

TEAM ID: **PNT2022TMID18390**

TITLE : **SMART WASTE MANAGEMENT USING IoT IN METROPOLITAN CITIES**

Project Report Format

1. INTRODUCTION:

1.1 Project Overview

Recently there are very poor solid waste disposal and collection mechanism for commercial and market areas. The waste/garbage in most these areas are not collected in a proper ways. The greenery does much more than add to the visual attractiveness. The trees clean the air by absorbing the pollutants. Similarly, improperly disposed trash leads to problems of land pollution and contamination apart from a dirty appearance. Everyone must take the responsibility to keep the city clean and green.

1.2 Purpose

The main aim of the project is to keep the metropolitan cities clean so we are building a model ,which is used for detecting garbage levels in the city and gaining the weight of the garbage bin and alerts the authorized person to empty the bin whenever the bins are full and the garbage level of the bins are monitored by the web app.

2. LITERATURE SURVEY

2.1 Existing problem

There is no arrangement of door to door collection and segregation of municipal waste at source in the city. The residents of city dump the household waste outside their residences from where sweepers collect waste by means of handcarts and dump the same into the containers or roadside (open dump). Very poor solid waste disposal and collection mechanism for commercial and market areas. The waste/garbage in most these areas is collected once in two or three days. The common and prevalent problems faced by general public in markets areas is improper garbage disposal causing the blockage of roads, foul smell, clogging of drains.

2.2 References

<https://www.iotforall.com/smart-waste-management>

2.3 Problem Statement Definition

The main aim of the project is to keep the metropolitan cities clean so we are building a model ,which is used for detecting garbage levels in the city and gaining the weight of the garbage bin and alerts the authorized person to empty the bin whenever the bins are full and the garbage level of the bins are monitored by the web app.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

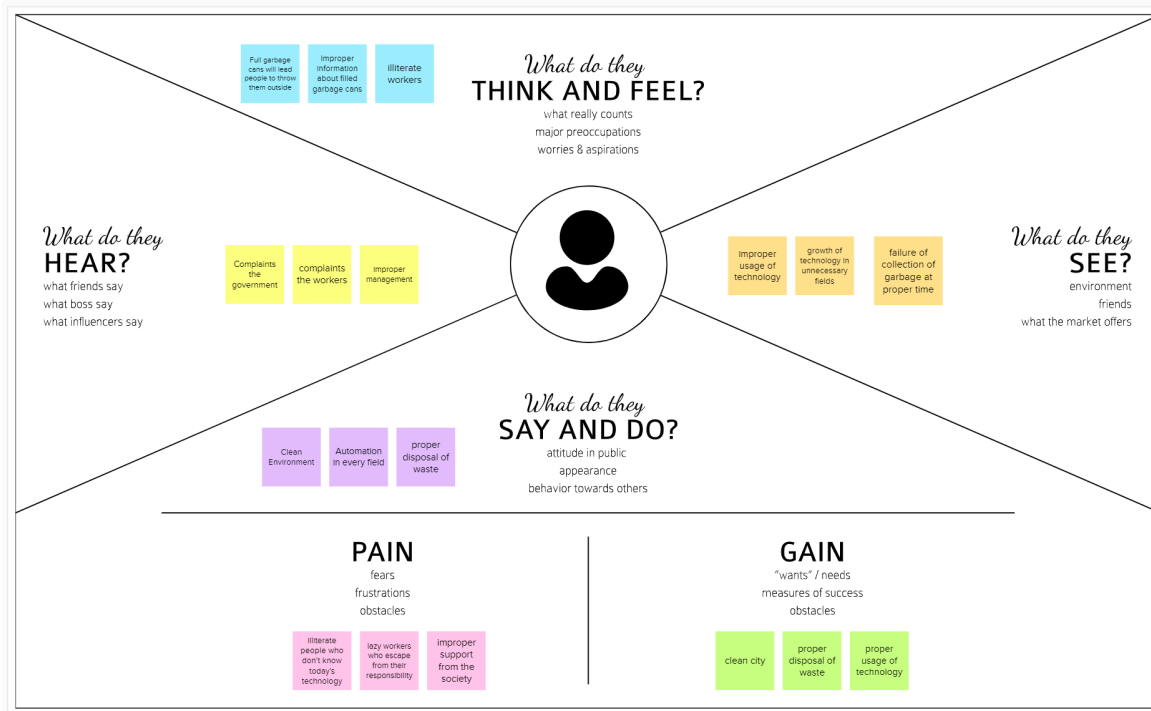
Edit this template
Right-click to unlock

Empathy Map Canvas

Gain insight and understanding on solving customer problems.

1

Build empathy and keep your focus on the user by putting yourself in their shoes.



Share your feedback

3.2 Ideation & Brainstorming

Brainstorm & idea prioritization

- 10 minutes to prepare
- 1 hour to 24 hours
- 24 people recommended

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1 Define your problem statement

5 minutes

PROBLEM

Design a smart waste system to segregate the waste and to efficiently collect the same by municipality using IOT

2 Brainstorm

10 minutes

Rajeev	Navya	Yasaswini	Sushwanth
Usage of conveyor belt for the movement of waste	Detecting the type of waste using sensors	Usage of LED lights to indicate status of filling of bins	Notifying municipal authorities about status of bins
Incinerator to burn the harmful waste	Reusing the heat produced to run the DC motor	Automatic cleaning using sprinkler system	Wrapping the waste automatically

3 Group ideas

10 minutes

Split rollers, Pipeline system, Chained conveyer belt, Wrapper, LEDs, Incinerator, Sensors, DC motor, Bins

4 Prioritize

10 minutes

Importance
Rank of ideas based on their importance to the project

Feasibility
Rank of ideas based on their feasibility to implement

3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	The municipal workers who are engaged in the collection of garbage require a sustainable, streamlined process for an efficient waste collection system and to integrate the databases containing information about waste from each of the municipal offices to design an improvised system where the garbage collectors or municipal workers will be given an alert regarding the availability of waste.
2.	Idea / Solution description	Smart waste management helps to reduce the waste , create waste to energy source also it helps to keep the environment clean and neat. All the city's urban local bodies depending upon the available technology have to spend the money and innovate the new concept of waste management that is the main purpose of smart waste management.
3.	Novelty / Uniqueness	<u>Sensoneo Analytics:</u> <u>Sensoneo Analytics</u> has a smart process for waste management, which includes placing sensors on garbage collection bins to monitor which of them are full or not. This integrates with their analytics software to help automate and optimize when and how waste is collected in the city
4.	Social Impact / Customer Satisfaction	<ol style="list-style-type: none"> 1. raise public awareness of utilizing renewable energy 2. improve street sanitation 3. collect and analyze area-specific data on waste volumes for better planning

5.	Business Model (Revenue Model)	As a result, time and fuel consumption are achieved and garbage collection operations are performed in a much more fluid way
6.	Scalability of the Solution	The device can use in all metropolitan cities. Major efficiency of device: Easily identify the level of waste in garbage because it has a sensor

3.4 Problem Solution fit

<p>1. CUSTOMER SEGMENT(S)</p> <p>The customer here is the people who lives around the public garbage bins and domestic animals and the person who collects the waste particularly the person with health issues.</p>	<p>6. CUSTOMER</p> <ul style="list-style-type: none"> ➤ People may feel disgusted to clean the garbage by themselves ➤ When the garbage or wastes spills out of the bins ➤ Bad odor resulting from the waste. 	<p>5. AVAILABLE SOLUTIONS</p> <ul style="list-style-type: none"> ➤ Can create a software for monitoring wastages ➤ Household wastes are incinerated in the backyard or nearby. ➤ Environmental racism
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Focus on J&P, tap into BE, understand RC	2. JOBS-TO-BE-DONE / PROBLEMS J&P <ul style="list-style-type: none"> ➤ Notifying the garbage collector about the overflow of trash containers to empty the garbage container frequently. ➤ Making the environment clean and eco-friendly. ➤ Preventing people from respiratory diseases. 	9. PROBLEM ROOT CAUSE RC <ul style="list-style-type: none"> ➤ No proper monitorization of the fill level of garbage in the bins kept for public disposal of waste. ➤ People's <u>lethargicness</u> and irresponsibility. 	7. BEHAVIOUR BE <ul style="list-style-type: none"> ➤ Monitoring of waste level by using some technologies and software to dispose if in the correct time. 	Focus on J&P, tap into BE, understand RC
Identify strong TR & EM	3. TRIGGERS TR <ul style="list-style-type: none"> ➤ Since wastes are collected and disposed properly at a right time, people will be aware of the act and triggered to put the waste only in the trash container. 	10. YOUR SOLUTION SL <ul style="list-style-type: none"> ➤ Proper monitoring of garbage level using sensors to avoid overflow of wastes ➤ Frequent collection of wastes by the waste collectors by the proper channel of communication. 	8.CHANNELS of BEHAVIOUR CH <p>Online:</p> <ul style="list-style-type: none"> ➤ Advertise or spread news over social media on keeping the environment clean. <p>Offline:</p> <ul style="list-style-type: none"> ➤ People who actually cares about the <u>sanitization</u> of environment conduct awareness campaign as volunteers, rally. ➤ Conduction of awareness programs. ➤ Inclusion of this issue in the schools books to create awareness and making the upcoming young generation with responsibilities and concern towards the society and its 	Identify strong TR & EM
	4. EMOTIONS: BEFORE / AFTER EM <ul style="list-style-type: none"> ➤ BEFORE : Frustration, fear of health issues like shin diseases and respiratory infections. ➤ AFTER : Satisfaction, Calm state of mind, cleanliness, Eco-friendly 			

4. REQUIREMENT ANALYSIS

4.1 Functional requirement

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Detailed bin inventory.	<p>All monitored bins and stands can be seen on the map, and you can visit them at any time via the Street View feature from Google.</p> <p>Bins or stands are visible on the map as green, orange or red circles.</p> <p>You can see bin details in the Dashboard – capacity, waste type, last measurement, GPS location and collection schedule or pick recognition.</p>
FR-2	Real time bin monitoring.	<p>The Dashboard displays real-time data on fill-levels of bins monitored by smart sensors.</p> <p>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 in the best waste management software..</p> <p>Sensors recognize picks as well; so you can check when the bin was last collected.</p> <p>With real-time data and predictions, you can eliminate the overflowing bins and stop collecting half-empty ones.</p>
FR-3	Expensive bins.	<p>We help you identify bins that drive up your collection costs. The tool calculates a rating for each bin in terms of collection costs.</p> <p>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.</p>

FR-4	Adjust bin distribution.	<p>Ensure the most optimal distribution of bins. Identify areas with either dense or sparse bindistribution.</p> <p>Make sure all trash types are represented within a stand.</p> <p>Based on the historical data, you can adjust bin capacityor location where necessary.</p>
FR-5	Eliminate inefficient picks.	<p>Eliminate the collection of half-empty bins.The sensors recognize picks.</p> <p>By using real-time data on fill-levels and pick recognition, we can show you how full the bins you collect are.</p>

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

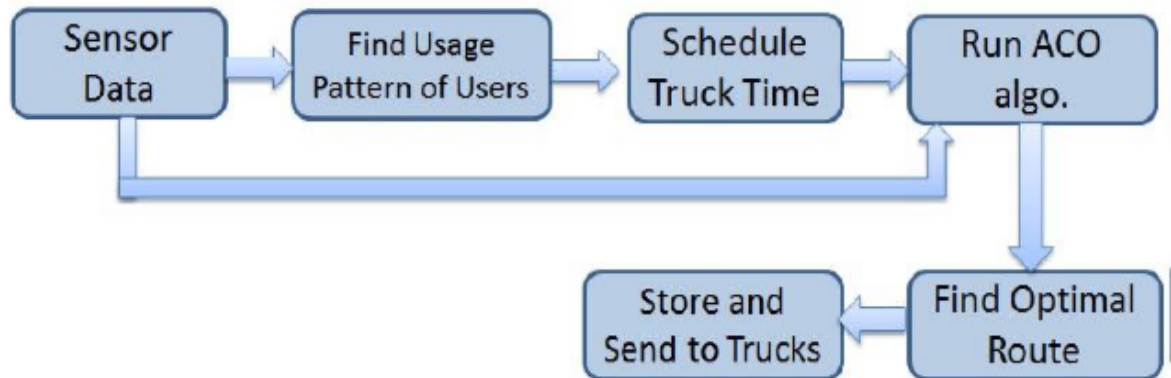
4.2 Non-Functional requirement

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	<p>IoT device verifies that usability is a special and important perspective to analyze user requirements,which can further improve the design quality. In thedesign process with user experience as the core, theanalysis of users' product usability can indeed help designers better understand users' potential needs in waste management, behavior and experience.</p>

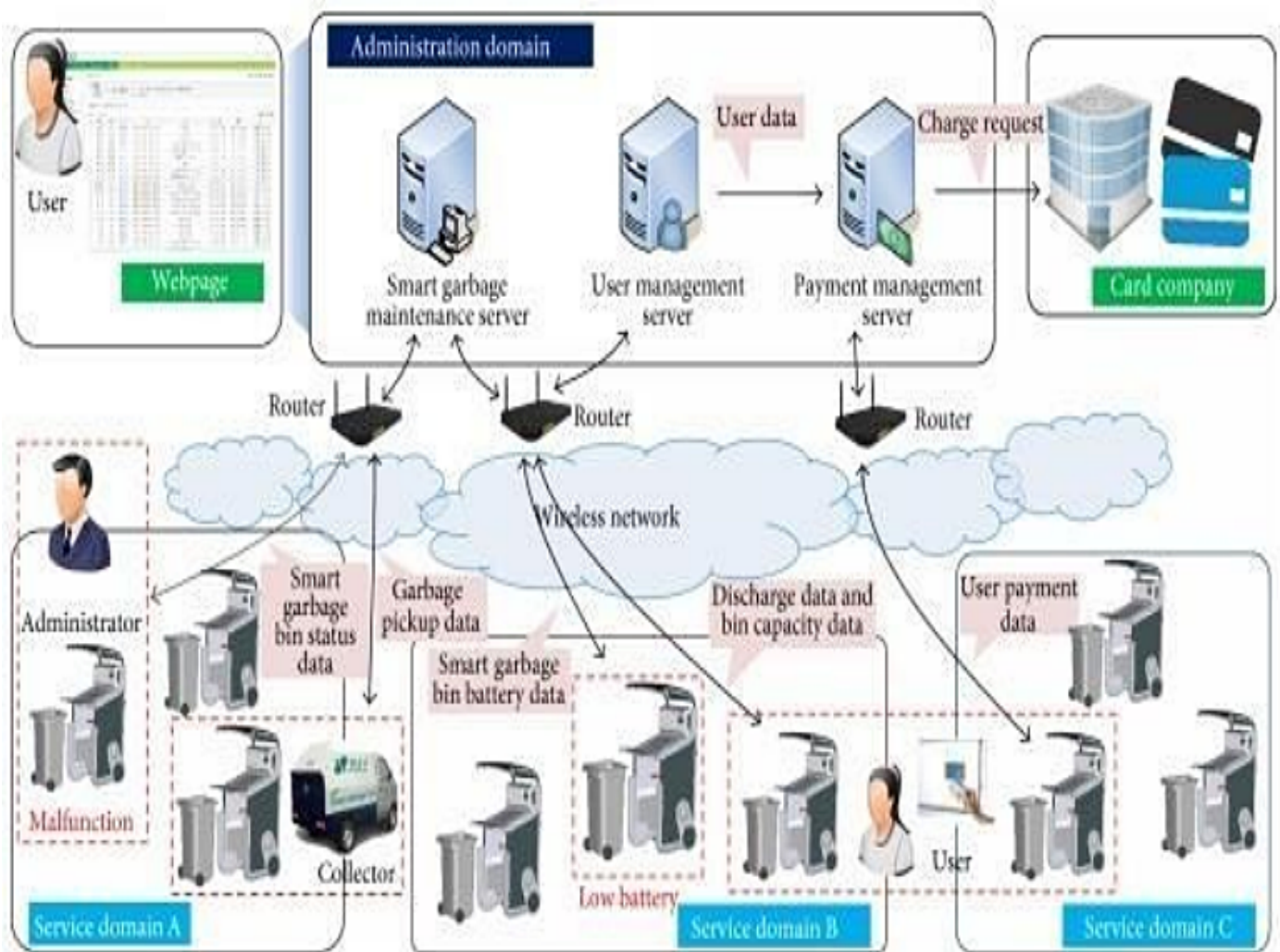
NFR-2	Security	<p>Use a reusable bottles</p> <p>Use reusable grocery bags</p> <p>Purchase wisely and recycle</p> <p>Avoid single use food and drink containers.</p>
NFR-3	Reliability	<p>Smart waste management is also about creating better working conditions for waste collectors and drivers. Instead of driving the same collection routes and servicing empty bins, waste collectors will spend their time more efficiently, taking care of bins that need servicing.</p>
NFR-4	Performance	<p>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%.</p>
NFR-5	Availability	<p>By developing & deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter.</p>
NFR-6	Scalability	<p>Using smart waste bins reduce the number of bins inside town , cities because we able to monitor cities</p>

5. PROJECT DESIGN

5.1 Data Flow Diagrams



5.2 Solution & Technical Architecture



Components and technologies


S.No	Component	Description	Technology
1.	User Interface	Mobile Application	HTML, CSS, JavaScript.
2.	Application Logic	Logic for a process in the application	Java
3.	Database	Data Type, Configurations etc.	MySQL
4.	Cloud Database	Database Service on Cloud	IBM Cloud
5.	File Storage	File storage requirements	Local File system and IBM cloud
6.	Infrastructure (Server / Cloud)	Application Deployment on Cloud Local Server Configuration	Local and Cloud Foundry

Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	GitHub	Internet hosting service
2.	Security Implementations	Application security: Veracode Firewall: cisco	Network automation
3.	Scalable Architecture	It provides the room for expansion more database of smart bins added additionally can be updated.	Cloud storage
4.	Availability	As the system control is connected to web server it is available 24*7 and can be accessed whenever needed.	Server
5.	Performance	Performance is high it uses 5mb caches	Wireless Sensor Network


5.3 Users Stories

Template



Customer experience journey map




Use this framework to better understand customer needs, motivations, and obstacles by illustrating a key scenario or process from start to finish. When possible, use this map to document and summarize interviews and observations with real people rather than relying on your hunches or assumptions.

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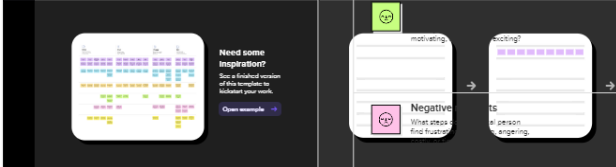
Document an existing experience

Narrow your focus to a specific scenario or process within an existing product or service. In the **Steps** row, document the step-by-step process someone typically experiences, then add detail to each of the other rows.

	 Enter <small>What do people experience as they begin the process?</small>	 Engage <small>In the core moments in the process, what happens?</small>	 Exit <small>What do people typically experience as the process finishes?</small>	
Scenario Browsing, booking, attending, and rating a local city tour				
Steps <small>What does the person (or group) typically experience?</small>	People think about how efficient the product is? THE REGULAR AT THE BEGINNING WILL HAVE LESS KNOWLEDGE ABOUT THE PROCESS OF OPERATION	Eco-Friendly No Health related issues Dust-Free environment	People feel satisfied and fulfilled after completion of the process People feels happy about the process which is being fast	
Interactions <small>What interactions do they have at each step along the way?</small> <ul style="list-style-type: none"> People: Who do they see or talk to? Places: Where are they? Things: What digital touchpoints or physical objects would they use? 	Will this product satisfy our needs as compared with collection of waste manually The people seek the review of the Smart bin from social platform	PEOPLE PLACE Digital touch point The product is efficient to use Placed in areas of Metropolitan cities Notification is received through cloud server	DIGITAL TOUCH POINT PEOPLE Create Awareness about this in Social resources. Finally the garbage bin is designed effectively to collect the garbage	
Goals & motivations <small>At each step, what is a person's primary goal or motivation? ("Help me..." or "Help me avoid...")</small>	People must know about the working process of smart bin	The primary goal of the person is to handle the smart bin properly without causing damages The motive is to use the garbage bin efficiently and effectively	The Motivation is to utilize the Garbage bin to the Maximum and to get the best Out of it.	
	EXCITEMENT People would feel excited about the product at the initial stage	HAPPY Smart waste bins minimise overflow creating a cleaner and safer working environment	The greatest advantage of waste management is keeping the environment fresh and neat. These waste disposal units also make the people go disease-free at all the resultant wastes are properly disposed and taken care of	
	CONFUSED People doesn't have clear idea about the technology	FRUSTRATING Depending upon the environmental conditions the notification about the full of the garbage doesn't reach the concerned waste collector, the bins gets overflowed as the people are frustrated	Stable Internet connection is required for transferring the instruction Because this is a new and emerging technology, there is a general misunderstanding of its operations	

Need some Inspiration?
See a finished version of this template to help you work.

[Open example](#)



TIP
 As you add steps to the experience, make each step flow to the left or right depending on the scenario you're documenting.

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Login	USN-1	As a Administrator, I need to give user id and passcode for ever workers over there in municipality	1 0	High	Lokeshwar P
Sprint-1	Login	USN-2	As a Co-Admin, I'll control the waste level by monitoring them real time web portal. Once the filling happens, I'll notify trash truck with location of bin with bin ID	1 0	High	Lokeshwar P
Sprint-2	Dashboard	USN-3	As a Truck Driver, I'll follow Co-Admin's Instruction to reach the filling bin in short roots and save time	2 0	Low	Madhankumar R

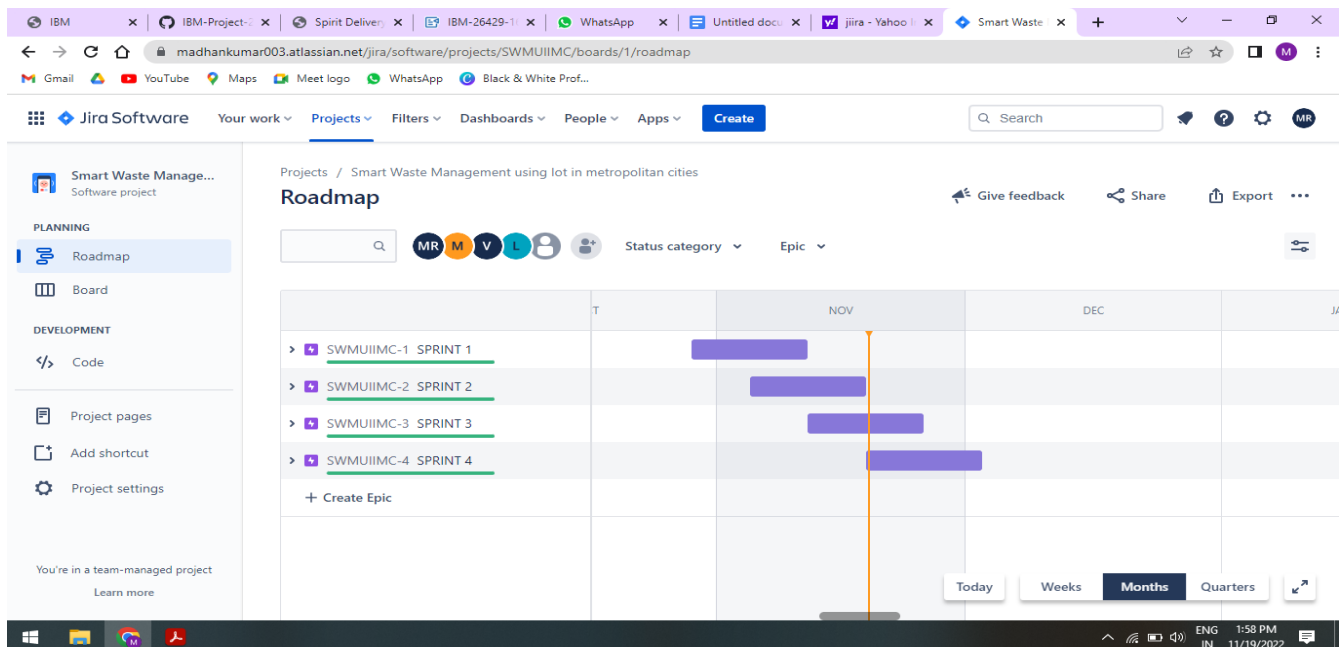
Sprint-3	Dashboard	USN-4	As a Local Garbage Collector, I'll gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills	2 0	Medium	Kancharla vengababu
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Sprint-4	Dashboard	USN-5	As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems	20	High	Manoj kumar A
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6.2 Sprint Delivery Schedule

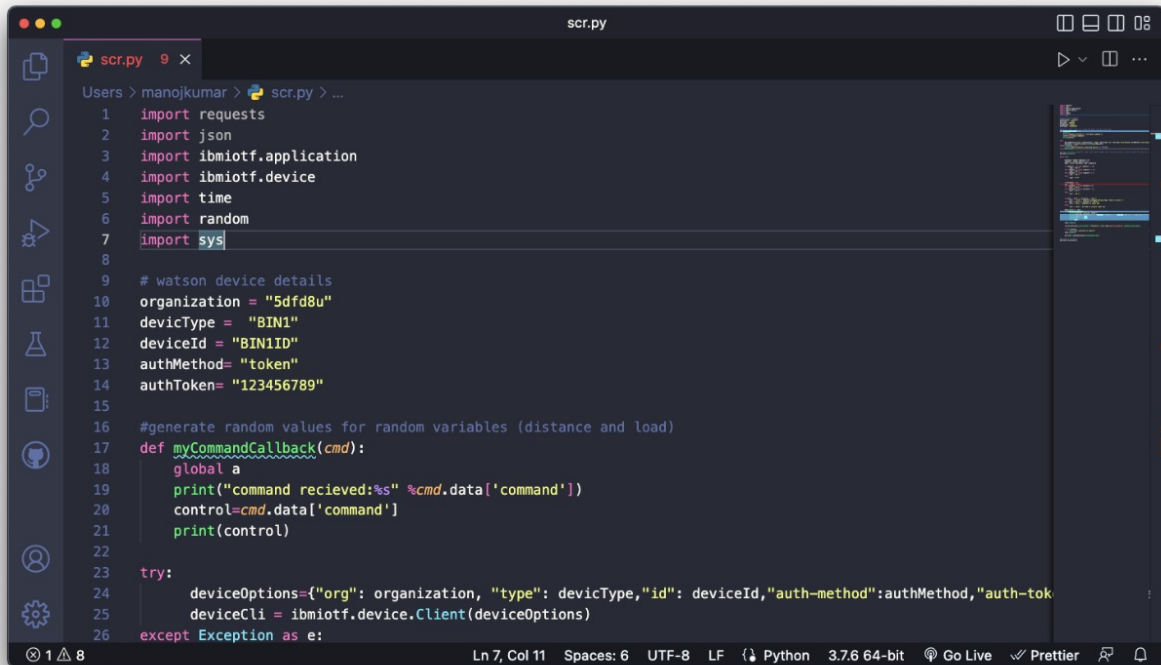
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

6.3 Reports from JIRA

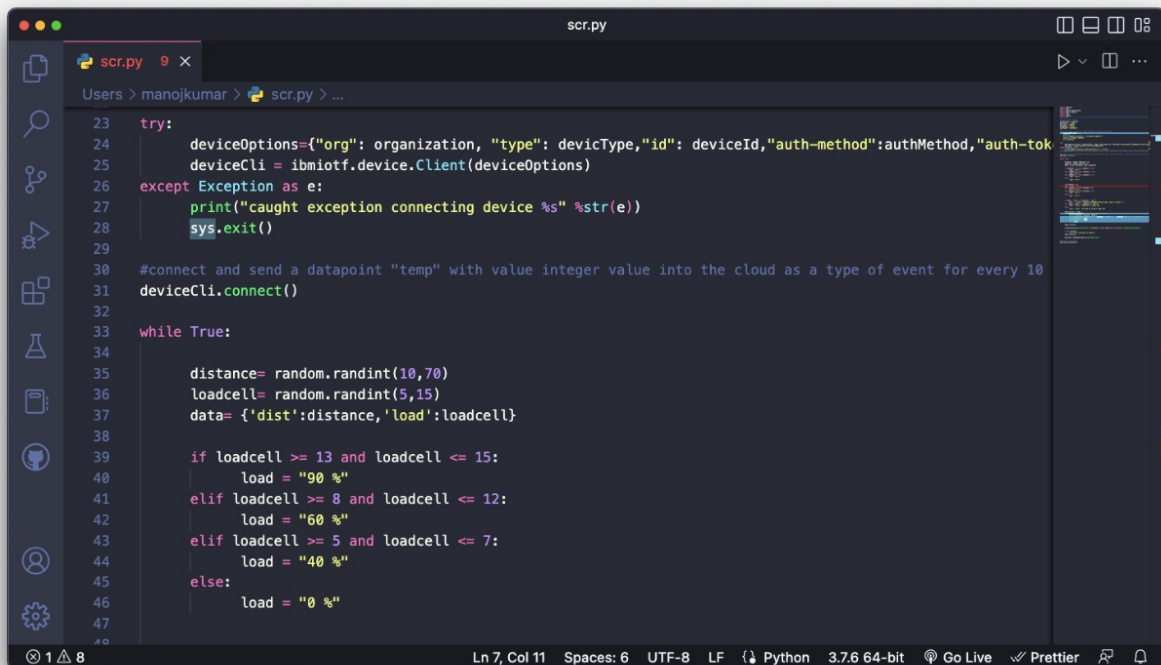


7. CODING & SOLUTIONING (Explain the features added in the project along with code)

7.1 Feature 1



```
scr.py 9 x
Users > manojkumar > scr.py > ...
1 import requests
2 import json
3 import ibmiotf.application
4 import ibmiotf.device
5 import time
6 import random
7 import sys
8
9 # watson device details
10 organization = "5dfd8u"
11 deviceType = "BIN1"
12 deviceId = "BIN1ID"
13 authMethod = "token"
14 authToken = "123456789"
15
16 #generate random values for random variables (distance and load)
17 def myCommandCallback(cmd):
18     global a
19     print("command recieved:%s" %cmd.data['command'])
20     control=cmd.data['command']
21     print(control)
22
23 try:
24     deviceOptions={"org": organization, "type": deviceType,"id": deviceId,"auth-method":authMethod,"auth-tok
25     deviceCli = ibmiotf.device.Client(deviceOptions)
26 except Exception as e:
```



```
scr.py 9 x
Users > manojkumar > scr.py > ...
23 try:
24     deviceOptions={"org": organization, "type": deviceType,"id": deviceId,"auth-method":authMethod,"auth-tok
25     deviceCli = ibmiotf.device.Client(deviceOptions)
26 except Exception as e:
27     print("caught exception connecting device %s" %str(e))
28     sys.exit()
29
30 #connect and send a datapoint "temp" with value integer value into the cloud as a type of event for every 10
31 deviceCli.connect()
32
33 while True:
34
35     distance= random.randint(10,70)
36     loadcell= random.randint(5,15)
37     data= {'dist':distance,'load':loadcell}
38
39     if loadcell >= 13 and loadcell <= 15:
40         load = "90 %"
41     elif loadcell >= 8 and loadcell <= 12:
42         load = "60 %"
43     elif loadcell >= 5 and loadcell <= 7:
44         load = "40 %"
45     else:
46         load = "0 %"
47
48
```

```
scr.py 7 X
Users > manojkumar > scr.py > [o] dist
48
49     if distance < 15:
50         dist = "17 %"
51     elif distance < 40 and distance > 16:
52         dist = "40 %"
53     elif distance < 60 and distance > 41:
54         dist = "60 %"
55     else:
56         dist = "90 %"
57
58
59     if load == "90 %" or distance == "90 %":
60         warn = 'Alert : Dumpster poundage getting high, Time to collect :)'
61     elif load == "60 %" or distance == "60 %":
62         warn = 'Alert : Dumpster is above 60%'
63     else:
64         warn = 'Alert : No need to collect right now'
65
66     data['alert'] = warn
67     def myOnPublishCallback(lat=10.678991, long=78.177731):
68         print("Location: Junction, Salem")
69         print("published distance = %s " % distance, "loadcell: %s " % loadcell, "lon = %s " % long, "lat = %s " % lat)
70         print("Load %: ", load)
71         print("dist %: ", dist)
72         print(warn)
73
```

```
scr.py 7 X
Users > manojkumar > scr.py > [o] dist
63
64     warn = 'Alert : No need to collect right now'
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66     data['alert'] = warn
67     def myOnPublishCallback(lat=10.678991, long=78.177731):
68         print("Location: Junction, Salem")
69         print("published distance = %s " % distance, "loadcell: %s " % loadcell, "lon = %s " % long, "lat = %s " % lat)
70         print("Load %: ", load)
71         print("dist %: ", dist)
72         print(warn)
73
74     time.sleep(10)
75
76     success=deviceCli.publishEvent ("IoTSensor", "json", data, qos=0, on_publish= myOnPublishCallback)
77
78     if not success:
79         print("not connected to ibmiot")
80     time.sleep(10)
81
82     deviceCli.commandCallback=myCommandCallback
83
84     #disconnect the device
85     deviceCli.disconnect()
```

Node-RED interface showing a flow diagram and node configuration.

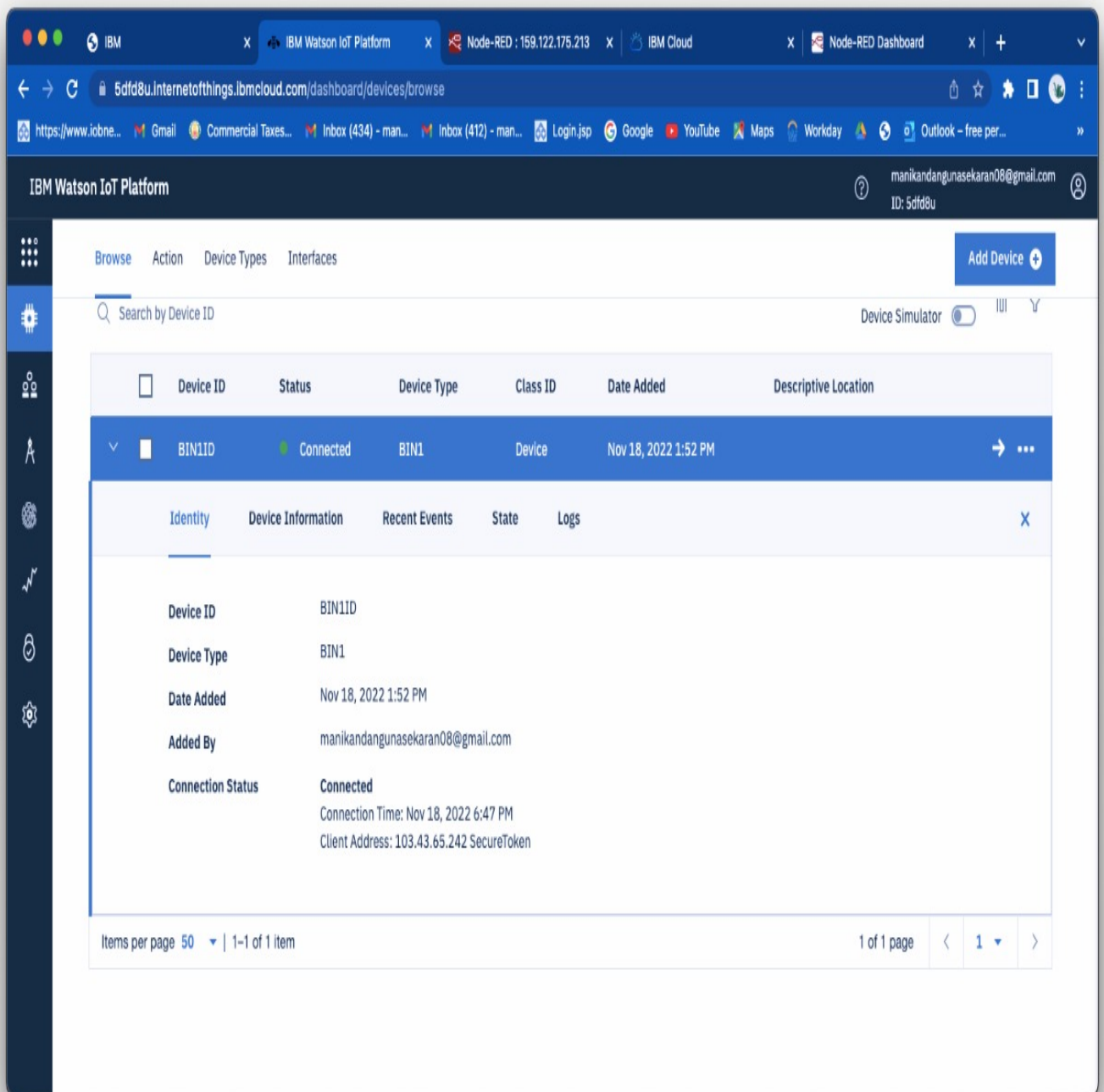
Flow Diagram:

```
graph LR; IoT[IBM IoT] --> alert_f[f alert]; IoT --> load_f[f load]; IoT --> distance_f[f distance]; alert_f --> alert_out[alert]; load_f --> load_out[Load 1]; distance_f --> distance_out[Distance 1]; IoT --> payload[msg.payload];
```

Node Configuration (Distance 1):

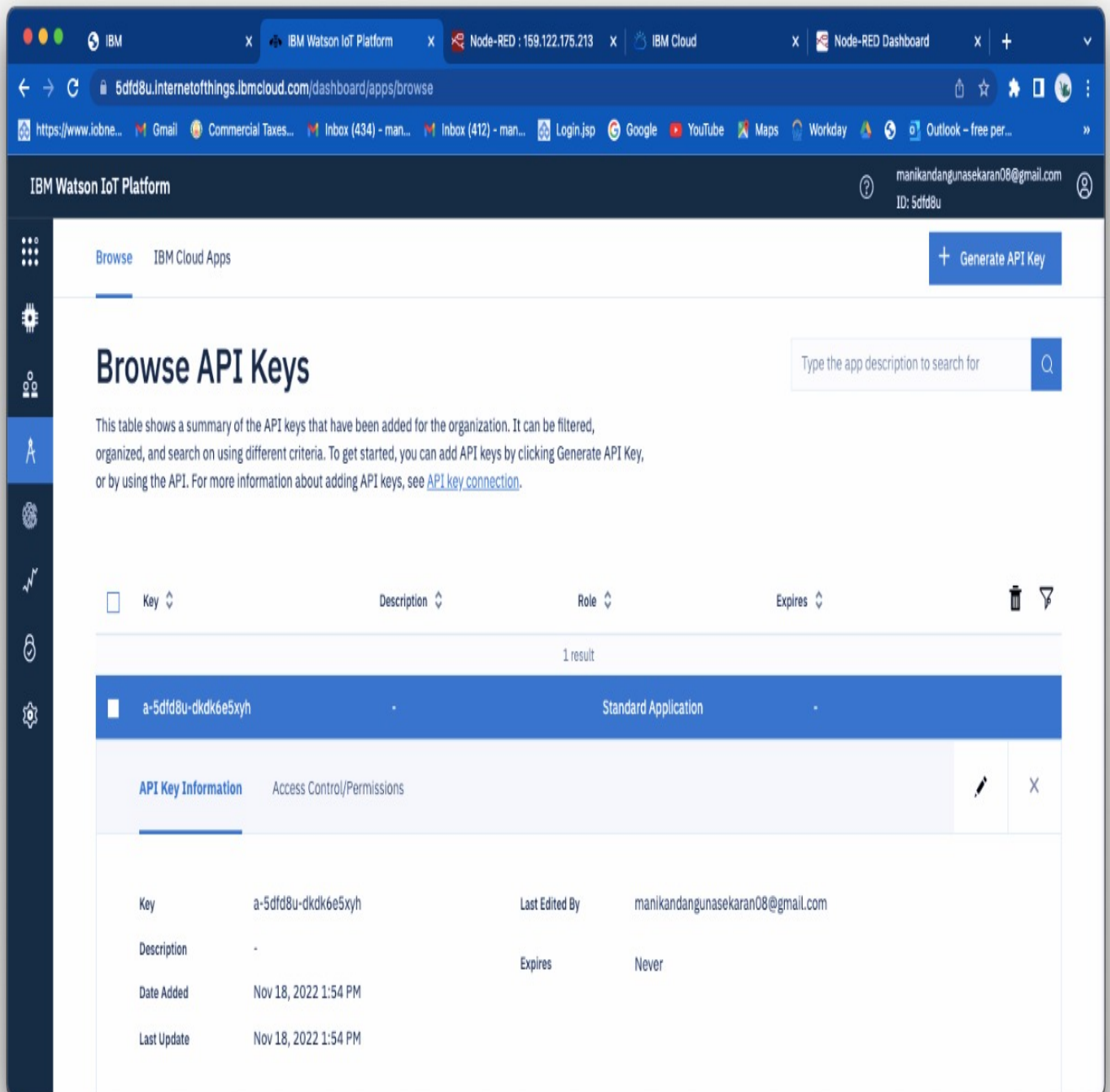
Property	Value
Node	"204e4b6053381d1e"
Type	ui_gauge

Additional information: %space will toggle the view of this sidebar

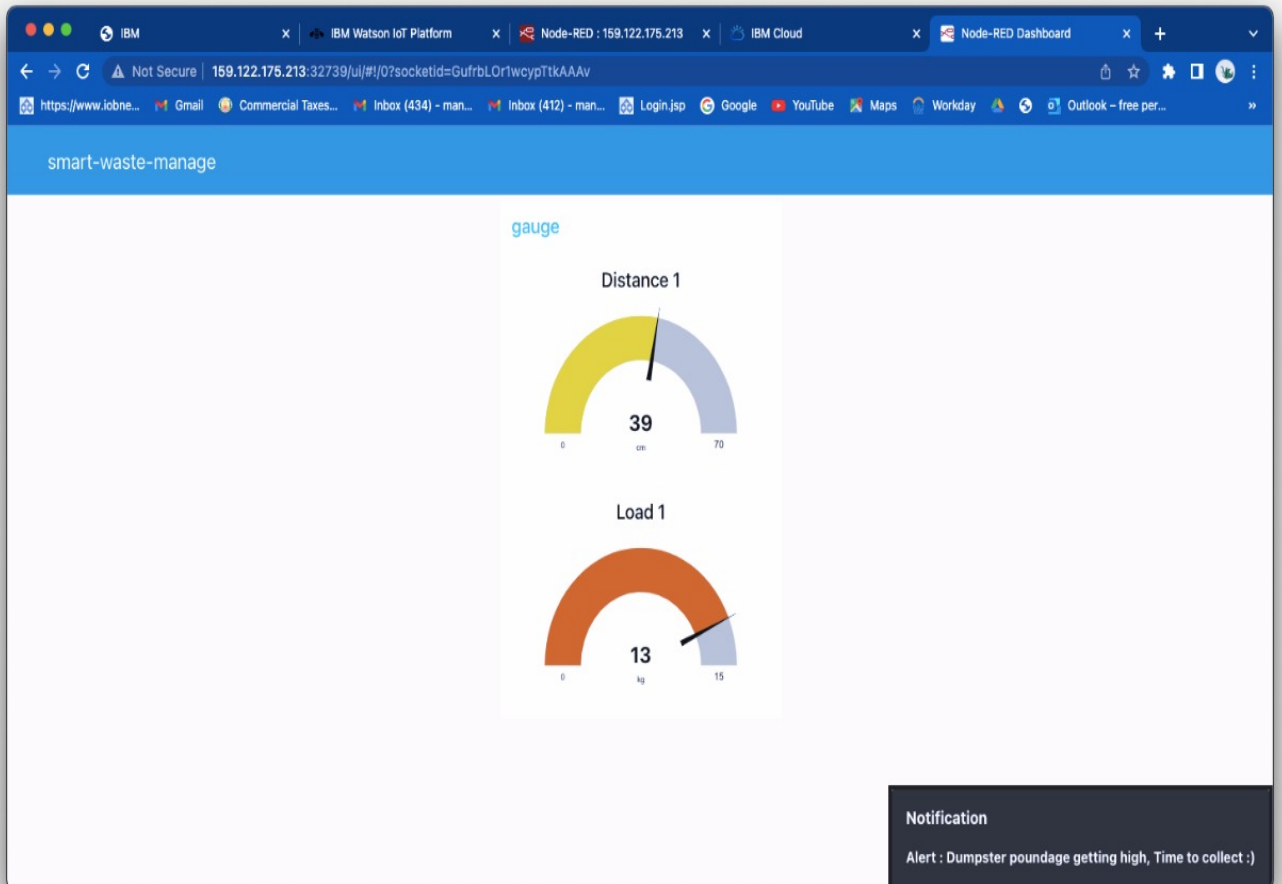


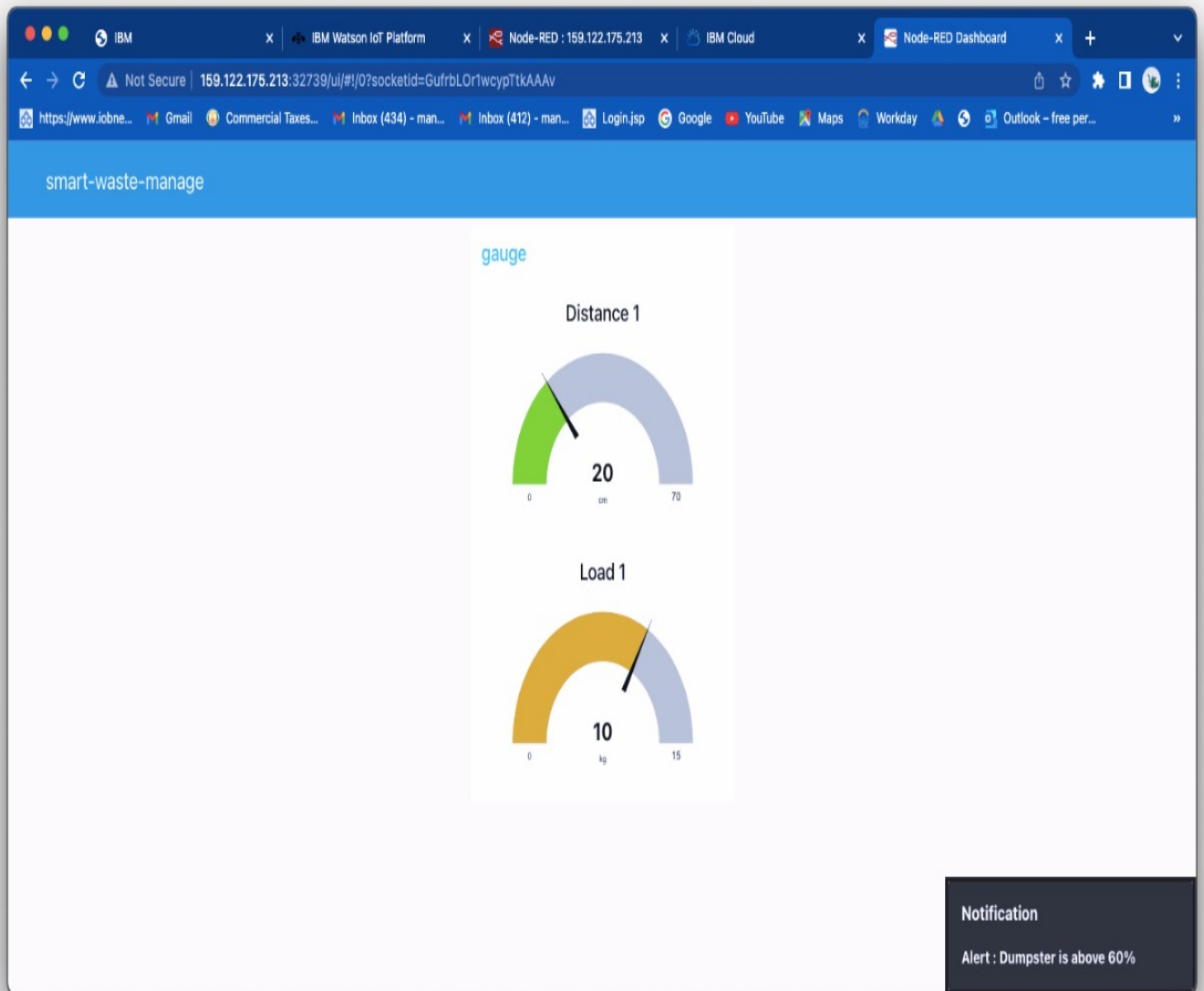
The screenshot shows the IBM Watson IoT Platform interface. The top navigation bar includes the IBM logo and the text 'IBM Watson IoT Platform'. The main content area is titled 'Device Drilldown - BIN1ID'. On the left, a sidebar lists navigation options: Connection Information, Recent Events, State, Device Information, Metadata, Diagnostics, Connection Logs, and Device Actions. The 'Recent Events' section is active, displaying a table of recent events. The table has four columns: Event, Value, Format, and Last Received. The events listed are from an 'IoTSensor' and contain JSON data with fields for 'dist', 'load', and 'alert'. The 'alert' field contains messages like 'Alert : Dumpster is a...' and 'Alert : No need to coll...'. The 'Last Received' column shows timestamps like 'a few seconds ago' and 'a minute ago'.

Event	Value	Format	Last Received
IoTSensor	{"dist":68,"load":12,"alert":"Alert : Dumpster is a..."}	json	a few seconds ago
IoTSensor	{"dist":35,"load":15,"alert":"Alert : Dumpster pou..."}	json	a few seconds ago
IoTSensor	{"dist":26,"load":13,"alert":"Alert : Dumpster pou..."}	json	a few seconds ago
IoTSensor	{"dist":17,"load":6,"alert":"Alert : No need to coll..."}	json	a minute ago
IoTSensor	{"dist":10,"load":12,"alert":"Alert : Dumpster is a..."}	json	a minute ago



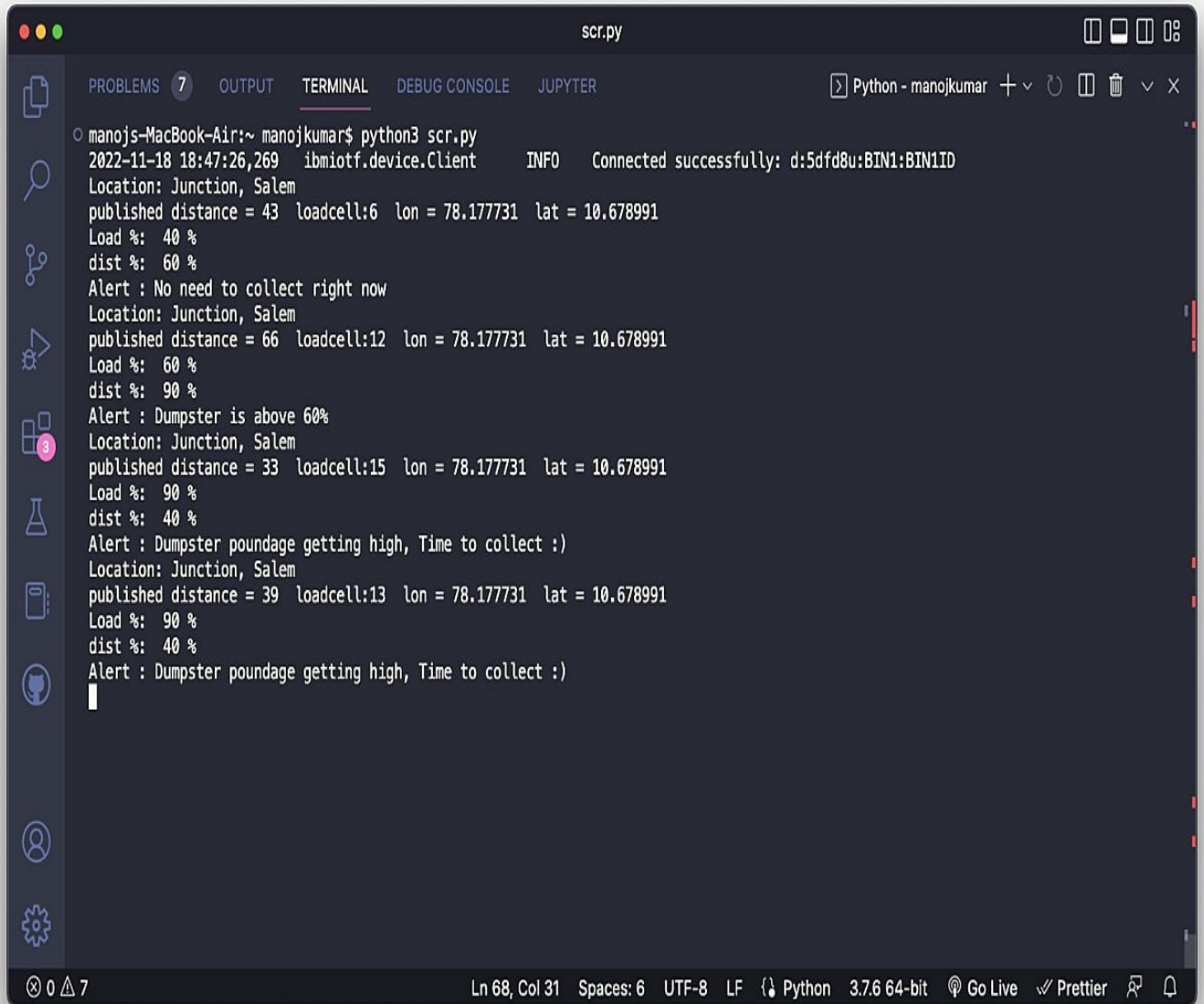
7.2 Feature 2





8 TESTING

8.1 Test Cases

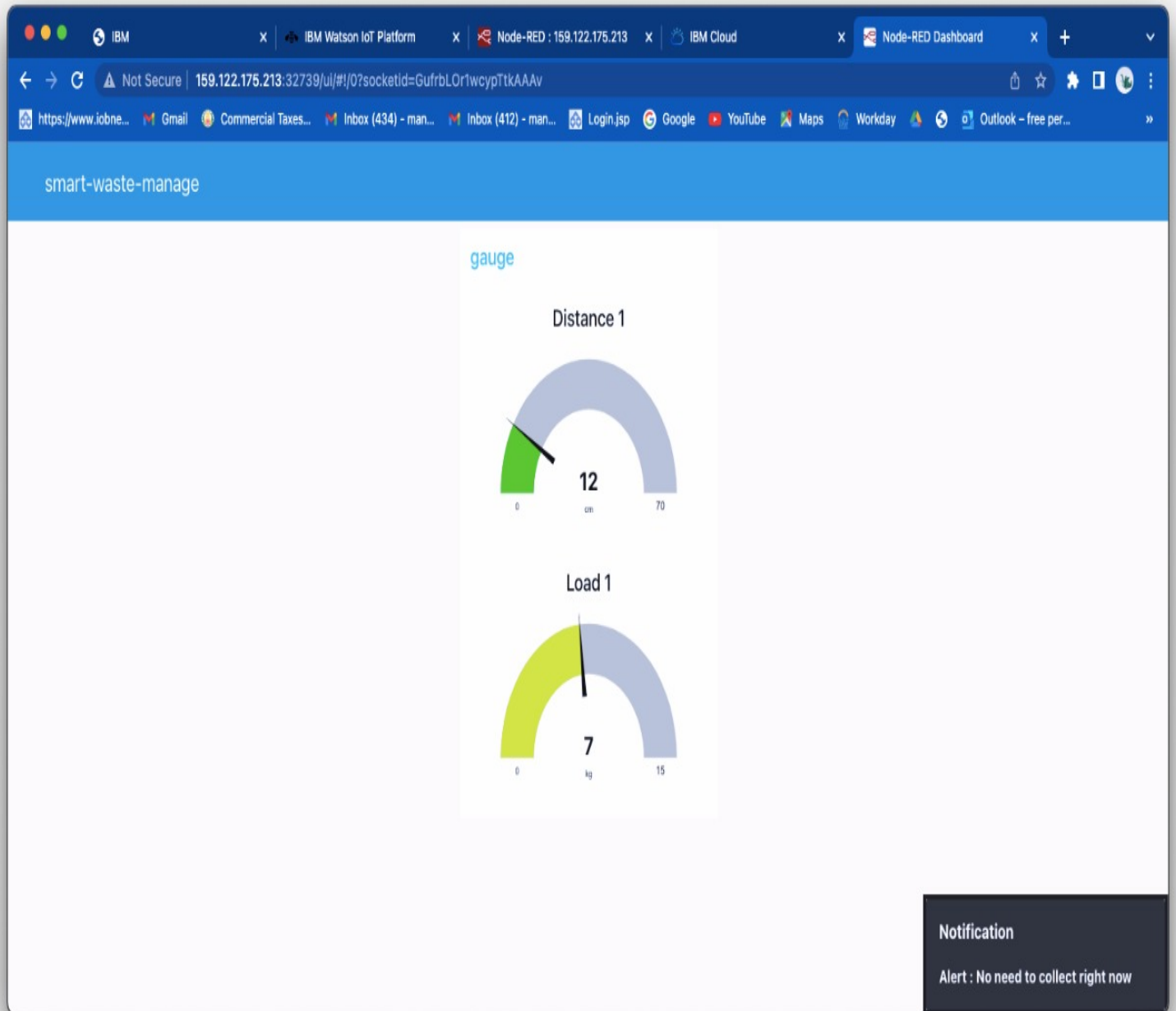


```
scr.py
2022-11-18 18:47:26,269 ibmiotf.device.Client INFO Connected successfully: d:5dfd8u:BIN1:BIN1ID
Location: Junction, Salem
published distance = 43 loadcell:6 lon = 78.177731 lat = 10.678991
Load %: 40 %
dist %: 60 %
Alert : No need to collect right now
Location: Junction, Salem
published distance = 66 loadcell:12 lon = 78.177731 lat = 10.678991
Load %: 60 %
dist %: 90 %
Alert : Dumpster is above 60%
Location: Junction, Salem
published distance = 33 loadcell:15 lon = 78.177731 lat = 10.678991
Load %: 90 %
dist %: 40 %
Alert : Dumpster poundage getting high, Time to collect :)
Location: Junction, Salem
published distance = 39 loadcell:13 lon = 78.177731 lat = 10.678991
Load %: 90 %
dist %: 40 %
Alert : Dumpster poundage getting high, Time to collect :)

```

9. RESULT

9.1 Performance Metrics



10. ADVANTAGES AND DISADVANTAGES

ADVANTAGES:

- 1) It saves time and money by using smart waste collection bins and systems equipped with fill level sensors.
- 2) It further reduces manpower requirements to handle the garbage collection process.
- 3) It keeps our surroundings clean and green and free from bad odour of wastes, emphasizes on healthy environment and keep cities more beautiful.
- 4) It helps administration to generate extra revenue by advertisements on smart devices.

DISADVANTAGES:

- 1) 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 methods.
- 2) Sensor nodes used in the dustbins have limited memory size.
- 3) It reduces man power requirements which results into increase in unemployments for unskilled people.
- 4)The training has to be provided to the people involved in the management.

11. CONCLUSION

Smart waste management is a idea where we can control lots of problems which disturbs the society in pollution and diseases. The waste management has to be done instantly else it leads to irregular management which will have adverse effect on nature. The Smart waste management is compatible mainly with concept of smart cities

12. FUTURE SCOPE

The future of IoT is virtually unlimited due to advances in technology and consumers desire to integrate devices such as smart phones with household machines. As we done for the random values from the sensor, there is a idea for developing lot devices with physical devices to more number of smart bins across the cities.

13. APPENDIX

Source Code :

https://docs.google.com/document/d/1d-ob9t33wG79poNXlvS5_SthFrQvQsC2dGLWq1EYFGU/edit?usp=sharing

Github :

<https://github.com/IBM-EPBL/IBM-Project-26429-1660026551>

Video Demo Link :

<https://drive.google.com/file/d/1mc0-LyUMYh4WGtPyikpffZBdzM2U9N3R/view?usp=drivesdk>