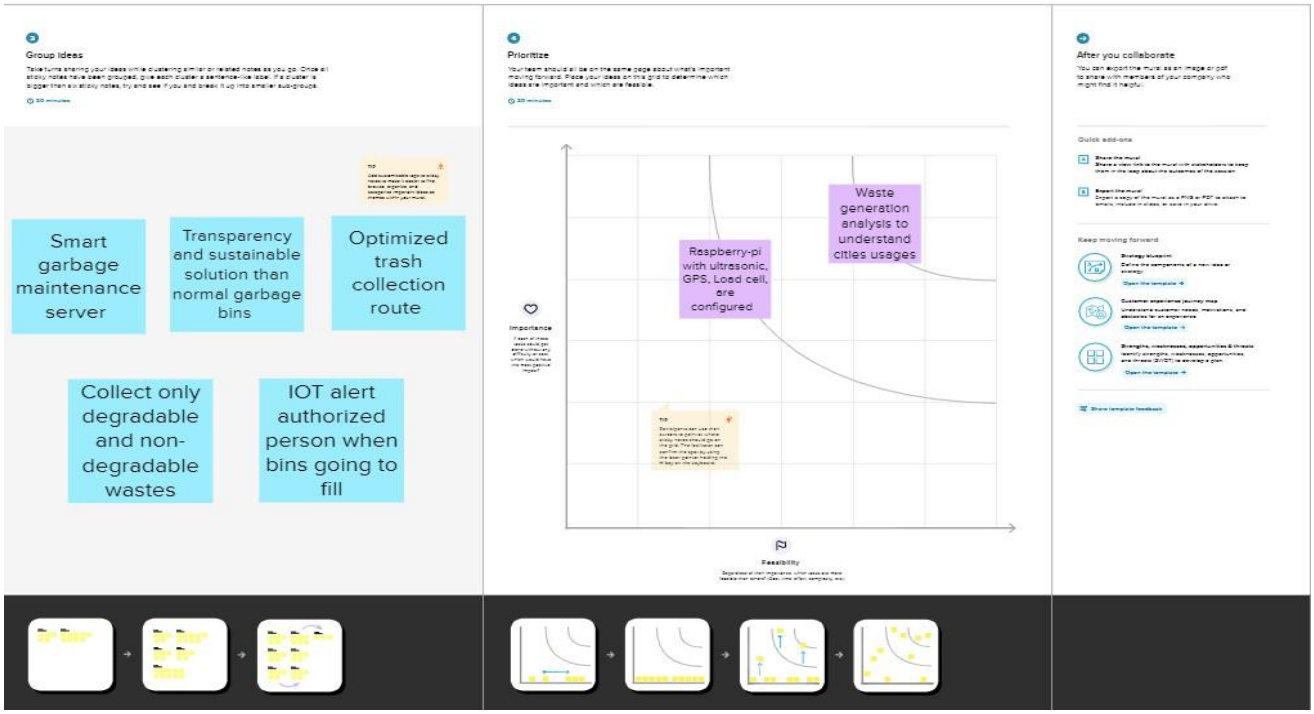
Empathy map Canvas

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.



Ideation & Brainstorming

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



Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	An inefficient waste management may create serious environmental impacts like infectious diseases, land and water pollution, climate changes. In this design of smart waste management is used for proper disposal and efficiently collection of waste by using a mobile application.
2.	Idea / Solution description	To create a web application to monitor the status of any bin and view it's location. Once if the garbagebin is full. The alert message is send to the authorized person.
3.	Novelty / Uniqueness	Each waste bins have unique ID in app for identification. Use GSM to send the SMS to authorized person, If the bin is fill. LORAWAN is used to data can be transmitted for long range and consumes low power. Use solar cell for alternative power supply.
4.	Social Impact / Customer Satisfaction	The proper waste collection will eliminate this risk as well as improving air quality and minimizing CO2 emissions. By having a more convenient route garbage trucks spend less time on the road. This means that truck drivers and citizens are saving less time stuck in traffic jams.
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.Published by Ian Tiseo, Jun 21, 2022. Waste Management Inc reported an operating revenue of 11.67 billion U.S. dollars from its collection services in 2021.
6.	Scalability of the Solution	Using of weight sensor to detect the level of garbage. This sensor gives more lifespan and reduce the damage of sensor. Use LORAWAN covers long range and consumes low power. The web app gives short route of truck to reduce the fuel cost. This design gives better efficiency.

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.

- 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

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	**Expensive bins**	As we are making up bins with sensors and other costly devices , this is somewhat expensive architecture to built. And so this requires more security settings as it requires more cost if we need to rebuilt it.
FR-2	**Implementing proper monitoring system**	All bins can be seen on the map, and you can visit them at any time via the Street View feature from Google. Bins 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-3	**Planning waste collection routes**	As well as planning is important where we need to set locations to particularize routes where bins are collected once it got filled. So, clear mapping of routes where the bin collecting truck need to travel. If we all set with clear plan, there is no need of wasting time and fuel by searching locations.
FR-4	**Separation of different kind of wastes**	Separation of different kind of wastes involves people responsibility too and so, proper education need to be provided. And bins should be implemented accordingly in each locations. And especially medical wastes should be disposed in a proper manner.

4.2 Non-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.

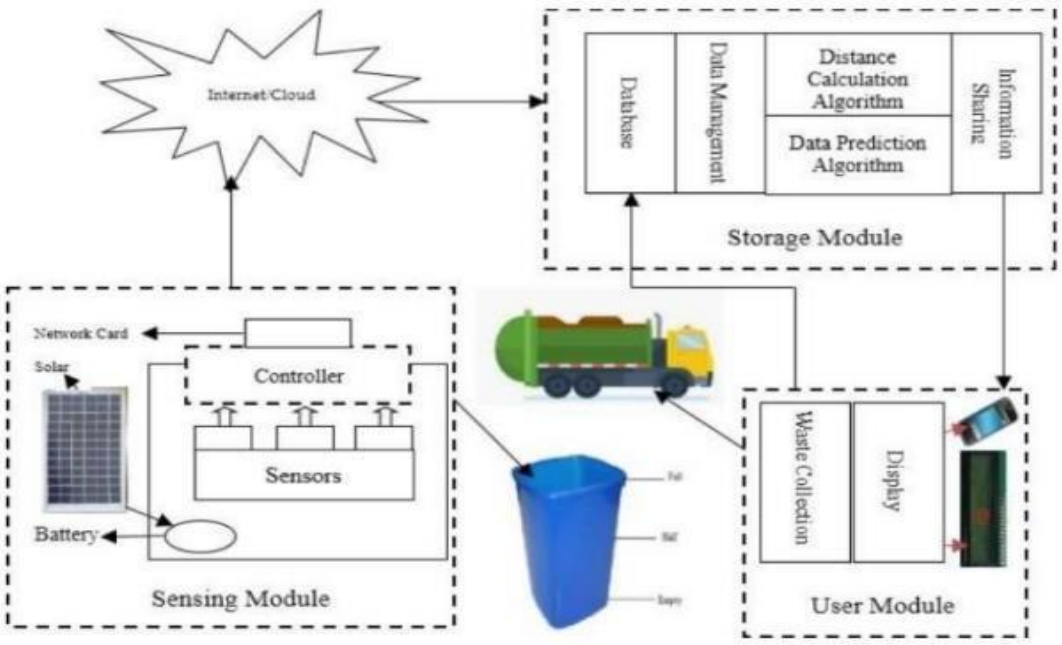
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	The current state of technology in the field of smart waste management involves the use of sensors that measure the fill level of the trash bin. Measured data is sent to the Cloud for further processing and analysis. By exploiting this data, trash collection can be planned as well as truck routes can be optimized. IoT device verifies that usability is a special and important perspective to analyse user requirements, which can further improve the design quality.

NFR-2	**Security**	Security ensures the level of assurance in data collection, processing and conveying. As this is totally depend upon cloud service we need to make security more particular without channel crash.
NFR-3	**Reliability**	Smart waste management is also about creating better working conditions for waste collectors. Instead of driving the same collection routes and servicing empty bins, waste collectors can spend their time more efficiently, taking care of bins that need servicing. This system is more reliable at any cost by taking care of garbage bins and monitoring bin activity.
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 IoT, GPRS), the sensors send the data to Sensor's Smart Waste Management Software System, a powerful cloud-based platform, for data-driven daily operations, available also as a waste management app. Customers are provided with required data-driven and decision making prototypes which would help uses to monitor its performance and encounter their quires.
NFR-5	**Availability**	Availability refers to already available solutions and the new renovative technology that we include in the system which we are building new now. This system have much available solutions for users and this made users to operate easily where we have used sensors, GPS detectors, and so on.
NFR-6	**Scalability**	We have to customize the number of bins in the town/city which we are going to monitor 24/7 a week and collect data. So, we need to measure the total bins and avail services to all bins in an proper rotational shifts.

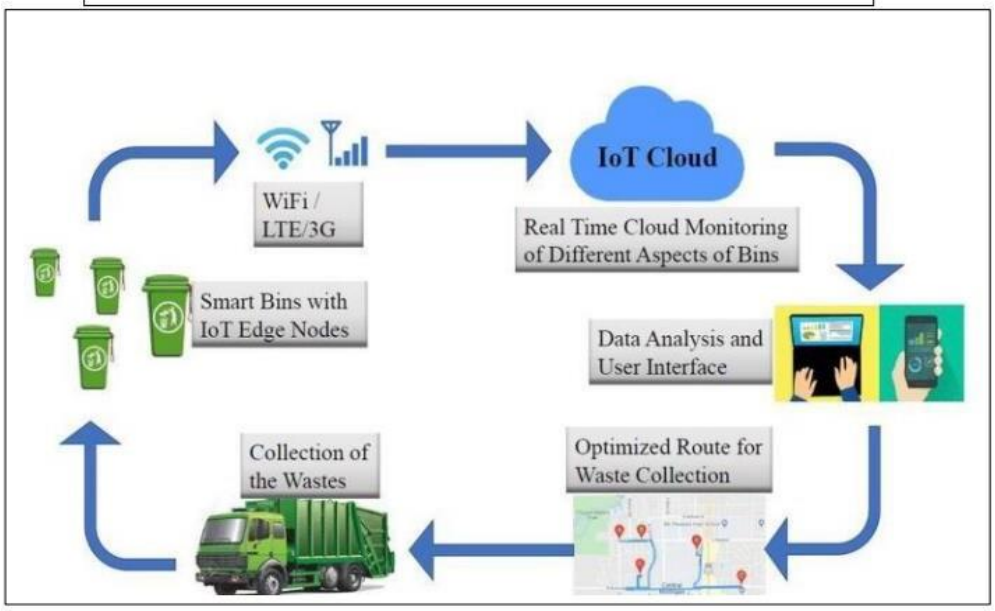
5. PROJECT DESIGN

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 Garbage bins (Industry Standard)



- The different parameters garbage level, gps, garbage weight, and then humidity are sensed using different 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 and whether data from the weather API.

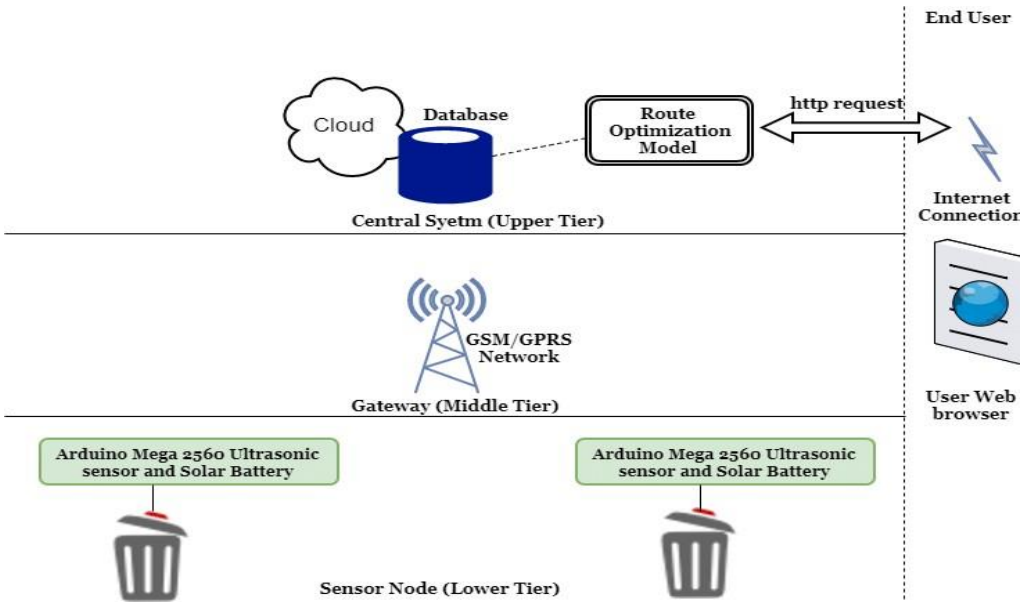
- NODE-RED is used as a programming tool to write the hardware, software, and APIs. The MQTT protocol is followed for the communication.

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.

Example - Solution Architecture Diagram



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

Sprint Delivery Schedule

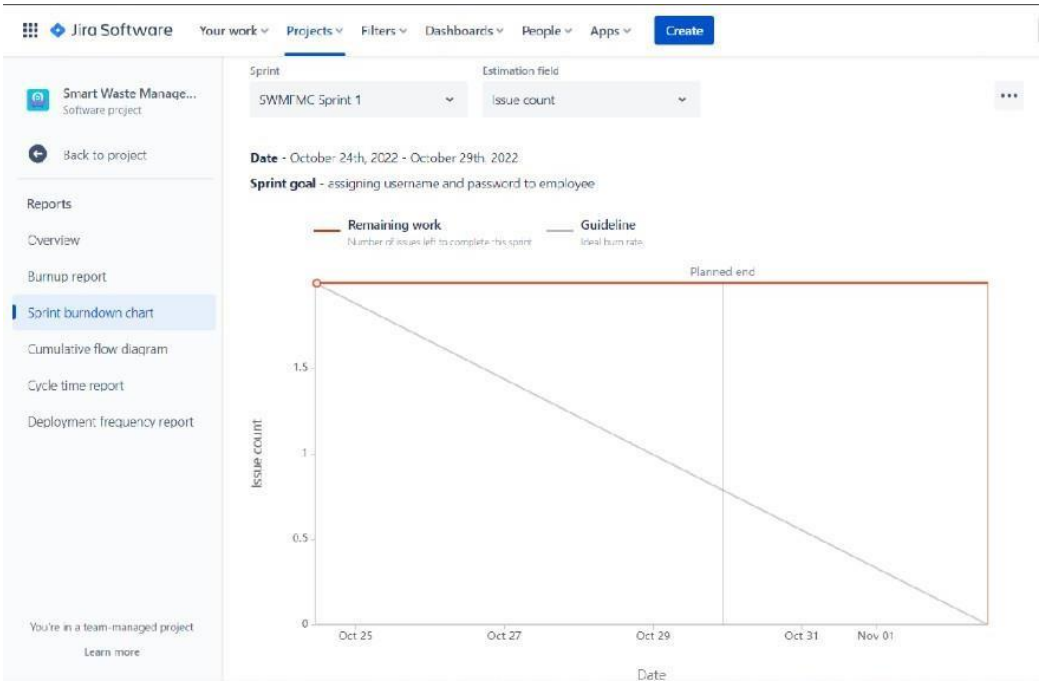
Project Tracker, Velocity & Burndown Chart

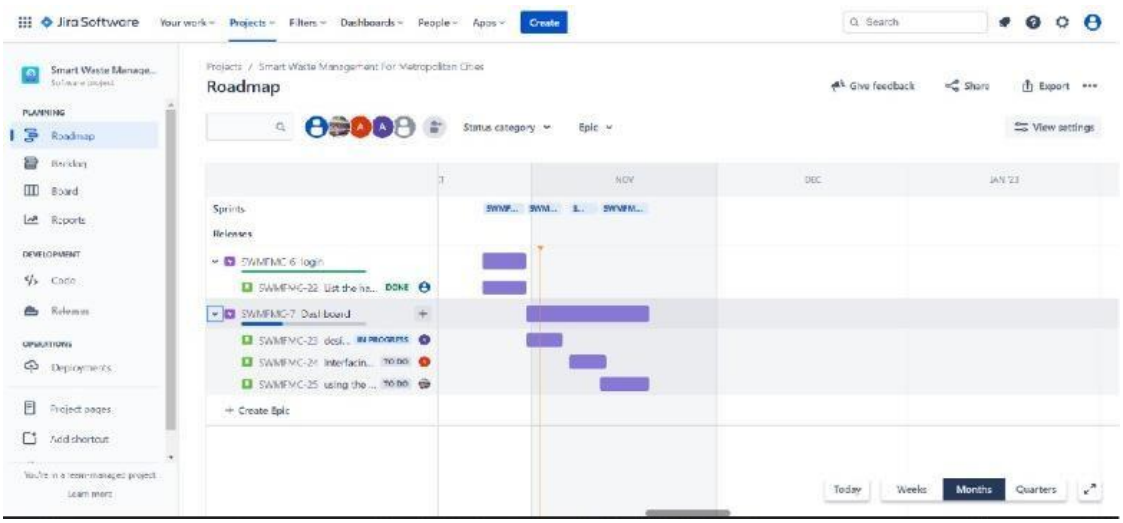
Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	5 Days	26 Oct 2022	28 Oct 2022	20	28 Oct 2022
Sprint-2	20	5 Days	2 Nov 2022	06 Nov 2022	20	06 Nov 2022
Sprint-3	20	5 Days	07 Nov 2022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




Jira Software
Your work
Projects
Filters
Dashboards
People
Apps
Create
Search
Smart Waste Manage...
Software project
PLANNING
Roadmap
Backlog
Board
Reports
DEVELOPMENT
Code
Releases
OPERATIONS
Deployments
Project pages
Add shortcut
You're in a team-managed project
Learn more
Projects / Smart Waste Management For Metropolitan Cities
Roadmap
Give feedback
Share
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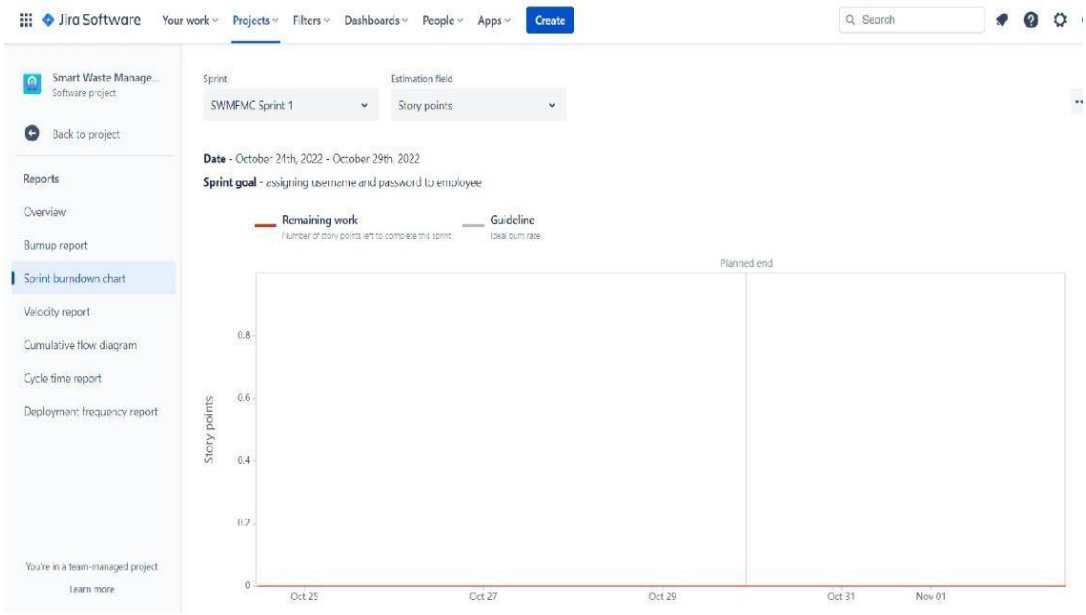
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Your work
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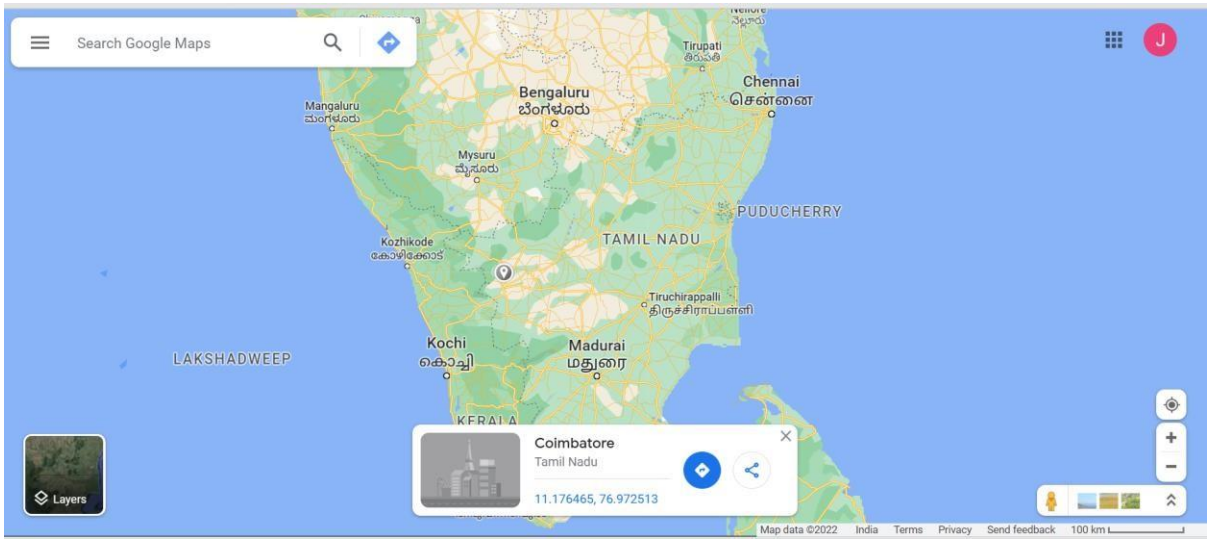
Smart Waste Manage...
Software project
Back to project
Reports
Overview
Burnup report
Sprint burndown chart
Velocity report
Cumulative flow diagram
Cycle time report
Deployment frequency report
You're in a team-managed project
Learn more
Sprint
SWMFMC Sprint 1
Estimation field
Story points
Date - October 24th, 2022 - October 29th, 2022
Sprint goal - assigning username and password to employee
Remaining work
Number of story points left to complete this sprint
Guideline
Ideal burn rate
Planned end
Story points
0.8
0.6
0.4
0.2
0
Oct 25
Oct 27
Oct 29
Oct 31
Nov 01

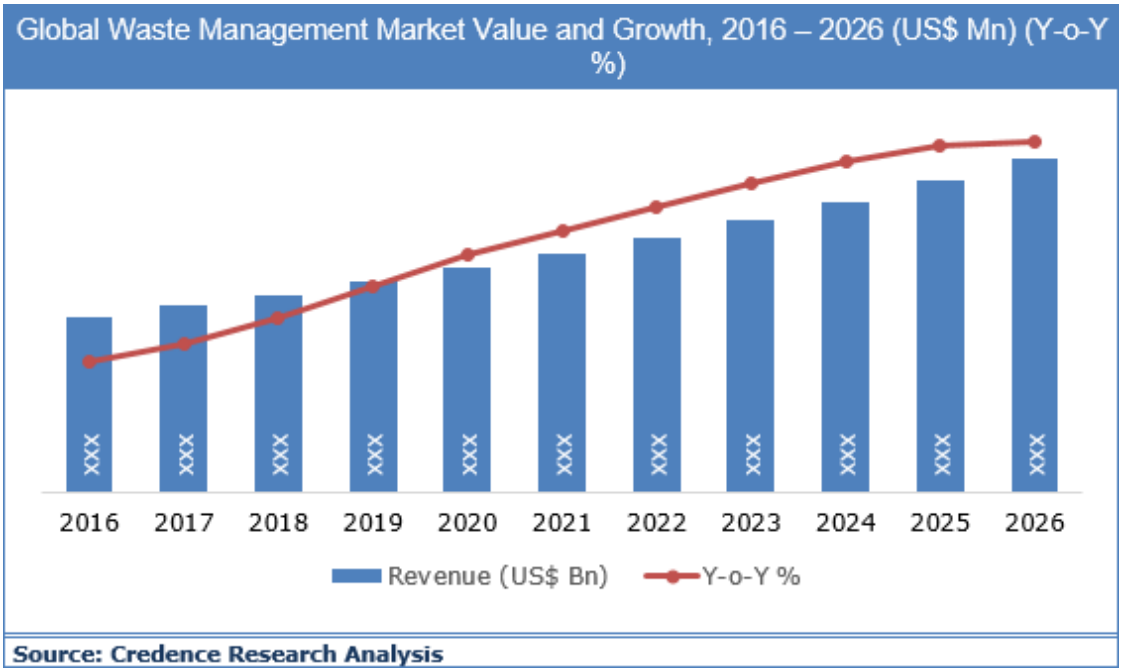
7. CODING & SOLUTIONING

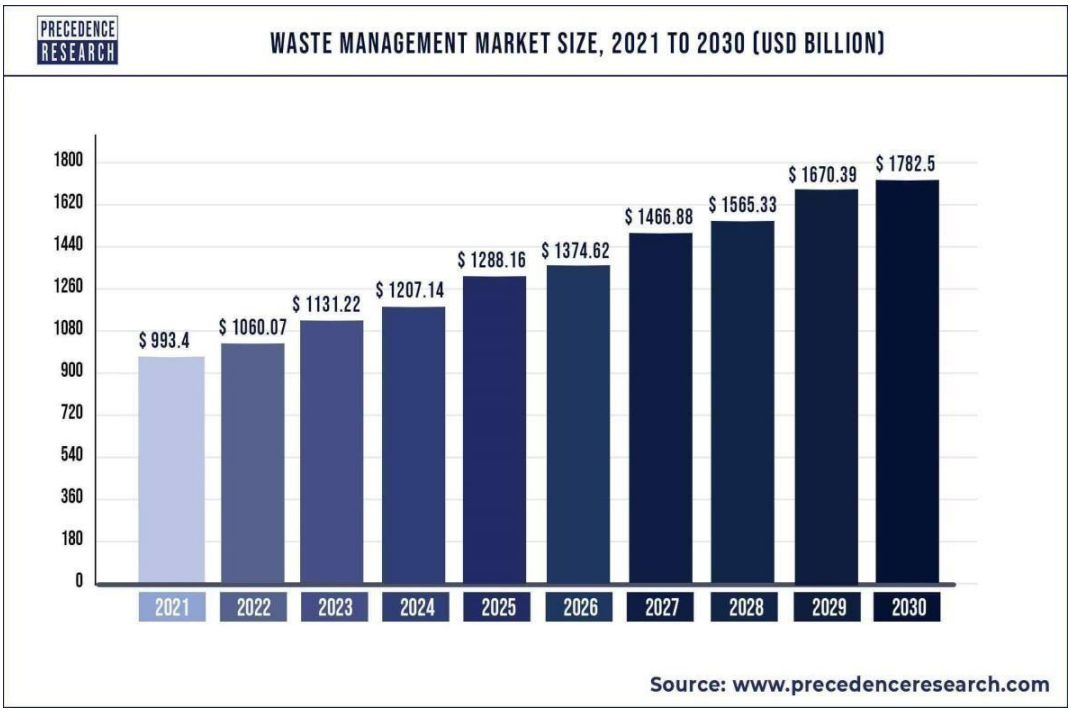
Feature



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=myOnPublishCallback)
        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-48730-1660812106