PROJECT FINAL REPORT

SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

TEAM ID : PNT2022TMID12751

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1. INTRODUCTION

1.1 Project Overview

Waste hasgr become a major worry for all of us due to the global population growth and industrialisation of nations. Over time, experts came to the conclusion that proper waste management requires more than just trash management.In this age of globalization, protecting our environment and keeping it clean are important. Researchers have developed IoT-based Smart Waste Management initiatives and solutions with the aid of technology, ensuring that the time and energy needed to deliver waste management services and lower the amount of waste generated is minimized. Unfortunately, a number of variables, including the socioeconomic context, prevent developing countries from implementing those current solutions.In order to assure effective household garbage disposal, collection, transportation, and recycling while using the fewest resources possible, we have focused our research on creating an intelligent Internet of Things-based waste management system for developing nations like INDIA.

1.2 Purpose

To efficiently establish a secure and sanitary workplace, we combine waste management with technology. Utilizing data and technology to make the trash business more effective is known as smart waste management. Smart trash management, which is based on Internet of Things (IoT) technology, aims to maximize resource allocation, lower operating costs, and improve the sustainability of waste services. This reduces the likelihood that any bin would be full for longer than a week while also enabling the trash collectors who empty the bins to plan more effective routes.The coordination between the trash haulers and the information provided by technology is good.This keeps them informed about the level of waste currently there and prompts them if the dumpsters exceed the threshold level. So that they can collect the trash on time and avoid cluttering the neighborhood, they are issued with alert messages. Historical data can be used to identify certain container fill trends, which can then be controlled long-term accordingly. Mobile applications are utilized to address issues with the conventional waste management system in addition to hardware fixes, such as tracking drivers while they are out in the field. As a result, smart waste management gives us the technology-assisted method that is most effective for managing garbage.

2. LITERATURE SURVEY

2.1 Existing problem:

In small towns and cities all around the world, waste management has grown to be a serious problem. Municipalities frequently have overflowing local dumpsters without being aware of it. This has a variety of effects on the locals, ranging from unpleasant odors to unsanitary and dangerous environments. Poor waste management, which includes anything from nonexistent collection infrastructure to inefficient disposal, contaminates the air, water, and land.Open and unclean environments can infect people, spread illnesses, and lead to the pollution of drinking water. As they accumulate throughout the food chain, toxic substances like persistent organic pollutants (POPs) pose particularly serious dangers to both human health and the ecosystem. Animals who consume polluted plants receive larger dosages of pollutants than those who are exposed to them directly. Hazardous elements from landfills, agricultural areas, feedlots, etc. will be absorbed by precipitation or surface water seeping through garbage and carried into surface and groundwater. Because it is frequently used for drinking, bathing, pleasure, as well as in agricultural and industrial processes, contaminated groundwater also offers a serious health danger. Various pests (insects, rodents, gulls, etc.) that seek out food in garbage might be drawn to landfills and waste transfer terminals. These pests pose a threat to human health because they can transmit viruses and bacteria (such as salmonella and ecol) that cause illnesses.

2.2 References

PAPER 1

TITLE: Waste Management Initiatives in India For Human Wellbeing

AUTHOR NAME: Dr. Raveesh Agarwal, Mona Chaudhary and Jayveer Singh

PUBLICATION YEAR: 2015

DESCRIPTION:

This essay's goal is to look at the current waste management practices employed in India to benefit the country's populace. The second objective is to provide suggestions for improving Indian municipal rubbish disposal methods. The foundation of this work is secondary research. The system is enhanced by taking a close look at the waste management reports that have previously been published and the proposals for improvement made by planners, NGOs, consultants, government accountability organizations, and significant corporate leaders.It offers a thorough grasp of the various waste management initiatives in India and indicates potential areas for waste management improvement. The purpose of the article is to help readers understand the significant role that our country's official waste management sector plays in the waste management process

PAPER 2

TITLE: IoT Based Waste Management for Smart City

AUTHOR NAME: Parkash Tambare, Prabu Venkatachalam

PUBLICATION YEAR: 2016

DESCRIPTION:

The quantity of garbage created each day is increasing, and as a result, we regularly see that the trash cans or dust cans that are placed in public areas of cities are overflowing. We intend to build "IoT Based Waste Management for Smart Cities" to avoid this since it leads to unhygienic living conditions for people and offensive odors in the neighborhood. The suggested system includes a large number of garbage cans that are dispersed across the city or on the campus. Each garbage can has a low-cost integrated gadget that monitors its level as well as a unique ID that makes it possible to track and identify it.

PAPER 3

TITLE: Arduino Micro controller Based Smart Dustbins for Smart Cities

AUTHOR NAME: K. Suresh, S. Bhuvanesh and B. Krishna Devan

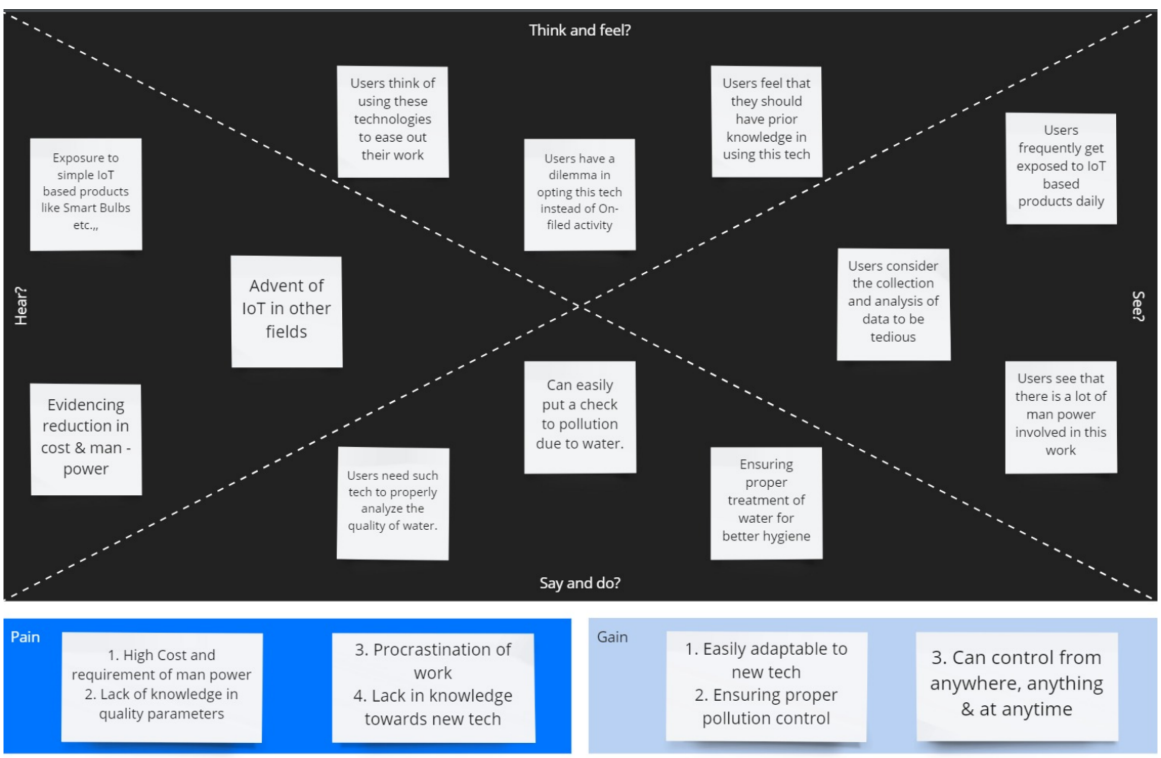
PUBLICATION YEAR: 2019

DESCRIPTION:

This essay describes a method for cleaning up our atmosphere and surrounds.The waste collection and disposal system has to be upgraded for the Indian government's smart city plan to make these communities even smarter than they presently are. Self-Monitoring Automated Route Trash (SMART) dustbins are designed for usage in smart buildings, including among others universities, hospitals, and bus stations. In this project, we used the Servo Motor to open the dustbin lid, the PIR and Ultrasonic sensors to detect human presence, and the Ultrasonic sensor to determine the amount of trash. A communication module is used to relay signals between two garbage cans, and the GSM module communicates the message to the operator.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.3.1.EMPATHY MAP

3.2 Proposed Solution

3.2.1. Problem Statement

This project deals with the problem of waste management in smart cities, where the garbage collection system is not optimized. This project enables the organizations to meet their needs of smart garbage management systems. This system allows the authorized person to know the fill level of each garbage bin in a locality or city at all times, to give a cost-effective and time-saving route to the truck drivers.

3.2.2. Idea / Solution description

• The proposed system would be able to automate the solid waste monitoring process and management of the overall collection process using IOT (Internet of Things).

• 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. • In the proposed system, the received signal indicates the waste bin status at the monitoring and controlling system.

3.2.3. Novelty

We are going to establish SWM in our college but the real hard thing is that cleaner don't know to operate these thing practically so here our team planned to build a wrist band to them, that indicate via light blinking when the dustbin fill and this is Uniqueness we made here beside from project constraints.

3.2.4. Social Impact / Customer Satisfaction

From the public perception, the worst impacts of present solid waste disposal practices are seen as direct social impacts such as neighborhood of landfills to communities, breeding of pests and loss in property values.

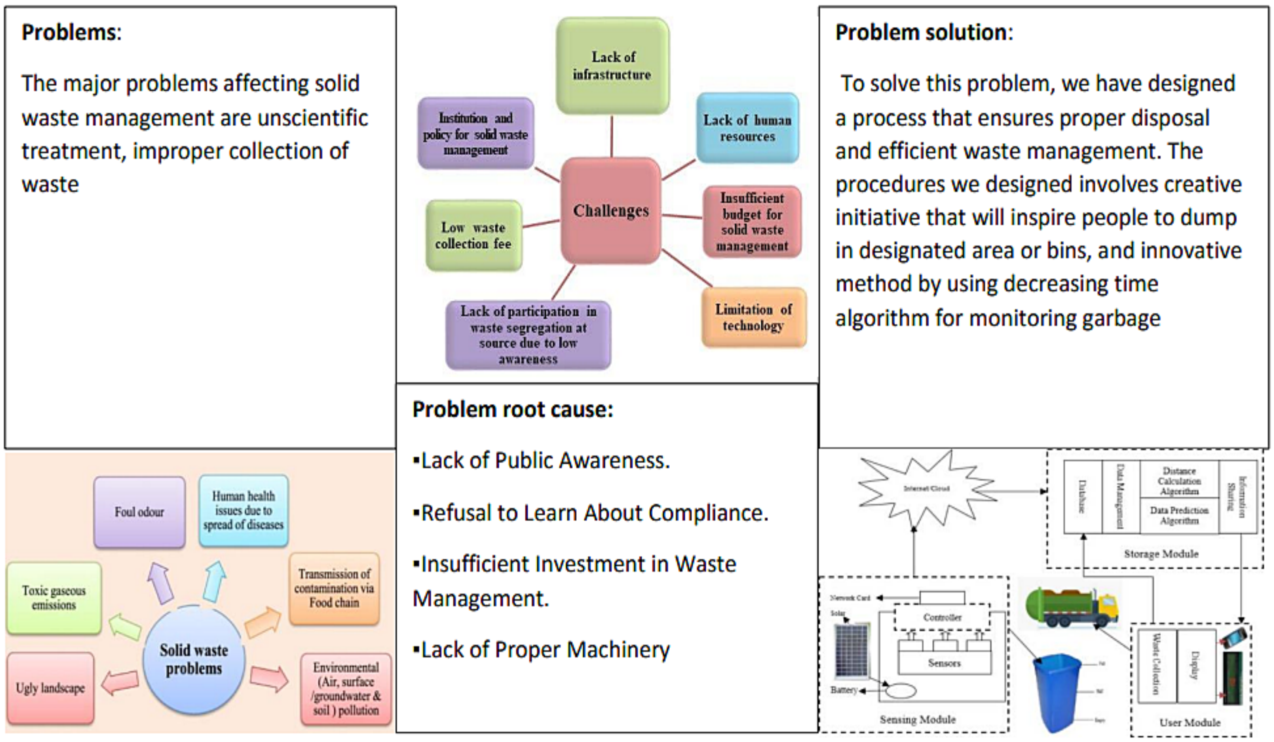
3.2.5. Business Model

Solid Waste, comprising the Company's waste collection, transfer, recycling and resource recovery, and disposal services, which are operated and managed locally by the Company's various subsidiaries, which focus on distinct geographic areas; and Corporate and Other, comprising the Company's other activities, including its development and operation of landfill gas-to energy facilities in the INDIA, and its recycling brokerage services, as well as various corporate functions.

3.2.6. Scalability of the Solution

Following this approach, this paper presented an efficient IoTbased and real-time waste management model for improving the living environment in cities, focused on a citizen perspective. The proposed system uses sensor and communication technologies where waste data is collected from the smart bin, in real-time, and then transmitted to an online platform where citizens can access and check the availability of the compartments scattered around a city.

3.3 Problem Solution fit



3.3.1 PROBLEM SOLUTION FIT

4. REQUIREMENT ANALYSIS

4.1 Functional requirement

Following are the functional requirements of the proposed solution

1.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.

2.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 of fill level, which is one of the features that even the finest waste management software lacks. As picks are also recognized by the sensors, you can determine 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.

3.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).

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.

5.Eliminate inefficient picks

Get rid of the collection of half-empty trash cans. Picks are recognized by sensors. We can show you how full the bins you collect are by utilizing real-time data on fill-levels and pick recognition. The report displays how full the bin was when chosen. Any choices below 80% full that are inefficient are seen right away.

6.Plan waste collection routes:

Route planning for rubbish pickup is semi-automated using the tool. You are prepared to act and arrange for garbage collection based on the levels of bin fill that are now present and forecasts of approaching capacity. To find any discrepancies, compare the planned and actual paths.

4.2 Non-Functional requirements

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

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 center.

2.Security

- Use a reusable bottles
- Use reusable grocery bags
- Purchase wisely and recycle
- Avoid single use food and drink containers

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 empty bins that need service rather than driving the same collection routes.

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 Sensoneo'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 hence provided data-driven decision making, and optimization of waste collection routes, frequencies, and vehicle loads resulting in route reduction by at least 30%.

5.Availability

By developing & deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter.

6.Scalability

Using smart waste bins reduce the number of bins inside town , cities becuase we able to monitor.

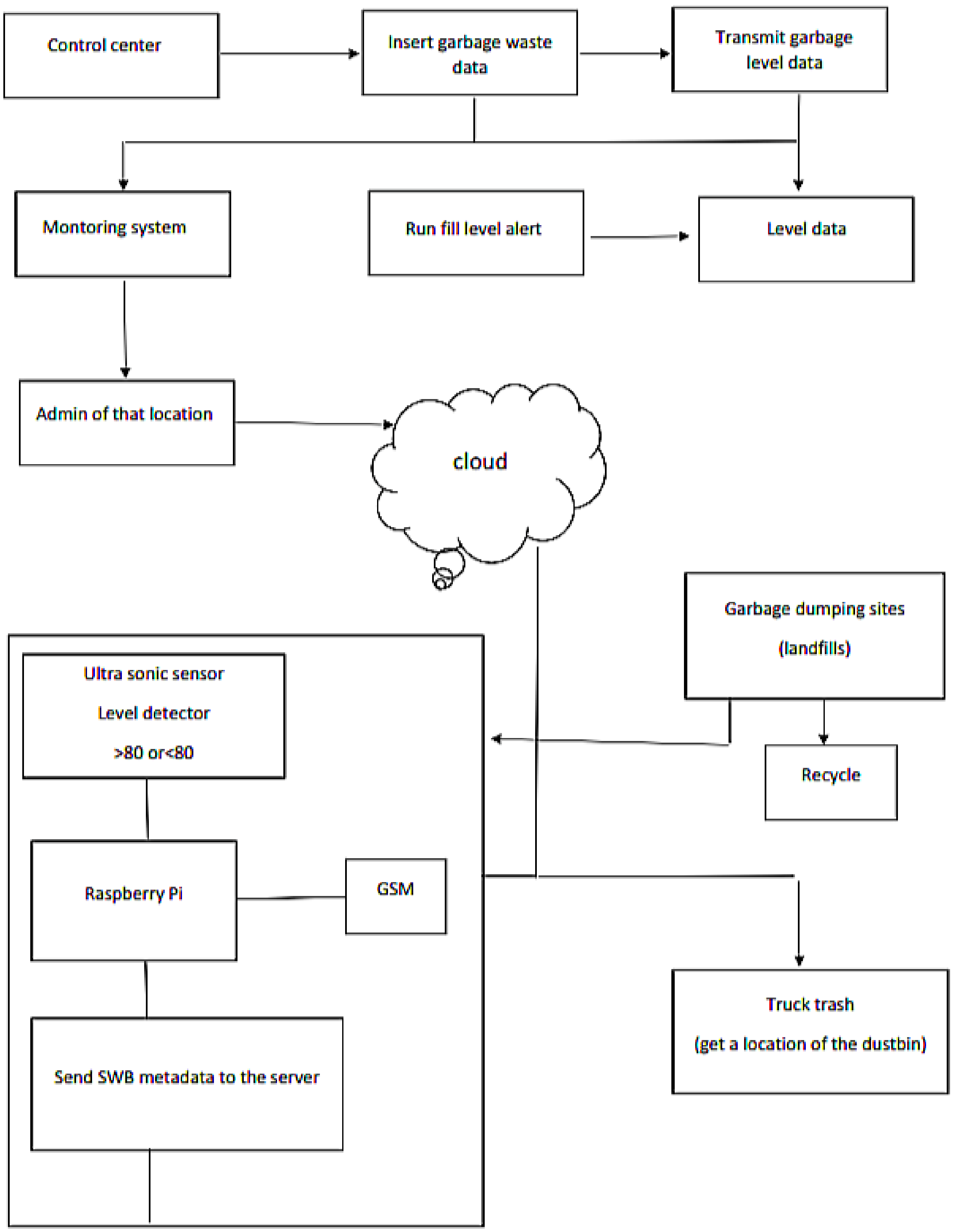
5. PROJECT DESIGN

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

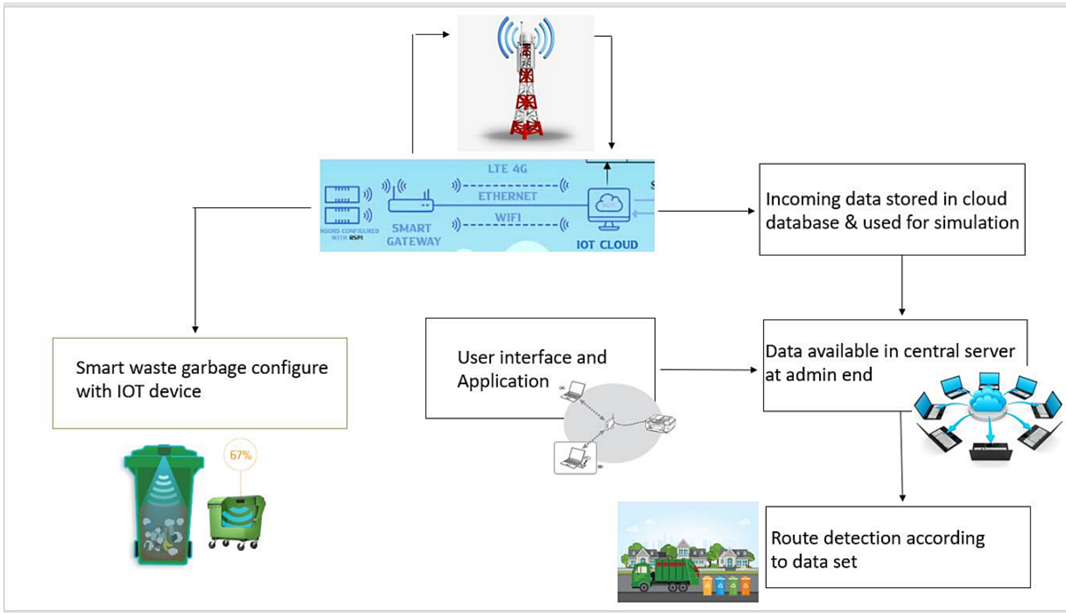
A smart waste management platform uses analytics to translate the data gather in your bins into actionable insights to help you improve your waste You can receive data on metric such as:

- The first test conducted is the situation where 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.

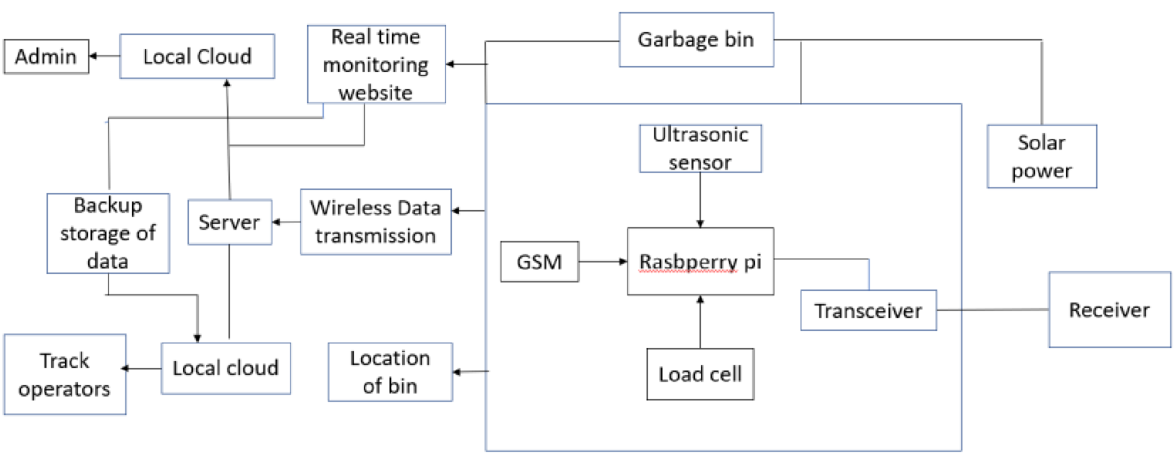


5.5.1.DATA FLOW DIAGRAM

5.2. Solution & Technical Architecture



5.2.1. SOLUTION ARCHITECTURE



5.2.2. TECHNICAL ARCHITECTURE

5.3 Technology Stack (Architecture & Stack)

5.3.1. Components & Technologies:

1.User Interface - Web Porta

Technology: HTML,CSS,NodeRed, Javascript.

2.Application Logic-1 - To calculate the distance of dreck and show the real time level in web portal , information getting via ultra sonic sensor and the alert message activate with python script to web portal. Technology: Ultrasonic sensor/ Python.

3.Application Logic-2 - To calculate the weight of the garbage and show the real time weight in web portal, this info getting via load cell and the alert message activate with python to web portal.Technology:Load cell/Python.

4.Application Logic-3 - Getting location of the Garbage.
Technology :GSM / GPS.

5.Cloud Database - Database Service on Cloud .
Technology :IBM DB2, IBM Cloudant etc.

6.File Storage - File storage requirements;
Technology :Github,Local file system.

7.Ultrasonic Sensor - To throw alert message when garbage is getting full.
Technology :Distance Recognition Model.

8.Infrastructure (Server / Cloud) - Application Deployment on Local System / Cloud Local Server
Configuration:localhost Cloud Server
Configuration:localhost,Firebase.
Technology :Localhost,Web portal.

5.4 Application Characteristics:
Technology - IOT

1.Open-Source Frameworks - NodeRed,Python,IBM Simulator.

2.Security Implementations - Raspberry Pi is connected to the internet and for example used to broadcast live data, further security measures are recommended and use the UFW(uncomplicated Firewall)

3.Scalable Architecture - Raspberry pi:Specifications

Soc: rspi ZERO W

CPU: 32-bit computer with a 1 GHz ARMv6

RAM: 512MB

Networking: WiFi

Bluetooth: Bluetooth 5.0, Bluetooth Low Energy (BLE).

Storage: MicroSD

GPIO: 40-pin GPIO header, populated

Ports: micro HDMI 2.0, 3.5mm analogue Audiovideo jack, 2x USB 2.0, 2x USB 3.0, Ethernet Dimensions: 88mm x 58mm x 19.5mm, 46g .

4.Availability - These smart bins use sensors like ultrasonic and load cell to send alert message about the trash level recognition technology, and artificial intelligence, enabling them to automatically sort and categorize recycling litter into one of its smaller bin.

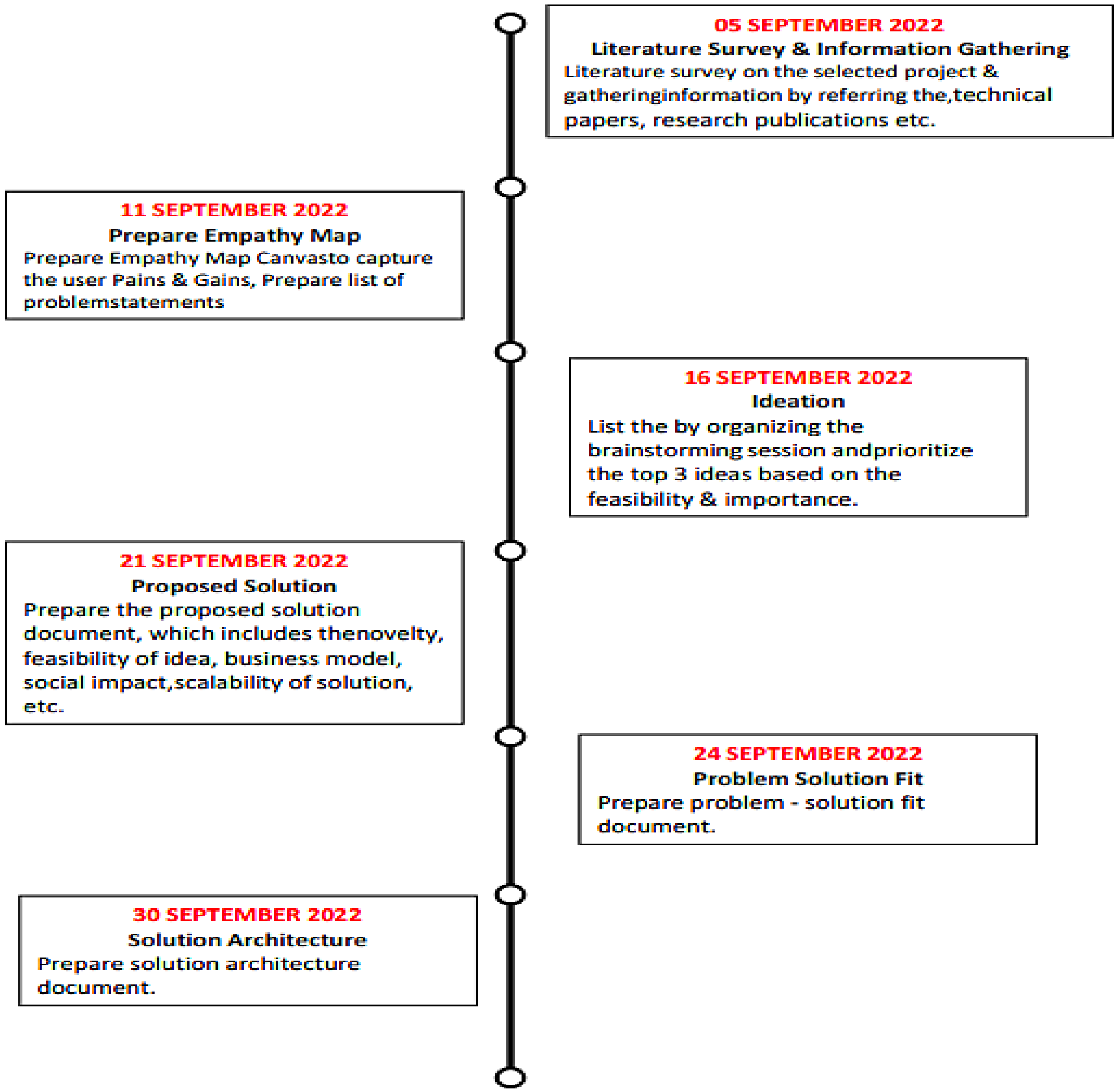
5.Performance - Number of request:RPI manages to execute 129139 read requests per second.

Use of Cache:512mb

Use of CDN’s:Real time

6.PROJECT PLANNING &SCHEDULING

6.1 Sprint Planning & Estimate



6.6.1.SPRINT PLANNING

05 OCTOBER 2022
Customer Journey
Prepare the customer journeymaps to understand the user interactions & experiences with the application (entry to exit).

8 OCTOBER 2022
Functional Requirement
Prepare the functional requirement document.

9 OCTOBER 2022
Data Flow Diagrams
Draw the data flow diagrams and submit forreview.

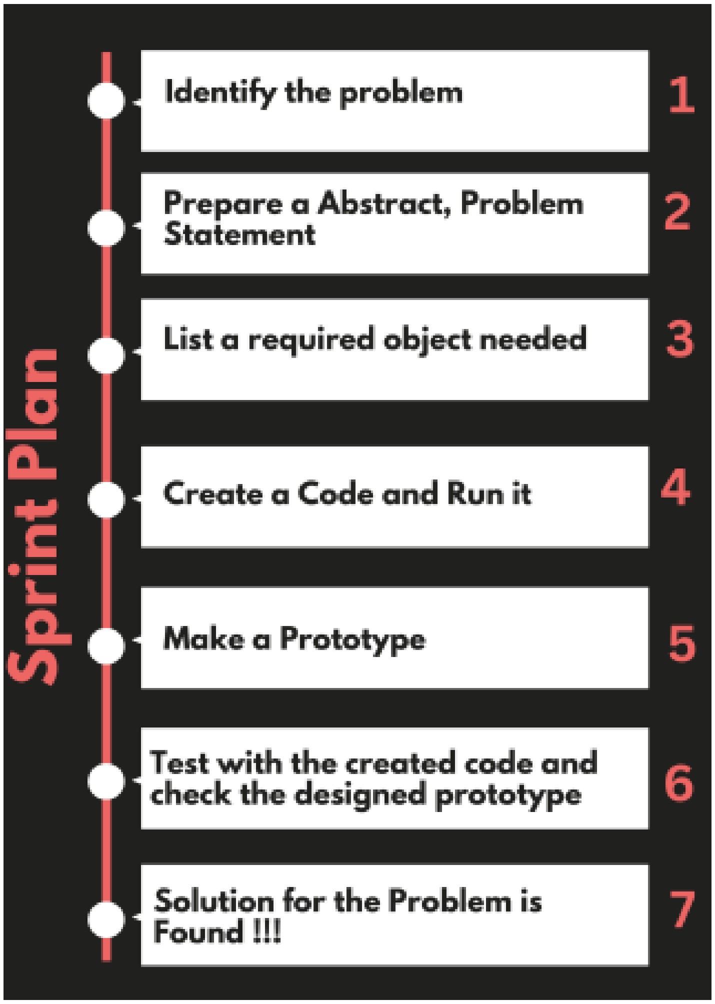
10 OCTOBER 2022
Technology Architecture
Prepare the technology architecture diagram.

22 OCTOBER 2022
Prepare Milestone & ActivityList
Prepare the milestones &activity list of the project.

IN PROGRESS...
Project Development - Delivery of Sprint-1, 2, 3 & 4
Develop & submit the developed code by testing it.

6.6.2.SPRINT PLANNING

6.2 Sprint Delivery schedule



6.2.1. SPRINT DELIVERY SCHEDULE

7. TESTING AND RESULTS

7.1. Testing

Python code is developed and then tested whether the code is generating random sensor data or not. This random sensor data is sent to the IBM Watson Cloud so that the level and weight of the garbage can be monitored along with the llocation described in latitude and longitude

```
{'dist': 42, 'load': 4, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 65, 'load': 17, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 21, 'load': 5, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 32, 'load': 20, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 16, 'load': 6, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 22, 'load': 1, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 10, 'load': 19, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 47, 'load': 10, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 3, 'load': 15, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 36, 'load': 17, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 33, 'load': 4, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 40, 'load': 1, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 47, 'load': 18, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 16, 'load': 16, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 12, 'load': 0, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 48, 'load': 2, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 30, 'load': 12, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 54, 'load': 0, 'latitude': 10.9368, 'longitude': 78.1366}
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{'dist': 71, 'load': 9, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 16, 'load': 14, 'latitude': 10.9368, 'longitude': 78.1366}
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{'dist': 67, 'load': 10, 'latitude': 10.9368, 'longitude': 78.1366}
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{'dist': 8, 'load': 19, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 18, 'load': 4, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 52, 'load': 2, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 21, 'load': 11, 'latitude': 10.9368, 'longitude': 78.1366}
{'dist': 50, 'load': 14, 'latitude': 10.9368, 'longitude': 78.1366}
```


7.1.1. OUTPUT FRON PYTHON SCRIPT

Recent Events

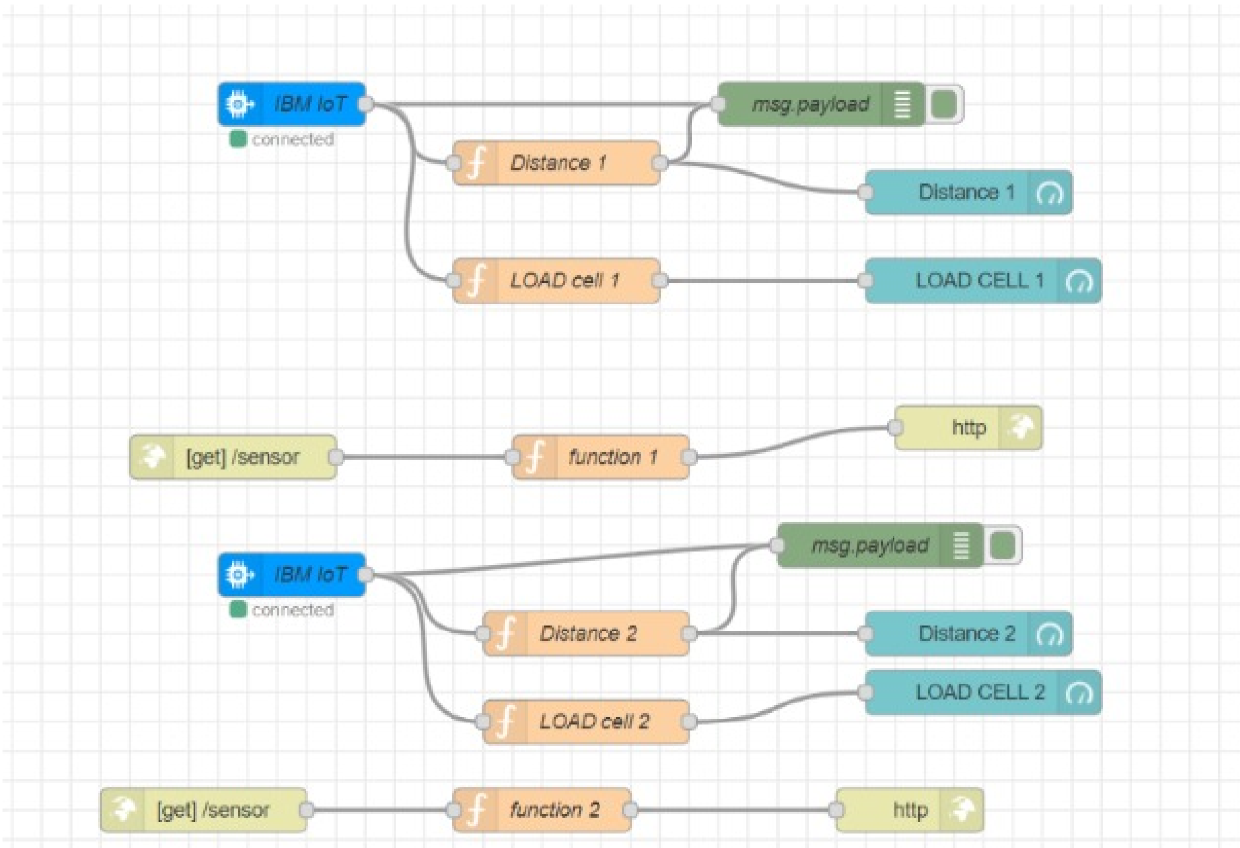
The recent events listed show the live stream of data that is coming and going from this device.

Event	Value	Format	Last Received
Status	{"dist":63,"load":19,"latitude":10.9368,"longitud...	json	a few seconds ago
Status	{"dist":65,"load":8,"latitude":10.9368,"longitude...	json	a few seconds ago
Status	{"dist":53,"load":13,"latitude":10.9368,"longitud...	json	a few seconds ago
Status	{"dist":24,"load":11,"latitude":10.9368,"longitud...	json	a few seconds ago
Status	{"dist":51,"load":20,"latitude":10.9368,"longitud...	json	a few seconds ago

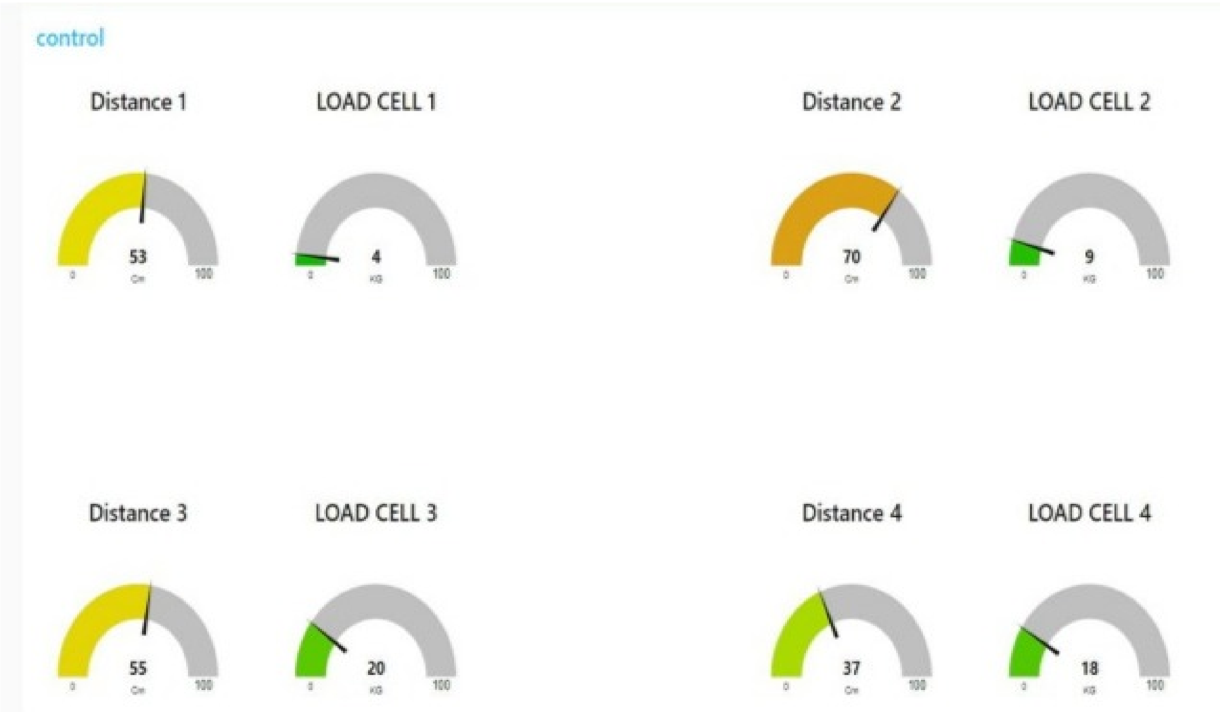
7.1.2. DATA SHOWN IN IBM CLOUD

7.2. Results

The data from IBM Watson IOT Platform is send to Node Red in order to view the data in Web app(UI). The Node Red Dashboard shows the level and load of the bin as well as the latitude and longitude of that particular bin



7.2.1. IMPLEMETATION IN NODE RED



7.2.2 FINAL OUTPUT

8. ADVANTAGES & DISADVANTAGES

8.1.ADVANTAGES:

- Provides the real-time level and load of bins as well as the location.
- Reduction of CO_2 gas.
- Provides a hygienic environment by preventing the overflow of waste.

8.2.DISADVANTAGES:

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

9. CONCLUSION:

Monitoring the fullness of bins through the use of sensors, it is possible to achieve a more efficient system than the current existing. Our idea of “Smart waste management system”, mainly concentrates on Monitoring the waste management, providing a smart technology for waste system, avoiding human intervention, reducing human time and effort and which results in healthy and waste ridden environment. The proposed idea can be implemented for smart cities where the residents would be busy enough with their hectic schedule and wouldn’t have enough time for managing waste. The bins can be implemented in a city if desired where there would be a large bin that can have the capacity to accumulate the waste of solid type for a single apartment. The cost could be distributed among the residents leading to cheaper service provision.

10. FUTURE SCOPE:

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

- In case there are more dustbins, we can also make separate dustbins for dry waste and wet waste.
- The proposed solution is flexible. And decoupled with respect to the determination of optimal number of bins and vehicles, or to the algorithm that defines the best route for vehicles.

APPENDIX

Source code:

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


# Watson device details
global warn
organization = "1p9sem"
devicType =  "smartwaste123"
deviceId = "76013"
authMethod= "token"
authToken= "12345678"

#generate random values for random variables (Distance and load)

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

try:
        deviceOptions={"org": organization, "type": devicType,"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 data point "Distance" with value integer value into the cloud as a type of event for every 10 seconds
deviceCli.connect()
```

```
while True:
    lat=10.9368
    lon=78.1366
    Distance= random.randint(1,75)
    Loadcell= random.randint(0,20)
    data= {'dist':Distance,'load':Loadcell,'latitude':lat,'longitude':lon}
    if Loadcell<5 and Loadcell>0:
        load="20%"
    elif Loadcell<10 and Loadcell>5:
        load="40%"
    elif Loadcell<15 and Loadcell>10:
        load="60%"
    elif Loadcell<18 and Loadcell>15:
        load="80%"
    elif Loadcell<20 and Loadcell>18:
        load="90%"
    else:
        load="100%"

    if Distance<7 and Distance>1:
        level="90%"
    elif Distance<15 and Distance>7:
        level="80%"
    elif Distance<30 and Distance>15:
        level="60%"
    elif Distance<45 and Distance>30:
        level="40%"
    elif Distance<60 and Distance>45:
        level="20%"
    elif Distance<75 and Distance>60:
        level="10%"
    else:
        level="0%"
    if(Distance=="90%" or load=="90%"):
        warn="High"

    deviceCli.publishEvent( event="Status", msgFormat="json", data=data, qos=0)
```

```
    print(data)
    time.sleep(2)
    deviceCli.commandCallback=myCommandCallback
#disconnect the device
deviceCli.disconnect()
```

GitHub Link:

https://github.com/IBM-EPBL/IBM-Project-37137-1660300785