SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES
TEAM ID: PNT2022TMID27943

NALAIYA THIRAN PROJECT BASED LEARNING

on

PROFESSIONAL READINESS FOR INNOVATION, EMPLOYABILITY AND ENTREPRENEURSHIP

Project Report Submitted by

311519106089-SNEHA PRIYA.R
311519106052-MAANASWINI.K
311519106109-VIJAYASHREE.V
311519106085-SHRUTHI.K

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

ABSTRACT

At present solid waste management is a major concern in the metropolitan cities of the developing and developed countries. As the population is growing, the garbage is also increasing. This huge unmanaged accumulation of garbage is polluting the environment, spoiling the beauty of the area and also leading to the health hazard. In this era of Internet, IOT (Internet of Things) can be used effectively to manage this solid waste. In this paper, we have discussed the definition of Internet of Things and its elements, testing and prototyping tool cooja simulator and finally the study of various literatures available on smart waste management system using IOT. Today big cities around the world are facing a common problem, managing the city waste effectively without making city unclean. Today's waste management systems involve a large number of employees being appointed to attend a certain number of dumpsters this is done every day periodically. This leads to a very inefficient and unclean system in which some dumpsters will be overflowing some dumpsters might not be even half full. This is caused by variation in population density in the city or some other random factor this makes it impossible to determine which part needs immediate attention. Here a waste management system is introduced in which each dumpster is embedded in a monitoring system that will notify the corresponding personal if the dumpster is full. In this system, it is also possible to separate wet and dry waste into two separate containers. This system provides an effective solution to the waste management problem.

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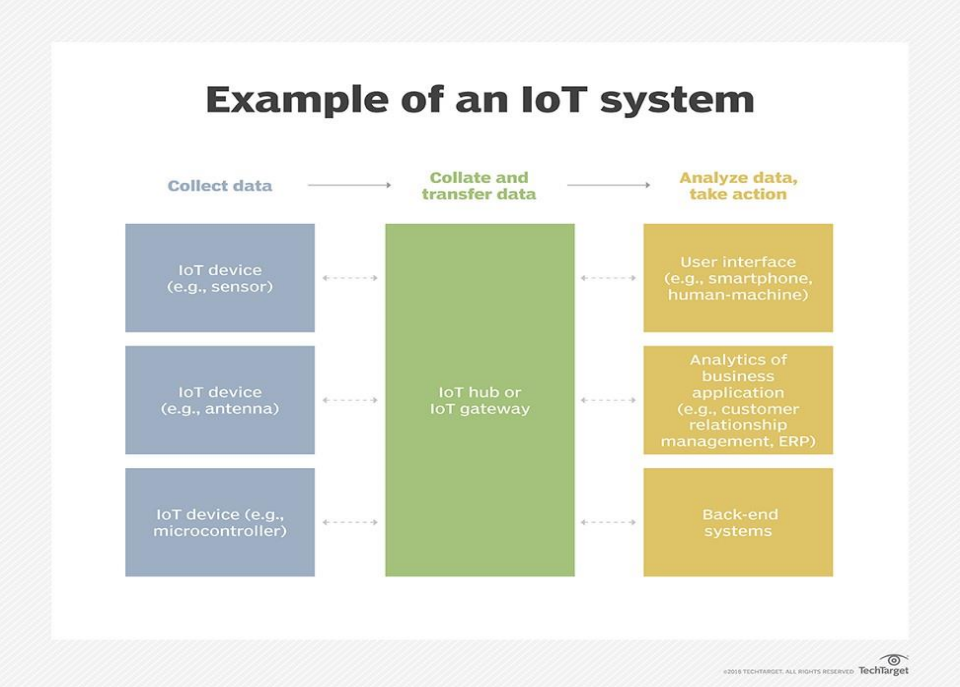
1. INTRODUCTION

Internet of Things (IoT) is a network of physical objects or people called "things" that are embedded with software, electronics, network, and sensors that allows these objects to collect and exchange data. The goal of IoT is to extend to internetconnectivity from standard devices like computer, mobile, tablet to relatively dumb deviceslike a toaster. IoT makes virtually everything "smart," by improving aspects of our life with
the power of data collection, AI algorithm, and networks. The thing in IoT can also be aperson with a diabetes monitor implant, an animal with tracking devices, etc.

How IoT works?



An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. **IoT devices** share the sensor data they collectby connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devicesdo most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

1.1 PROJECT OVERVIEW

Child safety is a major concern in any society due to the vulnerability of a child and consequently, higher rates of crimes against children. With this issue on our hands, a smart wearable Internet of Things sensor network for monitoring the environment of a child can be developed to help parents ensure the safety of their children. It must also necessarily include a mechanism for tracking the child. An advantage of this wearable device is that, according to its design, it can be accessed from any mobile device and does not mandate a lot of technical knowledge from the user to operate.

PROJECT FLOW

- ✓ 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.

To accomplish this, we have to complete all the activities and tasks listed below:

- ✓ Create and configure IBM Cloud Services
  - ii. Create IBM Watson IoT Platform
  - iii. Create a device & configure the IBM IoT Platform
  - iv. Create Node-RED service
  - v. Create a database in Cloudant DB to store location data
- ✓ Develop a web Application using Node-RED Service.
  - vii. Develop the web application using Node-RED.
- ✓ Develop a python script to publish the location details to the IBM IoT platform.

1.2 PURPOSE

Smart waste management is characterized by the usage of technology in order to be more efficient **when** it comes to managing waste. This makes it possible to plan more efficient routes for the trash collectors who empty the bins, but also lowers the chance of any bin being full for over a week. When the thrash in the bin crosses the level an alert is sent to the respective server. It further helps in preventing the environment to get polluted.

2.LITERATURE SURVEY

TOPIC1:

IoT-Based Smart Waste Management Systems for RevolutionaryChanges

AUTHORS:

https://evreka.co/blog/iot-based-smart-waste-management-systems/

ABOUT:

Our waste generation is constantly growing to form a **global garbage crisis**. Even though we compromise on creating a more sustainable and green world with 2050 climate targets before too late, we still fail to recycle or handle our waste generation. Combining technology support with a vision of social, economic and environmental sustainability is the only way out of this problem. **Solutions for smart cities,** of course, go through IoT technology, making it easier for us to perceive objects and communicate. From day to day, countries, regions, cities, and municipalities embrace the ‘’smart’’ systems and solutions intheir operations. Accordingly, key waste management players are already operating with digitized solutions. So, IoT technology is a crucial step to embed in your operations.

LIMITATIONS:

1. Increasing cost of the dustbin.
2. for ex: There are 3 different levels of sensors.3.One sensor

for each level.

4.Also rough action and usage of the user may cause damage to the sensor.

TOPIC2:

Smart Waste Management System for Crowded areaAUTHORS:

https://ieeexplore.ieee.org/document/8645576?denied =

ABOUT:

In implementing the smart cities the great challenge is how to manage waste withlow cost and high performance. Three factors make it a big challenge, behind its natural, small area, short period of time and the increasing of the Pilgrimages' member. The process of collected wastes, separated it, and transports the containers daily and quickly to avoid any prospect of a spread of diseases is a complex process. This paper aims to study the concept of the waste management and proposed smart systems for waste management system with recycling .The proposed system will use the sensors technique insite the container, as a lower level, to separate the waste into 4 categories [food, plastics, papers, and metal] and use actuator at a top level to inform the management system to collect the container. The proposed system will save time, money and efforts compared to the recent process of the waste management system and improve the society quality as all.

LIMITATIONS:

1.insufficient data collection.2.quality aspects-recycling.

3.energy recovery of waste.

TOPIC3:

Smart Waste Management using Wireless Sensor NetworkAUTHORS:

https://www.researchgate.net/publication/344664441_Smart_Waste_Management_using_Wireless_Sensor_Network

ABOUT:

In most of the places, the garbage bins are not cleaned at proper time intervals which results in overflowing of garbage resulting in hygiene problems, land pollution; also it creates ugliness to that place. This shows the need for a systemthat monitors the status of the garbage bin and provides information to the concerned authorities to manage the collection intervals for cleaning the bins. Asolution to this problem is proposed in this paper in the form of a 3 tier waste management system: Intelligent bin, gateway, remote base station. The parameters of the bin monitored are transmitted through a gateway to remote base station to be stored in a database.

LIMITATIONS:

1. It is prone to hacking by hackers.
2. Cannot be used for high speed communication.3.Expensive to build.

TOPIC4:

Smart waste management for green environmentAUTHORS:

https://ieeexplore.ieee.org/document/8075303

ABOUT:

The objectives of the project are to design a Smart Waste Management (SWM) system based on Bootstrap platform, develop the system and test its functionalityin fulfilling the requirements of the project. The methodological approach selected in this project is the waterfall methodology in which it comprises of four crucial phases: planning and analysis, system design, system implementation andsystem testing whereby each phase must be completed systematically prior to thecommencement of subsequent phase. It is expected that the Smart Waste Management (SWM) system would be able to fulfill all of the project's objectives. This system is aimed to address the problems of overflowing trash bins and public complaints on trash collection trucks. The development of this system brings a huge significance in which operators would be able to know which trash bins require immediate collection and request for immediate dispatchby collection trucks.

LIMITATIONS:

1. The site are often dangerous.
2. The resultant product has short life. 3.The practices are not done uniformly.

TOPIC5:

Smart Waste Collection System Based on Location Intelligence

AUTHORS:

https://www.sciencedirect.com/science/article/pii/S1877050915030008

ABOUT:

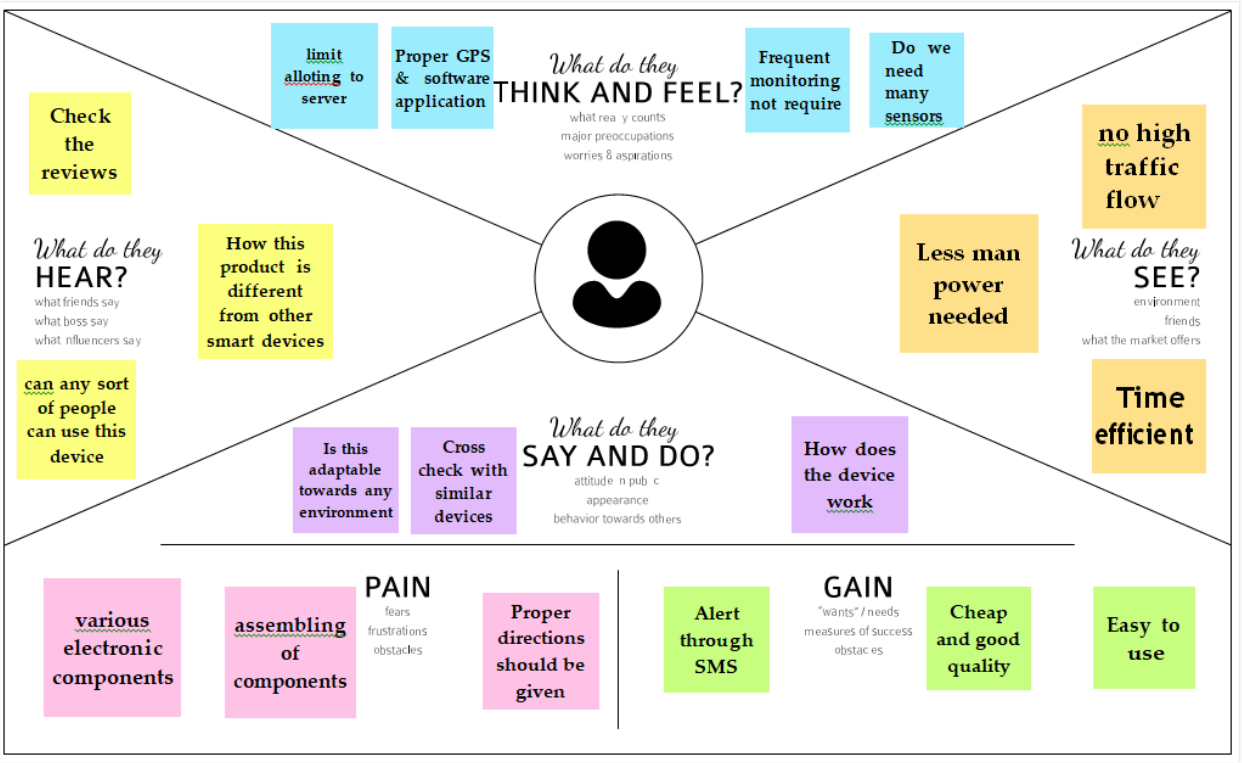
Cities around the world are on the run to become smarter. Some of these have seen an opportunity on deploying dedicated municipal access networks to support all types of city management and maintenance services requiring a data connection. This paper practically demonstrateshow Internet of Things (IoT) integration with data access networks, Geographic Information Systems (GIS), combinatorial optimization, andelectronic engineering can contribute to improve cities' management systems. We present a waste collection solution based on providing intelligence to trashcans, by using an IoT prototype embedded with sensors, which can read, collect, and transmit trash volume data over theInternet. This data put into a spatio-temporal context and processed by graph theory optimization algorithms can be used to dynamically and efficiently manage waste collection strategies.

LIMITATIONS:

1.Waste management can cause more problems.2.Process is always not cost effective.
3.Needs more global buy- in.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

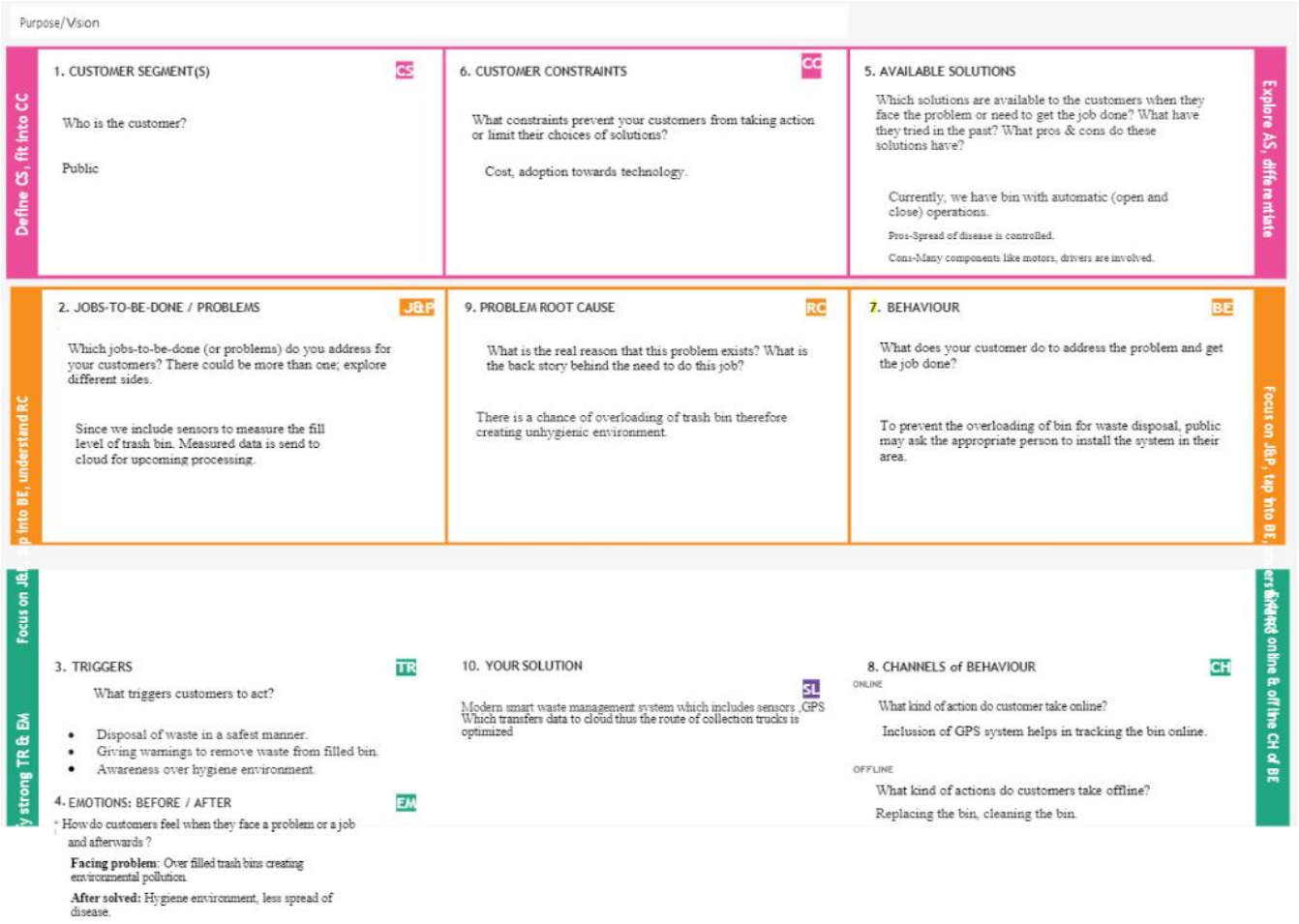


3.2 Ideation & Brainstorming

3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	To empty bins before they become overflowing with trash or recycling.
2.	Idea / Solution description	The smart sensor based dustbin will judge the level of waste in it and send the message directly to municipal corporation. It senses solidas well as liquid waste.
3.	Novelty / Uniqueness	The uniqueness of the project is about the collection of waste and proper usage of technology to choose shortest path for thedisposal of waste.
4.	Social Impact / Customer Satisfaction	It keeps surrounding clean and green ,free from bad odour of wastes, reducing manpower required to handle garbage collection.
5.	Business Model (Revenue Model)	Reduces infrastructure and maintenance costs. Favours smart city project. Marketing activities. Performance based model. Additional sharing model.
6.	Scalability of the Solution	In the field of IOT we proposed to deal with sensors, Arduino board, to achieve “Smart waste management system for meteropolitian cities” which is beneficial for the workers and the surrounding.

3.4 Problem Solution



4. REQUIREMENT ANALYSIS

4.1 Functional requirement

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	App installation	✓ Installation through link ✓ Installation through play store
FR-2	Detection of bin waste level	✓ Detecting via sensors. ✓ Monitoring the waste level.

FR-3	User Interface	✓ User Login Form. ✓ Admin Login Form.
FR-4	Database	✓ Stored in cloud for seamless connection. ✓ Increase in the waste above the level is indicated. ✓ Indication is sent to the main server.
FR-5	Server	✓ It connects the database and thefront end application. ✓ The backend server has been implemented to run as a serviceand is deployed in an IBM cloud instance. ✓ The backend server has been implemented to run as a service.It is deployed in an IBM cloud instance.
FR-6	API	✓ The value collected is sent to the database using an API.
FR-7	Node JS	✓ Node.js is used to generate the output via link. ✓ URL link displays the output.
FR-8	Battery Life	✓ Long lasting battery life. ✓ Battery lasts long and helps the sensor to monitor continuously.

4.2 Non-Functional requirements

NFR NO	Non-functional Requirements	Description
NFR-1	Reliability	✓ Portable ✓ Easy to use Flexibility
NFR-2	Performance	✓ Bin level is continuously monitored. ✓ If the waste in the bin crosses maximum level alert message is sent to the server.
NFR-3	Availability	✓ Tracking of the bin continuously. ✓ Data often shared and recorded.
NFR-6	Scalability	✓ Recording of waste level and weight of the waste.
NFR-7	Valuability	✓ Lessening the chances of pollution and paving way for clean environment.
NFR-8	Usability	✓ App can be installed and used at ease.

5. PROJECT DESIGN

5.1 Data Flow Diagrams

FLOWS:

1.Connecting IoT devices to the Watson IoT platform and exchanging the sensor data.2.The

GPS coordinates of the child location will be sent to the IBM IoT platform

3.Creates a database in Cloudant DB to store location data.

4.Develop a web Application using Node-RED Service.

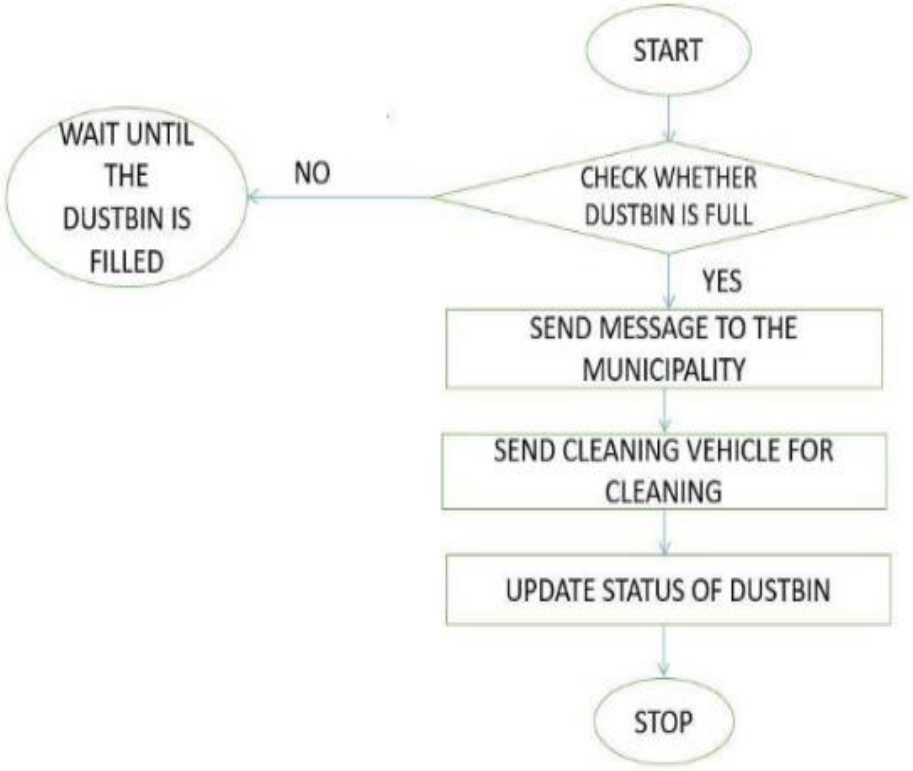
5. The web application will check if the bin level overflows or attained the fill level.

6. Message is passed to the server alerting to clean the bin.

5.2 Solution & Technical Architecture

SOLUTION ARCHITECTURE:

- Using the Minimum Viable Architecture model can ultimately result in a highly polished endproduct as it relies on testing assumptions with small experiments and guiding developmentusing the findings of said experiments.
- Providing a flexible framework that can help achieve target business objectives, MVA responds to evolving customer requirements and technologies and can go a long way inpromoting agility.
- The safety of a child at a large public event is a major concern for event organizers and parents. We address this important concern and proposes an architecture model of the IoT-enable smart child safety tracking digital system.



SOLUTION ARCHITRCTURE

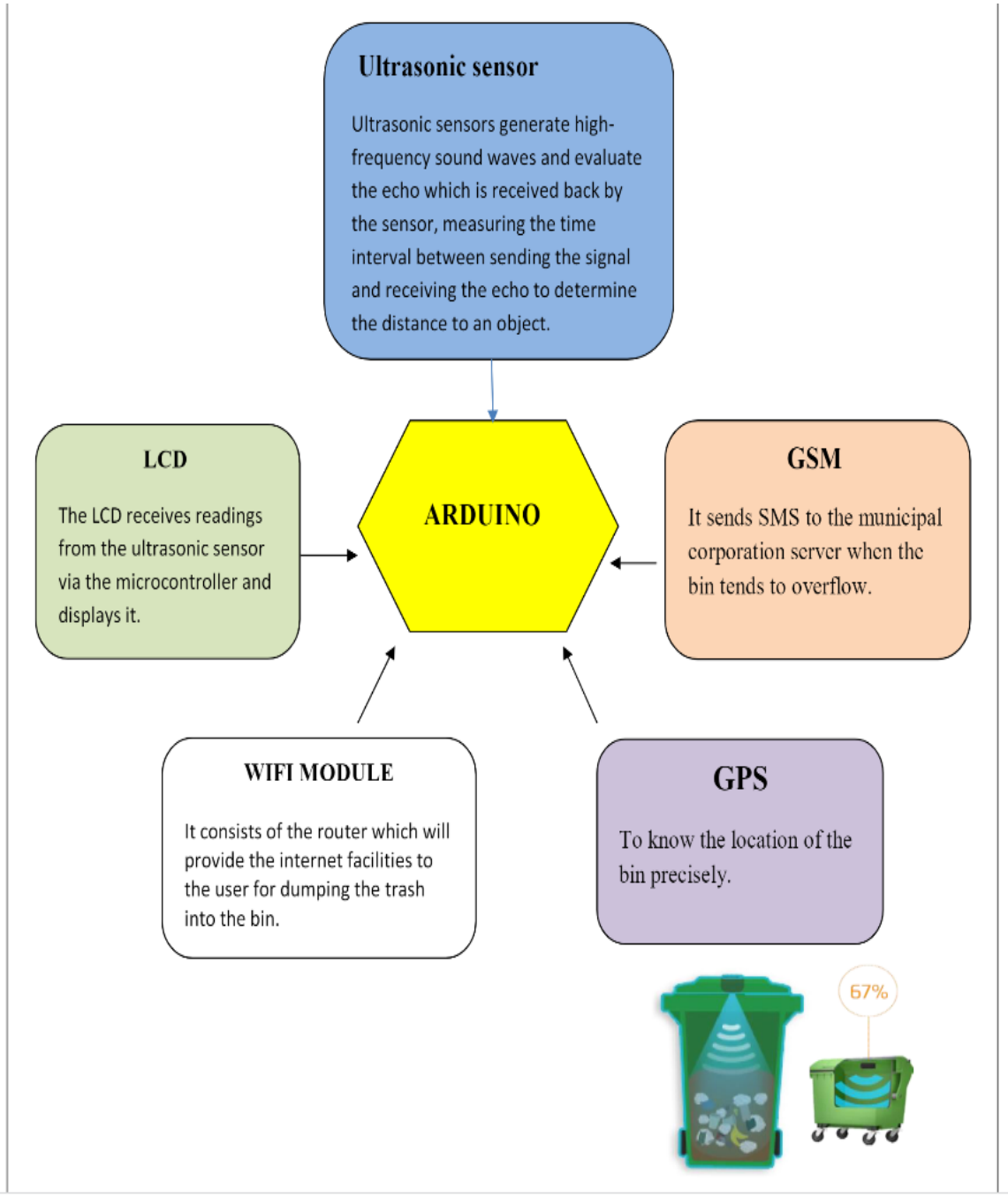


Table-1 :

Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	Web UI	node JS
2.	Application -1	To publish location details in IBM Watson Platform	Python
3.	Application -2	Process in the IoT Application	IBM Watson IoT Platform
4.	Application -3	It assists the IoT Platform	IBM Watson Assistant
5.	Database	Data Configuration & Types	IBM Bluemix & HTTP
6.	Cloud Database	Database Service on Cloud	IBM Cloudant
7.	File Storage	File storage requirements	IBM Block Data Storage
8.	External API-1	Connect the device to the IoT platform	IBM Device API
9.	External API-2	Connect the node-RED Services	Location API
10.	Machine Learning Model	It uses past behaviour to identify patterns and builds models that help predict future behaviour and events	Using program condition loop
11.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: Wireless local Server Cloud Server Configuration : IBM Cloud Server	Cloud Foundry

Table-2:

Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Sensors, software applications & Cloud application	Open connectivity foundation
2.	Security Implementations	The technology segment focused on safeguarding	Encryptions, monitor traffic congestion, using

		connected devices and networks in the IoT	admin, device authentication
3.	Scalable Architecture	If the communication stack from the end devices to the cloud is made asynchronous, so that load times are cut down	Agile methodology, IBM architecture
4.	Availability	use of distributed servers , the system must be available 24/7	client server, server service,GPS System
5.	Performance	number of requests per sec, stimulate devices from different locations and real time system	network technologies like wifi, 4G, etc. it works with popular chip sets

5.3 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-4
		USN-2	As a user, I will receive a confirmation email once I have registered for the application	I can receive confirmation email & get confirmed	High	Sprint-4
		USN-3	As a user, I can register for the application through browser	I can register & access the dashboard with Google Sign in	Low	Sprint-4
		USN-4	As a user, I can register for the application through Gmail	---	Medium	Sprint-4
	Login	USN-5	As a user, I can log into the application by entering	---	High	Sprint-4

			email & password			
	Dashboard	USN-6	As a user,I can see the desired information on the screen of the phone	I can access my screen	High	Sprint-2
Customer (Web user)	Users	USN-1	As a user, I can integrate all users in this account	I can configure the account, active and inactive	Medium	Sprint-2
	Web applicator	USN-2	As a web applicator, I can form backend server	I can progress the code in the server	Medium	Sprint 3
Customer Care Executive	Security	USN-1	As a customer care, I can secure the data in cloud database	I can secure the data location	High	Sprint-3

Administrator		USN-1	As a user,I can manage the application	I can configure the settings their account.	Medium	Sprint-3
Devices	Simulation	USN-1	As a user, I can connect the required parameter in device.	I can deliver the product	High	Sprint-1
		USN-2	As a user, I can activate the device	I can applicable to the bin levels.	Medium	Sprint-1
Message Sender	API requests	USN-1	As a message sender, API requests whenever some function is invoked from a device.	I can send or receive the from an application.	High	Sprint-2
	Fast SMS	USN-2	As a sender, I can send bulk messages using the sms	I can receive the messages in device	Low	Sprint-3
Programmer	Software	USN-1	As a programmer, I can ceate the user friendly program for ease access by parents	To configure the devices	High	Sprint-2
		USN-2	As a software, I compute coding in	To simultaneously run the device	High	Sprint-2

			devices			
Authenticator	User	USN-1	As a user, I can use identification technique in IoT device	I can emminent the security	High	Sprint-3
	Open Authorization	USN-2	As a user, I uses an open standard communication protocol	It provides tokens to the end users	Medium	Sprint-3
	Identifier	USN-3	User successfully register into the system	It stores the user's unique identification	Medium	Sprint-2
Admin	Admin Authorities	USN-1	In this other end-users are restricted	to add devices into the system	Low	Sprint-4
	User	USN-1	As a user, I can create organizations	The user to login to IoT Platform	High	Sprint-2
		USN-2	As a user, I allows admin to create & edit user accounts	For assigning access rights to user or device group	Medium	Sprint-2
		USN-2	As a software, I compute coding in devices	To simultaneously run the device	High	Sprint-2

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Product backlog, Sprint Schedule, Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint- 1	Simulation	USN-1	As a user, I can install online simulator	1	medium	Vijayashree.V
Sprint- 1		USN-2	As a user, I can connect the required parameters in device	1	high	Shruthi.K
Sprint- 1		USN-3	As a user, I can activate the device	2	medium	Snehapriya.R
Sprint- 1		USN-4	As a user, I will write the code in this stimulation	3	high	Maanaswini.K

Sprint- 1		USN-5	As a user, I can run the program to check whether the error is present or not.	5	high	Shruthi K
Sprint- 2	Cloud	USN-1	As a user, I create a cloud server	2	medium	Snehapriya R
Sprint- 2		USN-2	As a user, I can enter the device specification in the created cloud	2	medium	Maanaswini K
Sprint- 2		USN-3	As a user, I can integrate device into this cloud.	3	high	Vijayashree V
Sprint- 2		USN-4	As a user, I can connect device through wifi to the cloud.	5	high	Shruthi K
Sprint- 3	Programming Tool	USN-1	As a programmer, I can provide a browser-based editor.	2	low	Maanaswini K
Sprint- 3		USN-2	As an editor, I can easy to wire together flows using the wide range of nodes in the palette.	3	medium	Snehapriya R
Sprint- 3		USN-3	I can be deployed to its runtime in a single click.	5	high	Shruthi K
Sprint- 3	Platform	USN-1	As a programmer, I can use Node.js platform.	3	medium	Vijayashree V
Sprint- 3		USN-2	As a user, I can Use the MIT app.	3	high	Maanaswini K

Sprint- 3		USN-3	As a programmer, I can communicate through the app.	2	medium	Snehapriya R
Sprint- 4	API	USN-1	As a user, I can generate API tokens through cloud.	3	medium	Vijayashree V
Sprint- 4		USN-2	As a user, I use API keys to integrate the programming tool.	3	medium	Shruthi K
Sprint- 4		USN-3	As a user, I can register SMS services.	2	high	Snehapriya R
Sprint- 4	SMS	USN-1	As a user, I can send messages through API to the server.	2	high	Vijayashree V
Sprint- 4		USN-2	As a user, I can monitor the bin.	2	high	Maanaswini.K

6.2 Sprint Delivery Schedule

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	12	6 Days	24 Oct 2022	29 Oct 2022	12	29 Oct 2022
Sprint-2	12	6 Days	31 Oct 2022	05 Nov 2022	12	31 Oct 2022
Sprint-3	18	6 Days	07 Nov 2022	12 Nov 2022	18	12 Nov 2022
Sprint-4	12	6 Days	14 Nov 2022	19 Nov 2022	12	19 Nov 2022

Velocity:

AV for sprint-1 = 12/6 = 2 points

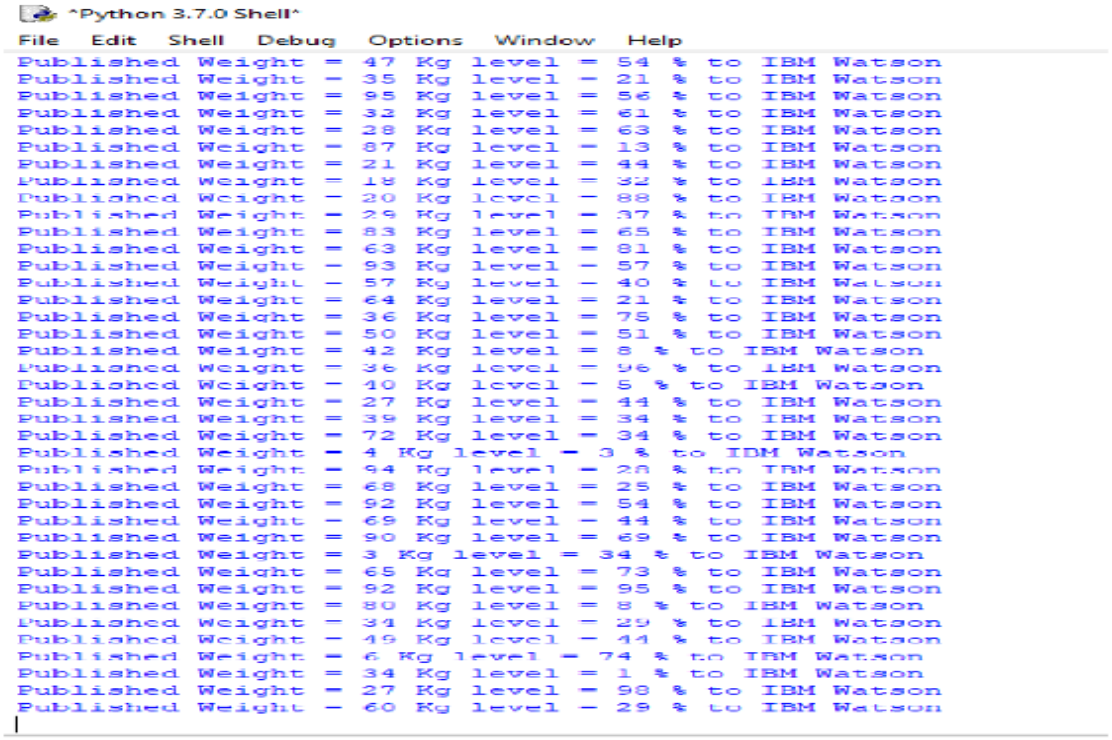
AV for sprint-2 = 12/6 = 2 points

AV for sprint-3 = 18/6 = 3 points

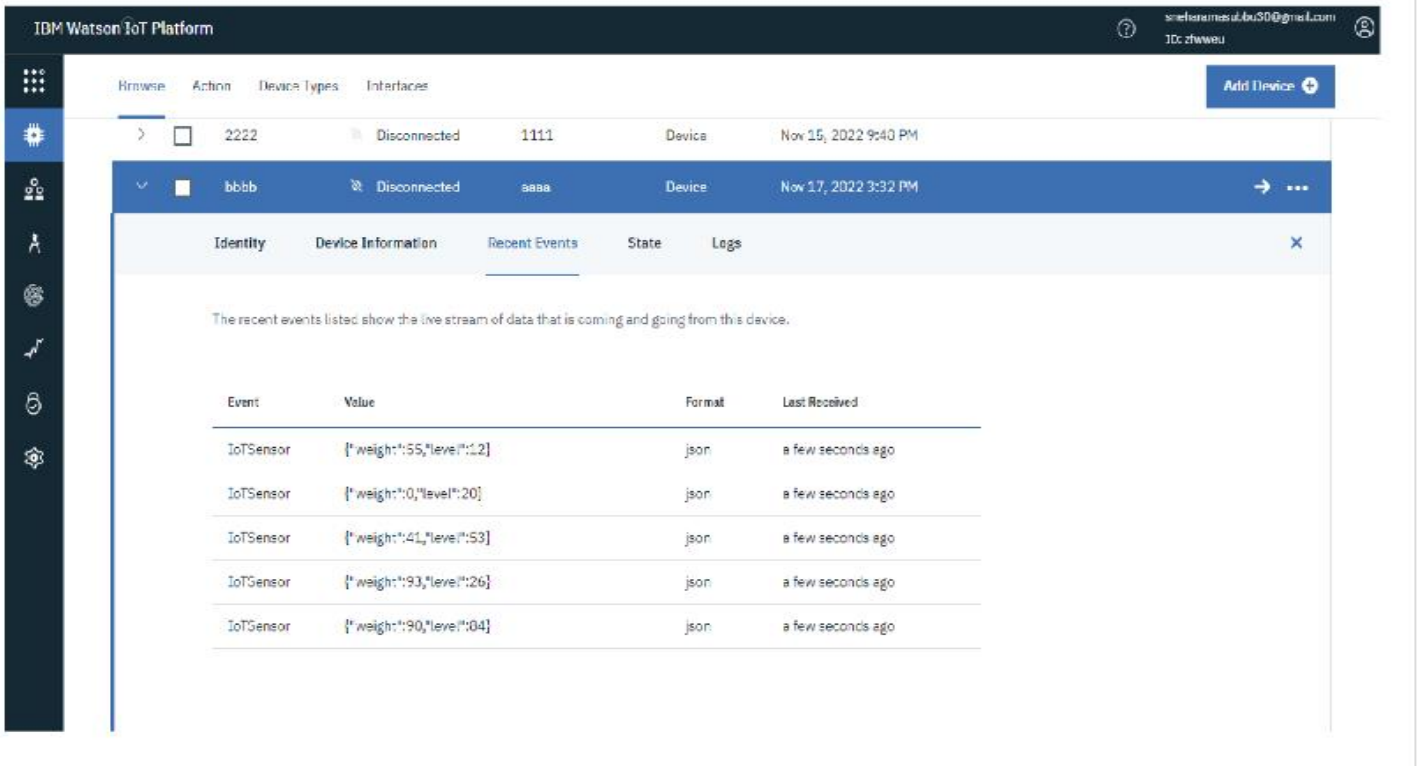
AV for sprint-4 = 12/6 = 2 points

Burndown Chart:

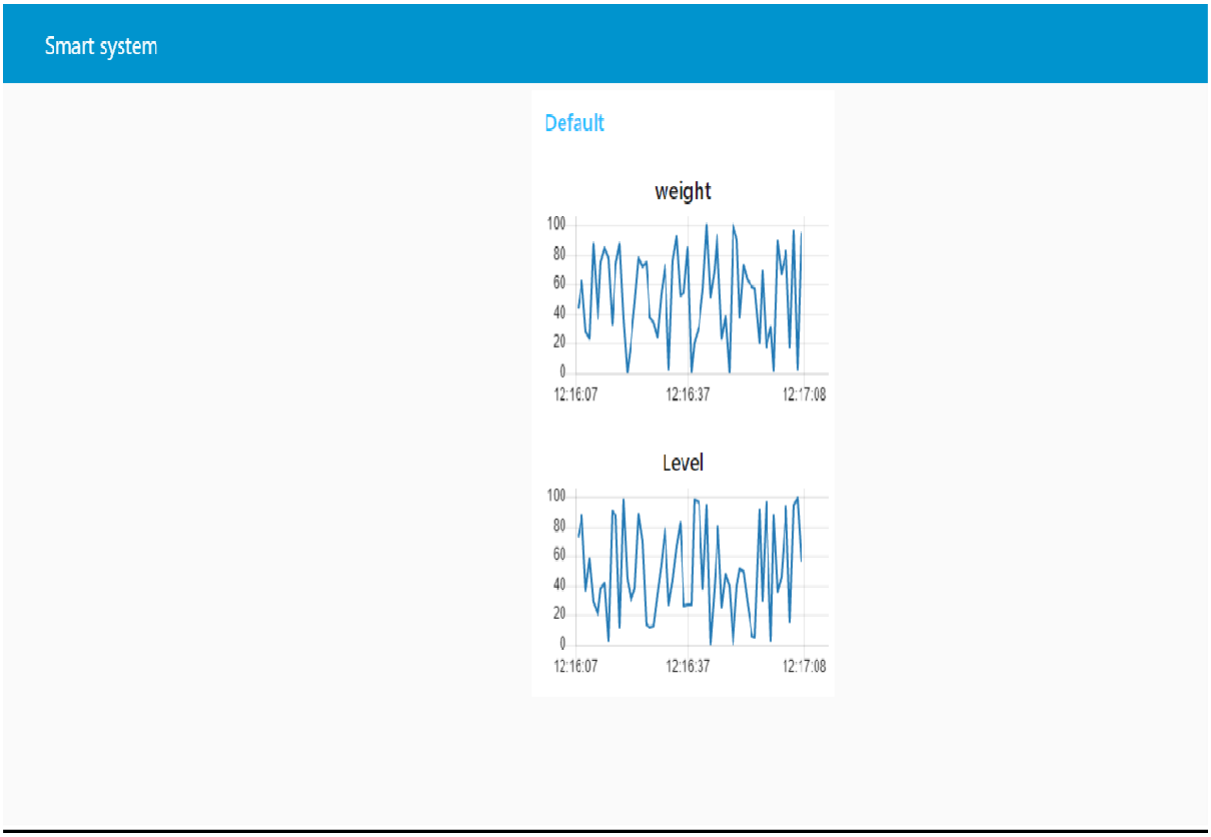
Sprint-1



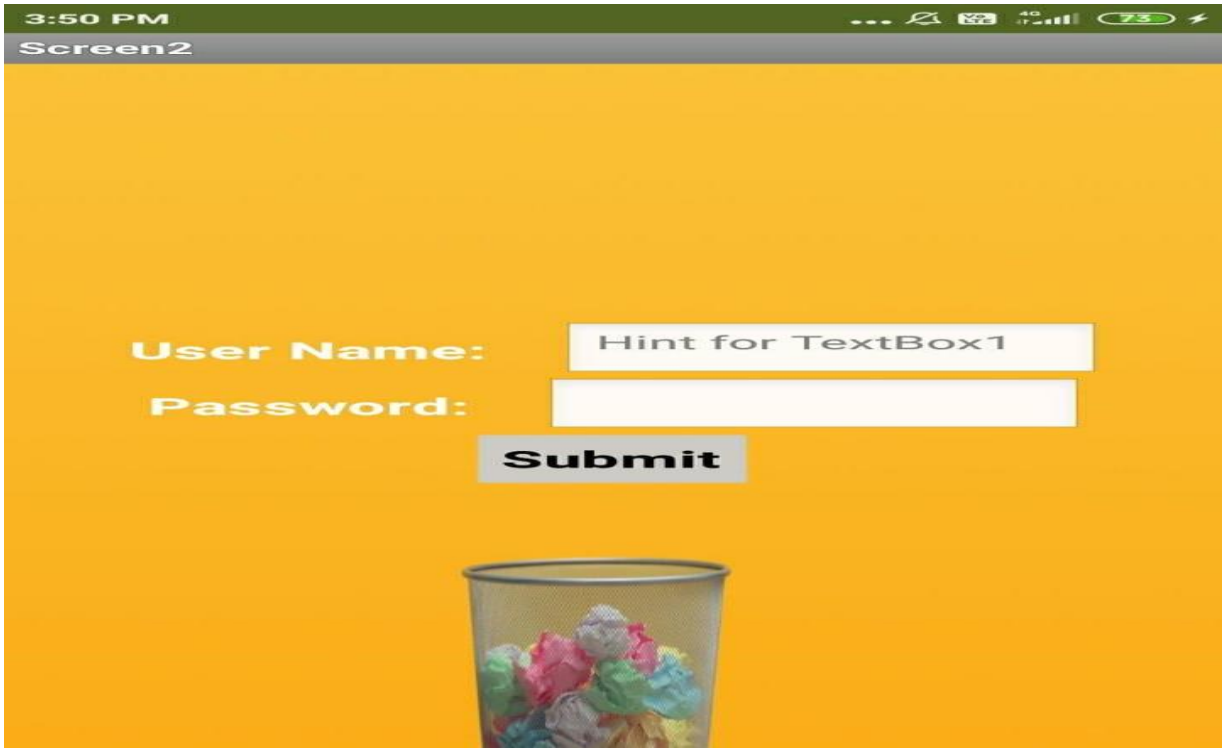
Sprint-2



Sprint-3



Sprint-4

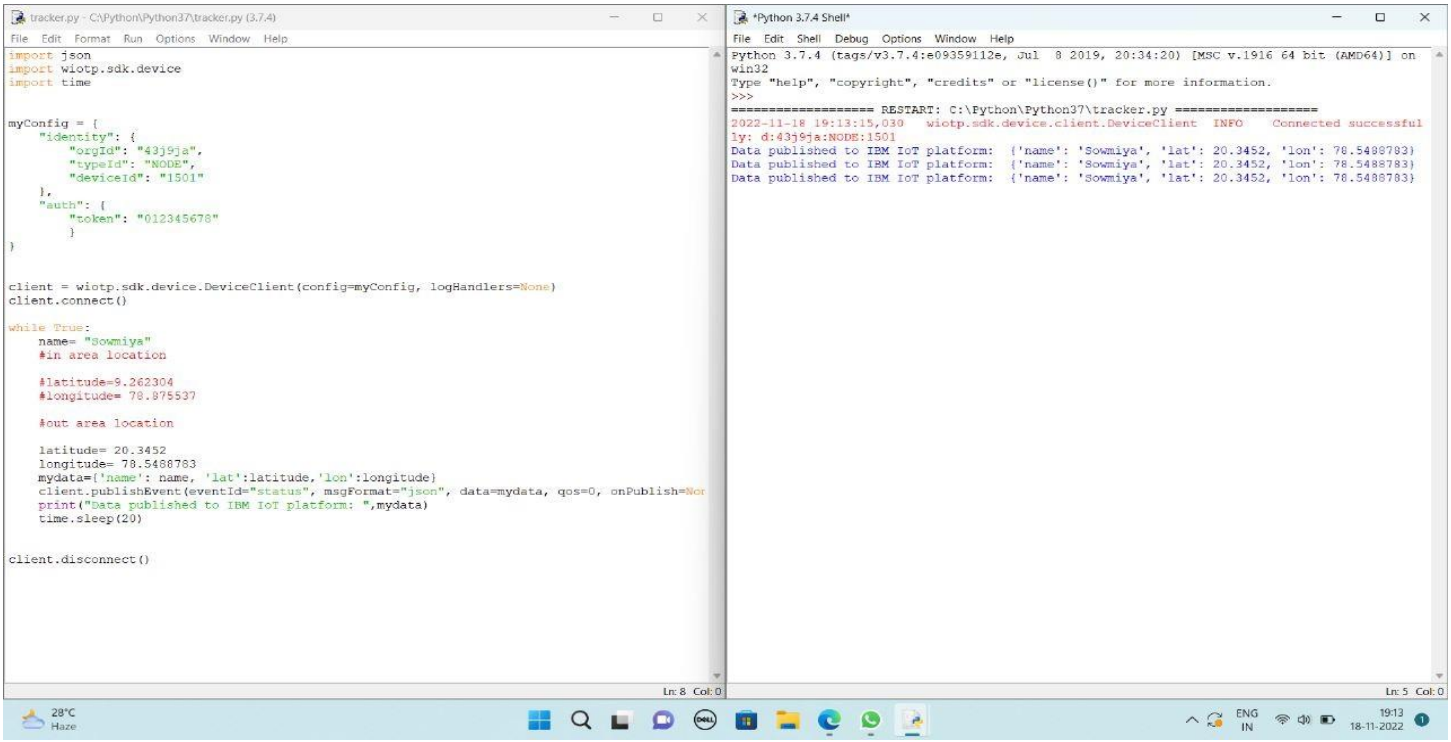

3:50 PM
Screen2
User Name:
Hint for TextBox1
Password:
Submit


3:51 PM
Screen3
Weight:
74
Level:
32

7. CODING & SOLUTIONING

7.1 Feature 1 - PYTHON CODE

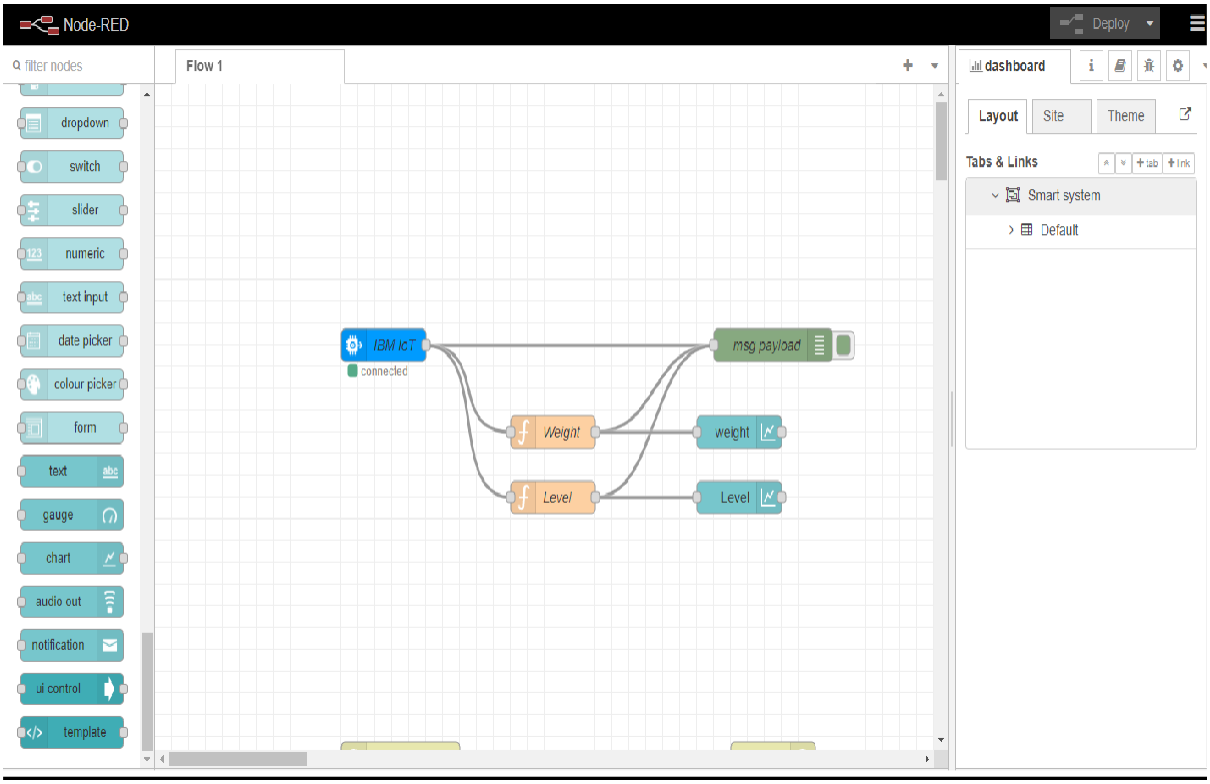
Instead of hardware, we are using python code. Python code connects the IBM Watson and the output of the code is displayed in the device.



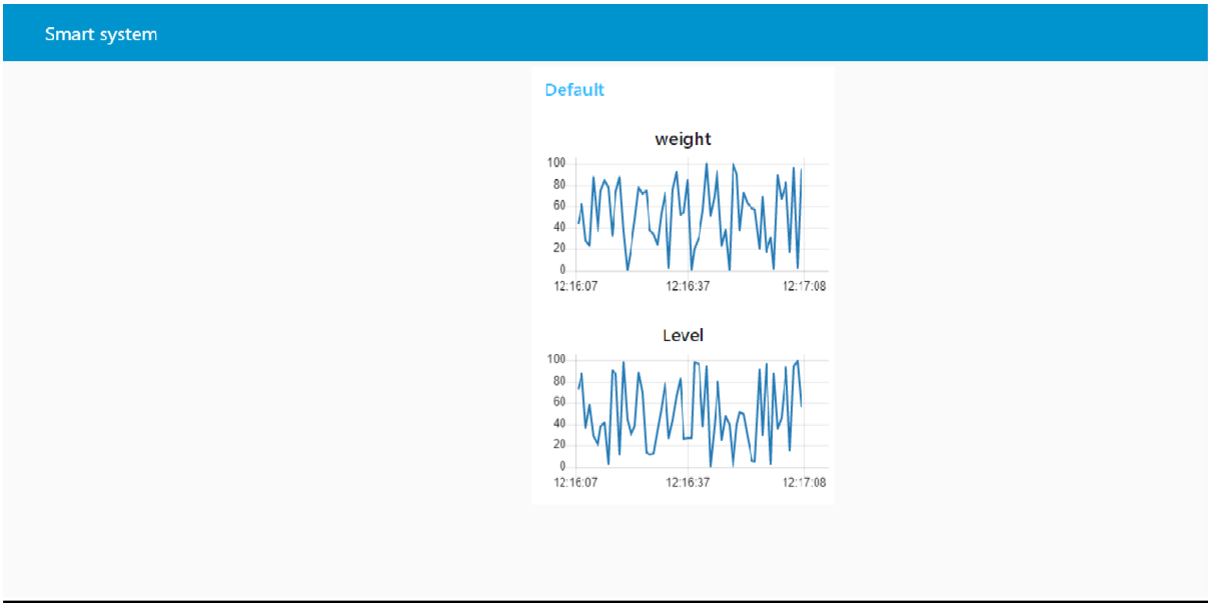
7.2 Feature 2 -NODE-RED Service

Node red service is used to display the output in the generated URL link.API key connects the IBM Watson and the Node red.Node red service displays the output of two functions(level, weight) in the URL link.

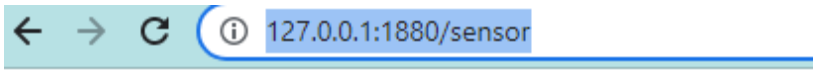
Node connections in node red for sensor:



Generated ouput for recent events:

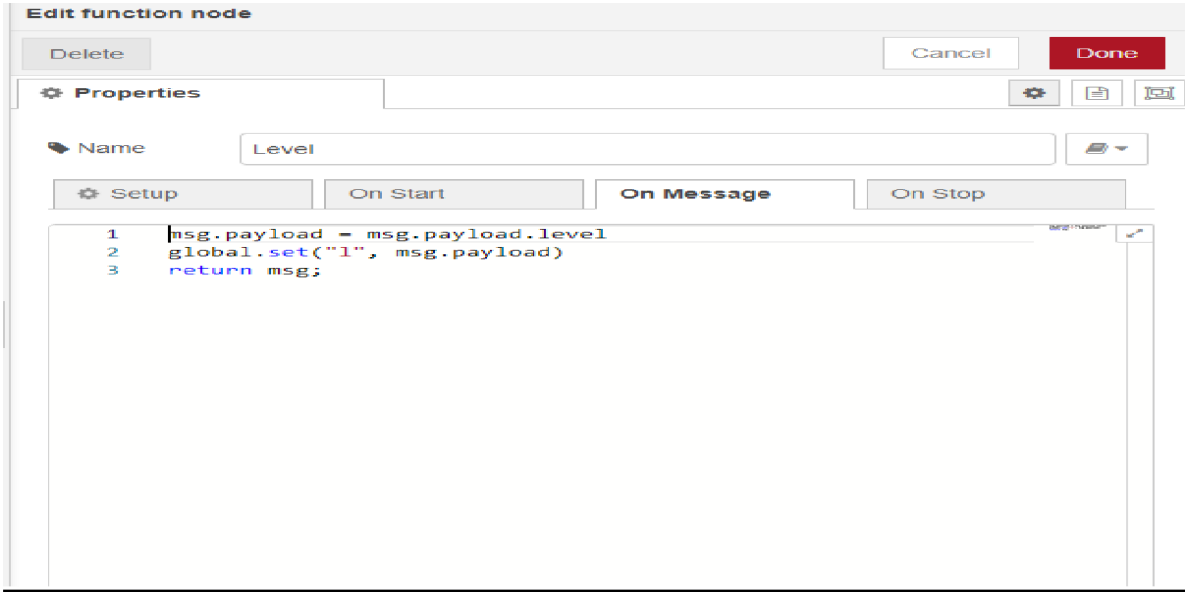


Detected values showing using url:

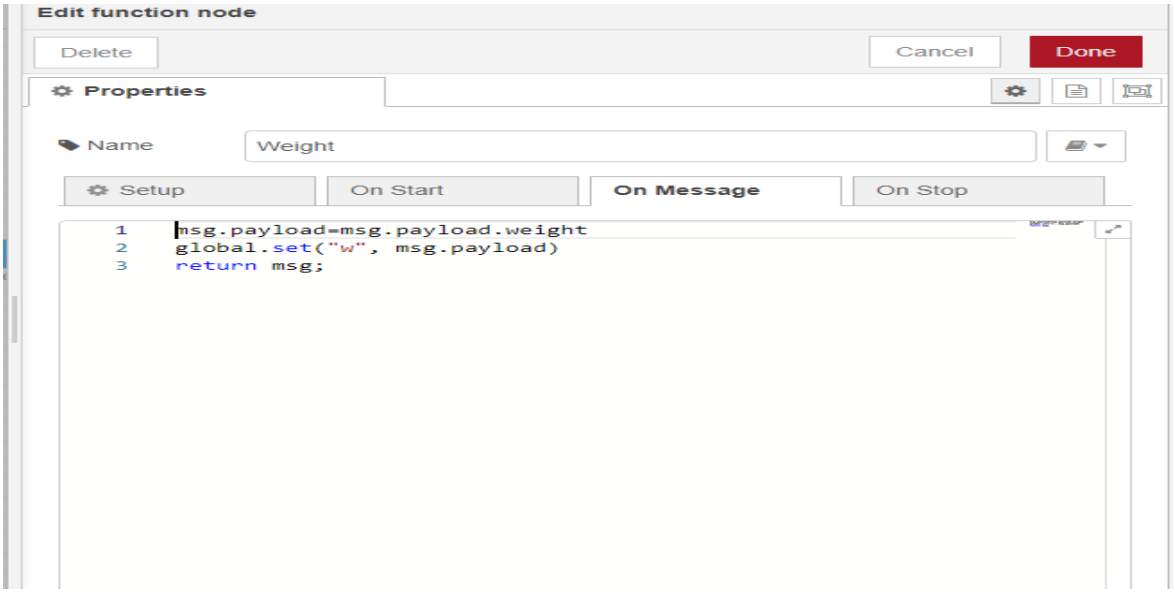


{"weight":81,"level":36}

Function for weight -on message:



Function for level -on message:



7.3 Feature 3 – Sensor detection

Sensor measures the level of the bin and indicates if it crosses the level.

Sensor-on message:

7.4 Feature 4 – MIT APP

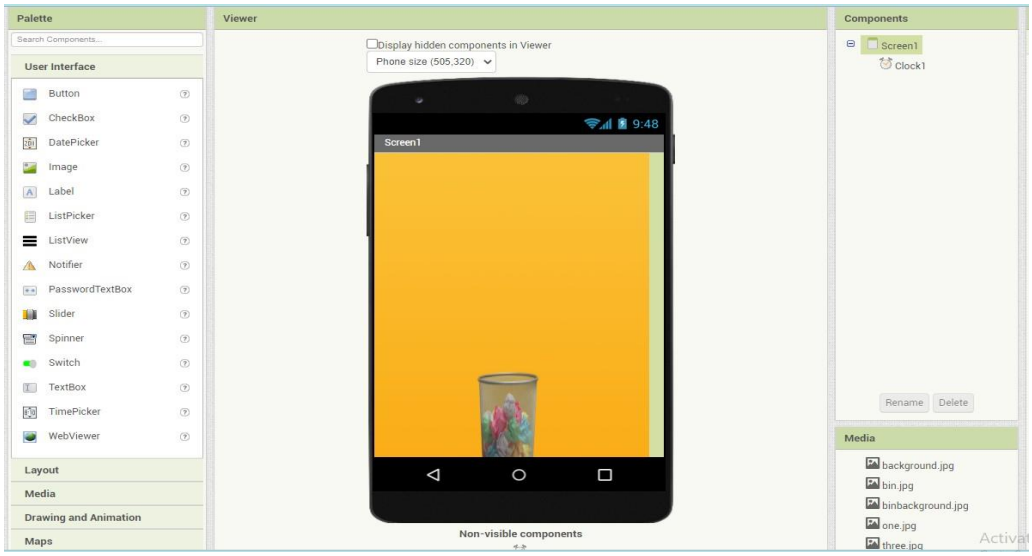
URL link is added to the MIT blocks.

This provides the output to be displayed in the MIT app.

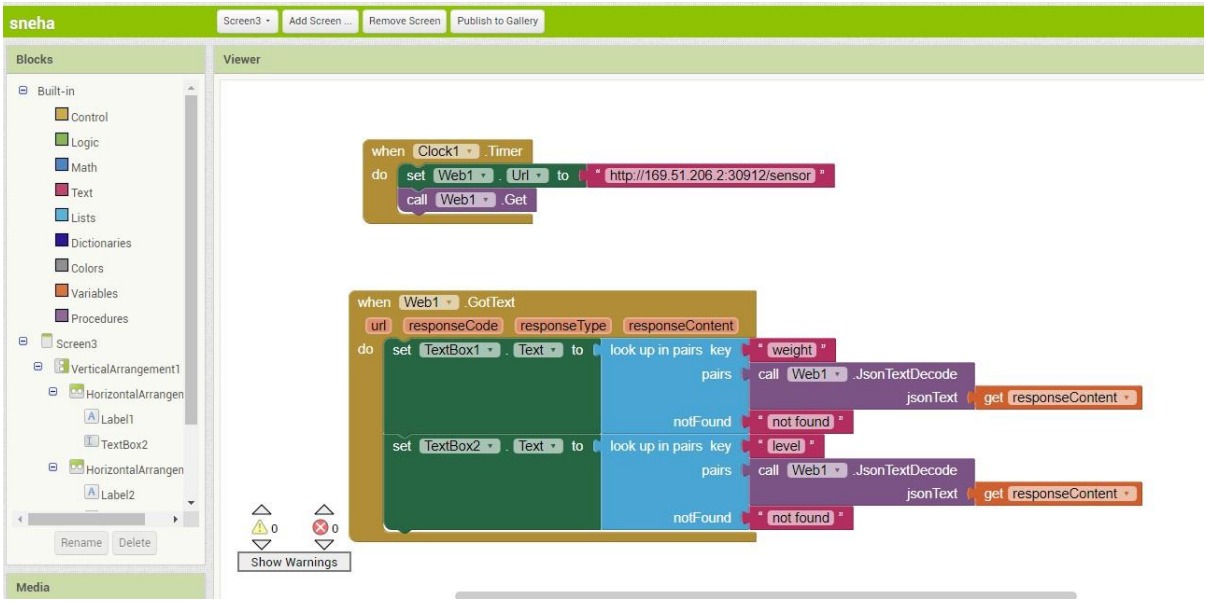
User name and password are to be entered to login in the application.

The output page displays the weight and level of the trash.

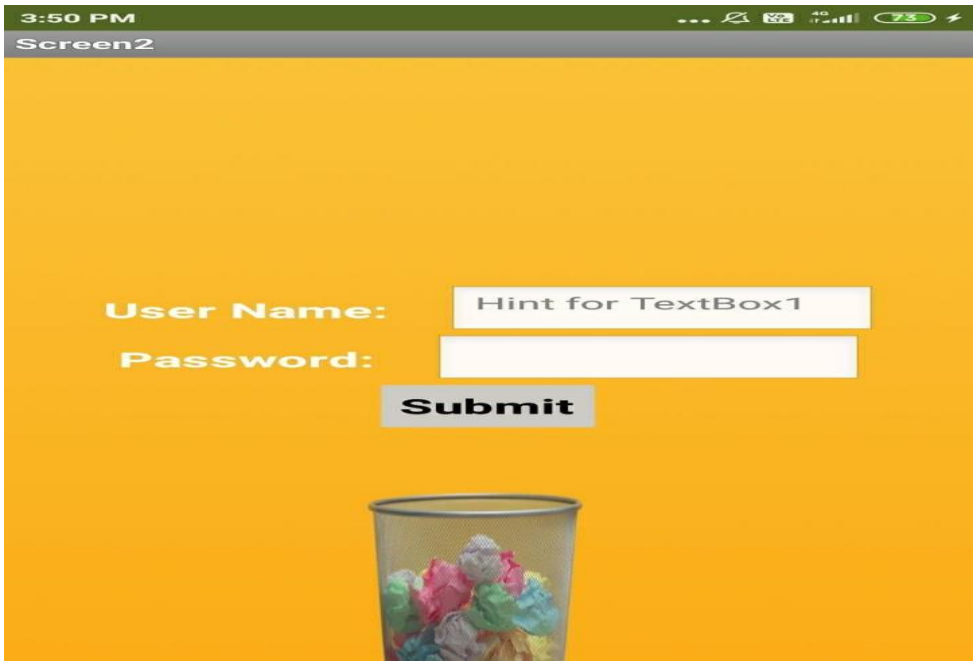
MIT APP DESIGN:

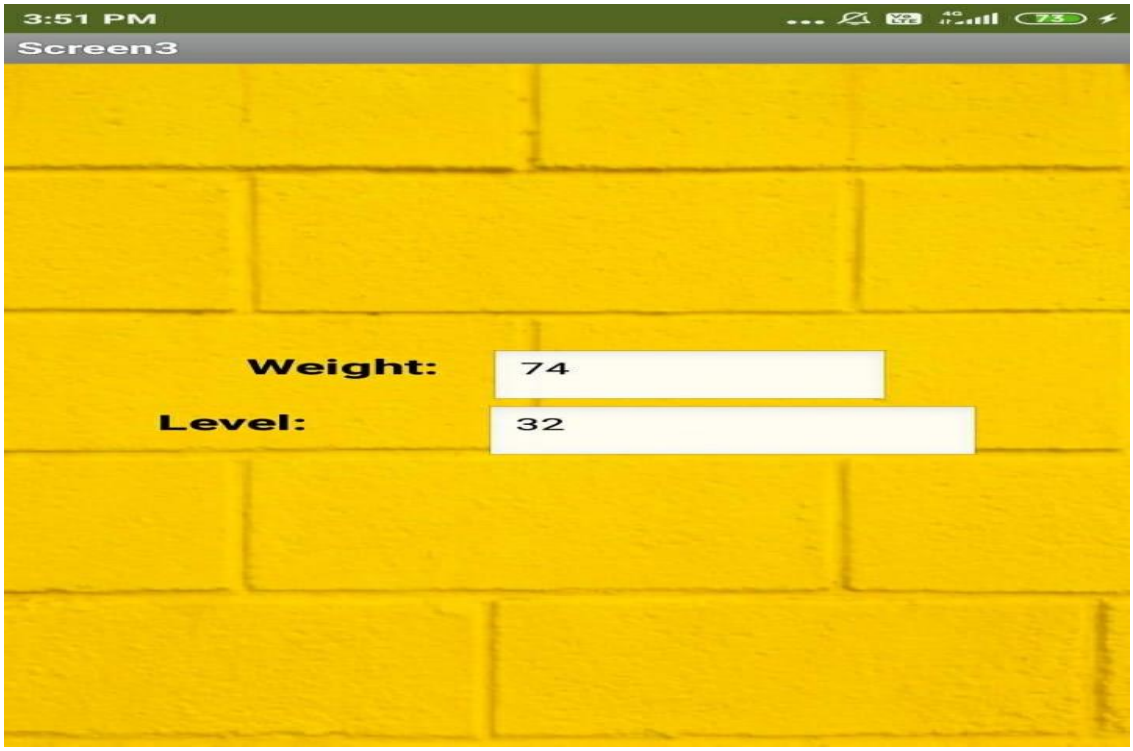


MIT BLOCK:



OUTPUT IN MOBILE APP:




3:51 PM
Screen3
Weight:
74
Level:
32

8. ADVANTAGES & DISADVANTAGES

Advantage:

1. Time-saving

By having a more convenient route garbage trucks spend less time on the road, therefore, congestion in smart cities can be decreased. This means that truck drivers and citizens are saving less time stuck in traffic jams. Additionally, using IoT technology for remote diagnostics also means not having to send staff all the way to monitor assets.

2. Cost-saving

With the huge increase in waste, more resources are allocated to waste collection and handling. If unnecessary collections are eliminated, public spending on waste management can be reduced.

This frees up resources for municipalities to allocate to other initiatives. Moreover, waste is properly handled and sorted and turned into recyclable assets, this provides a further potential income stream.

3. Sustainability

Overflowing bins will pollute the environment potentially contaminating areas and harming the general health of the public. An optimized route and system for waste collection will eliminate this risk as well as improving air quality and minimizing CO2 emissions. Smart cities can reduce their overall carbon footprint, bringing them closer to achieving the SDG goals.

4. Improving efficiency

Smart cities are all about using resources efficiently – achieving more by using less input. One of the benefits includes the availability of real-time data, allowing for decisions to be made quickly. This means that action can be taken before having an overflow of containers. Smart cities can remain highly responsive and challenge the current waste hierarchy, breaking patterns of inefficiency and high costs.

5. Transparency

By routes being monitored, the opportunity of the misuse of owned assets is eliminated.
Moreover, cities are encouraged to be transparent with their citizens by showing how waste is being managed. By making data publicly available, trust can be built with citizens. Smart cities should be encouraged by their operations and solutions to strive for more sustainable development, not limited by them.

6. Meet the increasing demand for sustainable solutions

As society is becoming more aware of the environmental issues – there is an increasing demand for more sustainable and environmentally friendly solutions, when choosing between services and products. Smart cities infrastructure and intelligent waste solutions have the potential to lead the shift towards a more sustainable future.

Disadvantage:

1. System requires more number of waste bins for separate waste collection as per population in the city.
2. This results into high initial cost due to expensive smart dustbins compare to other methods.

   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.

   The trainining has to be provided to the people involved in the smart waste management system.

9. CONCLUSION

- ✓ Due to the absence of sustainable waste management technology, the current waste disposal situation is likely to worsen.
- ✓ This work presents an enhanced solution to the problem of waste management by the littering of the garbage bins once they are full.Littering of the environment and the health hazards are minimized as timely disposal of the wastes is ensured as the system automatically sends a message alert to the garbage collector or the management authority once the bin is full thereby ensuring that the bin is made empty to avoid dumping of refuse on

10. FUTURE SCOPE:

- ✓ We can add GPS to this project.
- ✓ This will help to track the position in case there are more dustbins and also we can make separate dustbins for dry waste and wet waste .
- ✓ There are many birds and animals like dog , cat roaming around so we can add a cage to protect the dustbin from them.

11. REFERENCE LINKS:

https://evreka.co/blog/iot-based-smart-waste-management-systems/

https://ieeexplore.ieee.org/document/8645576?denied=

https://ieeexplore.ieee.org/document/8075303

https://www.sciencedirect.com/science/article/pii/S1877050915030008

12. APPENDIX:

Github link: https://github.com/IBM-EPBL/IBM-Project-18600-1659687492

Demo video link:

https://drive.google.com/file/d/1257NmFOxmLkgo26nJx0N1j33dgiy_g1-/view?usp=sharing

Mit app link: http://ai2.appinventor.mit.edu/#6432350230413312