Smart Waste Management for Metropolitan Cities

IBM–DOCUMENTATION

UNDER THE GUIDANCE OF

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ANNA UNIVERSITY :: 2019–2023

1. INTRODUCTION

Project overview

- Garbage level detection in bins.
- Getting the weight of the garbage in the bin.
- Alerts the authorized person to empty the bin whenever the bins are full.
- Garbage level of the bins can be monitored through a web App.
- We can view the location of every bin in the web application by sending GPS location from the device.

- Gain knowledge of Watson IoT Platform.
- Connecting IoT devices to the Watson IoT platform and exchanging the sensor data.
- Gain knowledge on Cloudant DB
- Creating a Web Application through which the user interacts with the device.

PURPOSE

Smart waste management is about using technology and data to create a more efficient waste industry. Based on IoT (Internet of Things) technology.

smart waste management aims to

- optimize resource allocation,
- reduce running costs,
- Increase the sustainability of waste services
- Reduce environmental pollution.
- Avoid overflowing of waste.
- Reduce harmful diseases.

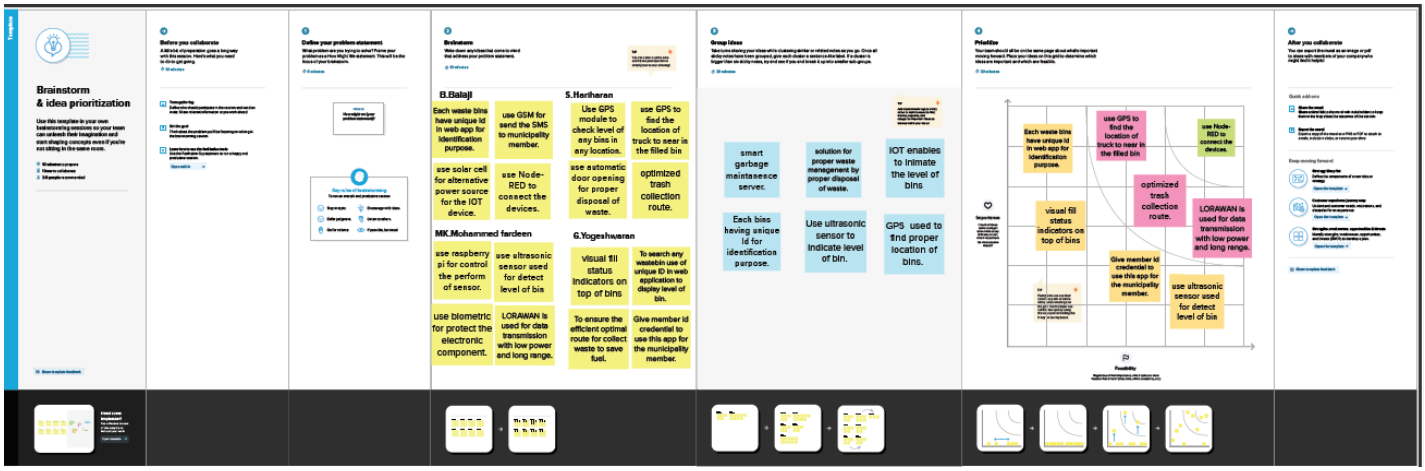
2. LITERATURE SURVEY

Title	Author and date of publication	Advantage	Disadvantage
IOT-Based route Recommendation for an Intelligent Waste Management System	MohammadHosseinghahramani -15th July 2022	It also maintains a good diversity in a newly generated population. Different types of mutation operations(e.g., insertion, invention and swap) have been considered in our model.	The main drawback of the state of art was that it cannot appropriately model the association among spatial objects, consequently find an optimal route
IoT-Enabled Smart Waste Management Systems for Smart Cities: A Systematic Review	Inna Sosunova-4th July 2022	Optimization of the garbage collection process, reduction of labor and resource cost, increase in efficiency and comfort of citizens. Improvement of the ecological situation in the city.	The main weakness of the current studies (and thus also a gap) is that none of them aims to propose a general holistic view at any level of operation.

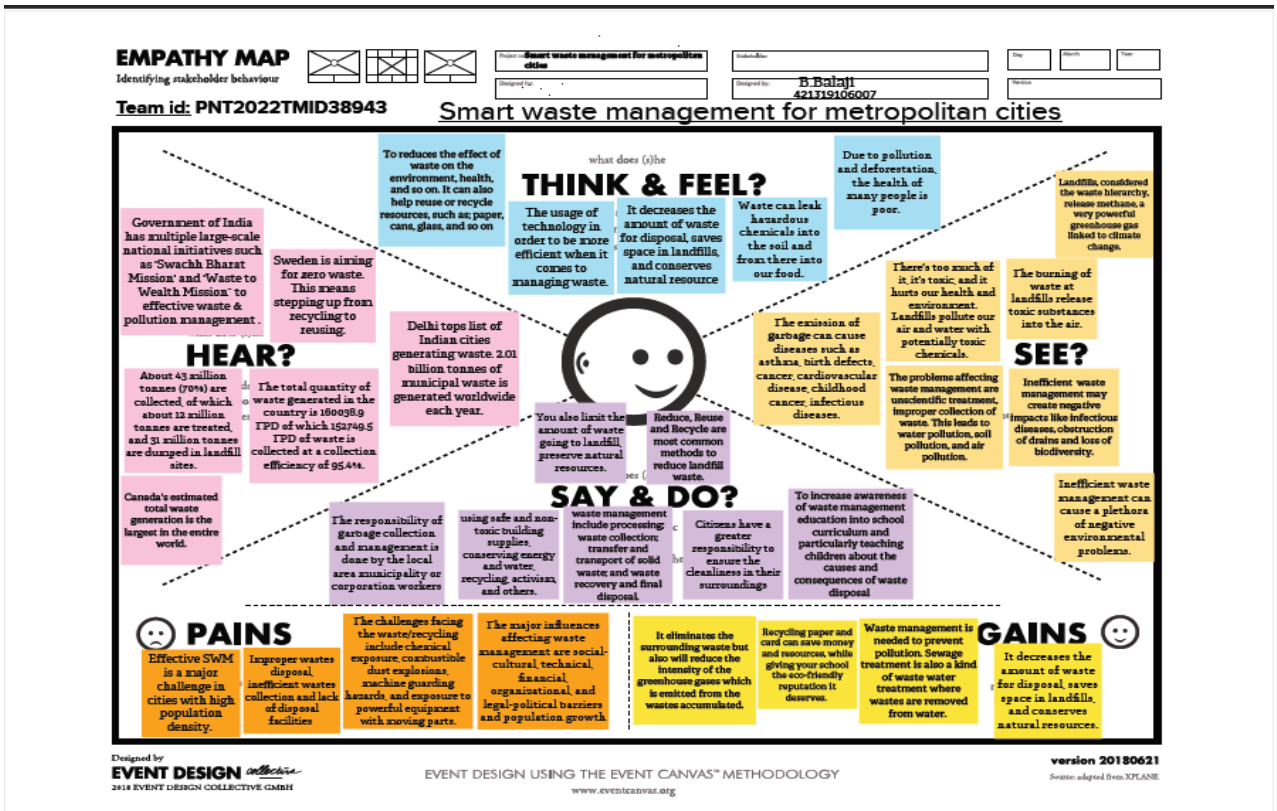
Assessing the Adaptation of Internet of Things (IoT) Barriers for Smart Cities' Waste Management Using Fermatean Fuzzy Combined Compromise Solution Approach	Arunodaya R. Mishra-1st April 2022	To improve the quality of life and achieve sustainability, the adoption of IOT technologies plays a key driver for the efficient and sustainable development of smart cities. The test shows that the method is practical and flexible for solving MADM problems in complex environments.	The proposed study is unable to deal with the new generation of smart applications with more complex sets of heterogeneous information, data, systems, sensors, devices, etc. Also, this study has not included several open technical and social challenges.
Assessment of Solid Waste Management Strategies Using an Efficient Complex Fuzzy Hypersoft Set Algorithm Based on Entropy and Similarity Measures.	Mohammad saeed-8th Nov 2022	Utilizing effective and appropriate SWM stragies is necessary to regulate many forms of pollution, prevent infectious illness, conserve natural resources, and recycle toxic substances. Blending a FS and HSS described in complex structure provides the CFHSS set.	When the features would be further split into attribute values and concerns that comprise two-dimensional content, all preceding restraints are abolished
Blockchain for Waste Management in Smart Cities: A Survey	Raja Wasim Ahmad-16th sep 2021	Blockchain technology can be leveraged for managing waste within smart cities in a manner that is decentralized,temper-proof, transparent, traceable and trackable, auditable, secure and trustworthy.	The performance of blockchain is severely affected by large-scale business applications.

3.Ideation and Proposed solution

Ideation and brainstroming



Empathy Map



Proposed Solution:

Project team shall fill the following information in proposed solution template.

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

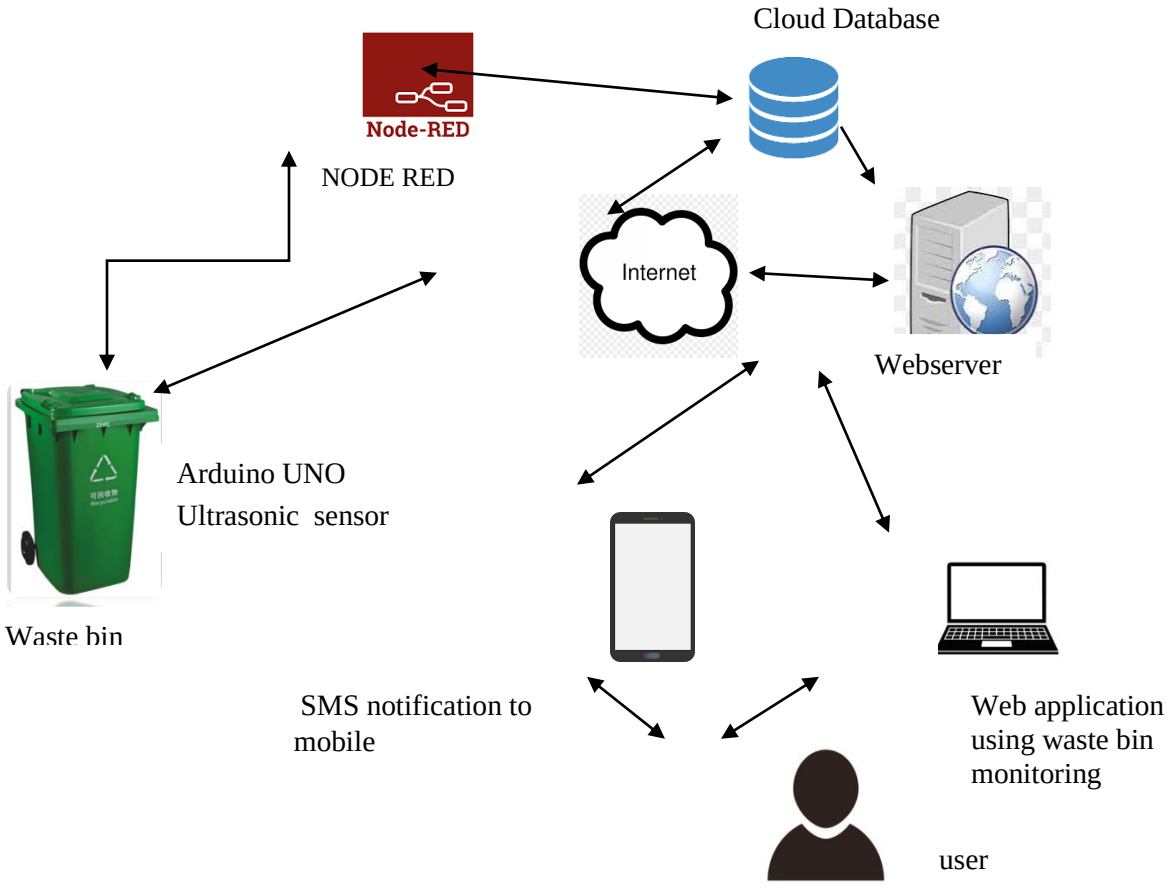
6.	Scalability of the Solution	Using of weight sensor to detect the level of garbage. This sensor gives more lifespan and reduce the damage of sensor. Use LORAWAN covers long range and consumes low power. The web app gives short route of truck to reduce the fuel cost. This design gives better efficiency.

Solution Architecture:

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Its goals are to:

- Find the best tech solution to solve existing business problems.
- Describe the structure, characteristics, behavior, and other aspects of the software to project stakeholders.
- Define features, development phases, and solution requirements.
- Provide specifications according to which the solution is defined, managed, and delivered.

Example - Solution Architecture Diagram:



Solution Architecture of Smart Waste management for Metropolitian Cities

PROBLEM SOLUTION FIT

1. CUSTOMER SEGMENT:

Public are the customer.

2JOBS TO BE DONE:

To create a clean environment and to intimate people to separate bio-degradable and non-bio degradable.

3.TRIGGERS:

Thinking to save environment, pollution free, protect health.

4.EMOTIONS –BEFORE /AFTER:

They ensure the hygienie atmosphere, they create the healthy environment and useful to prevent pollution.

5**. AVAILABLE SOLUTIONS:**

By allowing the people to reach through web app,website text message and also call

resorce accordingly.

6.CUSTOMER CONSTRAINTS:

Lack of communication while calling

7. **BEHAVIOUR:**
By contact service team through helpline.

8. **CHANNELS OF BEHAVIOUR:**
It is a online process.

9. **PROBLEM ROOT CAUSE:**

Improve the health, reduce pollution,ensure environment safety.

10. **YOUR SOLUTION:**

It create the pollution free pollution by clean and immaculate place and to intimate the people to separate the bio degradable and bio degrable waste tha helps in recycling and to protect the healthy.

4. 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	User login	Log in using user id and password. Log in through Gmail
FR-2	User Confirmation	Check the Log in credentials. If credentials are correct then move next page.
FR-3	Select the waste bin	In web application to Search the bin using unique id. You can see bin details such as capacity, bin level, GPS location.
FR-4	Node red and cloud	Node red used to connect the IOT devices. Details are stored in cloud and update periodically.
FR-5	Notifier and sensor	Notification should send automatically when bins are filled. The sensor is used to monitor the level of bins.
FR-6	Monitoring using real time examples	Display real-time data on fill level of bins monitored by smart sensors. with real-time data and predictions, you can eliminate the overflowing bins and stop collection half-empty ones

Non-functional Requirements:

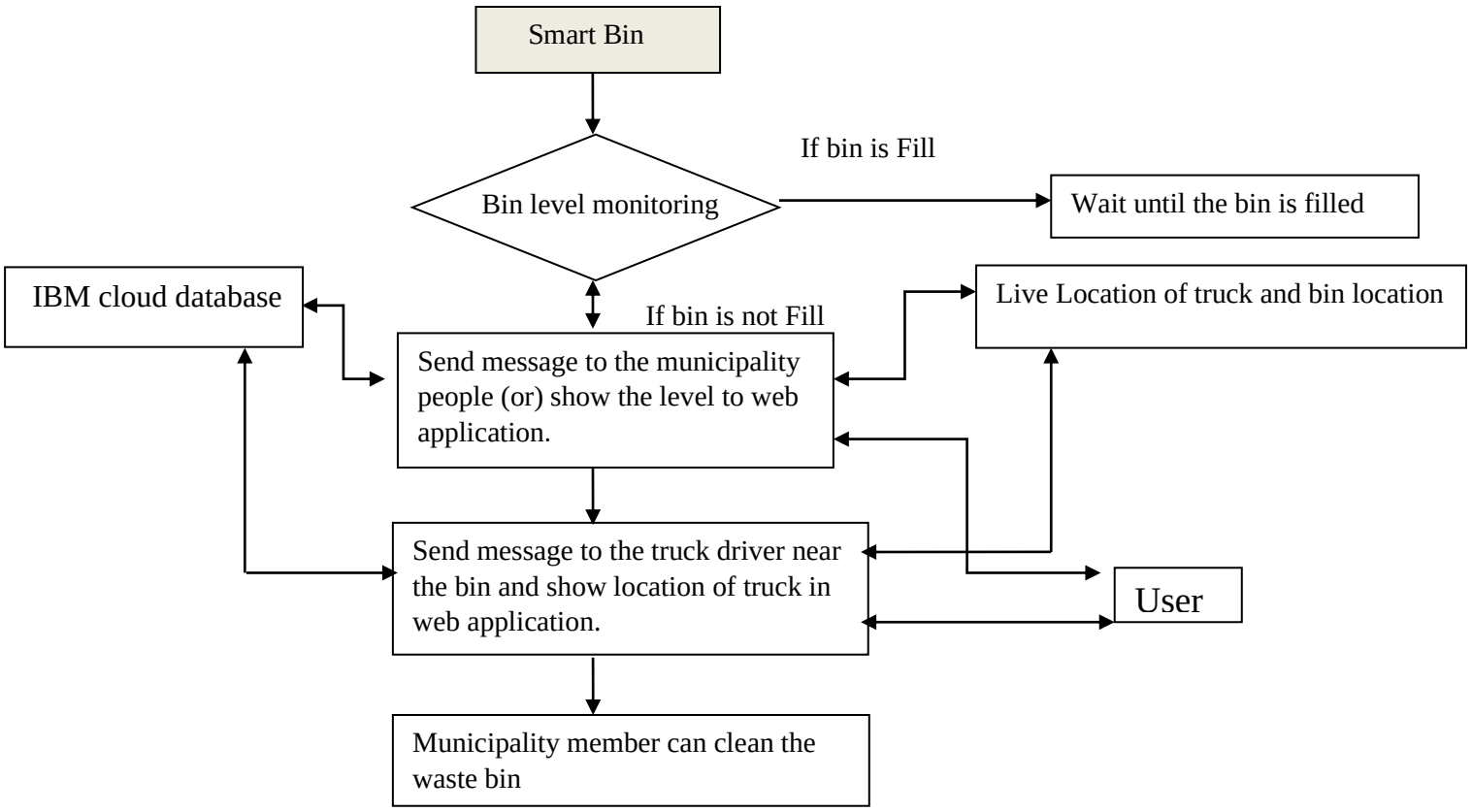
Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	It will stop overflowing of dust bins along roadsides and localities as smart bins are manage at real time.
NFR-2	**Security**	Details in the cloud are more secure. The electronic components in the bins are protected
NFR-3	**Reliability**	Smart waste management is also about creating better working conditions for waste collection. The details or data are maintained efficiently.
NFR-4	**Performance**	This software system is a cloud based platform for data driven operations, available also as a web app. Optimization of waste collecting routes, frequencies and vehicle loads resulting in route reduction by at least 30%. It aims to create clean environment
NFR-5	**Availability**	This method is available for all urban peoples for clean environment. By developing and deploying hardware and software we empower cities and countries to manage waste smarter.
NFR-6	**Scalability**	Using smart waste bins reduce the number of bins inside town, cities we able to monitor the garbage 24/7 most cost effect and scalability when we moves to smarter.

5. PROJECT DESIGN

Data Flow Diagrams:

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



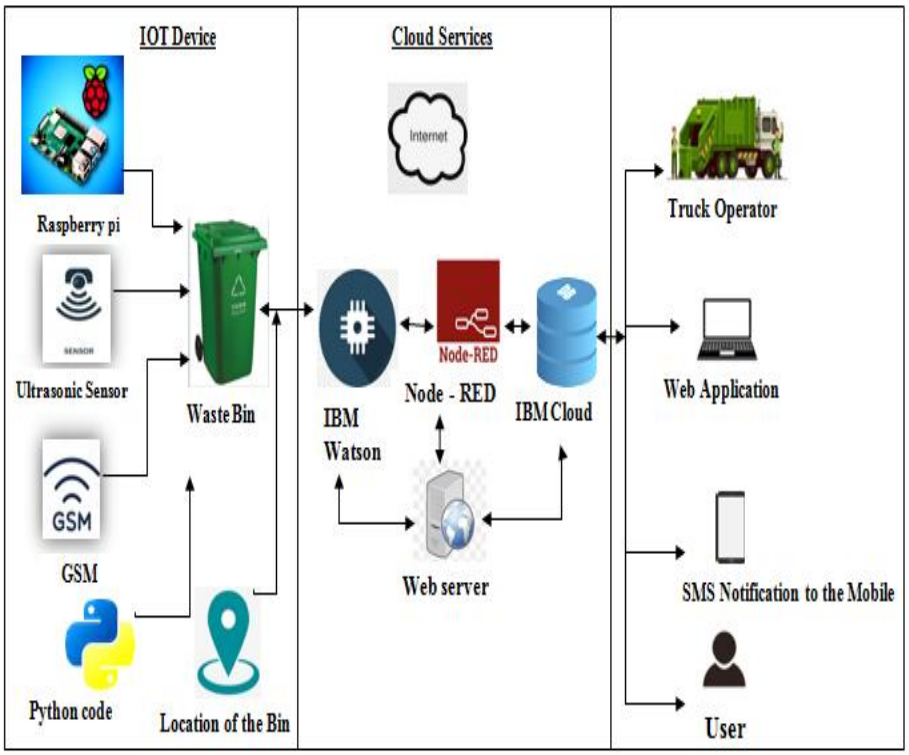
User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (web user admin)	login	USN-1	As a user, I can entering, member ID, my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
web user admin	login confirmation	USN-2	As a user, I will receive confirmation notification move to next page.	I can receive notification, move to dashboard	Medium	Sprint-1
web user admin	Dashboard	USN-3	As a user, I can Enter the bin ID, then view the bin level and its location and manage web server.	I can enter the bin ID to see the bin details	High	Sprint-2
Web user admin	Dashboard	USN-4	As a user, I can monitor the location of the trucks.	I can access the location of the truck	medium	Sprint-2
Mobile user	Notification	USN-5	As a user, I already register my mobile number. If bin is filled alert notification received by respective mobile number.	I receive notification through mobile number.	High	Sprint-3
Truck driver	dashboard	USN-6	As a truck driver. I reach to correct destination to correct the garbage.	I can login and access the location via dashboard	High	Sprint -2
Local garbage collector	Dashboard	USN-7	As a local garbage collector, I collect the garbage from the bins.	I can login and access the location.	High	Sprint-2

Technical Architecture:

The Deliverable shall include the architectural diagram as below and the information as per the table1 & table 2



Guidelines:

1. Include all the processes (As an application logic / Technology Block)
2. Provide infrastructural demarcation (Local / Cloud)
3. Indicate external interfaces (third party API's etc.)
4. Indicate Data Storage components / services
5. Indicate interface to machine learning models (if applicable)

Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	Web application, mobile SMS	HTML, C , JavaScript, Node Red, GSM etc.
2.	Application Logic-1	To calculate the distance of garbage in the waste bin and show the level in the web application. Sensor is used to measure the level of bin.	Ultrasonic sensor / Python
3.	Application Logic-2	Raspberry pi (or) Arduino UNO is used for performance of sensor and send the data to web application.	Raspberry pi/Arduino UNO

4.	Application Logic-3	Getting the location of waste bin show the web application	GSM/GPS
5.	Database	Real time hosting of database, all the bin informations	NoSQL
6.	Cloud Database	Bin data stored by using cloud database	IBM DB2, IBM Cloudant etc.
7.	File Storage	File storage requirements	IBM Block Storage or Other Storage Service or Local Filesystem
8.	External API-1	Firebase is a set of hosting services for any type of application. It offers NoSQL and real-time hosting of databases, content, notifications, such as a real time communication server.	Firebase
9.	Distance Recognition Model	To send alert message to municipality member, when garbage bin is full.	Distance Recognition/GSM.
10.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: Local host Cloud Server Configuration : Local host, fire base,MQTT	Local host, cloud, web application.

6. PROJECT PLANNING AND SCHEDULING

MILESTONE LIST

Milestone Name	Milestone Number	Description	Mandatory
Project Objectives	M-01	We connecting IOT devices to the Watson platform and exchange the sensor data. Creating the web application through which user interacts with device. Gain knowledge of IBM Watson, IBM cloud and Node red.	Yes
Pre-Requisites	M-02	To complete this project, we should have known about IBM cloud, python coding, Node red, simulation of circuit.	Yes
Create and configure IBM cloud services	M-03	To create IBM Watson IOT platform and devices, create Node-Red service, create a Database in cloudant Database.	Yes
Develop a python script.	M-04	To random sensor data to the IBM IOT platform.	Yes
Develop a web application using Node-Red service	M-05	A web UI should be created in Node-Red using dashboard nodes available in it.	Yes
Ideation Phase	M-06	Prepare Literature Survey on the selected Project and Information Gathering, empathy map and ideation	Yes
Project Design Phase-I	M-07	Prepare Proposed solution, problem-solution fit and Solution Architecture	Yes
Project Design Phase-II	M-08	Prepare Customer journey ,functional requirements, Dataflow diagram and Technology Architecture	Yes
Project Planning Phase	M-09	Prepare Milestone list , Activity list and Sprint Delivery Plan	Yes

Project Development Phase	M-10	Project Development delivery of Sprint 1, Sprint 2, Sprint 3, Sprint 4	Yes

ACTIVITY LIST

Activity Number	Activity	Sub Activity	Assigned To	Status
1.	PROJECT OBJECTIVES	Abstract	All Members	Completed
2.	PRE-REQUISITES	Create IBM account and software	All Members	Completed
3.	Create and configure IBM cloud services	To create IBM Watson IOT platform and devices, create Node-Red service, create a Database in cloudant Database.	All Members	Completed
4.	Develop a python script.	Develop a python script,publish data to the IBM cloud.	All Members	Completed
5.	Develop a web application using Node-Red service	Develop the web Application using Node-Red, Use dashboard Nodes for creating UI(web app)	All Members	In Progress
. 6.	IDEATION PHASE	Literature Review. Empathy map. Ideation.	All Members	Completed

7.	PROJECT DESIGN PHASE – I	Proposed Solution. Problem solution fit. SolutionArchitecture.	All Members	Completed
8.	PROJECT DESIGN PHASE -II	Customer journey. Functionalrequirement. Data flow Diagrams. TechnologyArchitecture.	All Members	Completed
9.	PROJECT PLANNING PHASE	Prepare milestoneand activity list. Sprint delivery plan.	All Members	Completed
10.	PROJECT DEVELOPMENT PHASE	Project development-Delivery of Sprint-1. Project development-Delivery of Sprint-2. Project development-Delivery of Sprint-3. Project development-Delivery of Sprint-4.	All Members	Completed

SPRINT DELIVERY SCHEDULE

Use the below template to create product backlog and sprint schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	simulation	USN-1	Simulation creation by connecting sensors, Arduino UNO with python code.	20	High	B. Balaji S. Hari haran MK.Mohamed fardeen G. Yogeshwaran
Sprint-2	Web application Login	USN-2	Create a web application for level detection of waste using MIT app inverter. As a user, I can log into the application by entering email & password.	10	Medium	B. Balaji S. Hari haran MK.Mohamed fardeen G. Yogeshwaran
Sprint-2	Login	USN-3	Check the Log in credentials. If credentials are correct then move next page.	10	Low	B. Balaji S. Hari haran MK.Mohamed fardeen G. Yogeshwaran
Sprint-3	Software	USN-4	Create device in the IOT Watson, workflow for IOT scenarios using local node red.	20	High	B. Balaji S. Hari haran MK.Mohamed fardeen G. Yogeshwaran
Sprint-4	dashboard	USN-5	Web UI to make interact with the software. Bin level view in web app and notification received By municipality member, if bin is full.	20	High	B. Balaji S. Hari haran MK.Mohamed fardeen G. Yogeshwaran

Project Tracker, Velocity & Burndown Chart:

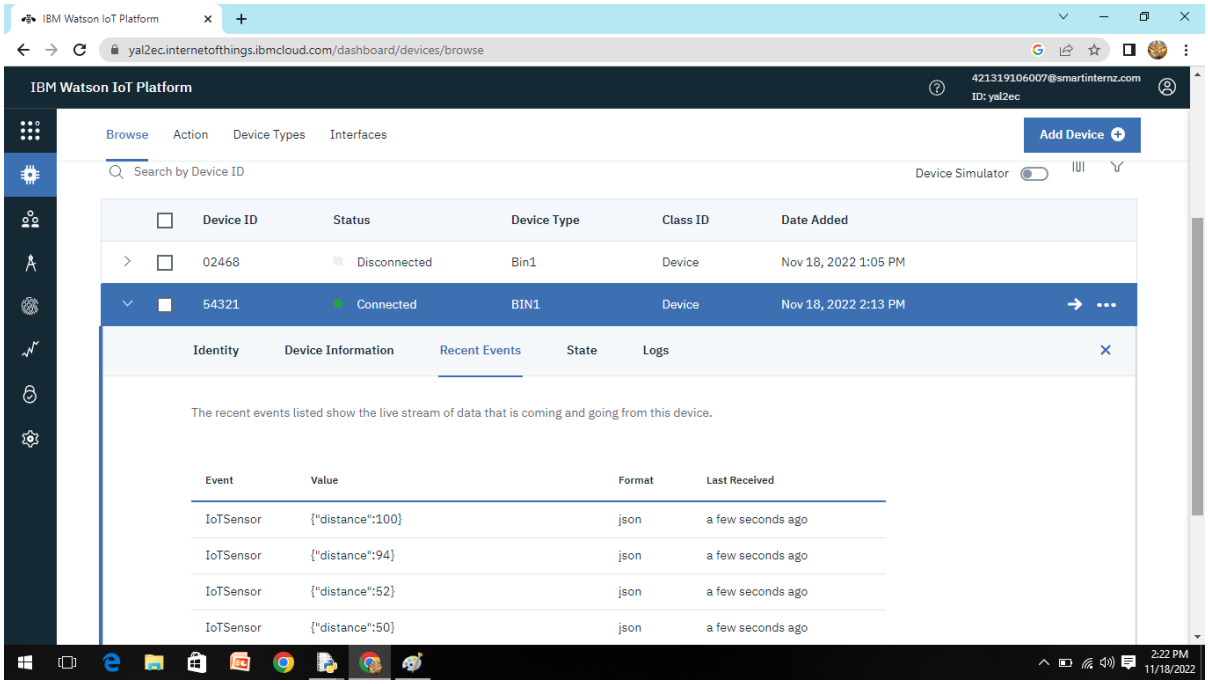
Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

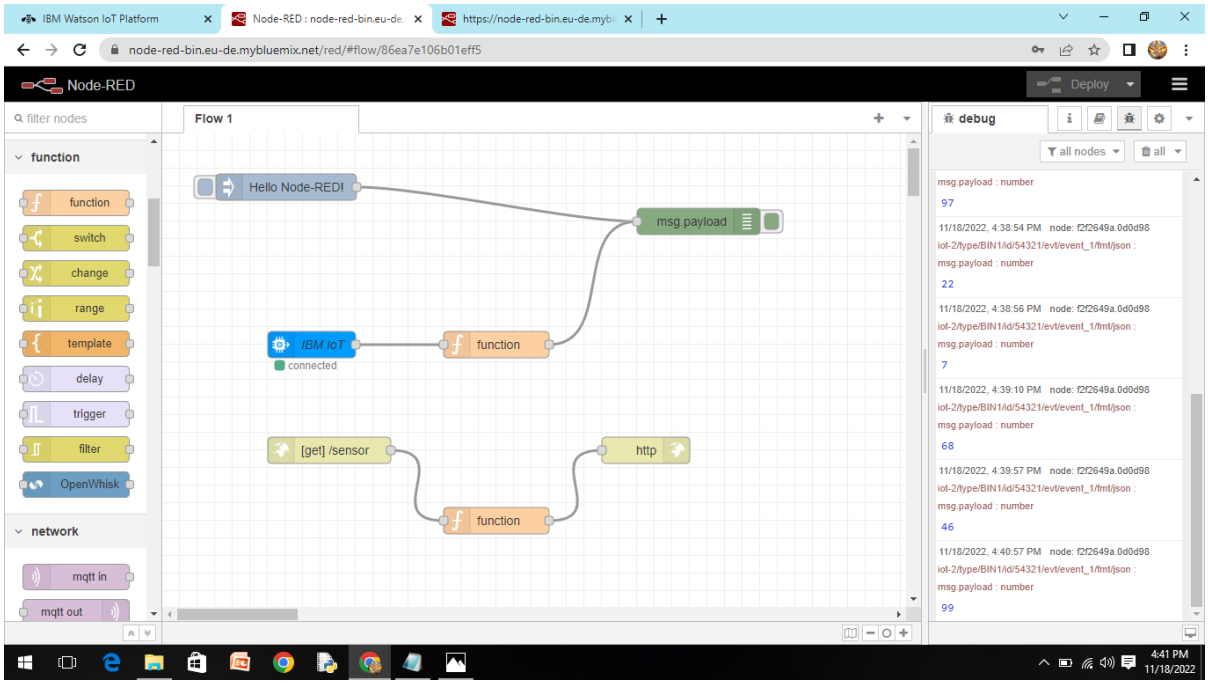
Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

IBM WATSON DEVICE CONNECTION:



NODE-RED CONNECTION:



7.FINAL CODING

PYTHON CODE

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

#Provide your IBM Watson Device Credentials
organization = "yal2ec"
deviceType = "BIN1"
deviceId = "54321"
authMethod = "token"
authToken = "12345678"

# Initialize GPIO
def myCommandCallback(cmd):
    print("Command received: %s" % cmd.data['command'])
    status=cmd.data['command']

try:
deviceOptions = {"org": organization, "type": deviceType, "id": deviceId, "auth-method": authMethod, "auth-token": authToken}
deviceCli = ibmiotf.device.Client(deviceOptions)
#.....

except Exception as e:
print("Caught exception connecting device: %s" % str(e))
sys.exit()
```

```
# Connect and send a datapoint "hello" with value "world" into the cloud as an event of type "greeting" 10 times
deviceCli.connect()


while True:
        #Get Sensor Data from ultrasonic
        distance= random.randint(5,100)
        data= {'distance':distance}
        if distance >5 and distance<=35:
          print("alert:' 'waste bin level high is 90%, Time to collect")
        elif distance>35 and distance<=50:
          print("Risk warning:' 'waste Bin is above 60%")
        elif distance >35 and distance <=70:
          print("waste Bin level is above 40%")
        elif distance >70 and distance <=85:
            print("waste Bin level is above 25%")
        elif distance >85 and distance <100:
            print("waste Bin level is above 10%")
        elif distance==100:
            print("waste Bin is Empty")



    #print data
        def myOnPublishCallback():
 print ("Published distance = %s " %distance ,"to IBM Watson"
 success = deviceCli.publishEvent("IoTSensor", "json", data, qos=0, on_publish=myOnPublishCallback)
  if not success:
  print("Not connected to IoTF")
```

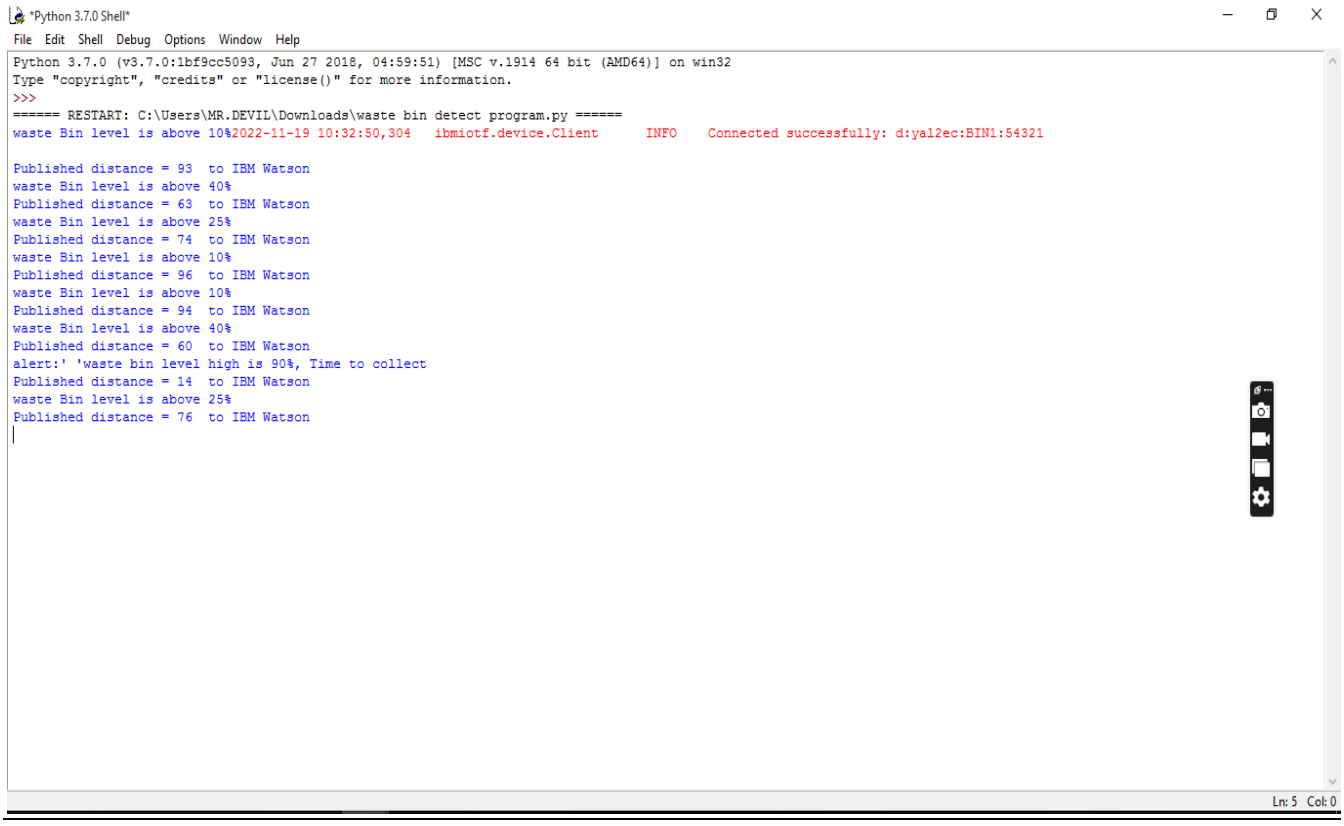
time.sleep(10)

deviceCli.commandCallback = myCommandCallback

Disconnect the device and application from the cloud

deviceCli.disconnect()

PYTHON OUTPUT:



8. RESULT:

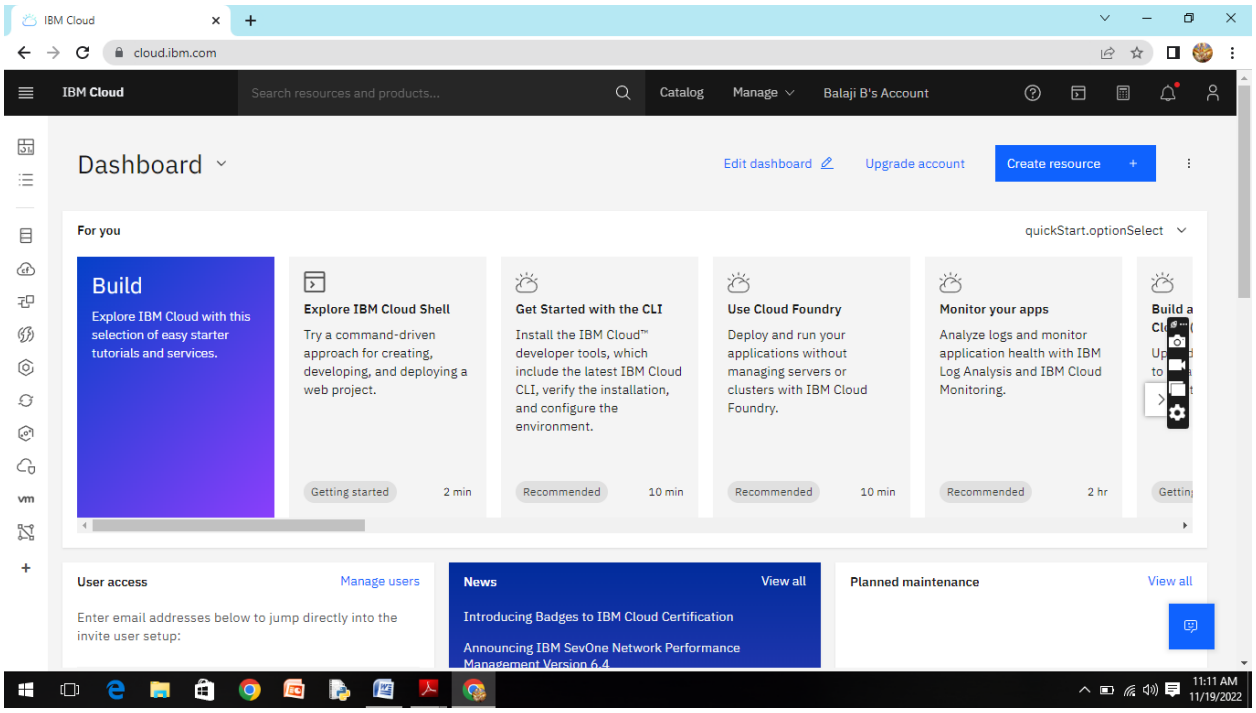
If the python code generate the values in the range, then the code is connected to the IBM Watson devices and check if connected or not.

The Watson is connected to the NODE-RED. To put the proper connections in NODE-RED.

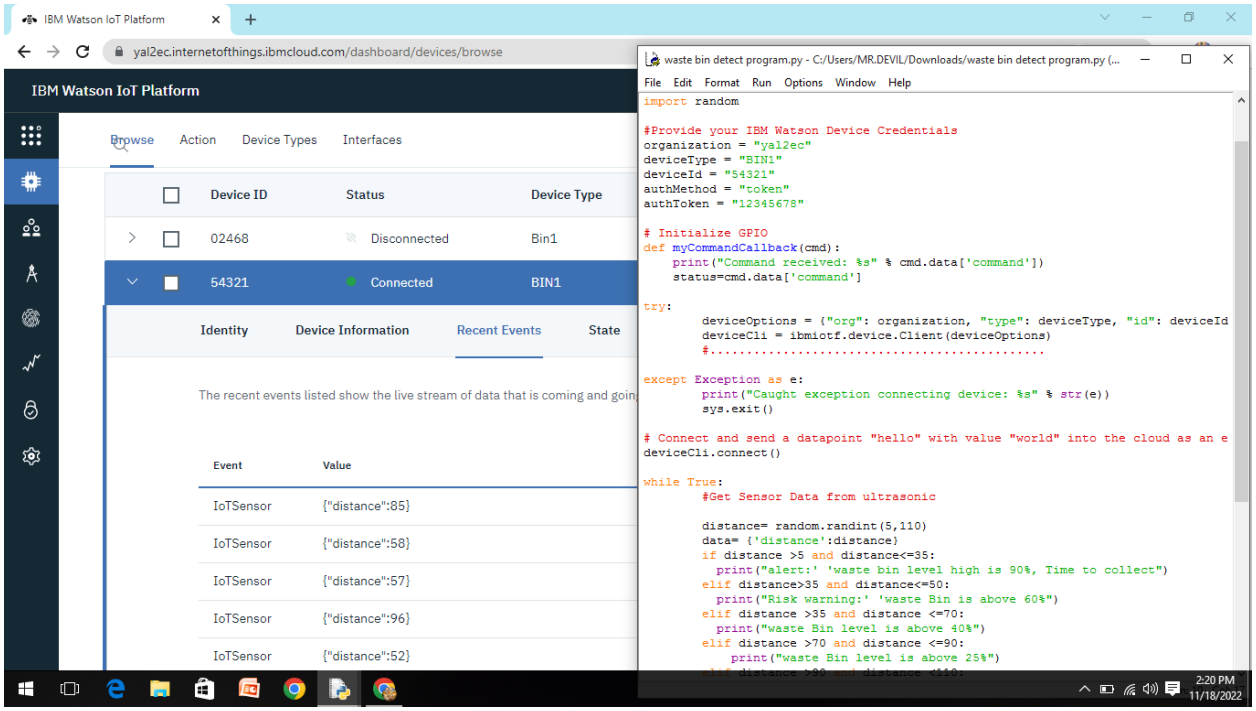
The NODE-RED is connected to the MIT APP INVERTER. It is used create your own application.

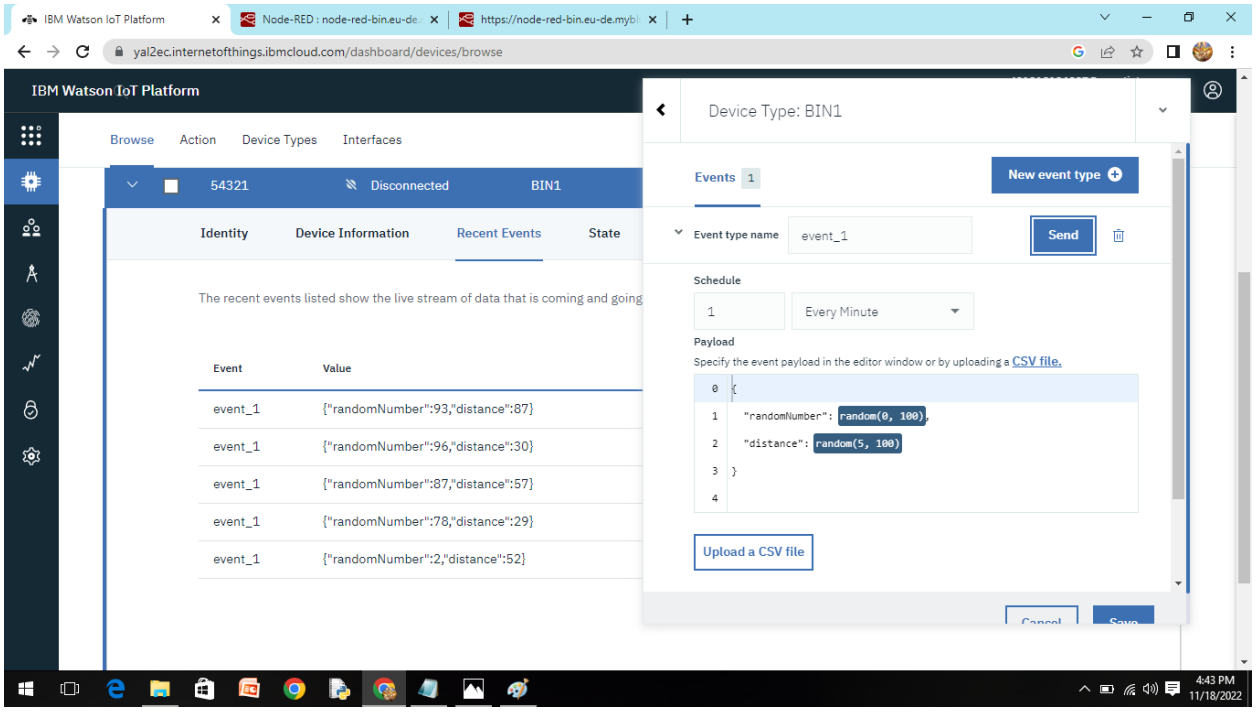
Finally, the python generating values is shown in your own app.

CREATE IBM CLOUD ACCOUNT:

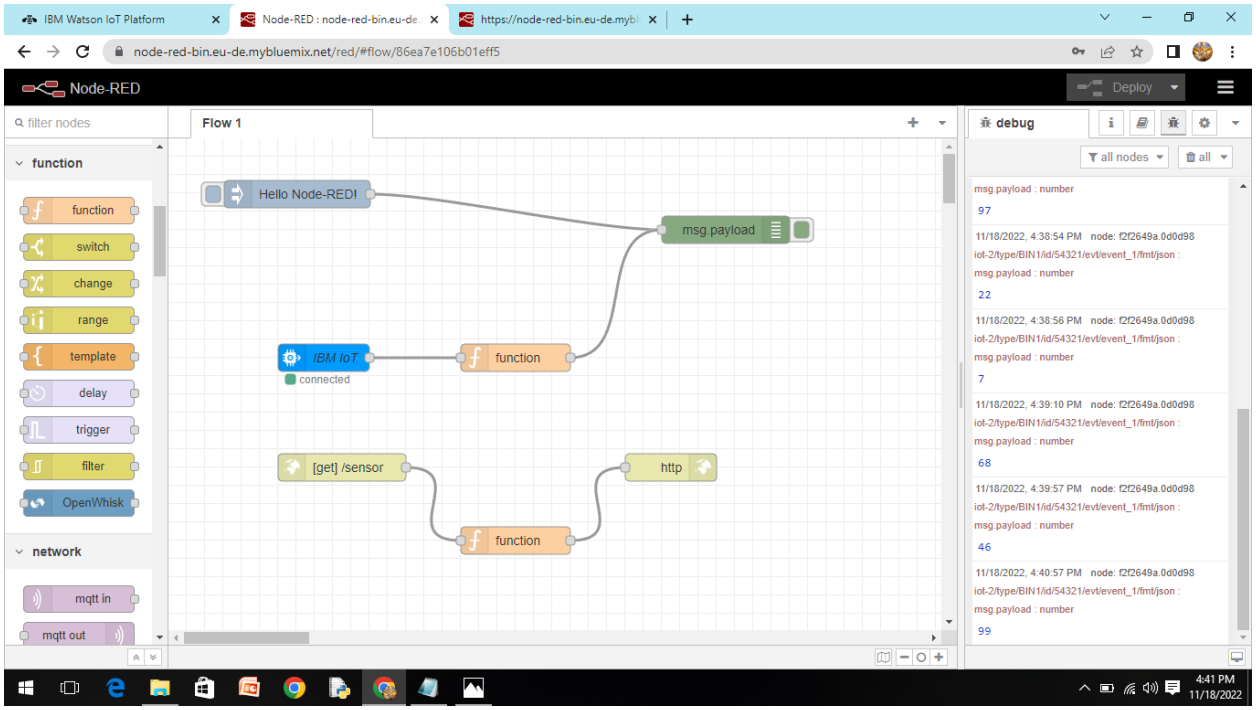


PYTHON CONNECT WITH WATSON:





NODE RED_CONNECTION:



MOBILE_APPLICATION:

The random value distance in python is shown in your App

ADVANTAGES

- No Missed Pickups.
- Reduced Overflows.
- Waste Generation Analysis.
- CO2 Emission Reduction.

DISADVANTAGES

- Process is not always cost-effective
- The resultant product has a short life

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.

FUTURE SCOPE

- In future waste can be collected in the automated system in real time any place.
- There are four tiers to waste management to reduce its environmental impact: pollution prevention and source reduction; reuse or redistribution of unwanted, surplus materials; treatment, reclamation, and recycling of materials within the waste; and disposal through incineration, treatment, or land burial.

12.APPENDIX

- Git up repository Direct Link
- Link- https://github.com/IBM-EPBL/IBM-Project-43127-1660713349
- IBM WATSON LINK
- LINK-https://yal2ec.internetofthings.ibmcloud.com/dashboard/devices/browse
- NODE-RED LINK
- LINK - https://node-red-bin.eu-de.mybluemix.net/red/#flow/86ea7e106b01eff5
- Demonstration video LINK
- LINK- https://youtu.be/r9l4ICkOwU8
- MIT APP INVERTER LINK
- Link- http://ai2.appinventor.mit.edu/#4963665393352704