SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

IBM NALAIYATHIRAN (HX8001)
PROJECT REPORT

Submitted by

DEEPAK C	**211719106011**
HARISH KUMAR	**211719106025**
JANAKIRAMAN S	**211719106030**
MANIKANDAN S	**211719106049**

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of

BACHELOR OF ENGINEERING

IN

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ANNA UNIVERSITY: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report **"SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES"** is the bonafide work of **"MANIKANDAN S (211719106049), DEEPAK C (211719106011),JANAKIRAMAN(211719106030),HARISH KUMAR S(211719106025)",** who carried out the project work under my supervision.

SIGNATURE:
Dr. S. MANJULA,
M.E., Ph.D,
HEAD OF THE DEPARTMENT,
Dept. of Electronics and Communication Engg.,
Rajalakshmi Institute of Technology,
Kuthambakkam Post,
Chennai - 600 124

SIGNATURE:
Mr. L Franklin Telfer,
M.E , Assistant Professor
MENTOR,
Dept. of Electronics and Communication Engg.,
Rajalakshmi Institute of Technology,
Kuthambakkam Post,
Chennai - 600 124

The viva-voce is held on_____.

INTERNAL EXAMINER **EXTERNAL EXAMINER**

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INTRODUCTION

Internet of Things (IoT) technology has brought revolution to each and every field of common man's life by making everything smart and intelligent. IoT refers to a network of things which make a selfconfiguring network. The development of Intelligent Smart Farming IoT based devices is day by day turning the face of agriculture production by not only enhancing it but also making it cost-effective and reducing wastage. The aim / objective of this report is to propose IoT based Smart Farming System assisting farmers in getting Live Data (Temperature, Soil Moisture) for efficient environment monitoring which will enable them to increase their overall yield and quality of products. The IoT based Smart Farming System being proposed via this report is integrated with Arduino Technology mixed with different Sensors and a Wifi module producing live data feed that can be obtained online using MIT app inventor.

LITERATURE SURVEY

1.TOPIC : An Internet of Things Based Smart Waste Management System Using LoRa and Tensorflow Deep Learning Model

AUTHOR : TEOH JI SHENG , MOHAMMAD SHAHIDUL ISLAM , (GraduateStudent Member, IEEE), NORBAHIAH MISRAN 1, (SeniorMember, IEEE), MOHDHAFIZ BAHARUDDIN 1 , (Member, IEEE), HASLINA ARSHAD , MD. RASHEDUL ISLAM , MUHAMMAD E. H. CHOWDHURY , (Member, IEEE), HATEM RMILI , (Senior Member, IEEE), AND MOHAMMAD TARIQUL ISLAM 1

DESCRIPTION : Traditional waste management system operates based on daily schedule which is highly inefficient and costly. The existing recycle bin has alsoproved its ineffectiveness in the public as people do not recycle their waste properly. With the development of Internet of Things (IoT) and Artificial Intelligence (AI), the traditional waste management system can be replaced with smart sensors embedded into the system to perform real time monitoring and allow for better waste management. The aim of this research is to develop a smart waste management system using LoRa communication protocol and TensorFlow based deep learning model. LoRa sends the sensor data and Tensorflow performs real time object detection and classification. The bin consists of several compartments to segregate the waste including metal, plastic, paper, and general waste compartment which are controlled by the servo motors. Object detection and waste classification is done in TensorFlow framework with pre-trained object detection model. This object detection model is trained with images of waste to generate a frozen inference graph used for object detection which is done through a camera connected to the Raspberry Pi 3 Model B+ as the main processing unit. Ultrasonic sensor is embedded into each waste compartment to monitor the filling level of the waste. GPS module is integrated to monitor the location and real time of the bin. LoRa communication protocol is used to transmit data about the location, real time and filling level of the bin. RFID module is embedded for the purpose of waste management personnel identification.

2.TOPIC : IoT-Based Smart Waste Bin Monitoring and Municipal Solid WasteManagement System for Smart Cities

AUTHOR : Tariq Ali1 · Muhammad Irfan1 · Abdullah Saeed Alwadie1 · Adam Glowacz2

DESCRIPTION : Increasing waste generation has become a signifcant challenge indeveloping countries due to unprecedented population growth and urbanization. From the literature, many issues have been investigated that signify direct connection with the increase in waste material generation and related difculties to handle it in a smart city. These issues are the resultants of an improper collection and disposal mechanism used for waste material, the increase in moving trends of peoples toward big cities and lack of intelligent technology used to support the municipal solid waste management system. Consequently, the management of waste material has become a challenge due to a large amount of waste littered everywhere. Furthermore, various problems also occur due to the existing systems that are not only inadequate and inefcient but also their non-scientifc procedures involved in the solid waste management. In this paper, an IoT-based smart waste bin monitoring and municipal solid waste management system is proposed. This system helps to solve the problems associated with management of waste material and the IoT-based waste collection for the smart city as discussed above. The proposed system is capable in the collection of waste efectively, detection of fre in waste material and forecasting of the future waste generation. The IoTbased device performs the controlling and monitoring of the electric bins. These devices are wirelessly connected with the central hub to transmit the information about the bins flling level with the existing location. The signifcant advantage of the system is to collect waste material on time in order to avoid the overfow of bins that would help in saving the environment from pollution. Keywords IoT · Bins · Waste material ·

3.TOPIC : Smart Agriculture Monitoring System Using IOT

AUTHOR : Yann Glouche Paul Couderc INRIA, Unite de Recherche Rennes-Bretagne-Atlantique ´ Campus de Beaulieu, Rennes,

DESCRIPTION : Radio Frequency Identification (RFID) is a pervasive computing technology that can be used to improve waste management by providing early automatic identification of waste at bin level. In this paper, we propose a smartbin application based on information self-contained in tags associated to each waste item. The wastes are tracked by smart bins using a RFID-based system without requiring the support of an external information system. Two crucial features of the selective sorting process can be improved using this approach.First, the user is helped in the application of selective sorting. Second, the smart bin knows its content and can report back to the rest of the recycling chain.

4. TOPIC : A Smart Waste Management Solution Geared towards Citizens

AUTHOR : Kellow Pardini , Joel J.P.C. Rodrigues * , Ousmane Diallo , AshokKumar Das , Victor Hugo C. de Albuquerque 7and Sergei A. Kozlov

DESCRIPTION : Global industry is undergoing major transformations with the genesisof a new paradigm known as the Internet of Things (IoT) with its underlying technologies. Many company leaders are investing more effort and money in transforming their services to capitalize on the benefits provided by the IoT. Thereby, the decision makers in public waste management do not want to be outdone, and it is challenging to provide an efficient and real-time waste management system. This paper proposes a solution (hardware, software, and communications) that aims to optimize waste management and include a citizen in the process. The system follows an IoT-based approach where the discarded waste from the smart bin is continuously monitored by sensors that inform the filling level of each compartment, in real-time.

5.TOPIC : Smart Waste Management using Internet-of-Things (IoT)

AUTHOR : Gopal Kirshna Shyam1, Sunilkumar S. Manvi2, Priyanka Bharti

DESCRIPTION : : To make the cities greener, safer, and more efficient, Internet of Things (IoT) can play an important role. Improvement in safety and quality of life can be achieved by connecting devices, vehicles and infrastructure all around in a city. Best technological solutions can be achieved in smart cities by making different stakeholders to work together [5][6][7]. System integrators, network operators and technology providers have a role to play in working with governments to enable smart solutions. But, building such solutions on an open, standardsbased communications platform that can be continuously used is a challenge. We present a waste collection management solution based on providing intelligence to wastebins, using an IoT prototype with sensors.

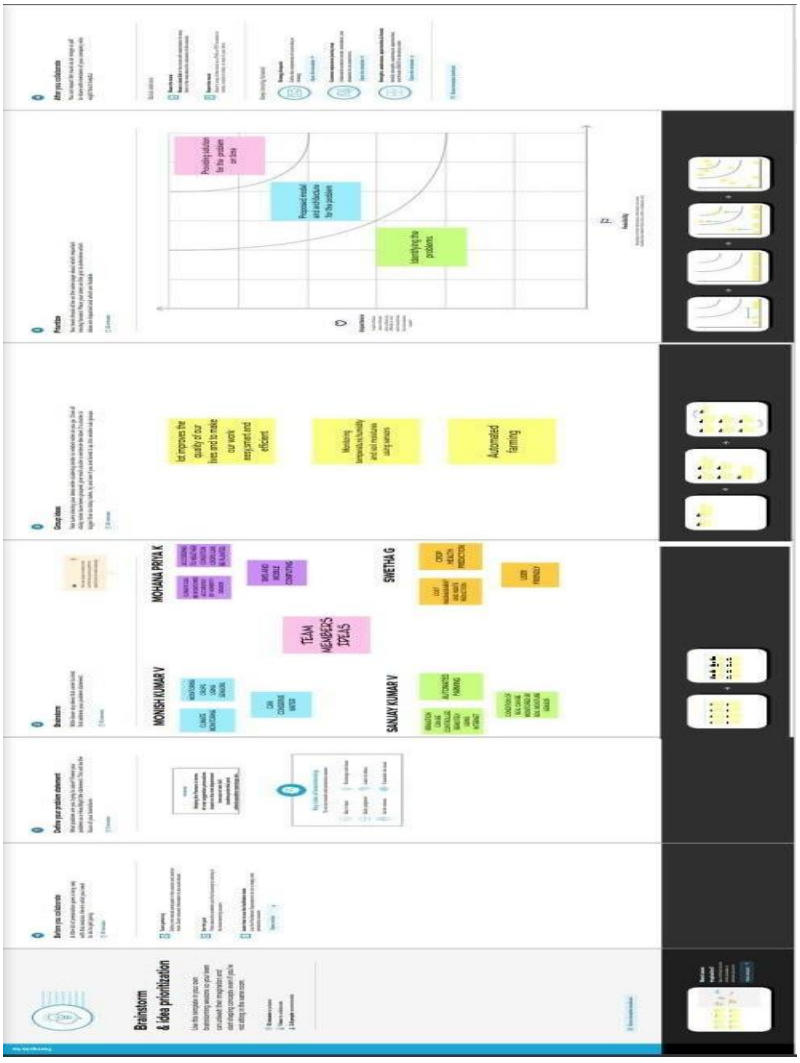
IDEATION & PROPOSED SOLUTION

1. Empathy Map Canvas:

An empathy map is a collaborative tool teams can use to gain a deeper insight into their customers. Much like a user persona, an empathy map can represent a group of users, such as a customer segment. The empathy map was originally created by Dave Gray and has gained much popularity within the agile community.

2.Ideation & Brainstorming:

Ideation essentially refers to the whole creative process of coming up with and communicating new ideas. Ideation is innovative thinking, typically aimed at solving a problem or providing a more efficient means of doing or accomplishing something. It encompasses thinking up new ideas, developing existing ideas, and figuring out means or methods for putting new ideas into practice. Ideation is similar to a practice known as brainstorming..



PROPOSED SOLUTION

The process in current city setting solves the waste problem partially while it creates other problems such as,Some trash bins are overfilled while others are underfilled by the trash collection time,overfilled trash bins create unhygienic conditions,unoptimized truck routes result in excessive fuel usage and environmental pollution and all collected trash is combined which complicates sorting at the recycling facility.Some of these problems can be mitigated by implementing smart waste management systems.

REQUIREMENT ANALYSIS

Functional Requirements:

Following are the functional requirements of the proposed solution.

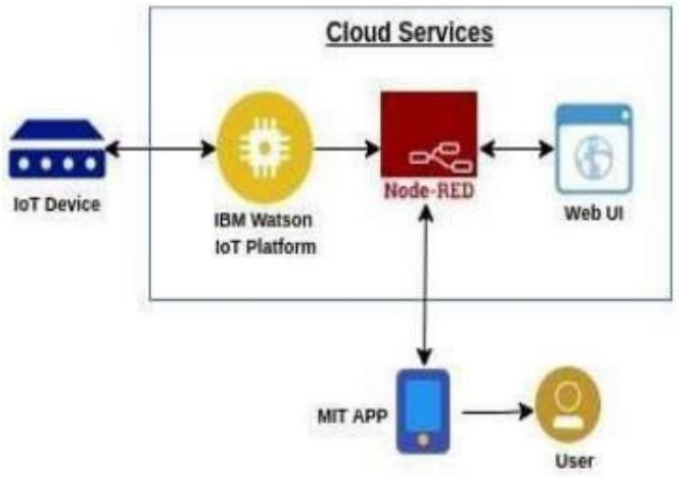
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	IoT devices	Sensors and Wifi module.
FR-2	Software	Web UI, Node-red, IBM Watson, MIT app

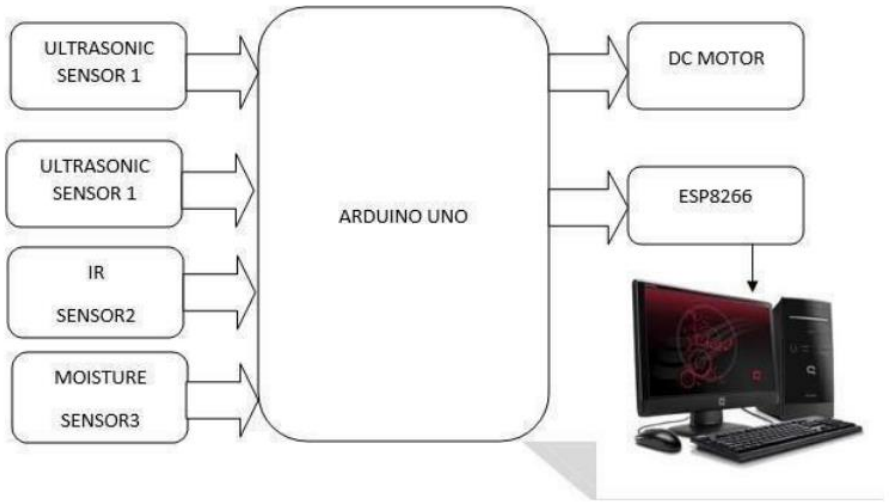
Non-functional Requirements:

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

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Time consumability is less, Productivity is high.
NFR-2	**Security**	It has high level of security features due to integration of sensor data
NFR-3	**Reliability**	Accuracy of data and hence it is Reliable.
NFR-4	**Performance**	Performance is high and highly productive.
NFR-5	**Availability**	With permitted network connectivity the application is accessible.
NFR-6	**Scalability**	It is perfectly scalable and many new constraints can be added.

PROJECT DESIGN





User Stories

User Type	Functional Requirement	User Story Number	User Story/Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password and confirming my password.	I can access my account/ dashboard	High	Sprint-1
	Permission	USN-2	As a user, I will receive confirmation email once I have registered for the application.	I can receive confirmation email& click confirm.	High	Sprint-1
Customer (Web user)	Login	USN-3	As a user, I can log into the application by entering email& password.	I can register & access the dashboard with Login	High	Sprint-2
	Check credentials	USN-4	As a user, I can register for the application through mobile application	Temperature and Humidity details	Medium	Sprint-1
	Dashboard	USN-5	As a user can view the dashboard and this dashboard include the check roles of access and then move to the manage modules	I can view the dashboard in this smart farming application system	Medium	Sprint-1
Customer care Executive	MIT app	USN-6	To make the user to interact with the software	Database to store in cloud services	High	Sprint-1
Administrator	IOT devices	USN-7	As a user once view the manage modules this describes the manage system admins and Manage Roles of user and etc..,		Medium	Sprint-1
	Log out	USN-8	Exit	Sign out	High	Sprint-1

PROJECT PLANNING & SCHEDULING

Product Backlog, Sprint Schedule, and Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Interfacing Sensors and IBM cloud	USN-1	Develop a python Code to Interface Sensorsand Motor Pump and IBM cloud.	20	High	Janakiraman S (member 1)
Sprint-2	Node-Red	USN-2	Develop a we b Application Using a Node-Red.	20	High	Manikandan S (Leader)
Sprint-3	Mobile Application	USN-3	Develop a mobile Application using MIT-App Inventor.	20	High	Deepak C(member 2)
Sprint-4	Testing	USN-4	Integrating Python Script, Web application &Mobile App	20	Medium	Harishkumar S(member 3)

Project Tracker, Velocity & Burndown Chart

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed	Sprint Release Date (Actual)
Sprint-1	20	6 Days	22/10/22	27 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31/10/22	05 Nov 2022	20	30 Nov 2022
Sprint-3	20	6 Days	07/11/22	12 Nov 2022	20	06 Nov 2022
Sprint-4	20	6 Days	14/11/22	19 Nov 2022	20	07 Nov 2022

CODING & SOLUTIONING

Python Code:

- For Connecting IBM Cloud
- For NODE RED
- Weather Map Information
- MIT App Inventor

Python Code:

```
import requests

import json
import ibmiotf.application
import ibmiotf.device
 import time
import randomimport sys

# watson device details organization = "dr2sg4"
devicType =  "PNT2022TMID26515"
```

```
    deviceId="96351910401" authMethod= "token"
    authToken="963519104041"

    #generate random values for randomovariables
    (temperature&humidity)

def myCommandCallback(cmd):global a
    print("command recieved:%s"
%cmd.data['command']) control=cmd.data['command']
    print(control)
    try:
          deviceOptions={"org": organization, "type":
    devicType,"id": deviceId,"auth-
    method":authMethod,"authtoken":authToken}
          deviceCli = ibmiotf.device.Client(deviceOptions)
    except Exception as e:
          print("caught exception connectingdevice %s"
    %str(e))
    sys.exit()

    #connect and send a datapoint "temp"
    with value integer value into the cloud as
    a type ofevent for every 10 seconds

    deviceCli.connect()
```

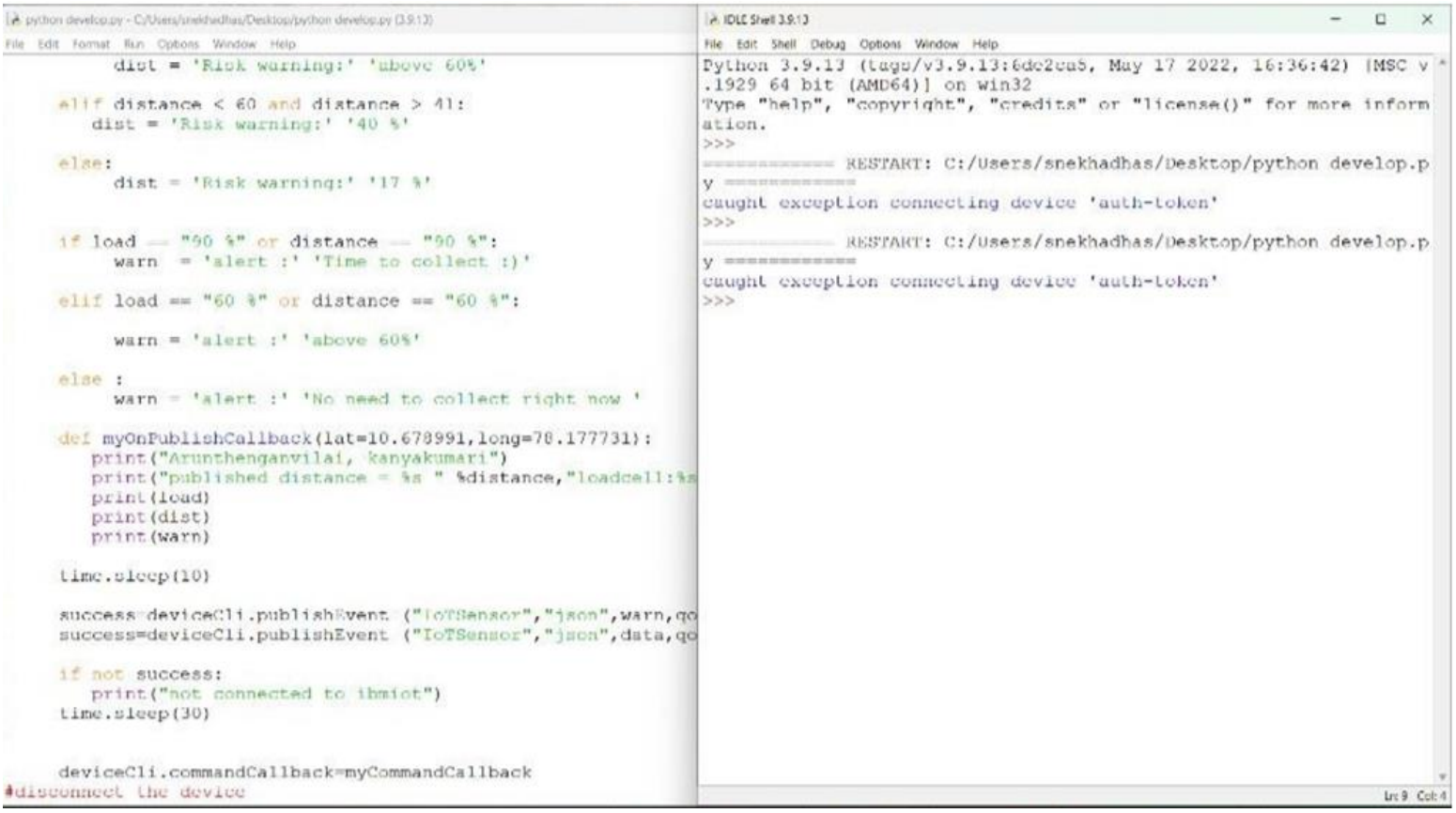
```
while True:
    distance= random.randint(10,70) loadcell=
    random.randint(5,15) data=
    {'dist':distance,'load':loadcell}


    if loadcell < 13 and loadcell > 15:load = "90 %"

    elif loadcell < 8 and loadcell > 12:load = "60 %"

    elif loadcell < 4 and loadcell > 7:load = "40 %"

    else:
        load = "0 %"

    if distance < 15:
        dist = 'Risk warning:' 'Time to collect :)
90 %'

    elif distance < 40 and distance >16: dist = 'Risk
        warning:' 'above 60%'

    elif distance < 60 and distance
      > 41:dist = 'Risk warning:' '40
      %'
```

```
else:
        dist = 'Risk warning:' '17 %'


    if load == "90 %" or distance == "90 %":warn  = 'alert :'
        'Time to collect :)'

    elif load == "60 %" or distance == "60 %":warn = 'alert

        :' 'above 60%'

    else :
        warn = 'alert :' 'No need to collect right
 now '

    def myOnPublishCallback(lat=10.678991,long=7
 8.177731):
       print("Arunthenganvilai, kanyakumari")
       print("published distance = %s "
 %distance,"loadcell:%s " %loadcell,"lon = %s" %long,"lat
 = %s" %lat)
       print(load) print(dist) print(warn)
time.sleep(10)
```

```
success=deviceCli.publishEvent
("IoTSensor","json",warn,qos=0,on_publ
ish=myOnPublishCallback)
    success=deviceCli.publishEvent
("IoTSensor","json",data,qos=0,on_publis
h=myOnPublishCallback)

if not success:
  print("not connected to ibmiot")
time.sleep(30)



deviceCli.commandCallback=myComma
ndCallback
#disconnect the device
deviceCli.disconnect
```

```
deviceCli.connect()
while True:
     distance= random.randint(10,70)
     loadcell= random.randint(5,15)
     data= {'dist':distance,'load':loadcell}


     if loadcell < 13 and loadcell > 15:
        load = "90 %"

     elif loadcell < 8 and loadcell > 12:
          load = "60 %"

     elif loadcell < 4 and loadcell > 7:
          load = "40 %"

     else:
          load = "0 %"

     if distance < 15:
          dist = 'Risk warning:' 'Time to collect :) 90 %'

     elif distance < 40 and distance >16:
          dist = 'Risk warning:' 'above 60%'

     elif distance < 60 and distance > 41:
        dist = 'Risk warning:' '40 %'

     else:
          dist = 'Risk warning:' '1% %'


     if load == "90 %" or distance == "90 %":
          warn  = 'alert :' 'Time to collect :)'

     elif load == "60 %" or distance == "60 %":
```

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

# watson device details
organization = "dr2sq4"
deviceType =  "PNT2022TMID52274"
deviceId = "963519104041"
authMethod= "token"
authToken= "963519104041"

#generate random values for randomo variables (temperature&humidity)

def myCommandCallback(cmd):
    global a
    print("command recieved:%s" %cmd.data['command'])
    control=cmd.data['command']
    print(control)
try:
        deviceOptions={"org": organization, "type": deviceType,"id": deviceId,"auth method":authMethod,"authtoken":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 "temp" with value integer value into the cloud as a type of event for every 10 seconds

deviceCli.connect()
while True:
     distance= random.randint(10,70)
     loadcell= random.randint(5,15)
     data= {'dist':distance,'load':loadcell}
```

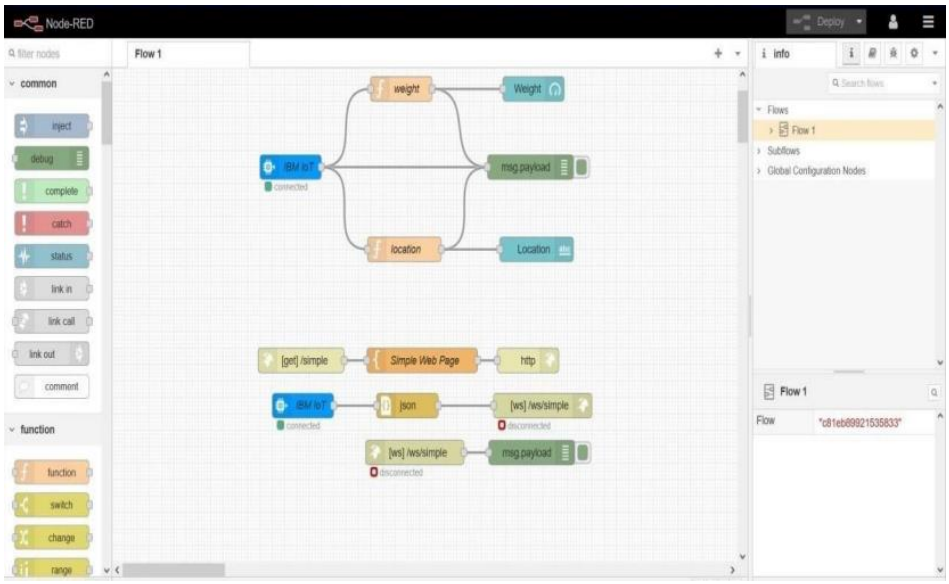

python develop.py - C:/Users/snekhadhas/Desktop/python develop.py (3.9.13)
File Edit Format Run Options Window Help
dist = 'Risk warning:' 'above 60%'
elif distance < 60 and distance > 41:
dist = 'Risk warning:' '40 %'
else:
dist = 'Risk warning:' '17 %'
if load == "90 %" or distance == "90 %":
warn = 'alert :' 'Time to collect :)'
elif load == "60 %" or distance == "60 %":
warn = 'alert :' 'above 60%'
else :
warn = 'alert :' 'No need to collect right now '
def myOnPublishCallback(lat=10.678991,long=78.177731):
print("Arunthenganvilai, Kanyakumari")
print("published distance = %s " %distance,"loadcell:%s
print(load)
print(dist)
print(warn)
time.sleep(10)
success=deviceCli.publishEvent ("IoTSensor","json",warn,qo
success=deviceCli.publishEvent ("IoTSensor","json",data,qo
if not success:
print("not connected to ibmiot")
time.sleep(30)
deviceCli.commandCallback=myCommandCallback
#disconnect the device
IDLE Shell 3.9.13
File Edit Shell Debug Options Window Help
Python 3.9.13 (tags/v3.9.13:6de2ca5, May 17 2022, 16:36:42) [MSC v
.1929 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more inform
ation.
>>>
========== RESTART: C:/Users/snekhadhas/Desktop/python develop.p
y ==========
caught exception connecting device 'auth-token'
>>>
========== RESTART: C:/Users/snekhadhas/Desktop/python develop.p
y ==========
caught exception connecting device 'auth-token'
>>>
Ln: 9 Col: 4

TESTING & RESULTS

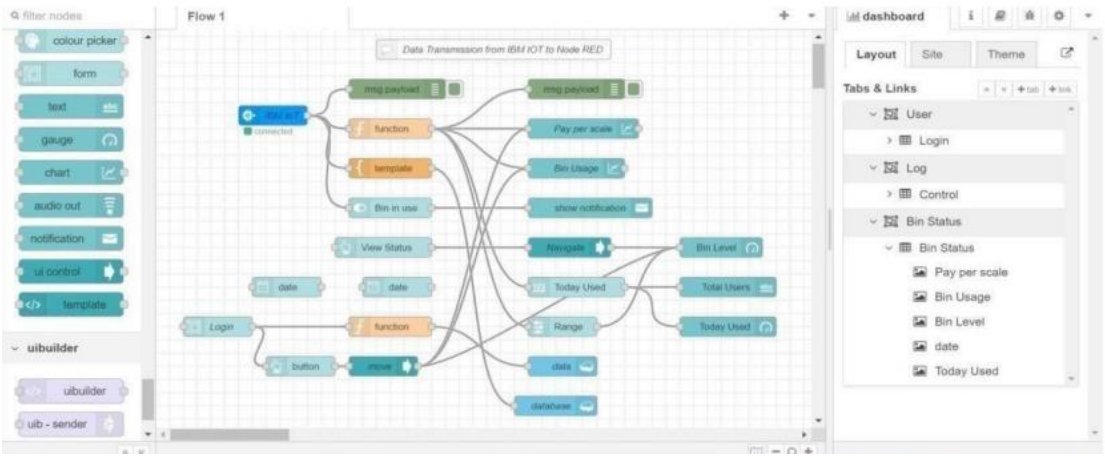
NODE RED Flow Connections

- **Interfacing IBM Cloud**
- **Intefacing & Getting Sensor Datas**
- **Connecting MIT App Inventor**

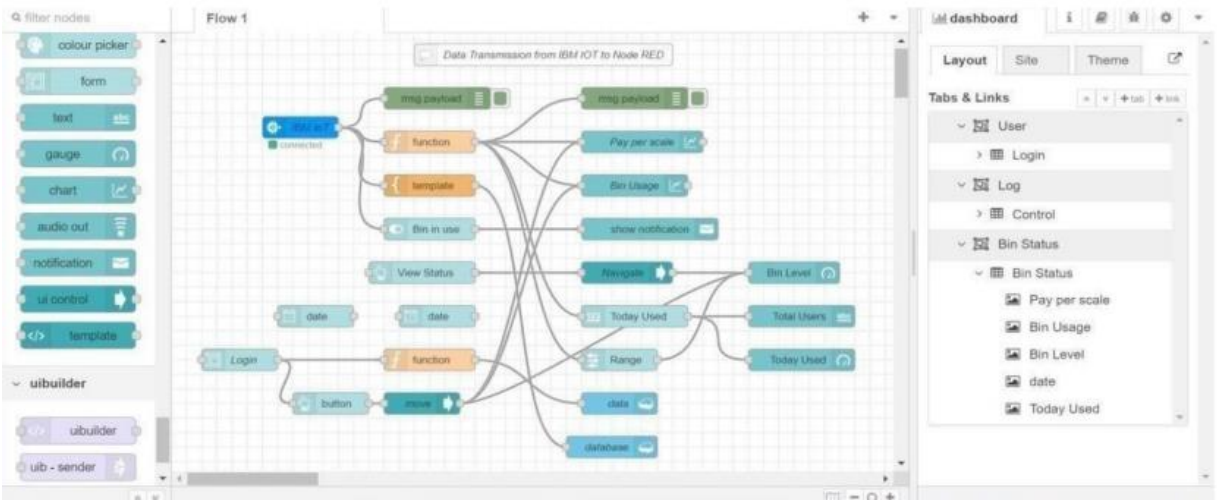
Flow:1



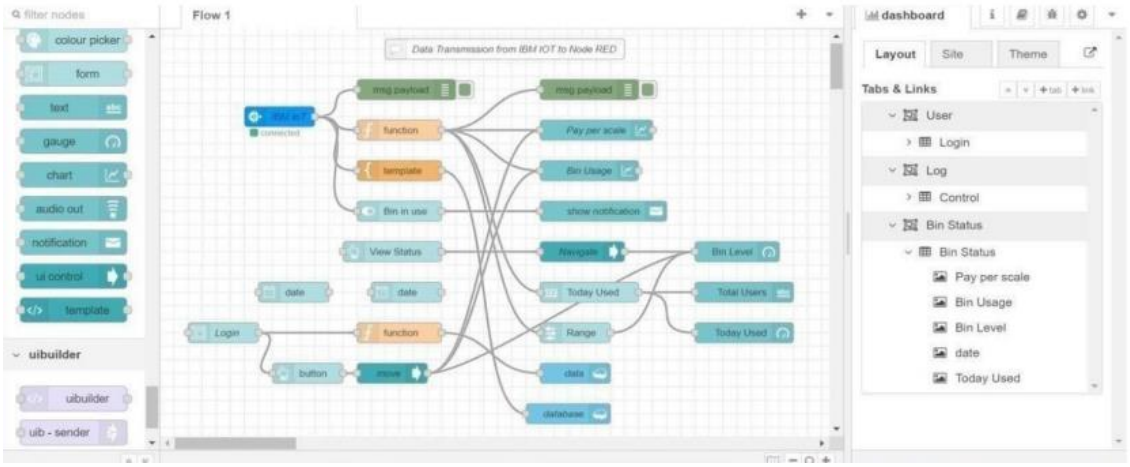
Flow:2



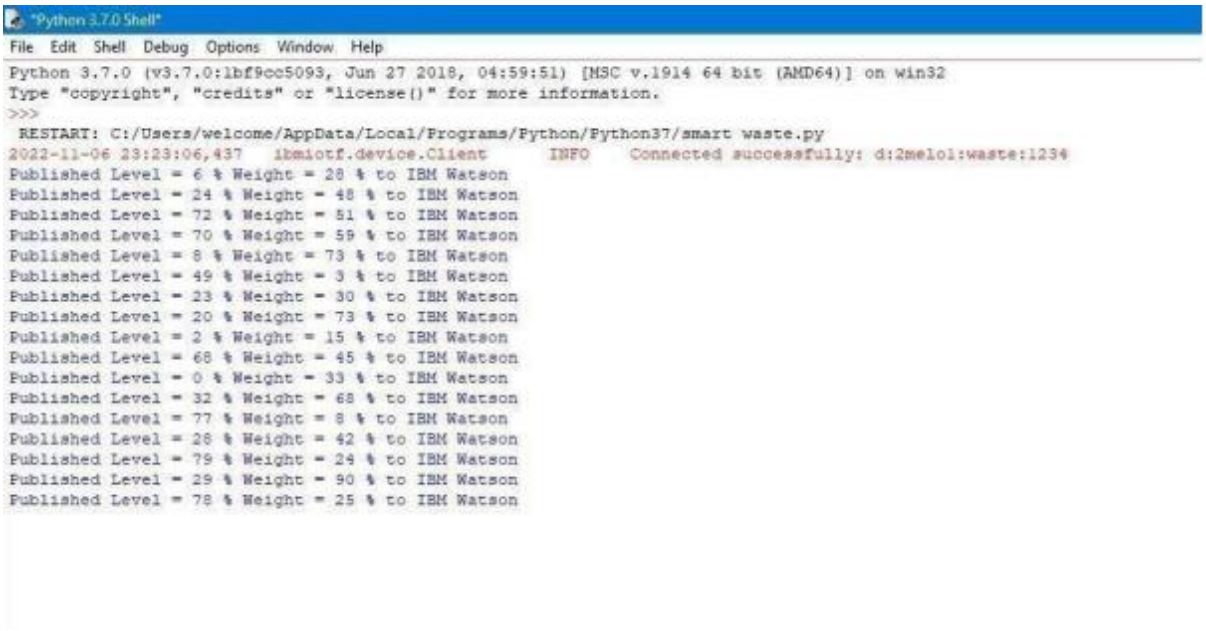
Flow:1 Configuring All Nodes With IBM IOT Platform



Flow:2 Configuring All Nodes With IBM IOT Platform

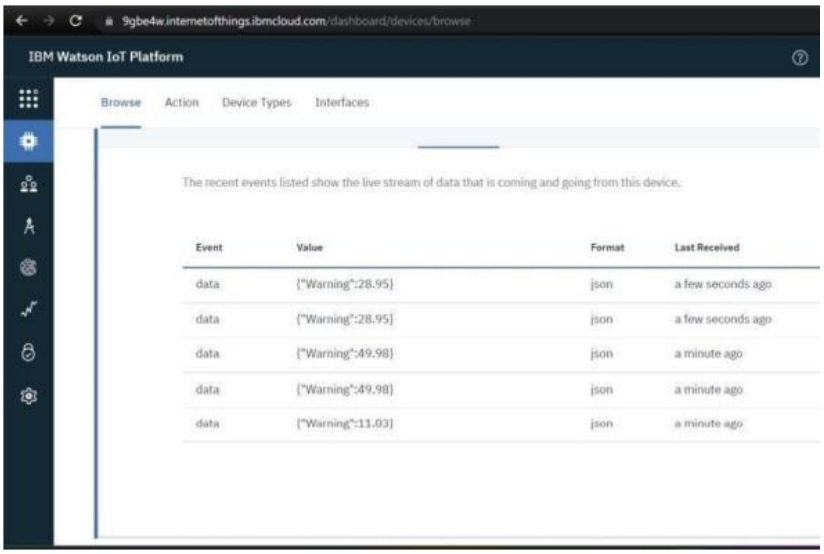


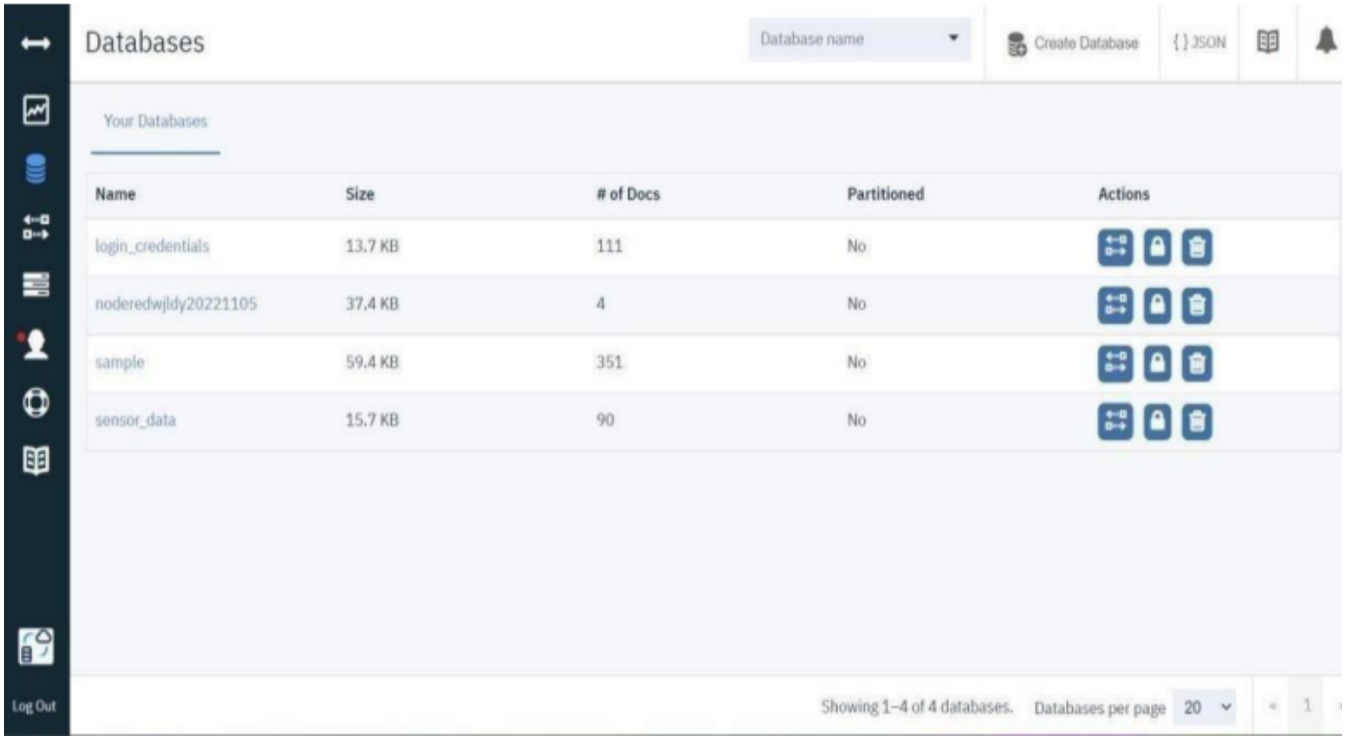
Execution of Python Program

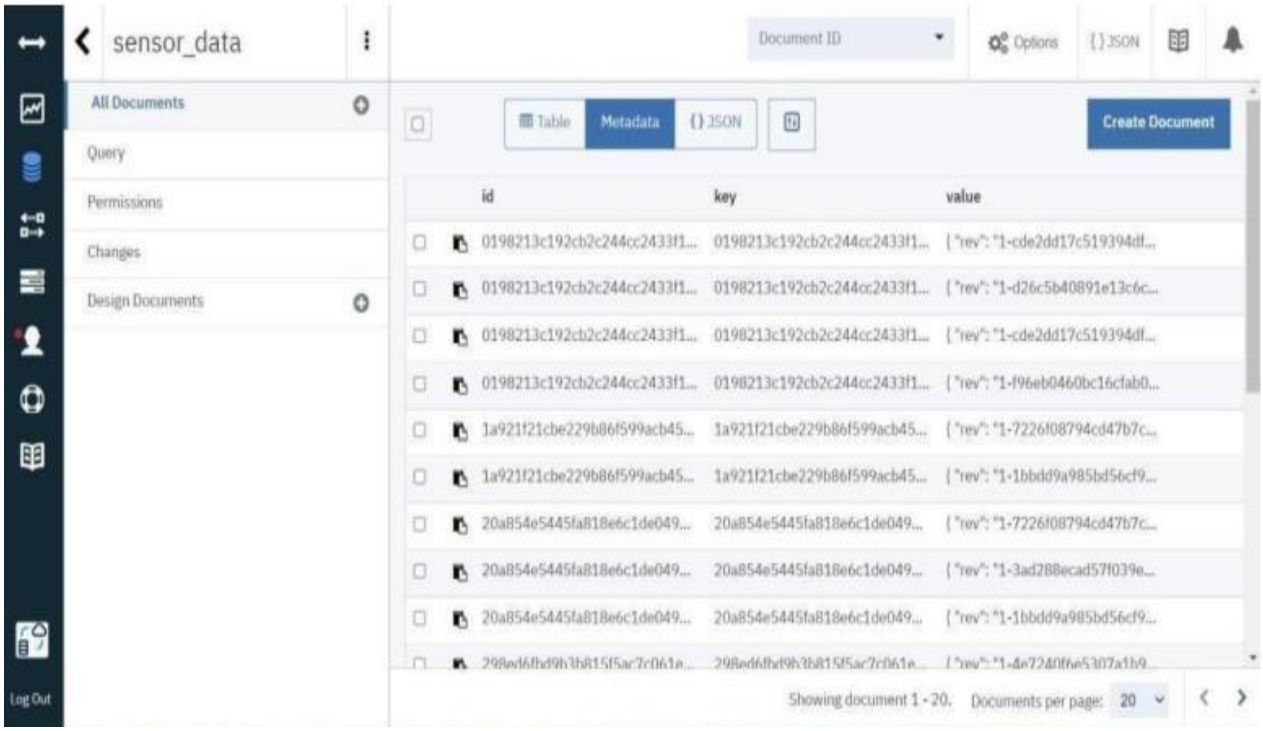


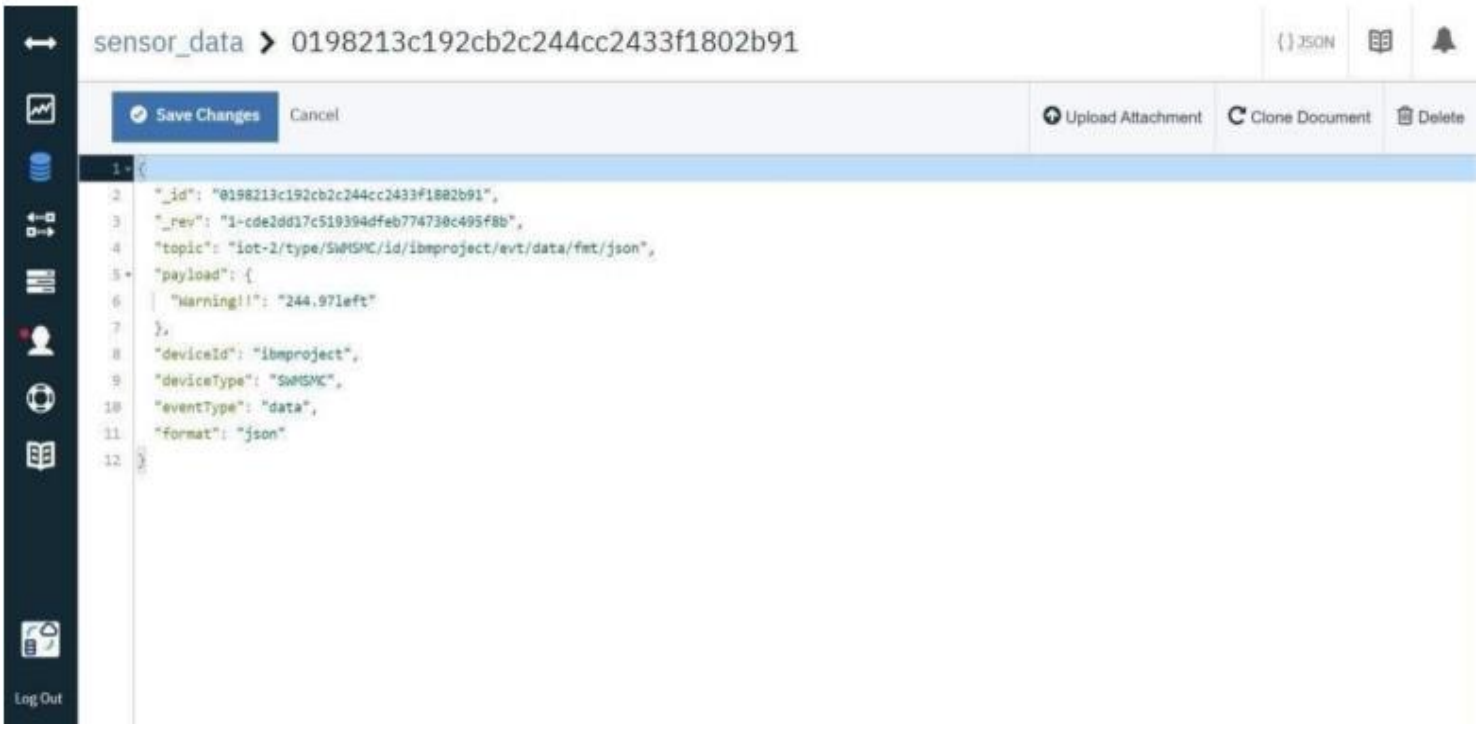
Web UI Output

IBM Watson IoT Platform Device Connect & Live Data






sensor_data
Document ID
Options
{ } JSON
All Documents
Query
Permissions
Changes
Design Documents
Table
Metadata
{ } JSON
Create Document
id
key
value
Showing document 1 - 20.
Documents per page: 20
Log Out


sensor_data > 0198213c192cb2c244cc2433f1802b91
{ } JSON
Save Changes
Cancel
Upload Attachment
Clone Document
Delete
{
"_id": "0198213c192cb2c244cc2433f1802b91",
"_rev": "1-cde2dd17c519394dfeb774730c495f8b",
"topic": "iot-2/type/SWMSMC/id/ibmproject/evt/data/fmt/json",
"payload": {
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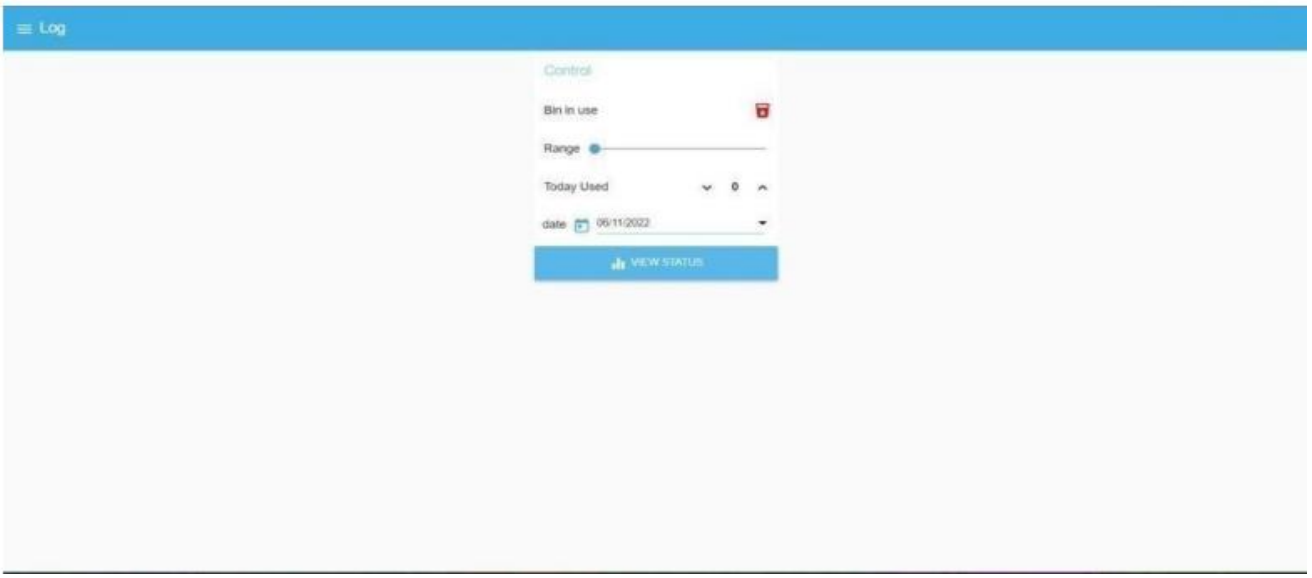
"deviceId": "ibmproject",
"deviceType": "SWMSMC",
"eventType": "data",
"format": "json"
}
Log Out


Log
Control
Bin in use
Range
Today Used
0
date
06/11/2022
VIEW STATUS


Bin Status
Bin Status
Bin Level
Today Used
Bin Level
200
150
100
50
0
100
75
50
25
0
6/11
27
date
06/11/2022
Today Used
27gallons

ADVANTAGES & DISADVANTAGES

Advantages -- A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion. A reduction in the number of waste bins needed. Analytics data to manage collection routes and the placement of bins more effectively. The major advantages of recycling are it protects the environment; a lot of energy is saved in the process, it is Ecofriendly, protects the biodiversity, reduces pollution, the resources are protected, it is cost effective and reduces waste considerably. The three R's if recycling is reduce, reuse, and recycle.

Disadvantages: According to the author there may be several disadvantages such as increasing cost of the dustbin. For example, if there are three different levels then three sensors has to be placed; one sensor for each level. Also rough action and usage of the user may cause damages to the sensors.

CONCLUSION

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, and increase the sustainability of waste services.

FUTURE SCOPE

Future of Solid Waste Disposal & Management in India.
Total of approximately 143,449 MT of municipal waste is generated daily. However, only 35,062 tons of waste is treated. A report from MNRE says that waste generation is expected to reach 300 million tons annually by the year 2047.

APPENDIX

https://careereducation.smartinternz.com/Student/guided_project_workspace/22728

https://cloud.ibm.com/

https://github.com/IBM-EPBL/IBM-Project-22728-1659857265