Smart Waste Management System For Metropolitan Cities

INTRODUCTION

OVERVIEW:

The main aim of our project is to develop a smart waste management system for metropolitan cities which will help us to keep track of the quantity in all bins and whenever the bins are full, it will automatically send alerts to their respective authorizer via message. Also, we can keep in touch with location with latitude and longitude in the text box and also in the map on the app.

PURPOSE:

In the existing waste management systems in metropolitan cities the waste service will collect waste in predefined routes for certain areas on a regular basis and empty trash and recycle receptacles. The system creates the possibility of half or partially filled bins being emptied which cause excess use of city resources and transportation services. With the integration of IoT into the system it can be transitioned into data-driven collection processes.Smart waste management systems uses sensors placed in waste receptacles to measure fill levels and to notify city collection services when bins are ready to be emptied.The data collected by sensors can be used to identify fill patterns, optimize driver routes and schedules, and also reduce maintenance and operational costs too. The cost of implementation of the system is comparatively low when compared to loss occurred due to excess usage of transportation services which leads to wastage of fuel. This also reduces the amount of time to travel and creates a user convenience to show which bin is available to deposit the waste and maintaining the surrounding environment is easier to keep it more hygienic.

LITERATURE SURVEY

Existing Problem

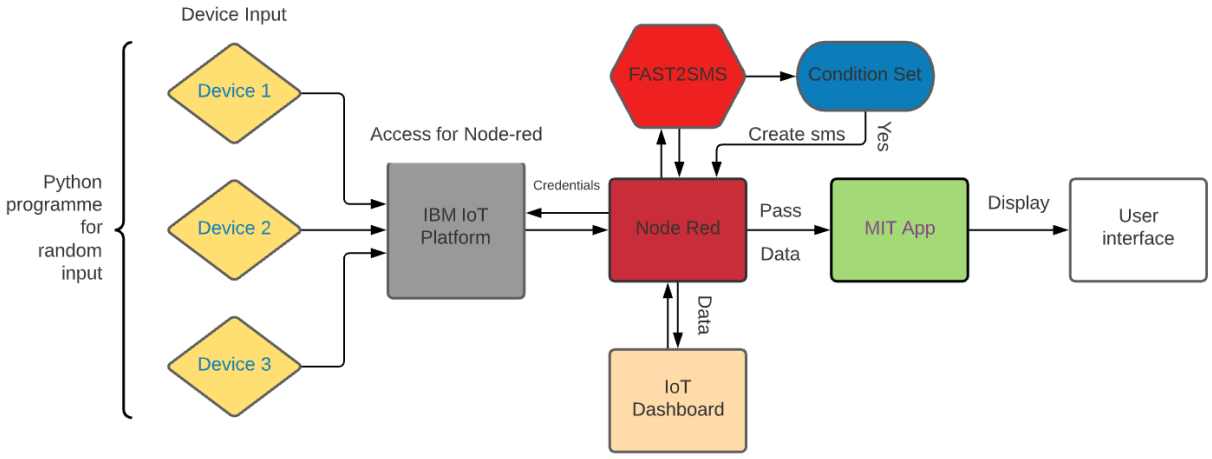
The management of waste is a critical aspect to look upon in the current world with increasing disposal rates. The traditional way of manually monitoring the wastes is a complex and cumbersome process which utilizes more human effort, time and cost which is not compatible with the growing present day technologies. Irregular management of waste which include domestic, industrial and environmental waste are major causes for many problems such as pollution, diseases and have adverse effects on the hygiene of living beings.The system also causes excess use of man-power and transportation services which can be used for other purposes. The amount of waste deposited is not in small quantities each day a tons of waste is generated from cities which are not properly disposed of or the bins are not cleaned properly as no one knows either cares to inform it thinking it as a waste of time which in turn cost more money and resources due to excess of waste dumped in street, cities and other places spending huge amounts of money and time every year for waste collection.

Proposed System

In order to overcome all these problems, we are proposing the idea of smart waste management system which helps in efficient management of waste to maintain a clean environment. The concept of smart waste management is implementable in cities where waste production is domestically high. This idea is compatible mainly with the metropolitan cities avoiding the congested collection of waste generated domestically which creates difficulty to manage its disposal. All cities, regardless of their size, their geographical location or their economic level, spend huge amounts of money every year for waste collection. The number of bins located in the streets and the number of vehicles used to empty them are generally estimated based on the number of citizens which make the waste management system a herculean task for the government. Using this proposed system, the data of each bin can be collected into a single application where users can see the details of each bin within the locality containing the details of bin capacity, amount of deposited wasted, bin space and which bin is available to deposit shown from a map using a marker to tell the location and navigate the user to the respective bin. The system is connected with a SMS creation system that automatically sends a text notification to the officials along with the details of the bin, this is used when a bin is completely filled saving time and keeping better track of all waste within cities.

THEORETICAL ANALYSIS

BLOCK DIAGRAM:



The python program is used for taking random values from user within python shell which are fed as input to the IBM IoT platform connected to Node Red app which consists of various predefined function which facilitate the creation of application and FAST2SMS service sends required message via SMS to the user. The designing of the web user interface is facilitated by MIT app inventor.

SOFTWARE DESIGNING:

- Firstly, create accounts in IBM Iot platform, MIT app inventor and FAST2SMS.
- In the IBM IoT platform, open the NODE red app and design the required flow for the given application along with entering API key and token and deploy it successfully.
- Using Fast2sms, create a url link to send the msg.payload from node red based on the condition set by the user to the respective phone number provided.
- This helps to notify the user when the bin is completely full and also forward a notification to the respective person to empty the bin at the provided location.
- For user convenience using the MIT app inventor, design the user interface(front-end) under “designer” section and back-end under” blocks” section which consists of the URL to the Node Red service.
- MIT app inventor is used to design a simple application showing the details of all bins within the system along with a button to toggle to visualize each device (bin) closer along with its location info and amount of quantity present.
- After integrating all the functions, create a python program which acts as a device, in this case a dustbin where users can input random values indicating the filling of the bin.

- Connect the python program to IBM Iot platform using the credentials provided by the platform such as device ID, device type, authentication token and essential code for the application.
- This also acts as a UI to show the amount present in each device for every instance.
- Run the code and observe the data published in Node-RED and the user interface dashboard.

EXPERIMENTAL INVESTIGATIONS

The system consists of 3 platforms used for implementation, Node -red in IBM IOT platform, python shell and MIT app inventor. The python is used as a virtual device in place of Hardware components which takes user input as waste amount to indicate the filling of the device (Bins). IBM cloud to connect the data imported from python to the IBM Iot Platform passed to Node-red which is the front-end of the project. MIT app to create a UI for user convenience.

For analyzing the system, we defined 3 devices: Bin 1, Bin 2 and Bin 3. Each device is configured to the IBM platform using the credentials to pass the data through IBM cloud to node-red. This data consists of Name of the device, weight of waste as user input with a total variable that adds the amount of waste for instance and location info. To visualize the change in data, a print condition is set so each for instance, the user is able to check the amount of waste and device details within the python shell to check if the data is sent to IBM.

Once the data is passed from python, the data is checked using a switch case condition to determine which device info is passed from the user. Once the data corresponding to the device is found, it is saved into 5 global variables. Now the data is passed using http request node in node-red as a URL to MIT app for later purposes. Then the system is set a condition on the amount of waste a bin can occupy, for this purpose we set it 200KG as full condition using another switch case. When the value of weight passed is less than 200, the data is directly sent to a gauge meter shown in the dashboard for visualization. To see the location of the device, the system uses geofence, a node which uses the location info such as latitude and longitude which is passed from python shell to create a region at the specified area with a maker icon to view the location in the world map. This can also be seen in the dashboard alongside gauge values.

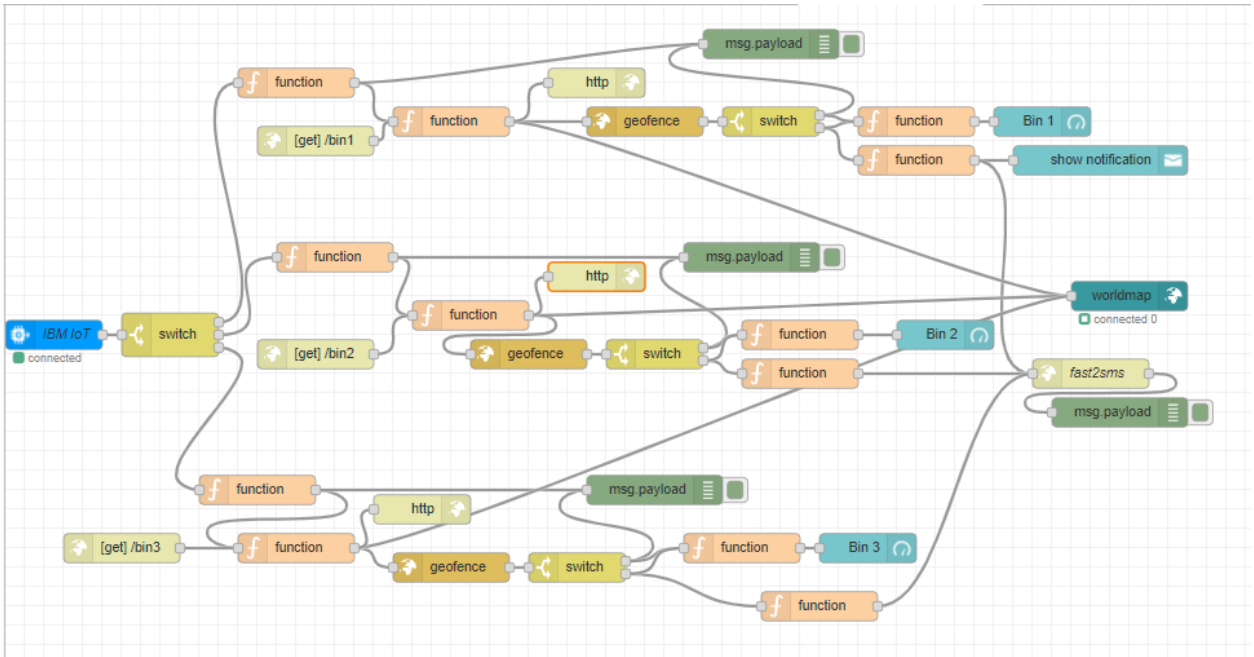
In case the value of weight is equal or greater to the capacity of the device (bin) which is 200kg, first the data is passed to gauge node so the data is seen in the dashboard, then a function node is set which consists of a message such as “empty this bin * name * along with the location of the bin. This is passed to a node called fast2sms which is a SMS service platform that generates a text message using a function call to the specified phone no in the node. The purpose of the node is to notify the user that the bin is full and contract respective officials to clean the bin. Fast2sms using a simple http push function which takes the specified info of the node and using the contact no as reference to pass the information which is very fast and avoids misplacement in destination.

Till now all components of the system is from the designer part view, for user inference, we used MIT app inventor which is an app developing software where the data from node-red is passed as http push and using a defined block flow takes the necessary data such as name of device, latitude and longitude and displays it in a text box for each device. It is convenient because when any update is done or bin data is changed every info is reflected back within the text box to indicate the change in device. This is useful as any change seen in the app is the real-time data collected from each bin located in the specified area. Using this app, in case of any waste to be deposited, users can navigate from the app to locate the bin which is not completely filled saving the time to search each bin in the locality thus saving energy.

The benefit of using a virtual device to test the system helps in reducing the occurrence of error and in case when the number of devices is increased, we can just copy the same node flow and block design and replace the variable to the bin count making it easy to modify and saves resources in final changes.

FLOWCHART

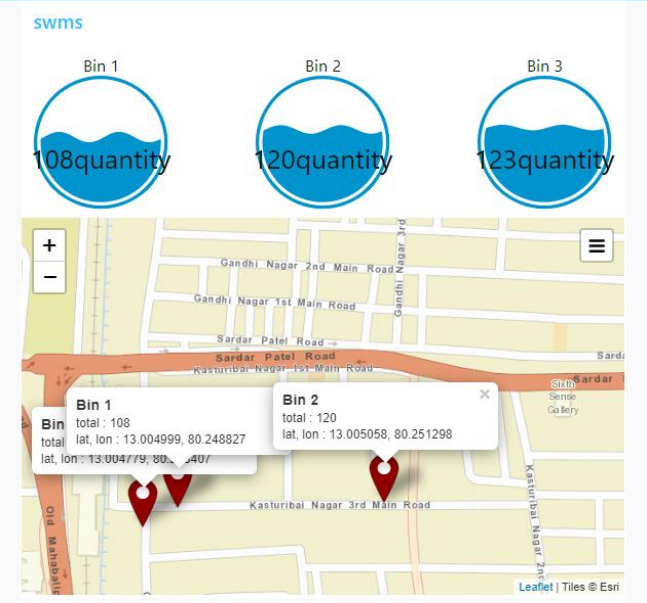
Node -red flow of three devices: Bin 1, Bin 2 and Bin 3 connected to IBM platform



RESULT

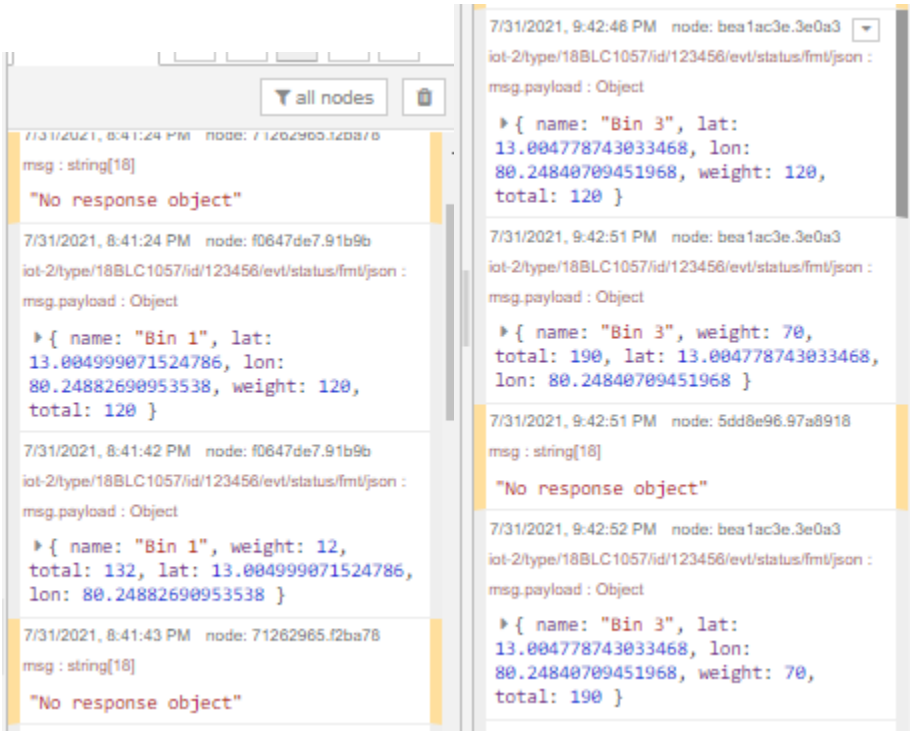
NODE-RED DASHBOARD:

Waste amount indicated in gauge for each device along with GPS locations in world map.



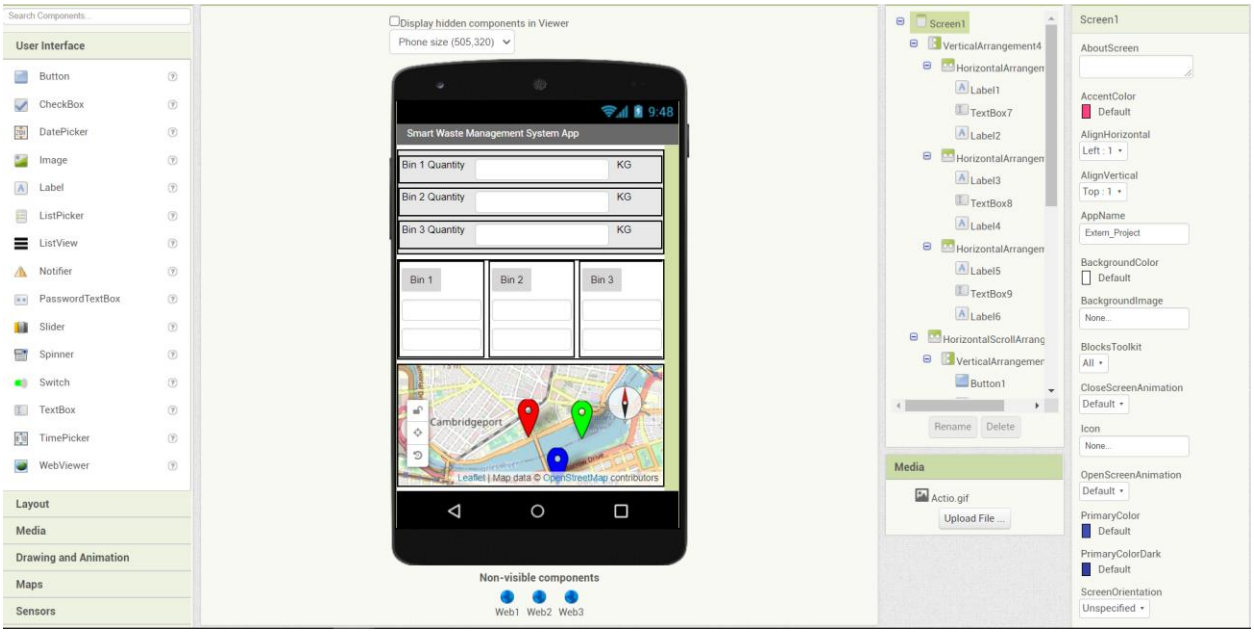
DEBUG WINDOW:

Shows all data pushed into IBM platform from python shell and function states

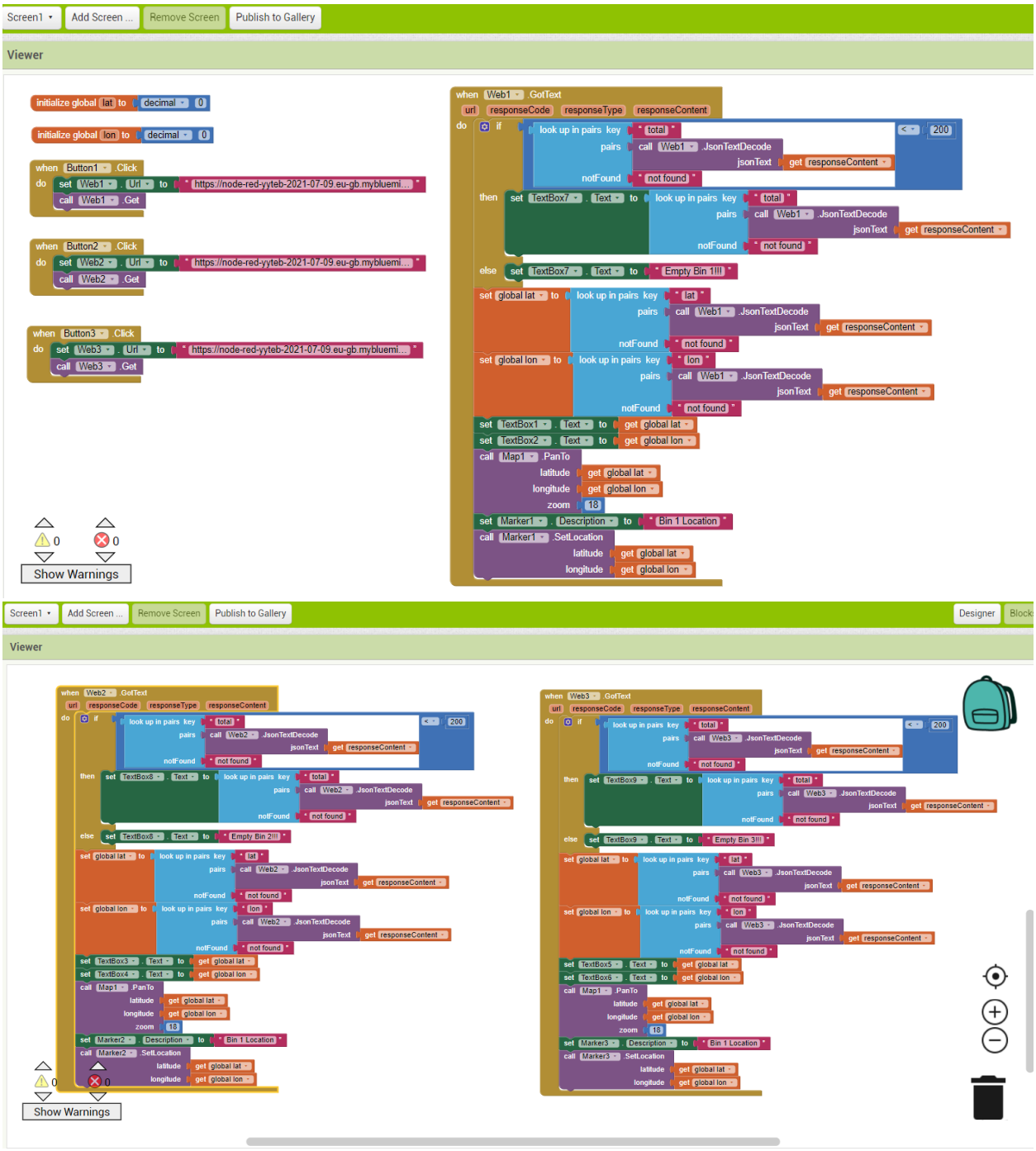


MIT APP:

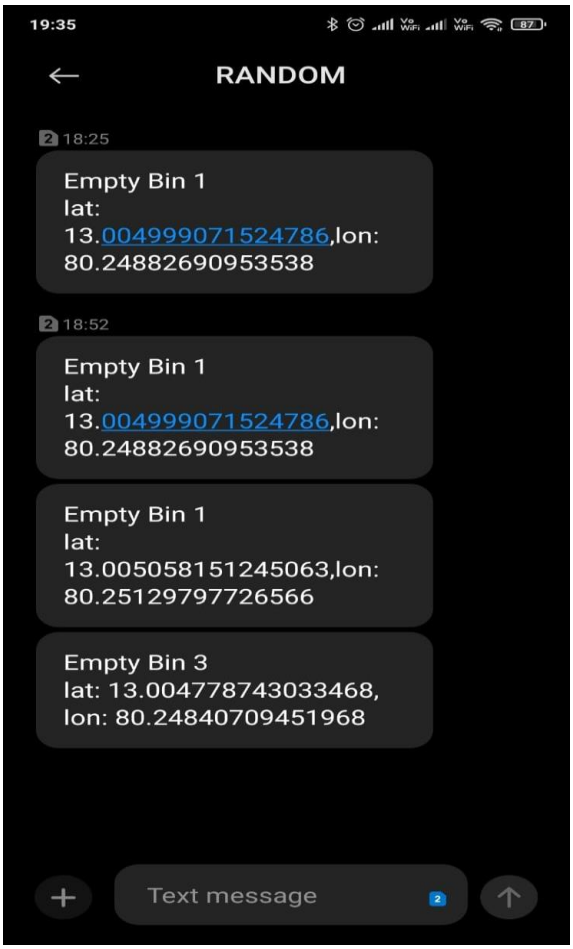
UI design of the app



BACKEND - BLOCK FLOW



MESSAGE OUTPUT:



ADVANTAGES

- The collection routes get optimized – Sensors and ultrasound technology used in waste containers monitor waste levels, record relevant information and relay it to the central management system. The data delivered to central management helps in designing the routes considering the waste levels. On the other side, the waste collection vehicles are outfitted with GPS and pollution sensors. Everything together forms an optimized waste collection cycle.
- Positive impact increases – Overflowing waste containers attract rodents and cause odors. The efficient use of vehicles and human resources in collecting waste as soon as it reaches the limit has an immediate positive impact on society.
- Energy-efficient – The advancement in technology brings to us devices that operate with enhanced energy-efficiency. Using sensors connected to bins we can send data faster that occupy very less spaces to implement. They can work on batteries for 10 years not requiring any manual intervention or replacement in the particular time span.
- Can Adapt to real-time events – The integration of big data and Smart City tech infrastructure to waste management systems enables the service to get notified on real-time events such as road restrictions or traffic congestions. With this, the system can ensure an efficient service even during unexpected incidents.
- Efficient management of waste containers – The sensors are connected to the waste network 24/7. In case a sensor stops working, an automatic alert is sent to the center. This enables them to send a maintenance staff immediately.
- In using the app, the need to travel place to place within localities to dump waste is removed as user can navigate using the app to selected the bin which are not fully filled.

DISADVANTAGES

- System requires more bins for separate waste collection as per population in the city. This results in high initial cost due to expensive smart dustbins compared to other methods.
- Sensor nodes used in the dustbins have limited memory size.
- Wireless technologies used in the system such as ZigBee and Wi-Fi have shorter range and lower data speed and other cases like using RFID based systems, RFID tags are affected by surrounding metal objects (if any).
- It reduces manpower requirements which results in an increase in unemployment for unskilled people.

APPLICATIONS

Some of the recent applications in regards to smart waste management have been mentioned below.

1. Sensoneo is a smart waste management solution provider that produces two types of ultrasonic sensors that are able to monitor the fill level for waste bins of various types and sizes. Their platform helps cities and businesses optimize waste collection routes by factoring in the fill levels of bins, the size of collection vehicle fleets, and the distance to landfills. They claim that their solution can reduce waste collection costs by at least 40 percent and lower carbon emissions in cities up to 60 percent.
2. The CleanCube, produced by eCube Labs, is a solar-powered trash compactor that can hold up to 8 times more waste than a non-compression bin. As trash accumulates in the CleanCube, its sensors monitor the fill level in real-time and automatically activate a compaction cycle when the bin is full. All sensor information is sent to their platform where data analytics can reveal patterns regarding waste collection.

3. In Times Square alone, an estimated 500,000 pedestrians pass through on a daily basis, creating roughly 15,300 pounds of garbage. In March 2013, Bigbelly smart waste and recycling stations were deployed in Times Square as part of the largest public space recycling initiative in New York City. The Bigbelly units are equipped with waste compaction capabilities, real-time fill level monitoring, and collection notifications. With the Bigbelly smart stations, the total trash capacity was increased by nearly 200 percent and the frequency of collection per bin decreased by 50 percent.

CONCLUSION

Monitoring the fullness of bins through the use of virtual devices, 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 a 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.

FUTURE SCOPE

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

1. Change the system of user's authentication and atomic lock of bins which would help in securing the bin from any kind of damage or theft.
2. Concept of green-points that would encourage the involvement of the residents or the end users making the idea successful and helping to achieve joint efforts for the waste management and hence fulfilling the idea of Swachch Bharath.
3. Having case study or data analytics on the type and times the waste is collected on the type of days or season making the bin filling predictable and removing the dependency on electronic components and fixing the coordinates.
4. Improving graphical interfaces for the Server and complete Android applications has the possibility of extending the system adding other use cases and applications for smart cities.
5. Moreover, 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. Therefore, future works can be made in the study of models that offer the best results in terms of decision-making.

BIBLIOGRAPHY

- H. N. Saha *et al*., "Waste management using Internet of Things (IoT)," *2017 8th Annual Industrial Automation and Electromechanical Engineering Conference (IEMECON)*, 2017, pp. 359-363, doi: 10.1109/IEMECON.2017.8079623.
- Indu Anoop , Ayush Jain , Shweta Pathak , Gauri Yadav "IOT based Smart Waste Management" international Journal of Advanced Research in Computer and Communication Engineering ISO 3297:2007 Certified Vol. 6, Issue 1, January 2017
- Insung Hong, Sunghoi Park, Beomseok Lee, Jaekeun Lee, Daebeom Jeong, Sehyun Park, "IoT-Based Smart Garbage System for Efficient Food Waste Management", The Scientific World Journal, vol. 2014, Article ID 646953, 13 pages, 2014. https://doi.org/10.1155/2014/646953
- Behzad Esmaeilian, Ben Wang, Kemper Lewis, Fabio Duarte, Carlo Ratti, Sara Behdad,The future of waste management in smart and sustainable cities: A review and concept paper,Waste Management,Volume 81,2018,Pages 177-195,ISSN 0956-053X,
- https://content.wisestep.com/advantages-disadvantages-waste-management/
- https://flows.nodered.org/node/node-red-node-geofence
- https://learn.vonage.com/blog/2019/04/17/send-sms-messages-node-red-dr/
- https://bridgera.com/iot-waste-management-renewing-the-face-of-waste/

APPENDIX:

SOURCE CODE

For the project, three python codes are created that act as three separate devices to pull data from different locations within an area. These data are then sent to the respective IBM account using the given device info.

Device 1:

Name - Bin 1, latitude = 13.004999071524786 , longitude = 80.24882690953538

CODE:

```
import wiotp.sdk.device

import time

import json

import random

myConfig = {

    "identity": {

        "orgId": "v34dpq",

        "typeId": "18BLC1057",

        "deviceId":"123456"

    },

    "auth": {

        "token": "123456789"
```

```
    }
}
client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)
client.connect()
s=0
while True:
    name="Bin 1"
    wt=int(input())
    la= 13.004999071524786
    lon= 80.24882690953538
    s=s+wt
    myData={'name':name,'weight':wt,'total':s,'lat':la,'lon':lon}
    client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0,
onPublish=None)
    print("Published data Successfully: %s", myData)


    time.sleep(5)
client.disconnect()
```

Device 2:

Name : Bin 2, latitude = 13.005058151245063 longitude = 80.25129797726566

CODE:

```
import wiotp.sdk.device

import time

import json

import random

myConfig = {

    "identity": {

        "orgId": "v34dpq",

        "typeId": "18BLC1057",

        "deviceId":"123456"

    },

    "auth": {

        "token": "123456789"

    }

}

client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)

client.connect()
```

```
s=0

while True:

    name="Bin 2"

    wt=int(input())

    la= 13.005058151245063

    lon= 80.25129797726566

    s=s+wt

    myData={'name':name,'weight':wt,'total':s,'lat':la,'lon':lon}

    client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0,
onPublish=None)

    print("Published data Successfully: %s", myData)



    time.sleep(5)

client.disconnect()
```

Device 3:

Name : Bin 3, latitude = 13.004778743033468 longitude = 80.24840709451968

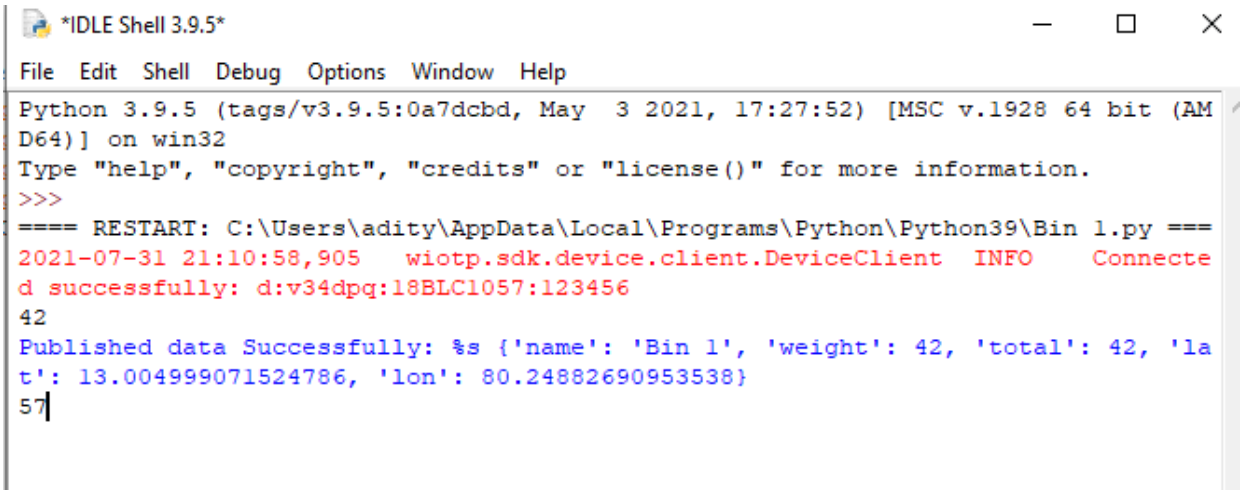
CODE:

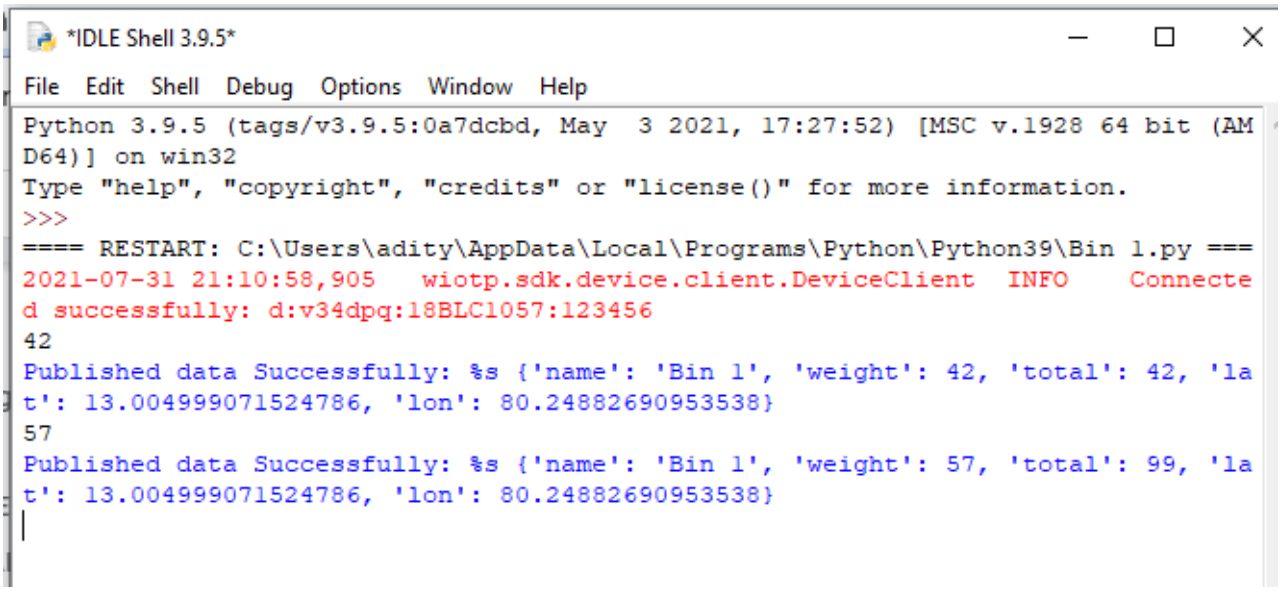
```
import wiotp.sdk.device

import time

import json

import random

myConfig = {

    "identity": {

        "orgId": "v34dpq",

        "typeId": "18BLC1057",

        "deviceId":"123456"

    },

    "auth": {

        "token": "123456789"

    }

}

client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)
```

```
client.connect()

s=0

while True:

    name="Bin 3"

    wt=int(input())

    la= 13.004778743033468

    lon= 80.24840709451968

    s=s+wt

    myData={'name':name,'weight':wt,'total':s,'lat':la,'lon':lon}

    client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0,
onPublish=None)

    print("Published data Successfully: %s", myData)



    time.sleep(5)

client.disconnect()
```

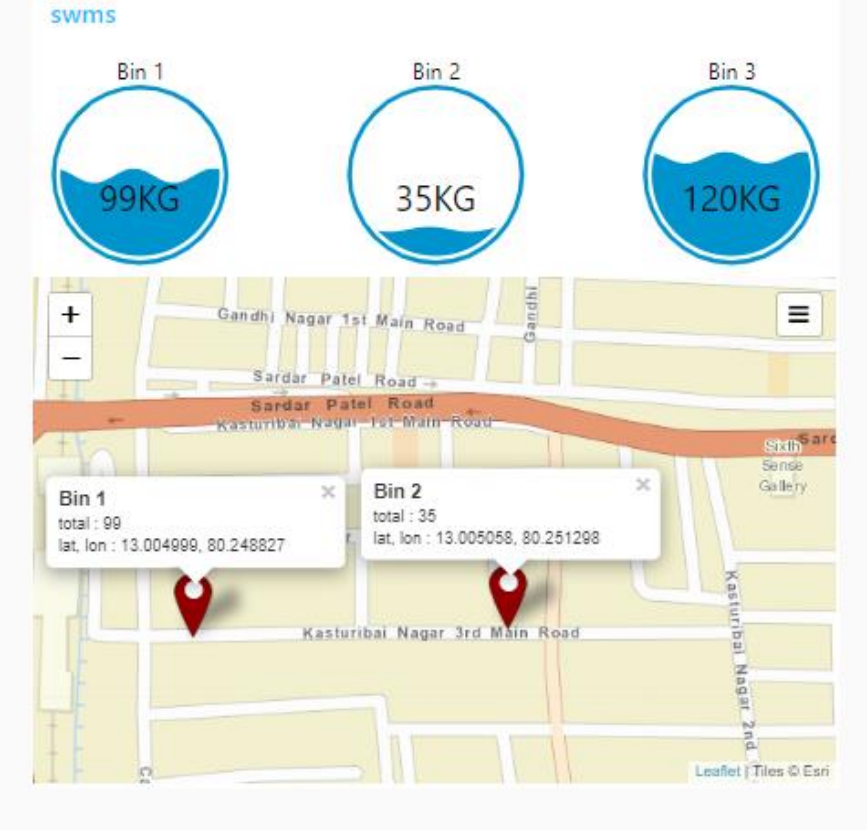
UI OUTPUT :

Each device or python script has a UI entry section where the value of waste to each bin is added, seen from the python shell indicating the filling of bins followed with the details of respective device location and quantity.



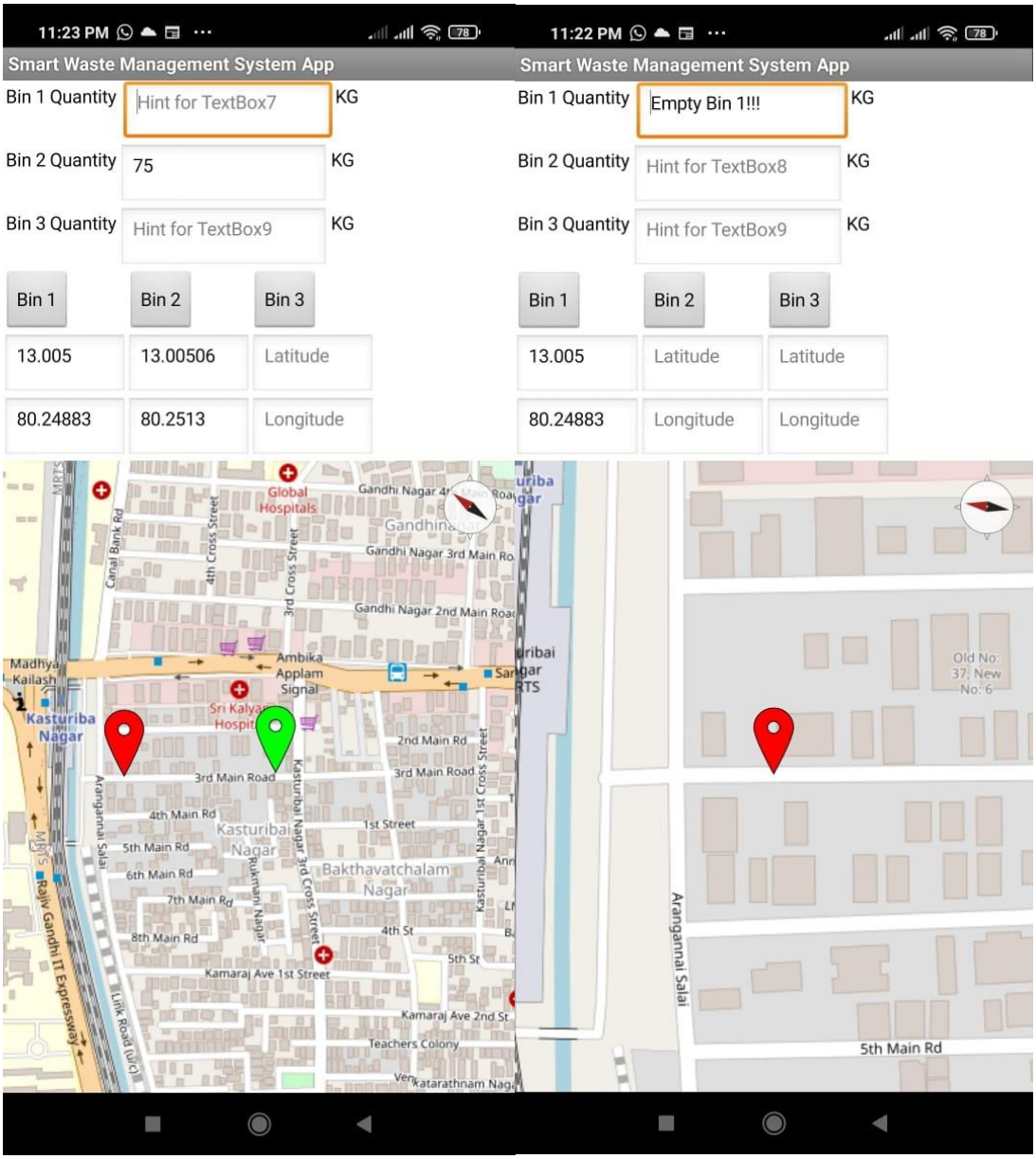


This is also seen from the debug window in node-red. Each time a device aka bin is filled , the quantity in the dashboard is updated and a map shows the location of the bin with the amount of waste contained in it.

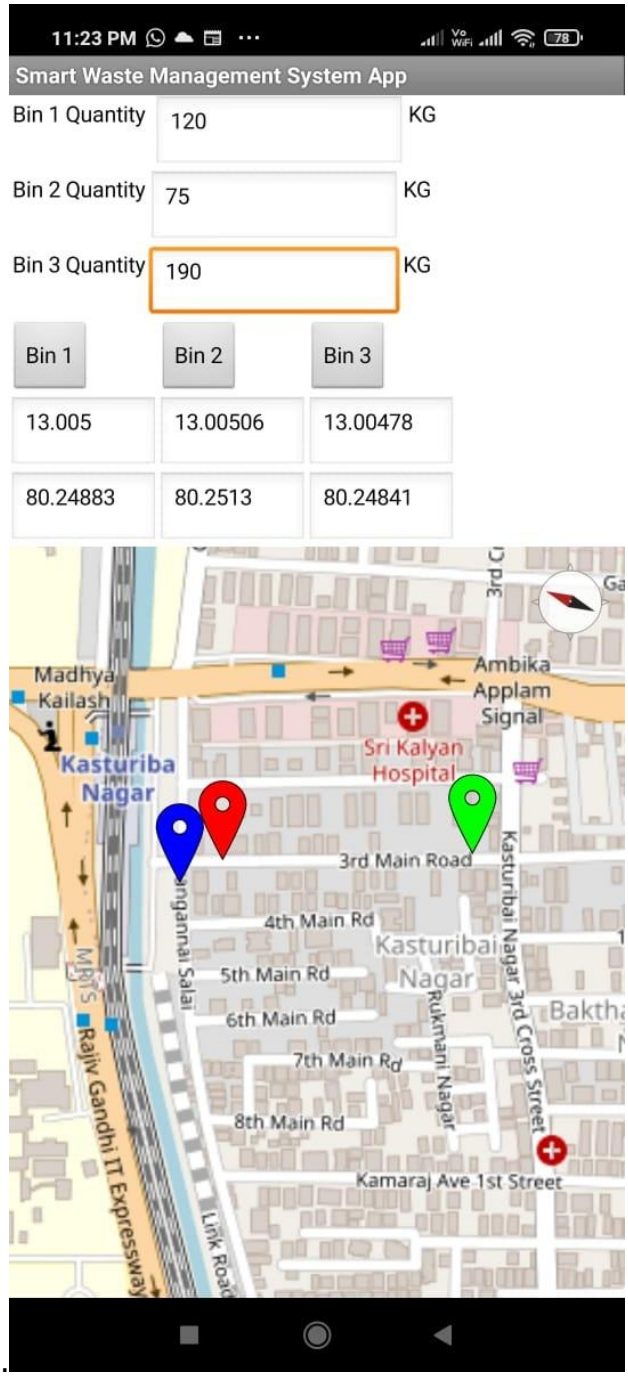


Each bin is set to have a capacity of 200 KG , when full or exceeded a message notification is set to forward a sms to the provided user contact using fast2sms platform.

An app is created to show all the details of each bin and its location.



The app has a selection button to individually see each bin information for user convenience to show the availability of free space to deposit waste when needed saving time to travel and energy



Team Members

Member 1:
• Name: S Vaideeshwaran
• Registration No: 18BLC1106
• Mail ID: s.vaideeshwaran2018@vitstudent.ac.in
• GitHub Project Link:
https://github.com/smartinternz02/SI-GuidedProject-4533-1626948684

Member 2:
• Name: G V R Kameshwar Rao
• Registration No: 18BEC1094
• Mail ID: gv.rkameshwarrao2018@vitstudent.ac.in
• GitHub Project Link:
https://github.com/smartinternz02/SI-GuidedProject-4532-1626948668

Member 3:
• Name: Aditya Jaganath
• Registration No: 18BLC1057
• Mail ID: aditya.jaganath2018@vitstudent.ac.in
• GitHub Project Link:
https://github.com/smartinternz02/SI-GuidedProject-4534-1626948712