SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

PROJECT DOCUMENTATION

PROJECT TITLE	SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES
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CONTENTS

INTRODUCTION :

IOT-based waste management for smart cities has various examples around the world. These systems not only offer optimization for your operational plans but can also help reduce extra spending and ensure a more intelligent budget. In addition, they set an example for eco-friendly waste management, and the new resources created by advanced recycling practices make an important contribution to the circular economy.

PURPOSE:

The Ultrasonic sensor which is used in this project detects the level of the waste in the bin and other detects the person approaching the bin to dispose the waste . One of the best types of smart bin sensors, the Fill Level Sensor, supported by IoT technology, We can Track the location with real-time data. View fullness levels for creating daily optimized routes for collection.

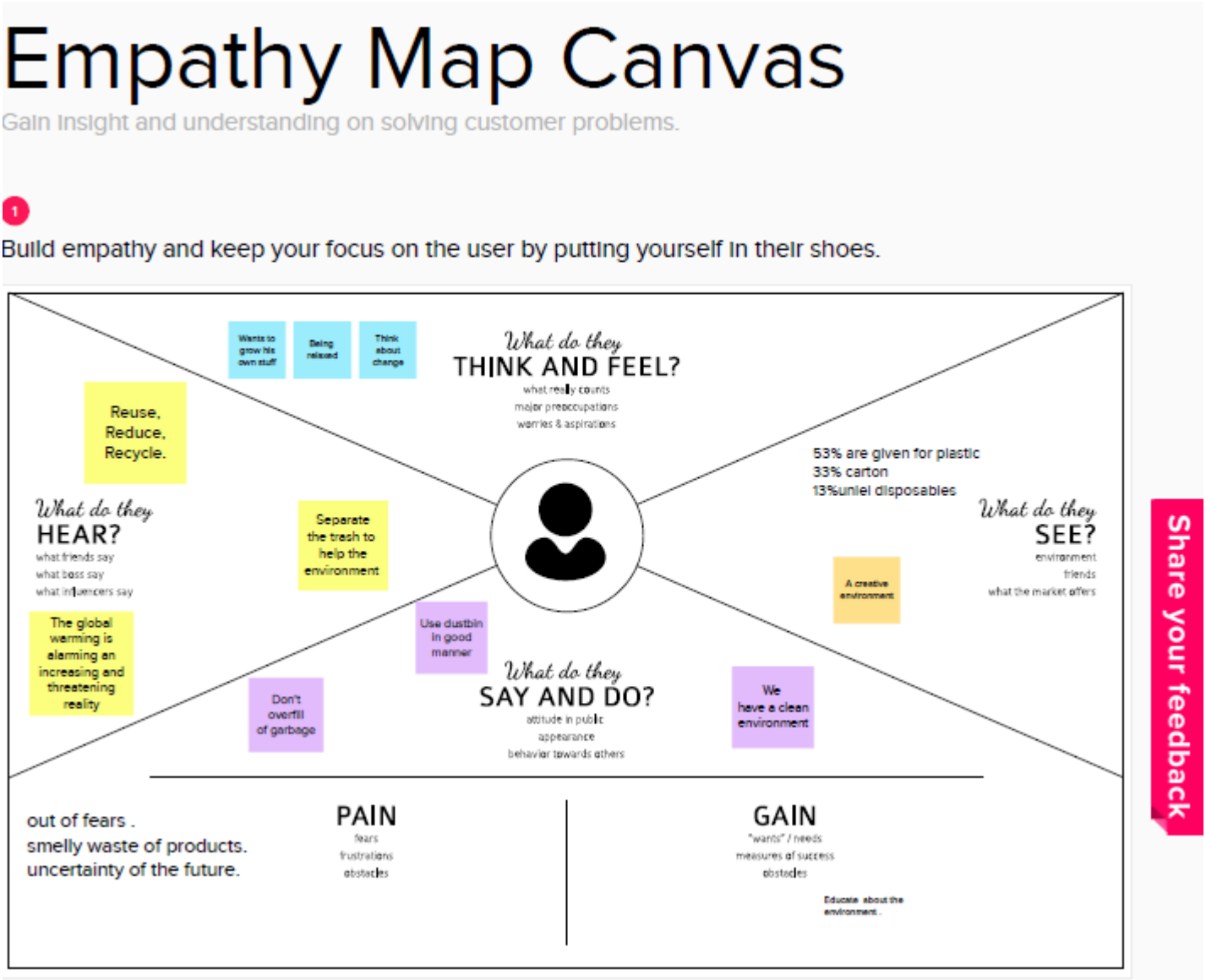
LITERATURE SURVEY:

INTRODUCTION		SURVEY/BODY OF REVIEW		
Title	**Author**	**Problem**	**Methodology**	**Input parameters**
GARBAGE MONITORING SYSTEM FOR SMART CITIES	Lilyan Anthony, Pradnya Chavan, Astrid Ferreira, Prerana Gadhave, Archana Shirke	In this paper, a model has beenproposed in which the collection of garbage is made real time. A network is established using wireless sensors with each dustbin attached to a sensor circuitry.The sensor is placed in the garbage bin, setat a particular level. If that level is crossed by the garbage in the bin, the sensor will senda signal to the nearest vehicle driver along with the authorities in charge.	**Tools used:** Ultrasonic sensorsIoT BluetoothArduino Python **Implementation:** 1. Sensors All types of sensors used for implementation of asystem based on IOTare included here. 2. Communication Module Provides interface between the communication between Hardware (Sensor) and the Application (Web- page). 3. Processing Module Deals with data processing of the signals received from the sensors. In this system, the binsare connected to the internet to get the real time information of the garbage levels.	Garbage level, Density of garbage
IoT Enabled Smart WasteBin with Real Time Monitoring for efficient Waste Management in MetropolitanCities	Manju Mohan, RM. Kuppan Chetty, Vijayram Sriram, Mohd. Azeem , P. Vishal and G. Pranav	In this paper, design of a Waste Bin with real time monitoring is presented and a smart waste management system is proposed using the recent technical advancements of automation and Internet of Things (IoT). Thecapacitance sensor in the bin continuously monitors the level of the bin in real time and communicates to the central cloud where thebins are connected.	**Tools used:** Matlab Ultrasonic sensor Microcontroller Servomotor Arduino Capacitance sensor **Implementation:** The capacitance sensor in the bin continuously monitors the level ofthe bin in real time and communicates to the central cloud where the bins are connected. Ultrasonic sensor is used to open and close the lid of the bin whenever the persons are nearby the bin. Such smart bins are connected to the cloud, where the bin status are communicated, recorded and monitored by the local bodies throughand android app or acentralized server.	Garbage, Weather,Rain water

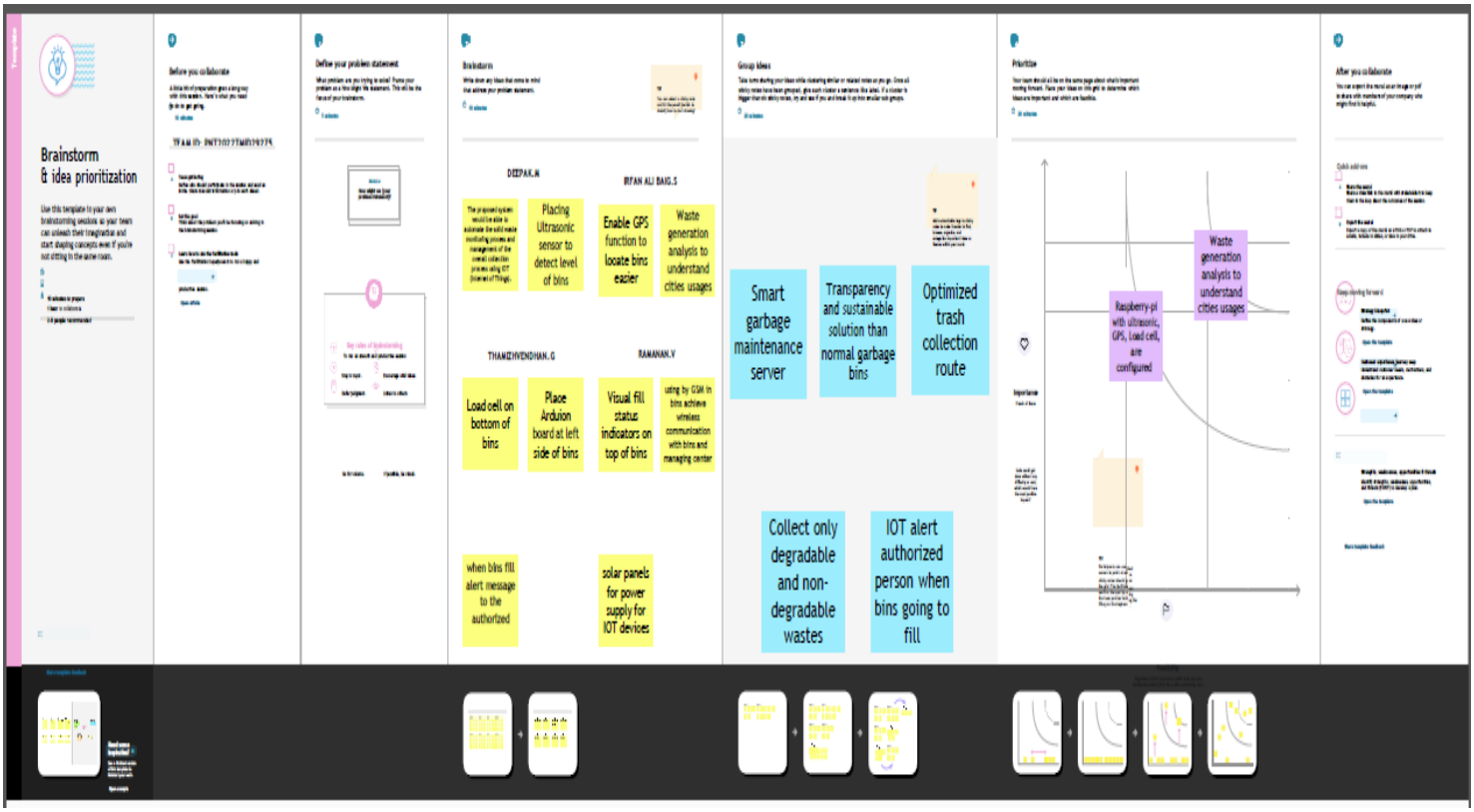
SMART GARBAGE MONITORING SYSTEM USING IOT	Dr. Ihtiram Raza Khan, Mehtab Alam, Anuj Razdan	Garbage Monitoring System using an ultrasonic sensor as a distance measurement sensor, GPS willassist in sendinga garbage bins location and GSM will assist in sending a message to municipal authorities.	**Tools used:** GPS GSM Arduino Ultrasonic sensor **Implementation:** • Sends a "DUSTBINFULL" warning message to municipal officials. • The purpose of theproject is to help manage waste management in urban and rural areas • The project will send an SMS to municipal officials containing information aboutdustbin. • SMS will be sentvia GPS location • Buzzer indicating astate of overflow.	Garbage, Weather conditions, Garbage level

Machine Learning and IoT-Based Waste Management Model	Rizwan Khan, Santosh Kumar, Akhilesh Kumar Srivastava, Niharika Dhingra, Mahima Gupta, Neha Bhati, and Pallavi Kumari	1. Lack of Awareness about Waste Management. 2. Participation of Organized Sector for Carrying Out Efficient Management of Waste. 3. Lack of Technical Solution and Public-Private Partnership. 4. Transport of Waste.	**Tools used:** Arduino UNO, Microcontroller, Sensors, GPS, ML & IoT **Implementation:** Ultrasonic sensor will depict the assorted distance from waste in the dustbins. It is used for the space measurement purpose and the moisture sensor determines whetherthe waste is moist ordry. Using image processing, we will measure the waste index of a specific dumping ground .A dumper truck database has been generated in the given system so thatdata and details of dumper truck ID, meeting date, meeting time of garbage collection, and so on are collected. Mobile application developed will monitor important time movement andtrack vehicular movement. It will send an optimized track to destination waste to the teamster.	Moisturecontent in the garbage. Garbage level, Bin location.

IDEATION AND PROPOSED SOLUTION:



IDEATION AND BRAINSTROMING:



PROPOSED SOLUTION:

S.No	Parameter	Description
1	Problem Statement (Problemto besolved)	Detecting the level of garbage and informing thegarbagecollectors through a proper communication channel about the garbage level and alerts them to collect it at a specified time efficiently.
2	Idea / Solution description	> By using fill level sensors we can detect the garbage level.Improving the communication channel using proper technology like WiMAX. > Using GPS for tracking the location of bin and sorting outthe short routes. > Using cloudservice for the storage purpose
3	Novelty / Uniqueness	By using IoT, GPS and GSM like technologies which if properly usedin the establishment of this projecthelpsto detect the garbage level and intimating about it to the authority and initiating them to collect the garbageon time.
4	Social Impact/ Customer Satisfaction	It keeps our surroundings clean and green and free frombad odour of wastes, emphasizes on healthy environment. Reduces air pollution.
5	Business Model (Revenue Model)	Smart wastemanagement system is an innovative andeffective step to analyze the production of waste annually and it helps to find the ways to reduce thefactors which increases the waste produced.
6	Scalability of the Solution	Smart waste management can attain its scalability by still more advancement in IoT and using many sensors to detect its accurate levelaccurately. Its implementation canbe enhanced by using 5G type of technology for faster communication. AI recycling robots can be used in the nearer future.

PROBLEM SOLUTION FIT:

Smart waste management system

Team ID : PNT2022TMID48488

STEP 1

Problem Solving Cards

-Basic question

#Problem Statement

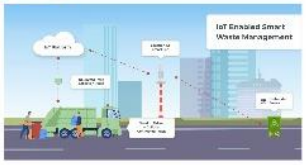
1. *What's most valuable to the customer?*
2. *What are we the best at?*
3. *Where are we looking to improve?*

STEP 2

Framing Statements

Smart waste management system framing

How can we use our Optimization skills to increase the customers value of Saving Time in order to improve the waste management?



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 and 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 and collecting methods. Not only that, there is even no systematic methodology for the collected garbage for treating and recycling thus most of them end up in land filling and river water, making the environment unhealthier.
The prime impediment of implementing smart waste management system based on IoT in a developing country is the social and economic infrastructure of the country itself. The initial stage of this system comprises of proper disposal and collection, which is the biggest challenge. In addition, to motivate and influence people to follow proper waste disposal methods is also important.

STEP 3

Ideas

Problem Solution

Example ideas:

Ai-based smart waste bin, designed for public places, enabling them to Monitor and Manage

Reduce the number of bins required & DE-cluttering and improving the street scene

Previously there were numerous initiatives on waste management and educating people to dispose waste properly, and as they failed to achieve significant results, we have figured out the scopes that could be develop. To solve this problem, we have designed a process that ensures proper disposal and efficient waste collection. The procedures we designed involves creative initiative that will inspire people to dump in designated area or bins, and innovative method by using Decreasing Time algorithm or DTA for monitoring garbage generation and collection of the garbage's.

REQUIREMENT ANALYSIS:

FUNCTIONAL REQUIREMENTS:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Detailed bin inventory.	All monitored bins and stands can be seen onthe 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-2	Real time bin monitoring.	The Dashboard displays real-time data onfill-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 inthe 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-3	Expensive bins.	We help you identify bins that drive up your collection costs. The tool calculates a rating for each bin in terms of collection costs. The tool considers the average distance depo-bin- discharge in the area. The tool assigns bin a rating (1-10) and calculates distance from depo-bin discharge.
FR-4	Adjust bin distribution.	Ensure the most optimal distribution of bins. Identify areas with either dense or sparse bin distribution. Make sure all trash types are represented within a stand. Based on the historical data, you can adjustbin capacity or location where necessary.

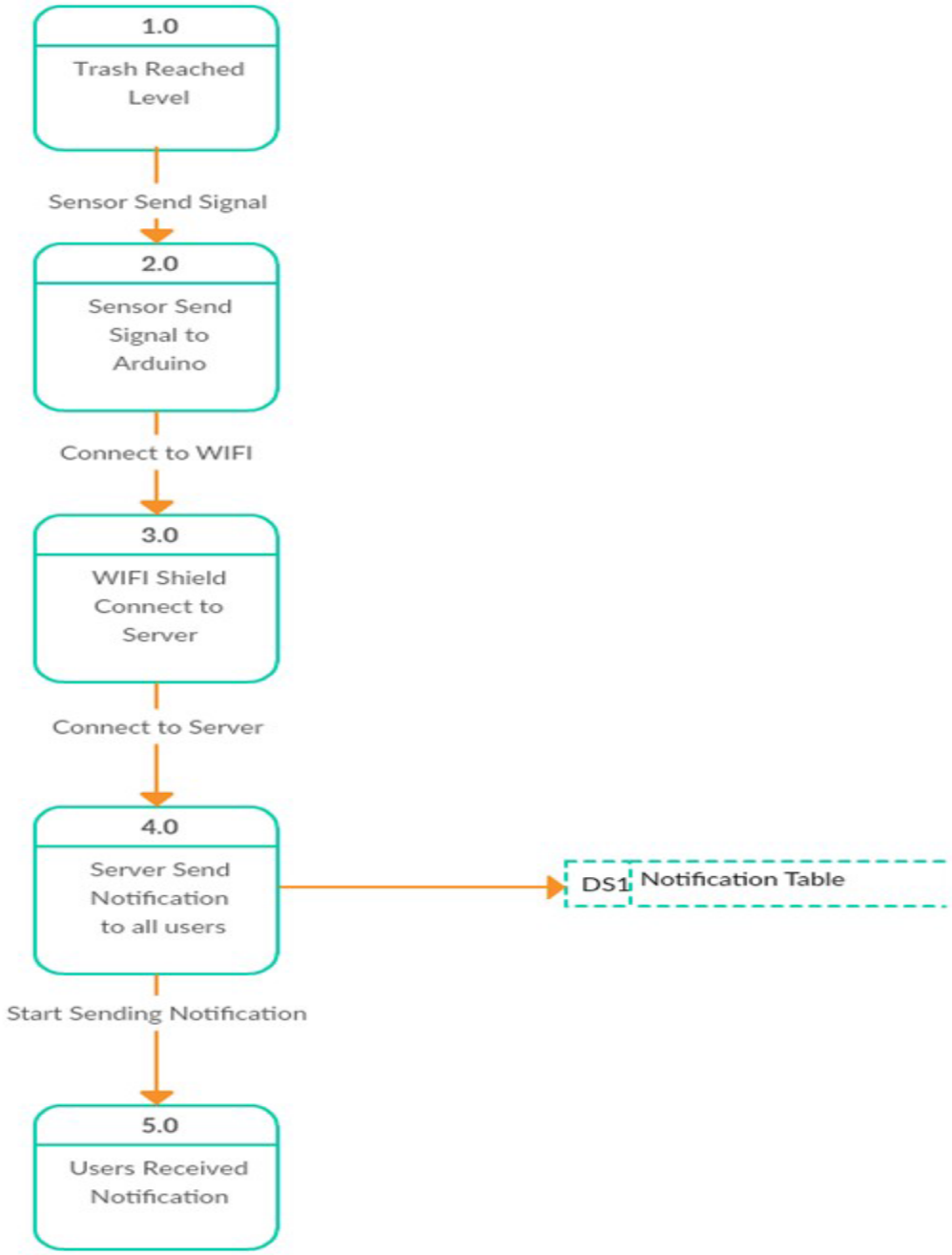
FR-5		The report shows how full the bin was when picked. You immediately see anyinefficient picks below 80% full.
FR-6	Plan waste collection routes.	The tool semi-automates waste collection route planning. Based on current bin fill- levels and predictions of reaching full capacity, you are ready to respond and schedule waste collection. You can compare planned vs. executed routesto identify any inconsistencies.

NON - FUNCTIONAL REQUIREMENTS:

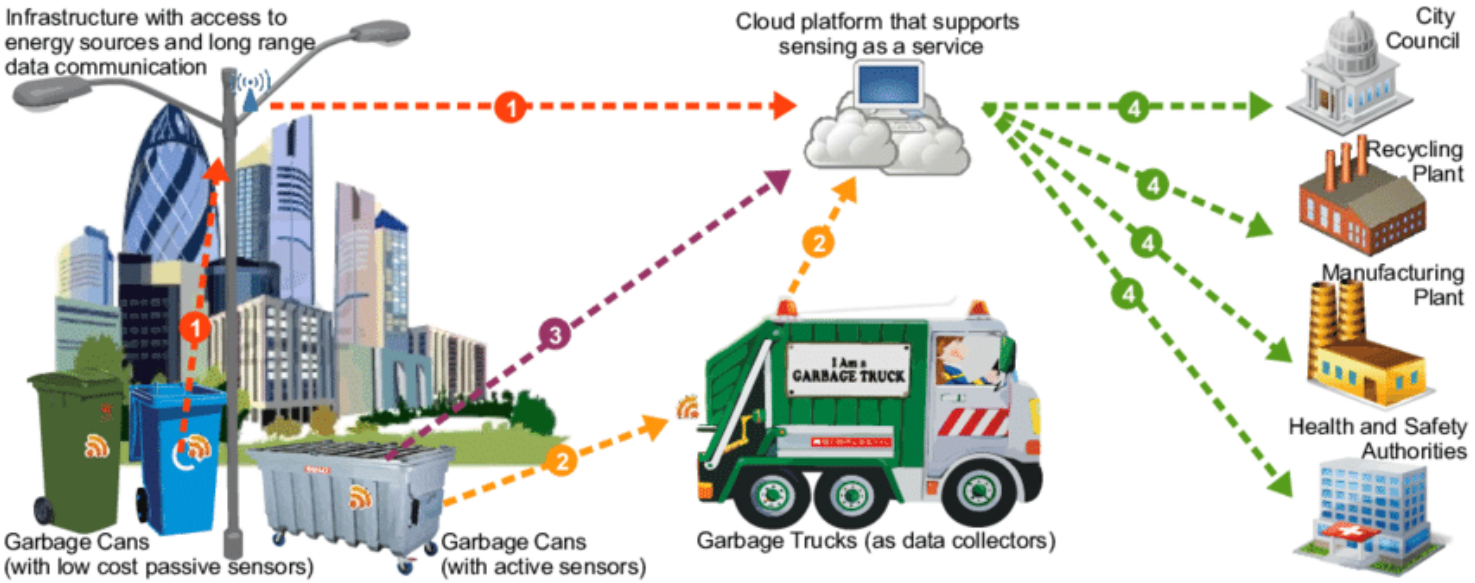
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	IoT device verifies that usability is a special and important perspective to analyze user requirements, which can further improve the design quality.
NFR-2	**Security**	We propose a Secure Incentive based Waste monitoring system to encourage garbage segregation at the initial level.
NFR-3	**Reliability**	Smart waste management is also about creating better working conditions for waste collectors and drivers. Instead of driving the same collection routes and servicing empty bins, waste collectors will spend their time more efficiently, taking care of bins that need servicing.
NFR-4	**Performance**	The Smart Sensors use ultrasound technology to measure the fill levels. focuses on solving the previously mentioned solid waste management problems using sensors, intelligent monitoring systems, and mobile applications.
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 as we are monitoring the whole 24 hours of 7days Smart waste bins are more cost efficient and scalability

PROJECT FLOW DIAGRAM:

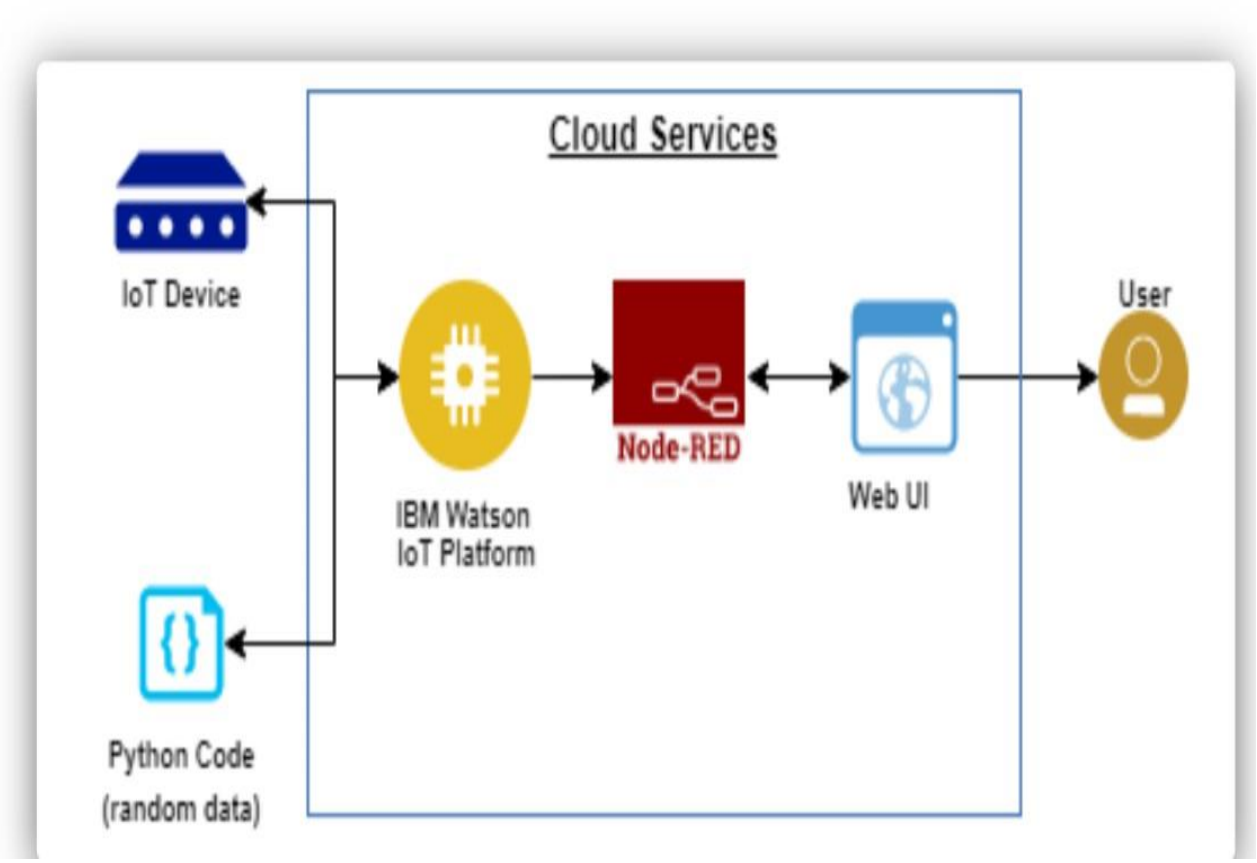
DATA FLOW DIAGRAM:



SOLUTION ARCHITECTURE:



TECHNICAL ARCHITECTURE:



USER STORIES:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Admin(who manages server)	Web server login	USN-1	As a admin, I can able to track the truck driver name, id, contact number, location, and also the location of the dustbin.	I can Manage and direct workers through web server	High	Sprint-1
Co-Admin	Login	USN-2	As a co-admin I'll monitor the workers, whether the work has been done properly, checking the availability of workers and also monitor the waste collected by the truck driver within the	I can monitor the garbage bin activity	High	Sprint-1

			scheduled time.			
Customer (Web user)	User	USN-3	As a user , I can able to raise queries to higher authorities about the maintenance and disposal of waste	I can raise queries	Medium	Sprint-2
Customer Care Executive	Worker	USN-4	As a customer care executive I will try to rectify the queries from customers by contacting co-admin. In case of emergency situation query can be reported to Admin.	I can attend calls and respond people and solve their problems	High	Sprint-1
Truck driver	Worker	USN-5	The truck driver is a worker who has been assigned to collect the garbage and he have to report to admin about when and where and also the timings , the garbage has been picked up according the daily schedule.	I will do the work properly and report the data at the scheduled time	High	Sprint-1

PROJECT PLANNING AND SCHEDULING:

SPRINT PLANNING AND ESTIMATION:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Prioriy	TEAM MEMBERS
Sprint-1	Login	USN-1	As a Administrator, I need to give user id and passcode for every workers over there in municipality	10	High	Irfan Ali Baig
Sprint-1	Login	USN-2	As a Co-Admin, I'll control the waste level by monitoring them by real time web portal. Once the filling happens, I'll notify trash truck with location of binwith bin ID	10	High	Thamizhvendhan
Sprint-2	Dashboard	USN-3	As a Truck Driver, I'll follow Co-Admin'sInstruction to reach the filling bin in short roots and save time	20	Low	Deepak
Sprint-3	Dashboard	USN-4	As a Local Garbage Collector, I'II gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills	20	Medium	Ramanan
Sprint-4	Dashboard	USN-5	As a Municipality officer, I'll make sureeverything problems	20	High	Ramanan

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint ReleaseDate (Actual)
Sprint-1	20	8 Days	24 Oct 2022	02 Nov 2022	20	02 Nov 2022
Sprint-2	20	8 Days	02 Nov 2022	10 Nov 2022	20	10 Nov 2022
Sprint-3	20	8 Days	10 Nov 2022	18Nov 2022	20	18 Nov 2022
Sprint-4	20	8 Days	18 Nov 2022	26 Nov 2022	20	26 Nov 2022

SPRINT DELIVERY SCHEDULE:

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	Literature survey on the selected project & gathering informationby referring the, technical papers,research publications etc.	07 OCTOBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements	07 OCTOBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	07 OCTOBER 2022
Proposed Solution	Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalabilityof solution, etc.	08 OCTOBER 2022
Problem Solution Fit	Prepare problem - solution fit document.	08 OCTOBER 2022
Solution Architecture	Prepare solution architecture document.	08 OCTOBER 2022
Customer Journey	Prepare the customer journey maps to understand the user interactions & experiences with the	20 OCTOBER 2022

	application (entry to exit).	
Functional Requirement	Prepare the functional requirement document.	26 OCTOBER 2022
Data Flow Diagrams	Draw the data flow diagrams and submit for review.	26 OCTOBER 2022
Technology Architecture	Prepare the technology architecture diagram.	26 OCTOBER 2022
Prepare Milestone & Activity List	Prepare the milestones & activity list of the project.	26 OCTOBER 2022
Project Development - Delivery of Sprint-1,2, 3 & 4	Develop & submit the developed code by testing it.	COMPLETED…

REPORTS FROM JIRA:

CODING AND SOLUTIONS:

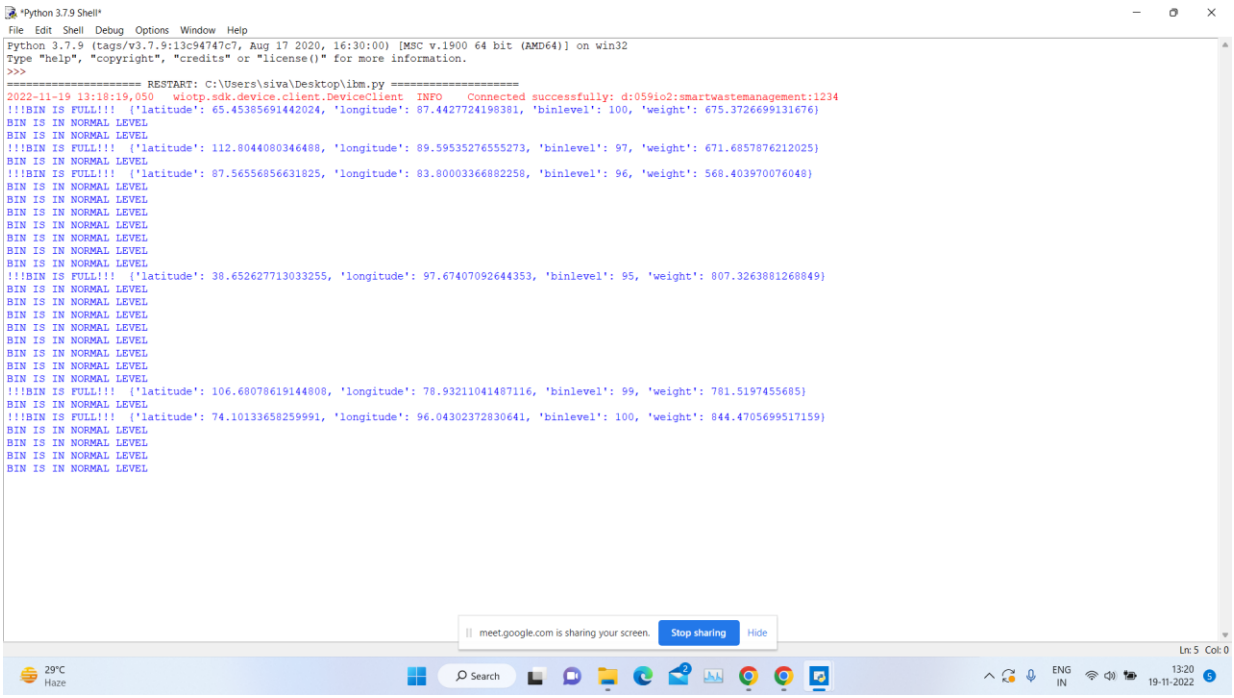
PYTHON CODE:

```
import wiotp.sdk.device
import time
import random
myConfig = {
"identity": {
"orgId": "059io2",
 "typeId": "smartwastemanagement",
 "deviceId":"1234"
 },
 "auth": {
 "token": "12345678"
 }
}
def myCommandCallback(cmd):
    print("Message received from IBM IoT Platform: %s" % cmd.data['command'])
    m=cmd.data['command']
client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)
client.connect()
while True:
    latitude=random.uniform(27.2046,125.25)
    longitude=random.uniform(77.4977,100.1526)
    binlevel=random.randint(10,100)
    weight=random.uniform(500,1000)

    if binlevel >= 90:
        myData={'latitude':latitude, 'longitude':longitude,'binlevel':binlevel,'weight':weight}
        client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0,
                        onPublish=None)

        print("!!!BIN IS FULL!!! ",myData)
        client.commandCallback = myCommandCallback
        time.sleep(4)
    else :
        print("BIN IS IN NORMAL LEVEL")
        time.sleep(4)
 client.disconnect()
```

OUTPUT:

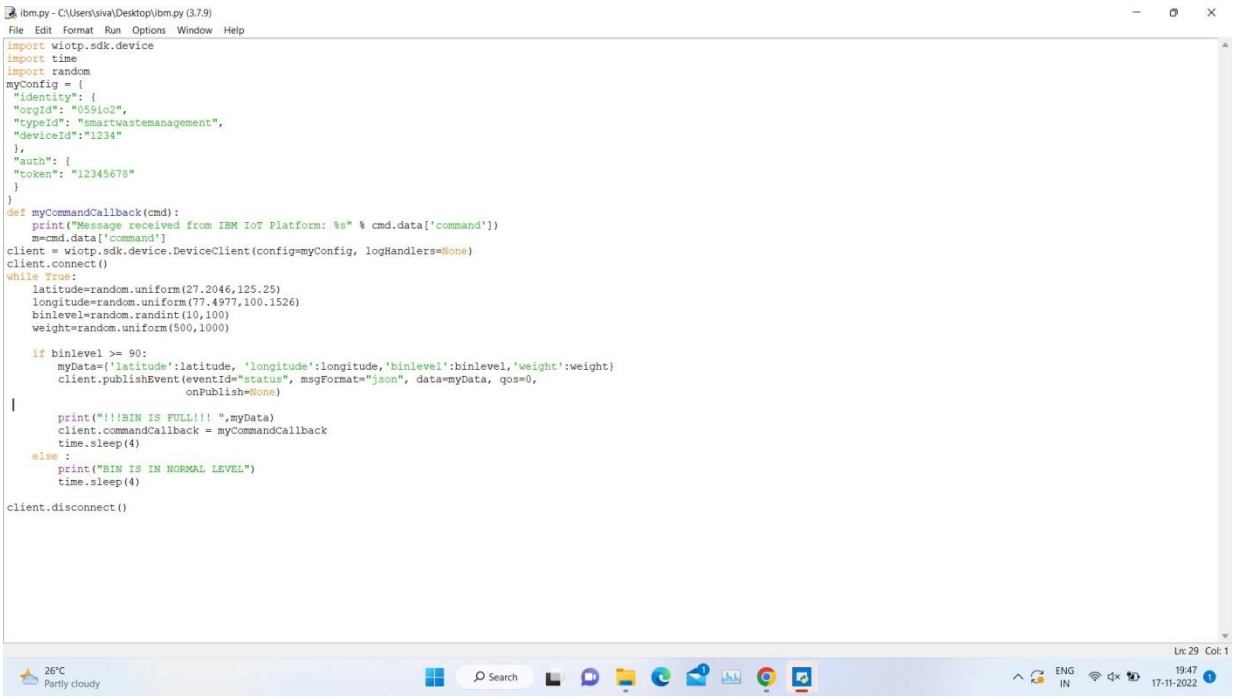


FEATURES ADDED:

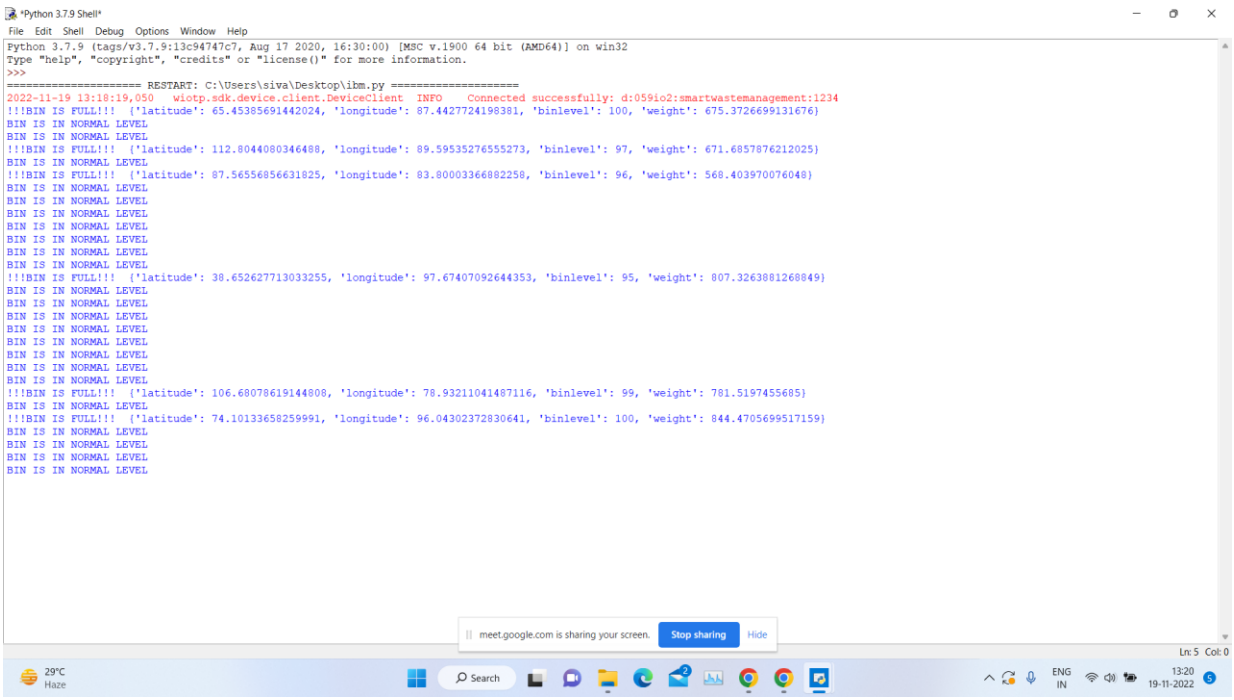
- ✓ In this project we have used python programming for coding purpose.
  Imported random module in python to generate randon vaalues of latitude,longitude, binlevel and weight.
- ✓ And We used IoT platform of IBM and integrated python 3.7.0 with IBM IoT platform using typeID, deviceID and etc..,
- ✓ In IBM IoT paltform ,created a device and generated variables and data using random function.
- ✓ Node-RED was created and Node-RED flow was designed to get data from the devive of IoT.
- ✓ Node flow was created using dashboard nodes in Node-RED.
- ✓ And by the Node-RED flow the web UI was created successfully.
- ✓ To get to know about the details of garbage level and location ,a mobile application was created using MIT app inventor.
- ✓ Cloudant DB is created in the IBM cloud which is used to store the data
- ✓ The details from node RED after execution is stores the collected data about the latitude, longitude,binlevel, in the cloudant DB.

TESTING:

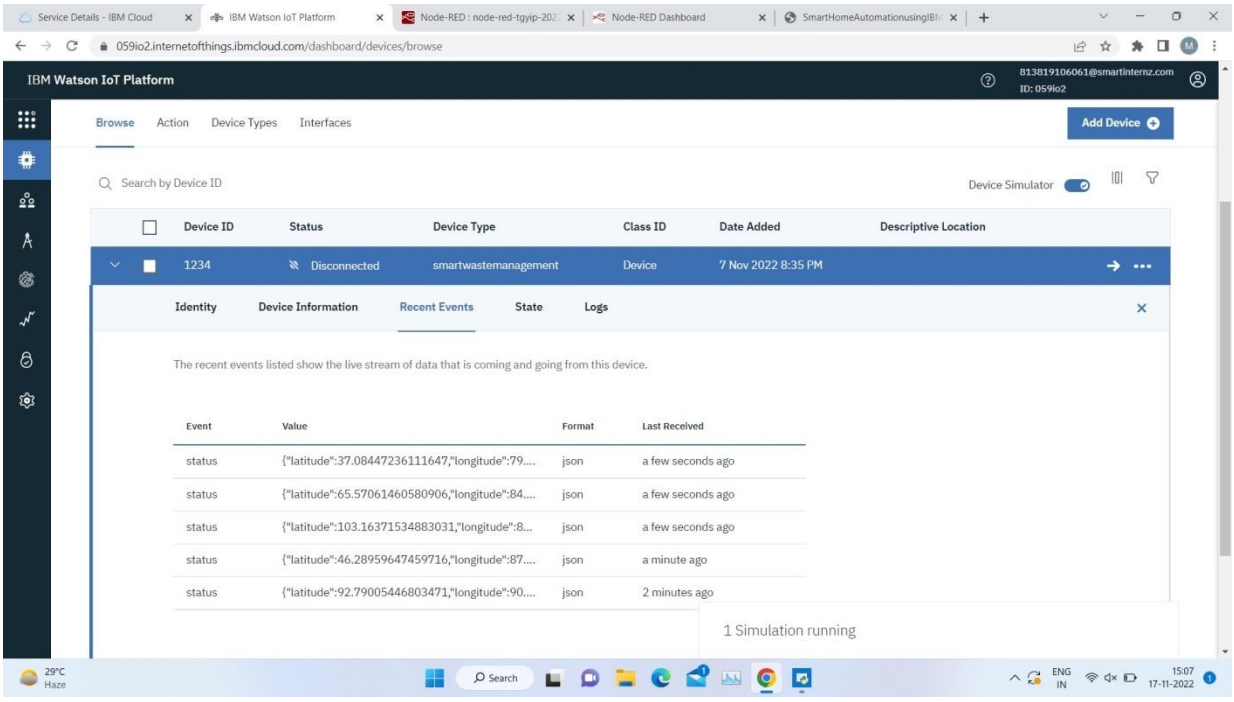
1.) The python program has been developed for smart waste management by importing random,time functions . And variables are assigned to hold the latitude,longitude,binlevel and weight values which is randomly generated .



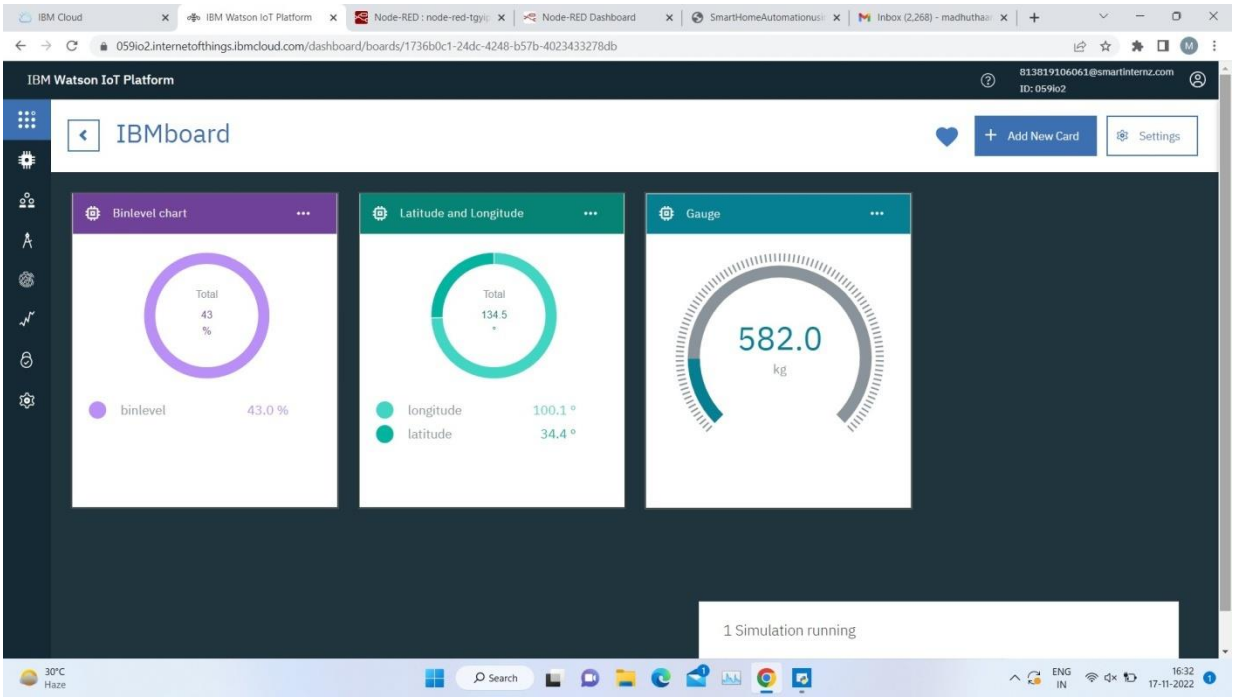
2.) The python program is now executed and the respective values are stored in the IoT platform of IBM for this the connection has been established between the python 3.7.0 and IoT platform (devices).



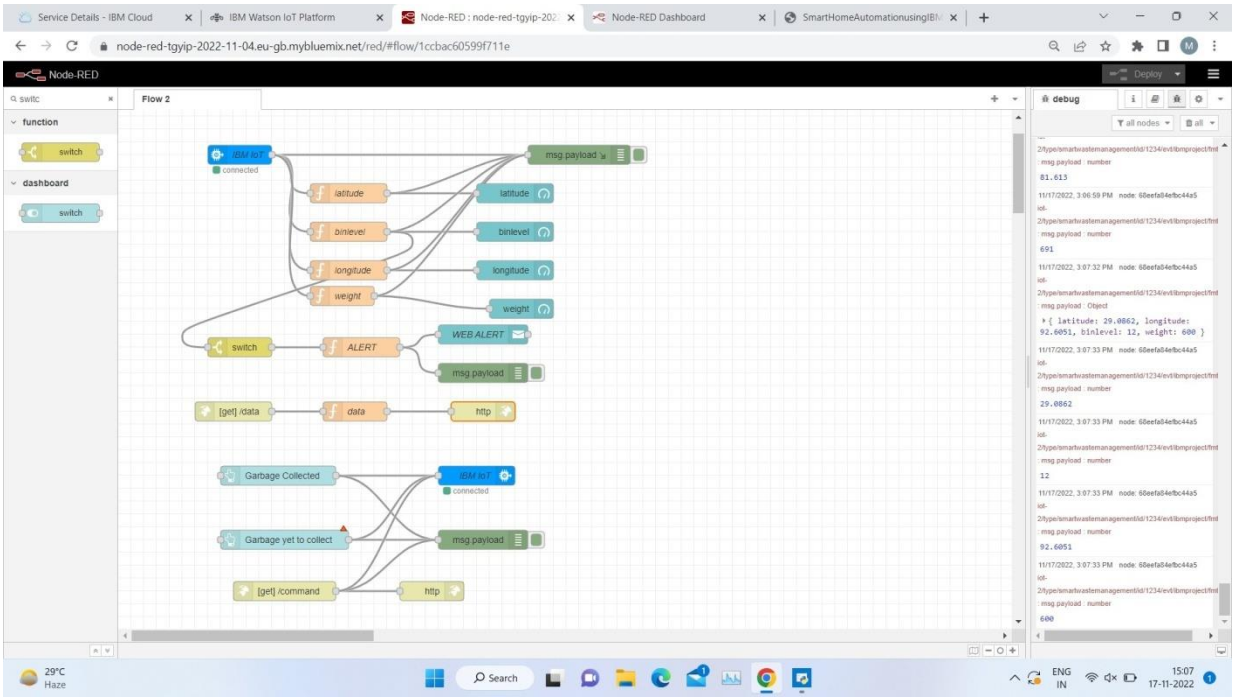
3.) The devices are created with respective variables to get feeded with the data when the python code has been executed and it used random function to generate the values.



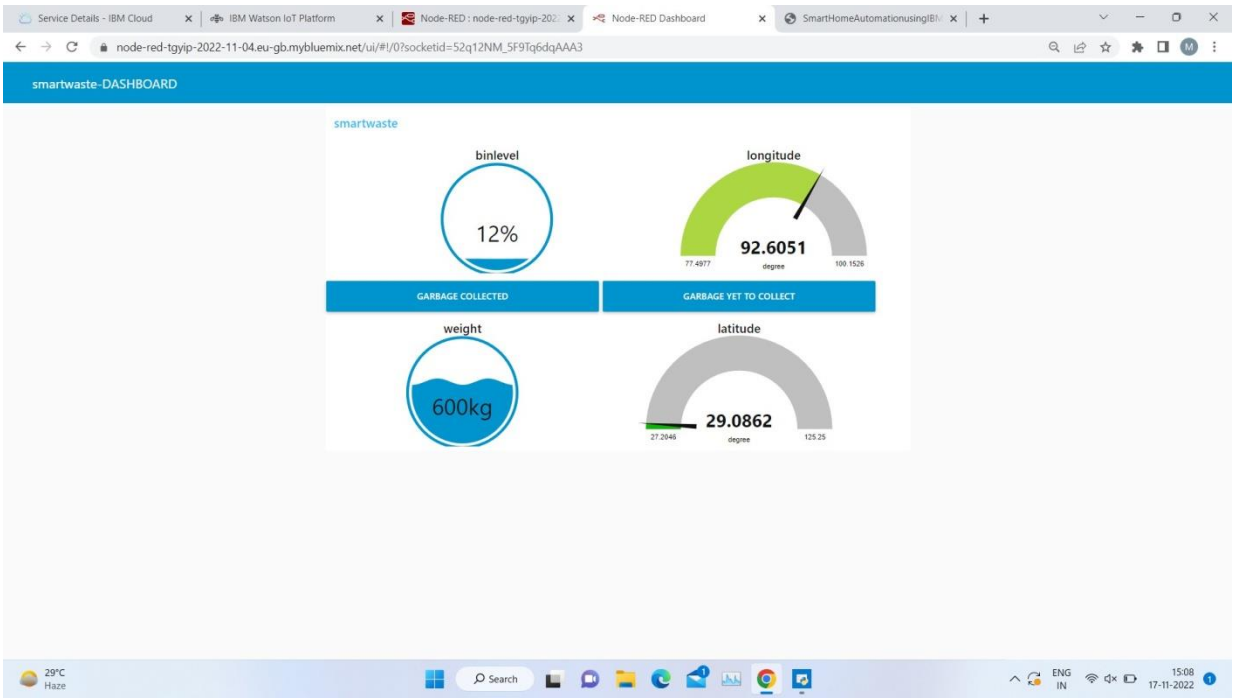
4.) The cards are created in IoT platform which receives the values from the device and it represents the values in graphical representation.



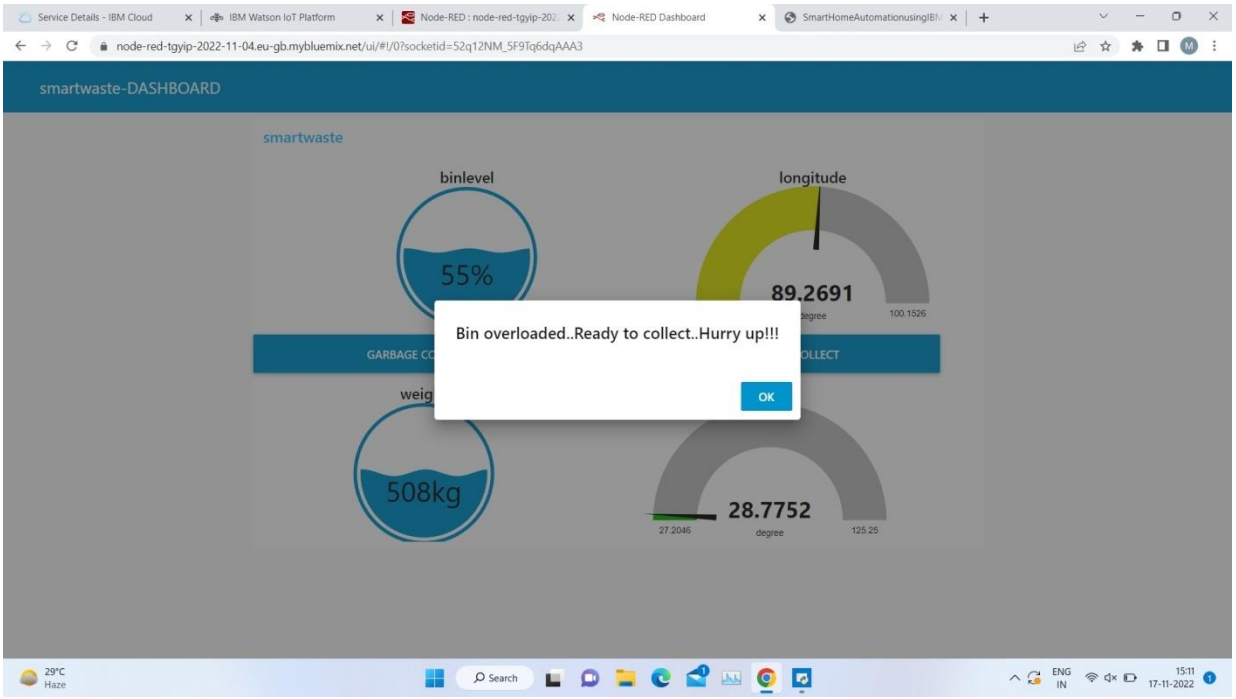
5.) The Node-RED account was created and it is connected with the IBM IoT devices to fetch data.
The node flow diagram was designed using dashboard nodes.



6.) The web application is created using the node flow execution while it is deployed. It returns back the command to the node RED when the person who collects the garbage acknowledges about whether he is yet to collect or it is collected.

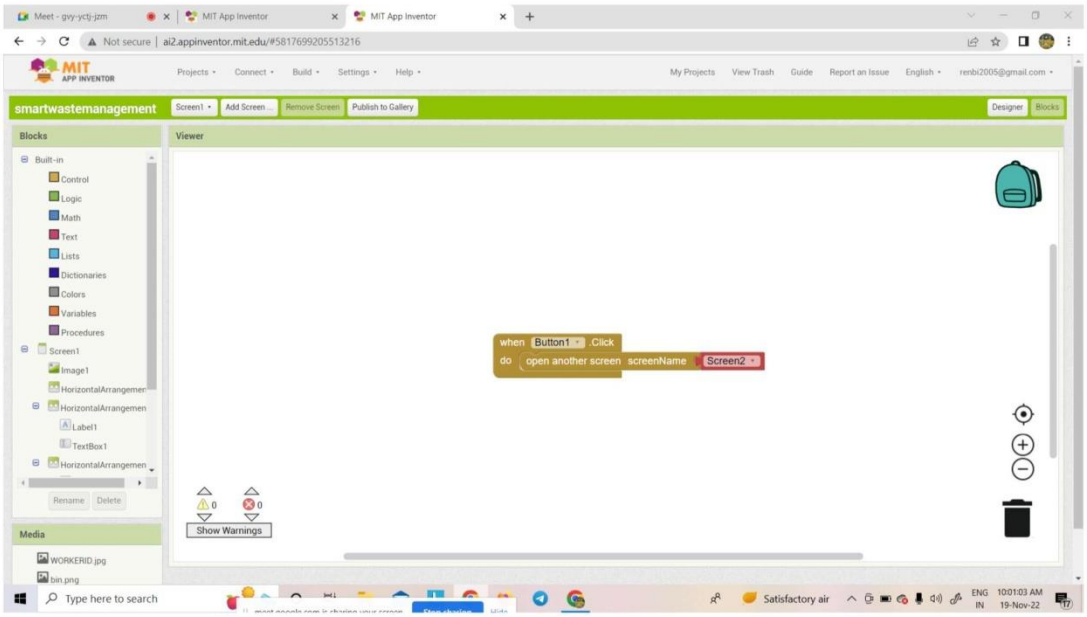


7.) It gives on the alert message on the web application screen at the moment when the bin level reaches above 90%.

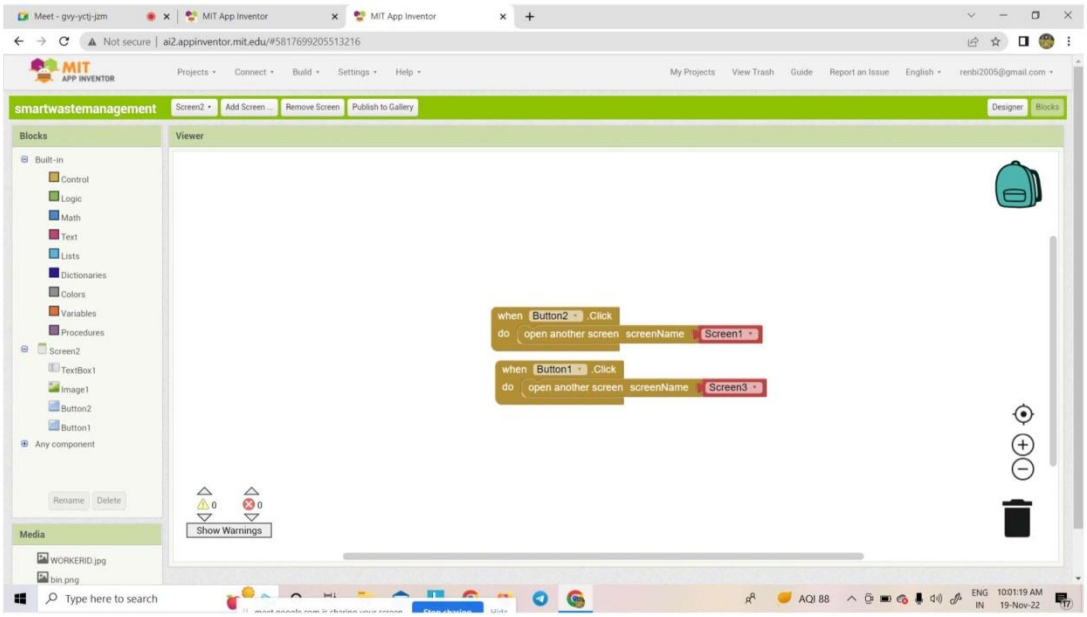


8.) A mobile application is created using MIT app inventor so that the person who is responsible to collect can get to know about the details of garbage level and its location and can also acknowledge the status in the mobile itself .

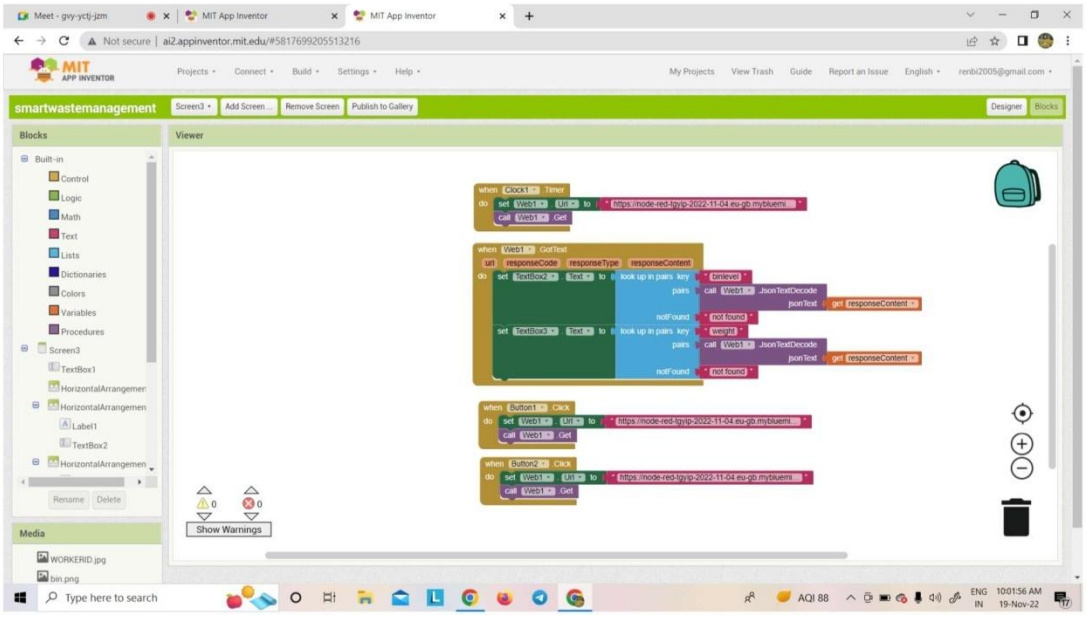

3:27
48%
Screen1
WORKER ID:
A274905
PASSWORD:
LOGIN


MIT App Inventor
Not secure | ai2.appinventor.mit.edu/#5817699205513216
smartwastemanagement
Screen1
Add Screen ...
Remove Screen
Publish to Gallery
Designer
Blocks
Viewer
when Button1 .Click
do open another screen screenName Screen2
Show Warnings
Media
WORKERID.jpg
bin.png
Type here to search
Satisfactory air
ENG
IN
10:01:03 AM
19-Nov-22

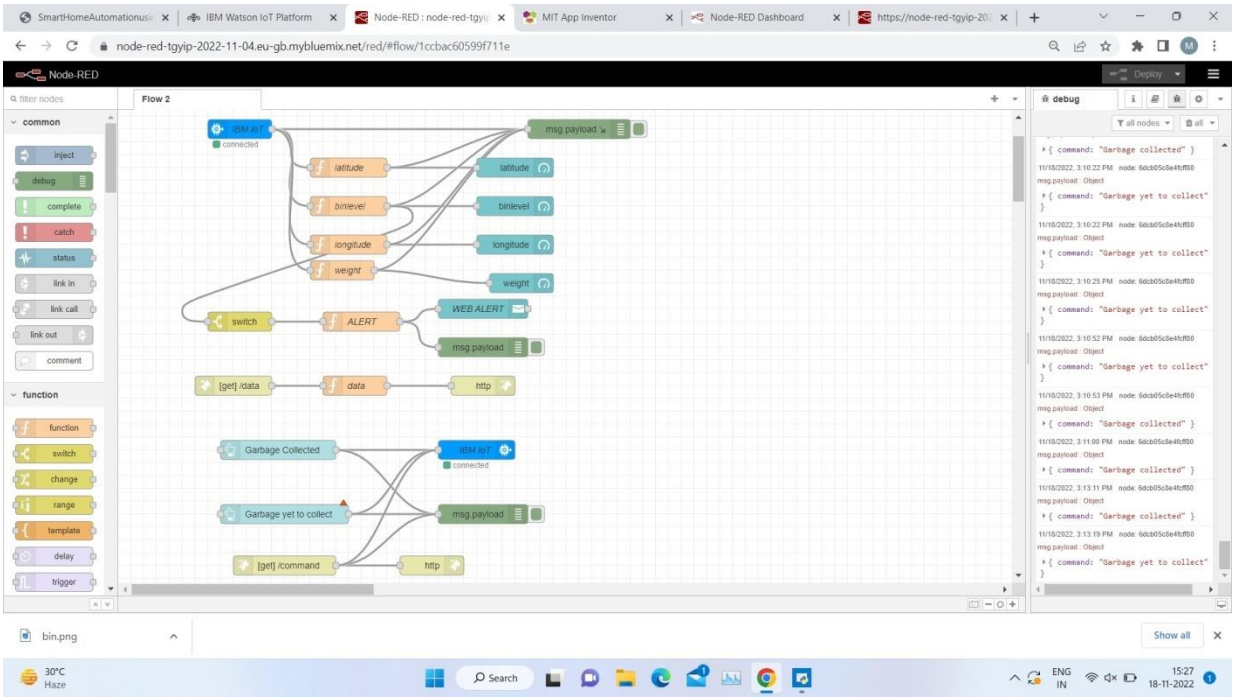
WORKER ID	BIN NUMBER	LOCATION	CONTACT NUMBER
A274901	B1	SAIDAPET	9876543210
A274902	B2	CHROMPET	9123456789
A274903	B3	NUGAM PAKKAM	9783300251
A274904	B4	VELACHERRY	9231456567
A274905	B5	T NAGAR	8251529005
A274906	B6	MADAVARAM	7345689010
A274907	B7	WEST MAMBALAM	9462759857




3:28
48%
Screen3
BIN_DETAILS
Binlevel : 46
Weight : 615
Garbage collected
Garbage yet to collect


MIT App Inventor
smartwastemanagement
Blocks
Viewer
Show Warnings

9.) The command is received back to the node-RED debug window when the person acknowledge about the status of the garbage collection.



RESULTS:

PERFORMANCE METRICS:

PARAMETER	PLATFORM	SCREENSHOT
Metrics	Python	
	Node Red	
	MIT App	

ADVANTAGES:

- ☆ It keeps our surroundings clean and green and free from bad odour of wastes, emphasizes on healthy environment and keep cities more beautiful.
- ☆ Applying smart waste management process to the city optimizes management and resources which makes it a "smart city".
- ☆ It saves time by using smart waste collection bins and systems equipped with fill level sensors. As smart transport vehicles go only to the filled containers or bins. It reduces infrastructure, operating and maintenance costs by upto 30%.
- ☆ It helps administration to generate extra revenue by advertisements on smart devices.

DISADVANTAGES:

- Sensor nodes used in the dustbins have limited memory size.
- Wireless technologies used in the system such as zigbee and wifi have shorter range and lower data speed.
- System requires more 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 method.
- The trainining has to be provided to the people involved in the smart waste management system.

CONCLUSION:

Improper disposal and improper maintainance of domestic waste create issues in public health and environment pollution thus this paper attempts to provide practical solution towards managing the waste collaborating it with the use of IOT.

Once the trash is dumped into the bin. the proposed system will definitely help to overcome all the serious issues related to waste and keep the environment clean.

FUTURE SCOPE:

- The WiMAX technology can be used instead of Bluetooth to cover large areas, but for cost effectiveness, we are implementing this system using Bluetooth.
- This system could find an application in smart buildings where the waste management could be practiced autonomously in a smarter way.
- Our future work is to investigate the performance of the proposed traditional and robotic waste management system in outdoor and indoor environment
- This method ensures that waste is collected as soon as it reaches the maximum level. As a result, the system will provide accurate reports, therefore boosting its efficiency.
- All bins are equipped with GPRS enabled embedded system. Central servers receive information from bins. It can store all necessary information Thus based on prediction of collected data on bin level, it enables optimization of number of vehicles used. An application for smartphone will be developed, through which citizens can report to municipal office.

APPENDIX:

SOURCE CODE:

PYTHON CODE:

```
import wiotp.sdk.device
import time
import random
myConfig = {
"identity": {
"orgId": "059io2",
 "typeId": "smartwastemanagement",
 "deviceId":"1234"
 },
 "auth": {
 "token": "12345678"
 }
}
def myCommandCallback(cmd):
    print("Message received from IBM IoT Platform: %s" % cmd.data['command'])
    m=cmd.data['command']
client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)
client.connect()
while True:
    latitude=random.uniform(27.2046,125.25)
    longitude=random.uniform(77.4977,100.1526)
    binlevel=random.randint(10,100)
    weight=random.uniform(500,1000)
    if binlevel >= 90:
        myData={'latitude':latitude, 'longitude':longitude,'binlevel':binlevel,'weight':weight}
        client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0,
                        onPublish=None)

        print("!!!BIN IS FULL!!! ",myData)
        client.commandCallback = myCommandCallback
        time.sleep(4)
    else :
        print("BIN IS IN NORMAL LEVEL")
        time.sleep(4)
 client.disconnect()
```

GITHUB LINK:

https://github.com/IBM-EPBL/IBM-Project-16513-1659616096

PROJECT DEMO LINK:

https://drive.google.com/file/d/1Of2Xkq51CqW8agc7rhSKJi8sYjPaC4Sj/view?usp=drivesdk