SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES

MICROSOFT INTERNSHIP

PROJECT REPORT

Submitted By

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BONAFIDE CERTIFICATE

Certified that this project report titled **"SMART WASTE MANAGEMENT SYSTEM FOR METROPOLITAN CITIES"** is the bonafide work of **"DHARSHANA SHRI S (611220106012) , ABIRAMI SV (611220106002), ANUPRIYA K (611220106004)** who carried out the project work under my supervision.

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CHAPTER -1
INTRODUCTION

1.1 PROJECT OVERVIEW

In the era of today, the smart city has become the trend and aim to be achieved by almost every country. To become a smart city, smart waste management is playing an important role in it. Smart waste management is the upgrade or optimization of traditional waste management with information technology. Waste management is the movements and actions that needed to direct waste from its beginning to last disposal. In simplest terms, it can be defined as the collection, transportation, and disposal of garbage, and other waste products. In this Smart Waste Management System (SWMS), Internet of Things (IoT) was used for implementing the project.

IoT is a recent technique which allow the interconnection of object with network. The plan of new idea in IT domain is maintaining things internet of mutual. IoT enables to interconnect endless of gadgets via web and it makes a rich circumstance by partner the contraptions with web and outcome them with ability to exchange as well as collect data. These sensors gather data regarding their environmental factors and send the data to the dependable through remote organization. The IoT makes an upheaval in the field of mechanization.

Besides, the system includes Android mobile application that allow user to get the data. The reason to develop mobile application within this project is because the mobile communication technologies are diffusing around the planet faster than any other communication technology to date. Nowadays, almost every people have their

own smartphone, the size of smartphone is relatively smaller and lighter compare to computer or laptop. In addition, the performance of smartphone getting better for now. Therefore, it is suitable to develop a mobile application for SWMS.

1.2 PURPOSE

This project IOT Garbage Monitoring system is a very innovative system which will help to keep the cities clean. The system monitors the garbage bins and informs about the level of garbage collected in the garbage bins via a web page. The Web Application is used to display the status of the level of garbage collected in the bins. Whereas a web page is built to show the status to the user monitoring it. The web page gives a graphical view of the garbage bins and highlights the garbage collected in colours in order to show the level of garbage collected. when the level of garbage collected crosses the set limit. Thus, the system helps to keep the city clean by informing about the garbage levels of the bins by providing graphical image of the bins via IBM IOT Platform. The idea struck us when observed that the garbage truck use to go around the town to collect solid waste twice a day. Although this system was thorough it was very inefficient. For example, let's say street A is a busy street and we see that the garbage fills up really fast whereas maybe street B even after two days the bin isn't even half full. The system does is it gives a real time indicator of the garbage level in a trashcan at any given time. Using that data, it can then optimize waste collection routes and ultimately reduce fuel consumption. It allows trash collectors to plan their daily/weekly pick up schedule.

CHAPTER -2

LITERATURE SURVEY

2.1 EXISTING PROBLEM

In today's world there is a need to monitor the garbage collection, since the existing methods involve human intervention to monitor the bins every day which takes more time to check every bin in the city manually. So, it would be easy to monitor and clear the garbage collection through an automated monitoring system.

2.2 REFERENCES

1. IoT Based Smart Waste Management System: Indiaprospective
   Name of the Author: Rishabh Kumar,Singhvi, Roshan LalLohar, Ashok Kumar, Ranjeet Sharma,Lakhan Dev Sharma,RiteshKumarSaraswat.

2. Waste Management System Using IoT:
   Name of the Author: Mohammed Adam, Mohammed Elnour Okasha, Omer Mohammed Tawfeeq, Mohammed Awad Margan, Bakri Nasreldeen.

3. An IoT enabled Smart Waste Management System in concern with Indian Smart Cities:
   Name of the Author: Pooja Devi, WajgeShubham Ravindra,Sai Prakash S.K.L.

4. IoT assisted Waste Collection and Management system using QR codes:
   Name of the Author: Aparna, Bhumijaa, Avila, Thenmozhi, Rengarajan Amirtharaja

CHAPTER -3

IDEATION AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviours and attitudes. It is a useful tool to helps teams better understand their users. Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user's perspective along with his or her goals and challenges.

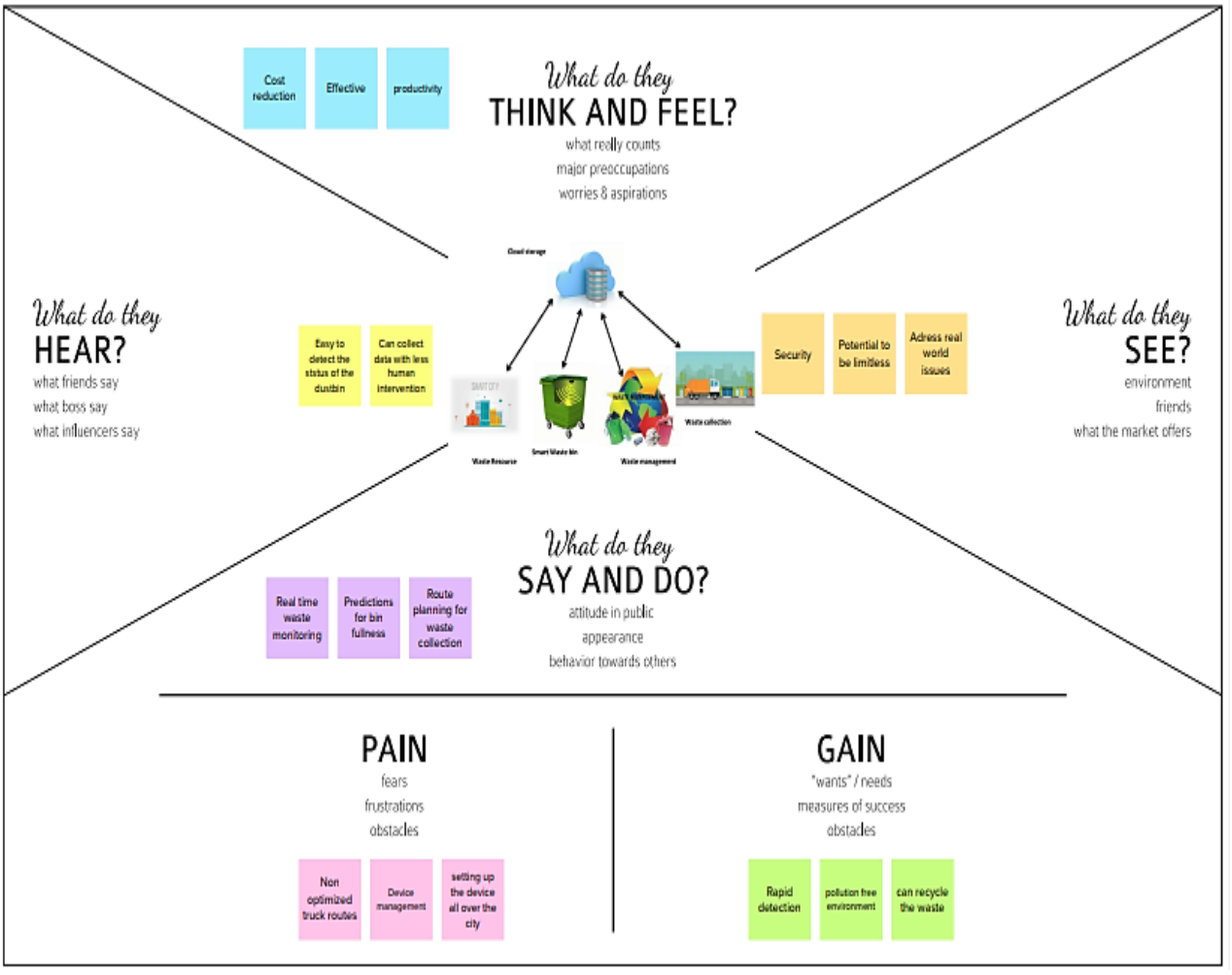

Figure 3.1.1 Empathy map

3.2 IDEATION AND BRAINSTROMING

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem-solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate, helping each other develop a rich number of creative solutions.

Step-1: Team Gathering, Collaboration and Select the Problem Statement

This step includes the formation of a team, collaborating with the team by collecting the problems of the domain we have taken and consolidating the collected information into a single problem statement.

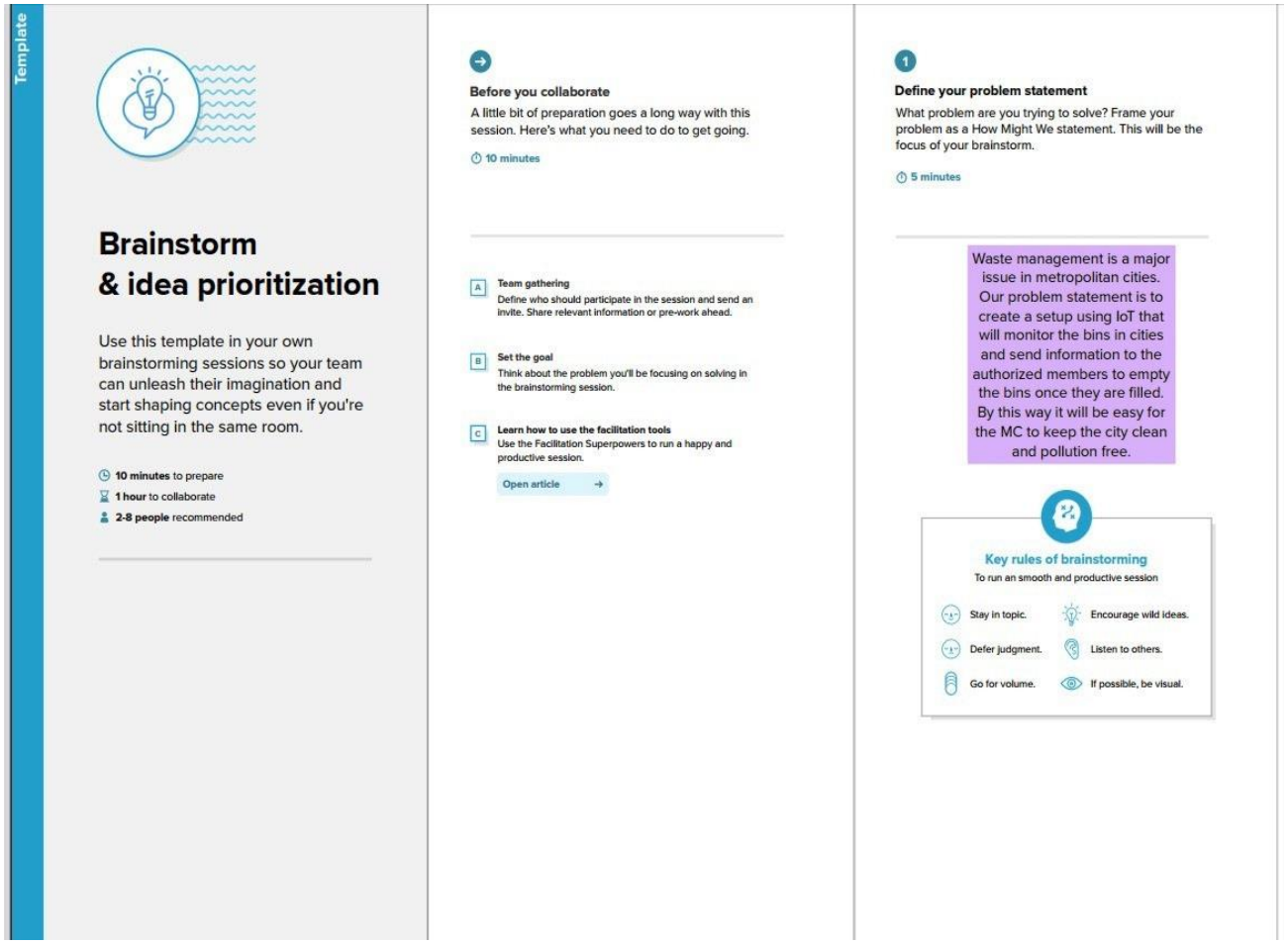

Figure 3.2.1 Team Gathering

Step 2: Brainstorm, Idea Listing and Grouping

This step of ideation includes the listing of individual ideas by teammates to help with the problem statement framed. All the individual ideas have been valued and made individual clusters.Then discussed as a team and finally made an ideation Cluster A and concluded with the most voted ideas from all the clusters together and Cluster B with the least needed ideas.

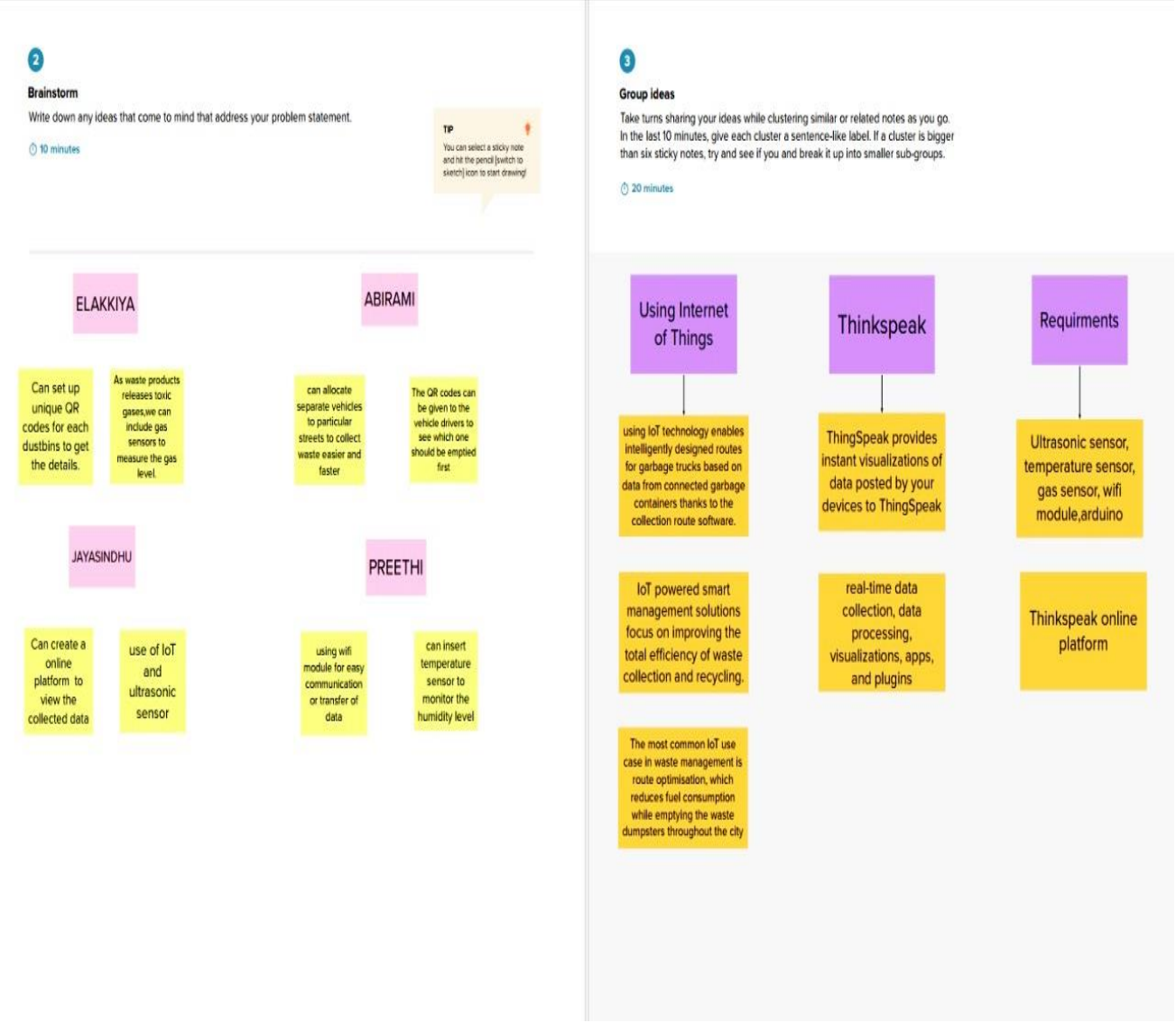

Fig:3.2.2 Idea listing and grouping

Step 3: Idea Prioritization

This step includes the process of listing necessary components to come up with the working solution and making a hierarchy chart by prioritizing the components based on importance, say from the higher being backend and lower being the user interfacing components.

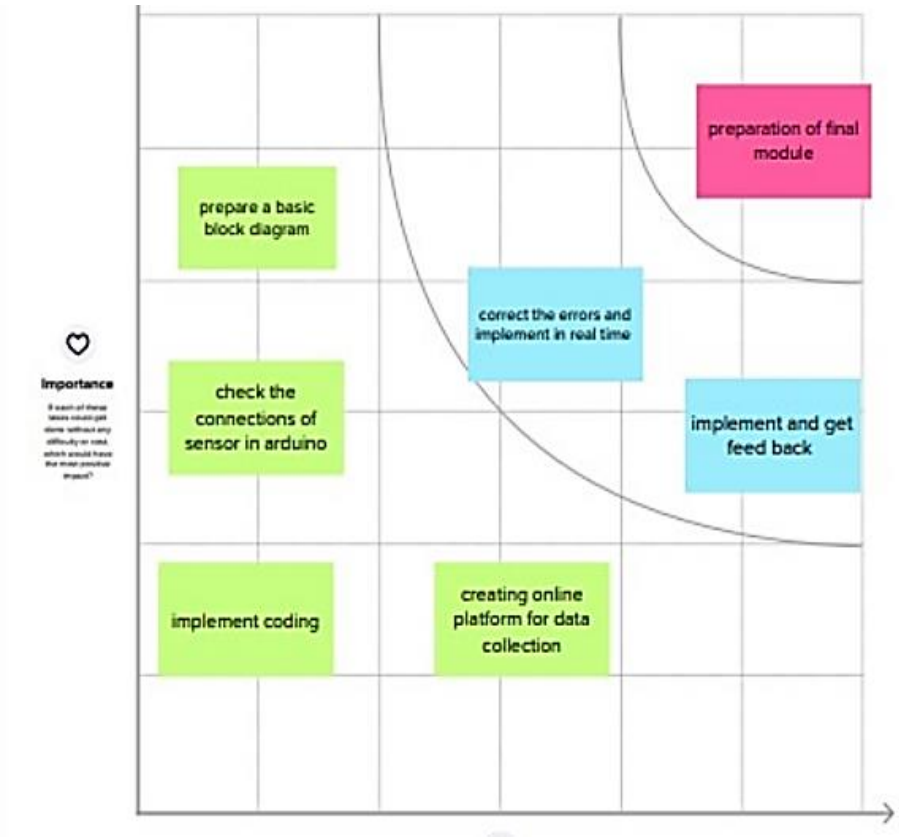

Fig:3.2.3 Idea Prioritization

3.3 PROBLEM STATEMENT

To create a web application using Internet of things that will monitor the bins in cities and send the information on the bin's data to the authorized members so that they can empty the bins on time.

Idea / Solution description:

The technology used here is IoT. By using Watson IoT platform, the bins data is generated. By using the node red, dashboard is created to receive the data. Then a web application is created using the MITAPP Inventor to receive the location and data in mobile device.

Novelty / Uniqueness:

The web application created will give the bin's location along with the bin's filled status, so that it will be easy for the truck to find the shortest route.

Social Impact / Customer Satisfaction

It helps to maintain cleaner and more hygienic environment and enhanced operational efficiency while reducing management time.

3.4 PROBLEM SOLUTION FIT

The Problem-Solution Fit simply means that the problem of the customer is solved in a step by step the process. It helps entrepreneurs, marketers and corporate innovators identify behavioural patterns and recognize what would work and why.

<table>
<tr><td>1.CUSTOMER SEGMENTS(S)
Public people</td><td rowspan="2">6.CUSTOMER LIMITATIONS
They should properly dispose the waste separately as bio degradable and non bio degradable in the waste bins.</td><td>5.AVAILABLE SOLUTIONS
(PROS AND CONS)
IoT assisted Waste Collection and Management system using QR codes.

QR based tracking and monitoring of household waste were carried out.</td></tr>
<tr><td>2.PROBLEMS/ PAINS
Non disposal of solid waste is a major issue in metropolitan cities of most developing countries.

It poses a serious threat to healthy living of the citizens.</td><td>9.PROBLEM ROOT/ CAUSE
They are not aware of the health issues caused because of non disposal of waste properly.

MC's are also not checking the bins and dispose it on time.</td><td>7.BEHAVIOR- ITS INTENSITY
Monitors and send data of the waste levels as they fills in the bins and gives alert messages to clear the bins on time.</td></tr>
<tr><td>3.TRIGGERS TO ACT
Proper checking and disposal of the wastes from the bins on time using ultrasonic sensors using IoT platform.</td><td rowspan="2">10.YOUR SOLUTION
Ultrasonic sensor senses the filling level of dustbin. Gas sensor measures the toxicity level of dustbin. If level is less than 10 cm or toxicity of gases is high then message is sent to MC through GSM module. The data of dustbin is also sent to the website after a fixed interval of dustbin so this information remains store on the website. The information is saved with date and time. If MC get to know about filling of dustbin then it will send truck driver to clean it. In this way the dustbins are cleaned timely.</td><td>8.CHANNELS OF BEHAVIOR (ONLINE)
Monitor and send send data to the online platform.</td></tr>
<tr><td>4.EMOTIONS
(BEFORE/ AFTER)
Before-overflow of waste
After-Proper disposal of waste</td><td>OFFLINE
Using the information gathered MC's take needed actions.</td></tr>
</table>

Figure 3.4.1 Problem Solution Fit

CHAPTER - 4

REQUIREMENTS ANALYSIS

4.1 FUNCTIONAL REQUIREMENT

- IBM IoT Platform-to generate the data of the bins.
- Node-red- to connect the IoT Platform and create a dashboard.
- Dashboard- to receive the bins data.
- MITAPP inventor- to create a mobile application.

4.2 NON-FUNCTIONAL REQUIREMENT

Usability:

The Web application's usability facilitates Use, to make it easier for the users to get the information generated by the IoT platform to monitor and decide based on that information.

Reliability:

Smart bins can detect the level of garbage in the bins with 95% accuracy.

Availability:

The web application is available at all conditions and can give the monitored bin status.

Scalability:

By monitoring the garbage level, the count of dustbins can be increased in busy streets where the garbage filling rate is faster than others.

CHAPTER - 5

PROJECT DESIGN

5.1 DATA FLOW DIAGRAM

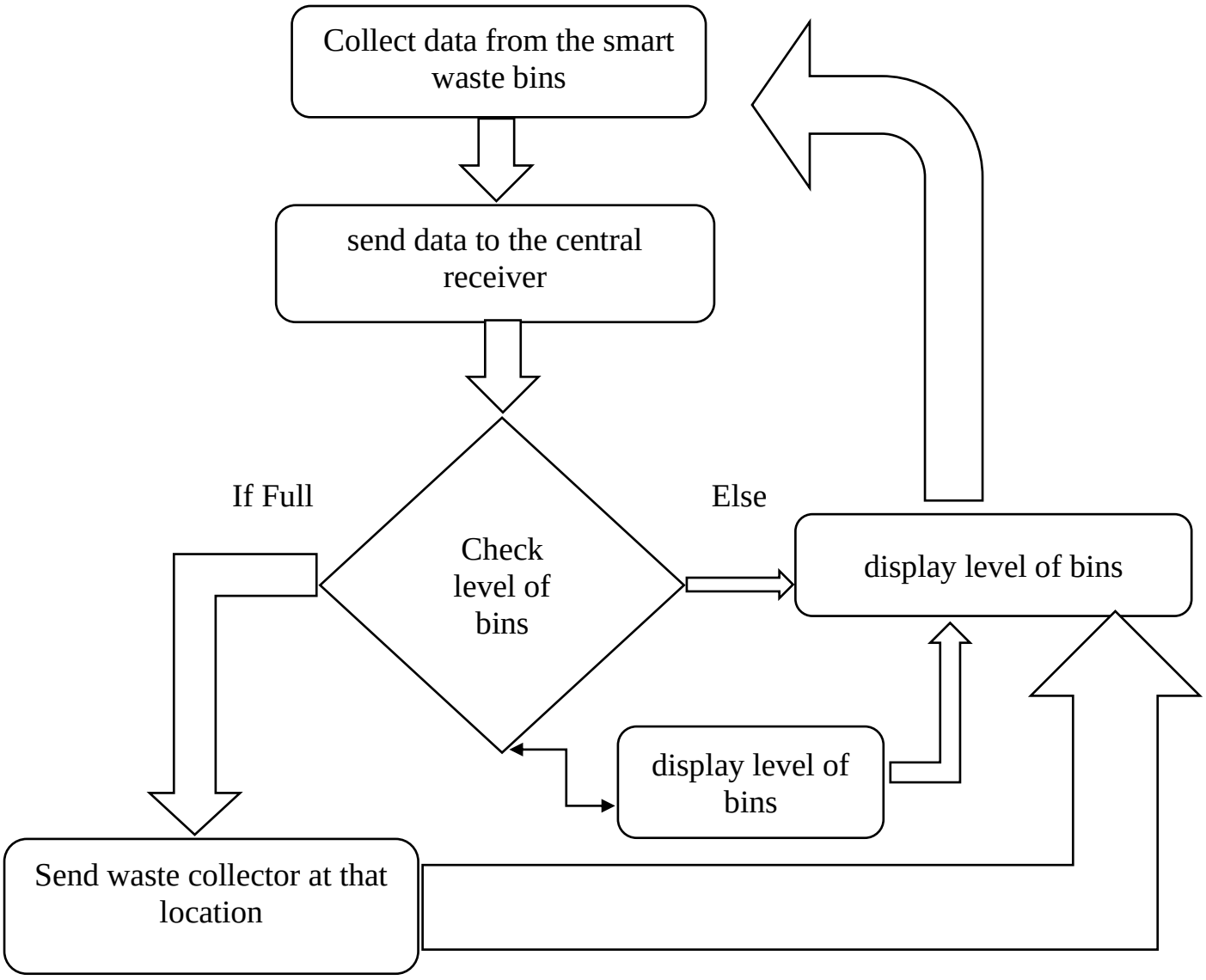

Figure 5.1.1 Data flow Diagram

The data flow diagram explains how this system works:

- The data from the smart waste bin is collected and the collected data is sent to the receiver (web application).

- If the bin is full, truck will be sent to that location to clear the garbage.
- If the bin is not full it is continued to collect the data.

5.2 SOLUTION AND TECHNICAL ARCHITECTURE

The solution architecture includes the components and the flow that have designed to deliver the solution.

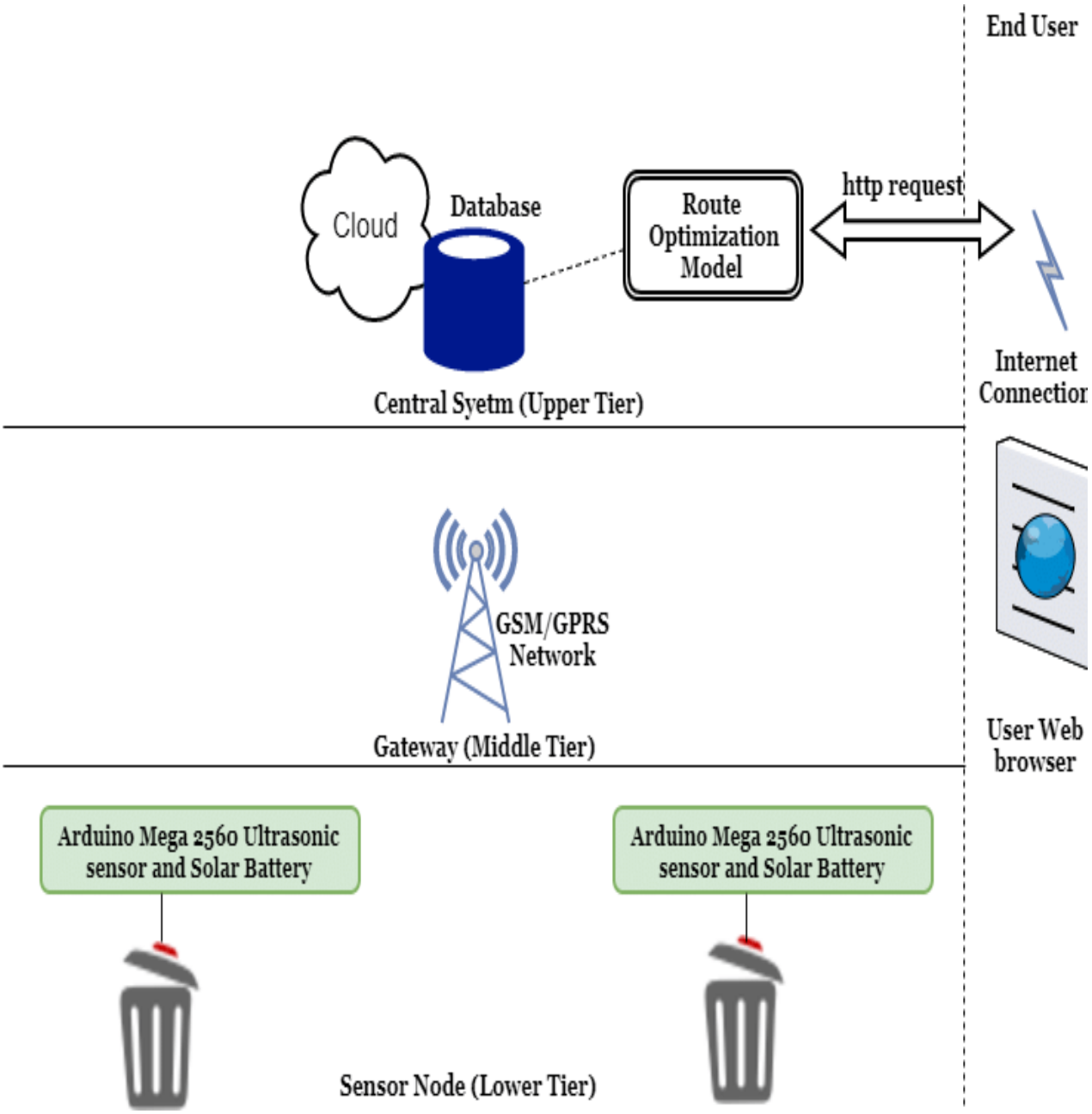

Figure 5.2.1 Solution and Technical Architecture

5.3 USER STORIES

Table 5.3.1. User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Priority	Release
Admin	IBM Watson	USN-1	Used to generate the data of the bin.	High	Sprint-1
Admin	Node-red	USN-2	Used to connect the Watson platform and create a dash board	High	Sprint-2
Customer	Dashboard	USN-3	Used to receive the bin's data	High	Sprint-3
Customer	Web application	USN-4	Used to receive the location and data of the bin	High	Sprint-4

A user story is an informal, general explanation of a software feature written

from the perspective of the end user or customer. The purpose of a user story is to articulate how a piece of work will deliver a particular value back to the customer.

CHAPTER - 6

PROJECT PLANNING AND SCHEDULING

6.1 SPRINT PLANNING AND ESTIMATION

SPRINT 1

The first sprint involves the setting up of IBM IoT Watson Platform to generate the bin's data (Internet of Things-mj). After that a device must be created and registered in the Watson IoT Platform. Then the device is switched on and then the coding part is given.

Organization ID: nmp0h6

Device Type: IoT

Device ID: 12345

Authentication Token: 123456789

Code for generating Random bin data:

{

"BIN 1": random (0,100),

"BIN 2": random (0,100),

"BIN 3": random (0,100),

"BIN 4": random (0,100),

"BIN 5": random (0,100)

}

The device simulator is switched on and the random bin values are generated and can be viewed in the recent events tab.

SPRINT 2

In this step, an organization called smart bin is created and registered. Then an API key is generated for the registered device. In node-red, the IBM Watson IoT Platform is connected using the API key, Device Type and Device ID.Then a msg.payload node is connected to receive the bin's data. Then the function node (Bin 1 value node, Bin 2 value node, Bin 3 value node, Bin 4 value node, Bin 5 value node) is connected with the IBM Watson in node and it is connected to the gauge dashboard node.

Code for each gauge:

```
msg.payload=msg.payload["BIN 1"];

global.get("b1");

return msg;

msg.payload=msg.payload["BIN 2"];

global.get("b2");

return msg;

msg.payload=msg.payload["BIN 3"];

global.get("b3");

return msg;

msg.payload=msg.payload["BIN 4"];

global.get("b4");

return msg;

msg.payload=msg.payload["BIN 5"];
```

global.get(“b5”)

return msg;

SPRINT 3

In Sprint 3, once the connection of gauge dashboard node is done with the function node, all the bin values are made to be appear in the dashboard page using the code below:

Code:

msg.payload={“BIN 1”:global.get(“b1”), “BIN 2”:global.get(“b2”),“BIN 3 ”: global . get(“b3”), “BIN 4”: global.get(“b4”), “BIN 5”: global.get(“b5”)};

return msg;

Then the http:in, function and http response nodes are connected with each other to create the dashboard we page. Then a url is created for the dashboard (https://node-red-yqmlm-2022-11-13.eu-gb.mybluemix.net/binvalues.ui).Then the output is seen in the dashboard web page in gauge form when the device simulator is switched on.

SPRINT 4

In this Sprint a mobile application is created using the MITAPP Inventor. In the frontend designer block, the mobile screen in which we wanted to view the data is created. Lables are created as BIN 1, BIN 2, BIN 3, BIN 4 and BIN 5. Two text boxes are created near each bin for receiving the location and bin value (in %). Web 1 and a clock is created for the backend process. In the backend process: web 1 is connected with the clock 1and a url is attached (https://n ode-red-yqmlm-2022-11-13.eu-gb.mybluemix.net/binvalues.ui). Then web1.GotText block is created. Decode is connected. And a get response content is attached. Likewise for all bins connections are established. Then a QR code is generated, by scanning the code we can view the output in mobile.

6.2 SPRINT DELIVERY SCHEDULE

Table 6.2.1 Sprint Delivery Schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	IoT Platform	USN-1	Creating random data for bin values in IoT Watson platform	20	High	Abirami N T
Sprint-2	Node-red	USN-2	Connecting IoT Watson to node-red and giving connections to create a dashboard	20	High	Jayasindhu P
Sprint-3	Web application	USN-3	Creating a web Application using MITapp inventor	20	High	Elakkiya M K
Sprint-4	Final output	USN-4	Connecting all connections and getting final result	20	Medium	Preethi K S

Sprint planning is an event in scrum that kicks off the sprint. The purpose of sprint planning is to define what can be delivered in the sprint and how that work will be achieved. Sprint planning is done in collaboration with the whole scrum team.

6.3 REPORTS FROM JIRA

Burndown Chart

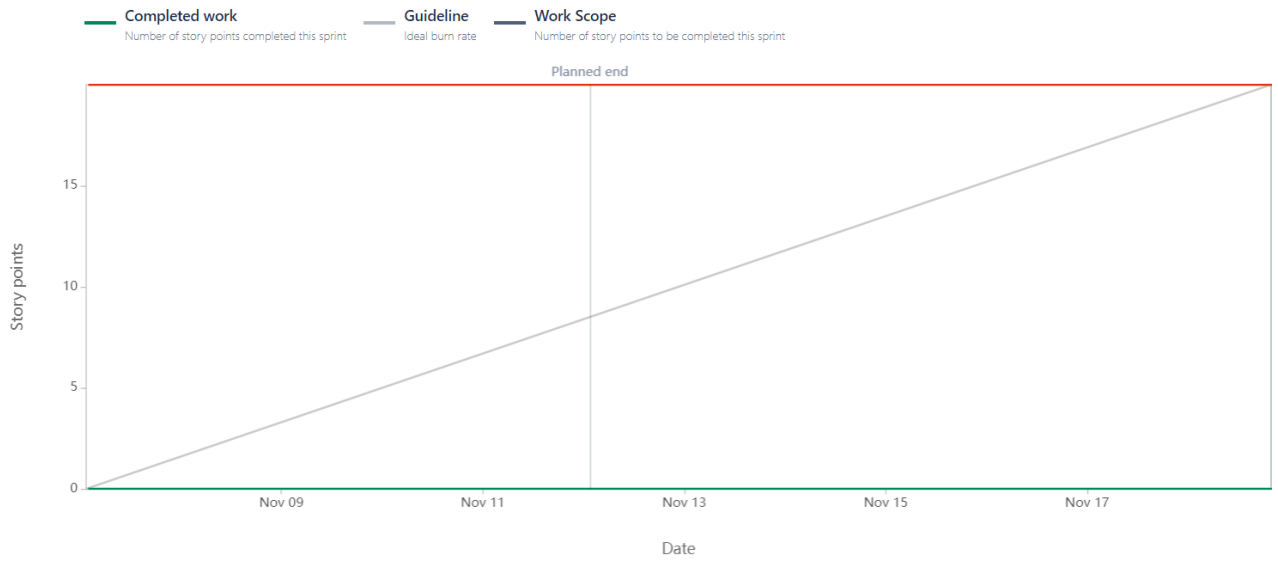

Fig 6.3.1 Burndown chart

The above burndown chart shows the amount of work that has been completed in an epic or sprint. Burndown charts are used to predict the team's likelihood of completing the work in the time available. It is also used for keeping the team aware of any scope creep that occurs. The x-axis represents time, and the y-axis refers to the amount of work left to complete.

Road Map

Fig 6.3.2 Road Map

The above roadmap provides crucial context for the team's everyday work.

CHAPTER -7

CODING AND SOLUTIONS

7.1 FEATURE 1

Code for generating Random bin data:

```
{

“BIN 1”: random (0,100),

“BIN 2”: random (0,100),

“BIN 3”: random (0,100),

“BIN 4”: random (0,100),

“BIN 5”: random (0,100)

}
```

7.2 FEATURE 2

Code for each gauge:

```
msg.payload=msg.payload[“BIN 1”];

global.get(“b1”);

return msg;

msg.payload=msg.payload[“BIN 2”];

global.get(“b2”);

return msg;

msg.payload=msg.payload[“BIN 3”];

global.get(“b3”);
```

return msg;

msg.payload=msg.payload[“BIN 4”];

global.get(“b4”);

return msg;

msg.payload=msg.payload[“BIN 5”];

global.get(“b5”);

return msg;

Code for dashboard:

msg.payload={“BIN 1”:global.get(“b1”), “BIN 2”:global.get(“b2”),“BIN 3 ”: global . get(“b3”), “BIN 4”: global.get(“b4”), “BIN 5”: global.get(“b5”)};

return msg;

CHAPTER-8

TESTING

8.1 TEST CASE 1

Event	Value	Format	Last Received
event_1	{"BIN 1":6,"BIN 2":82,"BIN 3":86,"BIN 4":70,"BI...	json	a few seconds ago
event_1	{"BIN 1":99,"BIN 2":72,"BIN 3":37,"BIN 4":65,"B...	json	a few seconds ago
event_1	{"BIN 1":15,"BIN 2":18,"BIN 3":22,"BIN 4":25,"B...	json	a few seconds ago
event_1	{"BIN 1":86,"BIN 2":67,"BIN 3":5,"BIN 4":75,"BI...	json	a few seconds ago
event_1	{"BIN 1":12,"BIN 2":37,"BIN 3":67,"BIN 4":50,"B...	json	a few seconds ago

Fig 8.1.1 Test Case 1(Runtime)

TEST CASE 2

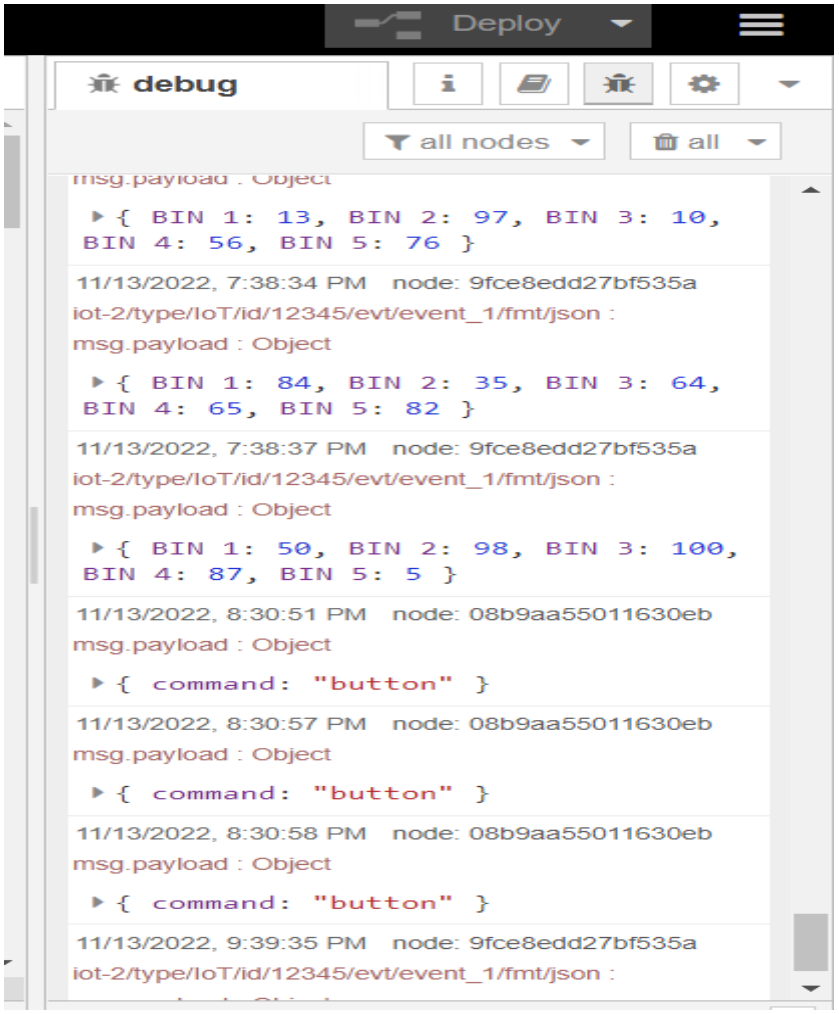

Fig 8.1.2 Test Case 2

8.2 USER ACCEPTANCE TESTING

The purpose of this document is to briefly explain the test coverage and open issues of the Smart waste management system for metropolitan cities project at the time of the release to the User Acceptance Testing (UAT).

Defect Analysis

Table 8.1. Defect Analysis

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	8	5	3	1	16
Duplicate	0	0	2	3	5

External	2	3	0	1	6
Fixed	9	2	4	9	24
Not Reproduced	0	0	2	0	2
Skipped	0	0	0	1	1
Won't Fix	0	0	0	1	1
Totals	19	10	11	16	55

Test case Analysis

Table 8.2. Test case Analysis

Section	Total Cases	Not tested	Fail	Pass
User Application	5	0	0	5
Web Application	20	0	0	20
Security	3	0	0	3
Outsource Shipping	4	0	0	4
Exception Reporting	8	0	0	8
Final Report Output	3	0	0	3
Version control	1	0	0	1

CHAPTER -9

RESULT

9.1 PERFORMANCE METRICS

Table 9.1. NFT-Detailed Test Plan

S.No	Project Overview	NFT Test Approach	Assumption/Dependencies/Risks	Approvals/ Sign Off
1	Bin Monitoring Web-UI	Stress	App Crash/Developer team/ Site Down	Approved
2	Bin Monitoring Web-UI	Load	Server Crash/Developer team/ Server Down	Approved

End of Test Report

Table 9.2. End of Test Report

Project Overview	NFT Test approach	NFR-Met	GO/NO-GO Decision	Identified Defects	Approvals/ Sign Off
Bin Monitoring Web-UI	Stress	Performance	GO	Closed	Approved
Bin Monitoring Web-UI	Load	Scalability	NO-GO	Closed	Approved

CHAPTER-10

ADVANTAGES & DISADVANTAGES

A) ADVANTAGES:

- The garbage will be collected on time-to-time basis.
- Less manpower, emission, fuel use and traffic congestion.
- Analytics data to manage collection routes and placement of bins needed.
- Improved environment (i.e, no overflowing bins and less unpleasant odours.)
- Reduction in Collection Cost, Reduction in CO2 emission.
- No missed pickups

B) DISADVANTAGES

- It requires a well-structured hardware.
- The process is not always cost-efficient.
- The resultant product may have a short lifespan.
- Increased cost of the dustbins.

CHAPTER -11

CONCLUSION

This project work is the implementation of smart waste management system using Watson IoT platform, node-red and MITAPP Inventor. This system assures the cleaning of dustbins soon when the garbage level reaches its maximum. This reduces the total number of trips of garbage collection vehicle and hence reduces the overall expenditure associated with the garbage collection. It ultimately helps to keep cleanliness in the society. Therefore, the smart Waste management system makes the garbage collection more efficient. Smart dustbins help us to reduce pollution. This project ensures waste collection on time which in turn ensures less contamination of environment, no spread of disease and a cleaner surrounding.

CHAPTER -12
FUTURE SCOPE

By deploying sensors, network infrastructure, and data visualization platforms, waste management will be able to generate actionable insights, to make informed decisions. And the message can be sent directly to the cleaning vehicle instead of the contractor’s office. This will reduce the time and manpower. Gas sensors can be used to monitor the toxicity of gases produced by the waste materials. Apart from this,

differentiation can be made between dry trash bin and wet trash bin collecting plastic dry waste and biodegradable waste respectively.

CHAPTER -13

APPENDIX

13.1 SCREENSHOTS

SPRINT 1

Event	Value	Format	Last Received
event_1	{"BIN 1":6,"BIN 2":82,"BIN 3":86,"BIN 4":70,"BI...	json	a few seconds ago
event_1	{"BIN 1":99,"BIN 2":72,"BIN 3":37,"BIN 4":65,"B...	json	a few seconds ago
event_1	{"BIN 1":15,"BIN 2":18,"BIN 3":22,"BIN 4":25,"B...	json	a few seconds ago
event_1	{"BIN 1":86,"BIN 2":67,"BIN 3":5,"BIN 4":75,"BI...	json	a few seconds ago
event_1	{"BIN 1":12,"BIN 2":37,"BIN 3":67,"BIN 4":50,"B...	json	a few seconds ago

Fig 13.1.1 Sprint 1

SPRINT 2

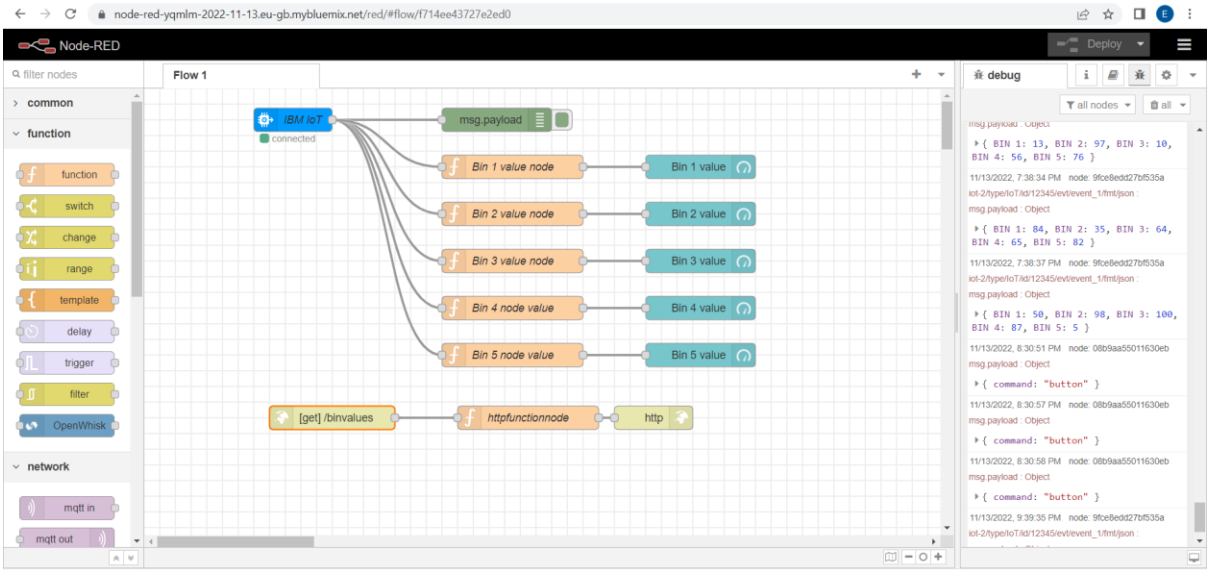

Fig 13.1.2 Sprint 2

SPRINT 3

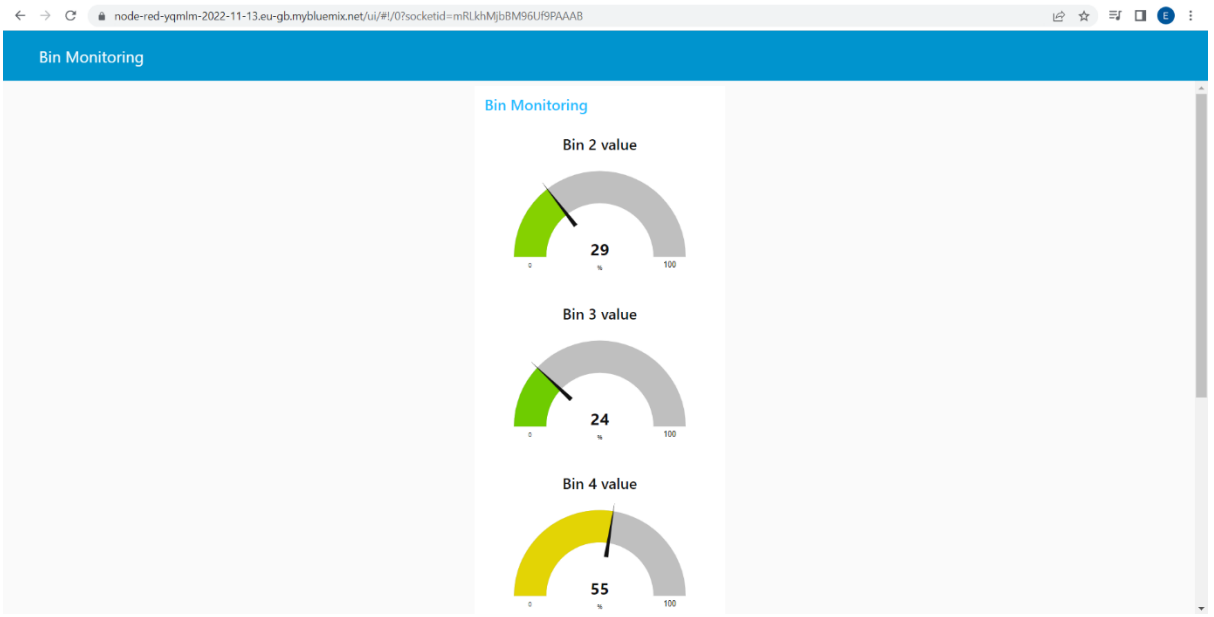

Fig 13.1.3 Sprint 3(1)

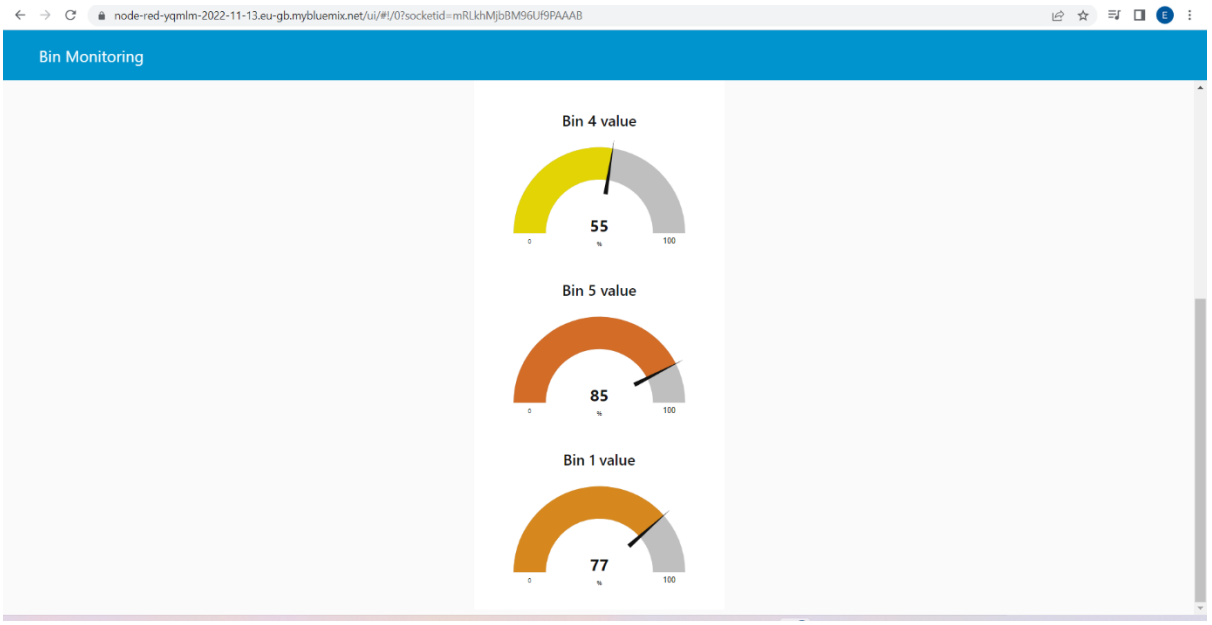

Fig 13.1.4 Sprint 3(2)

SPRINT 4

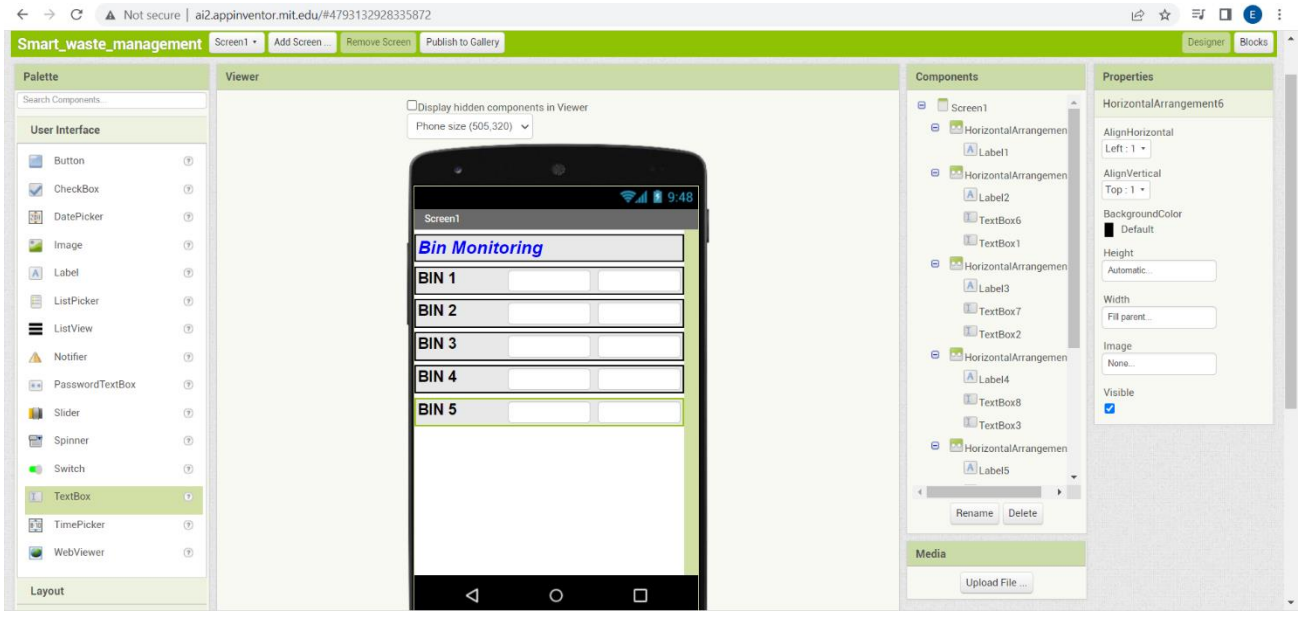

Fig 13.1.5 Sprint 4(1)

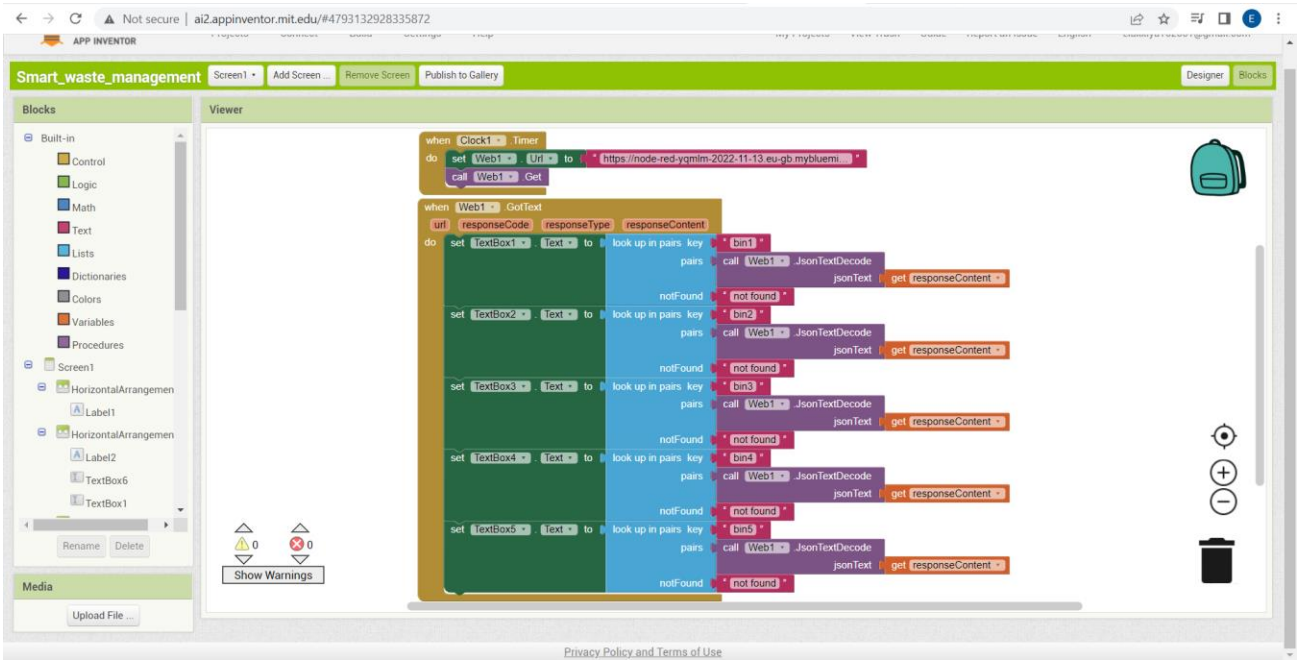

Fig 13.1.6 Sprint 4(2)

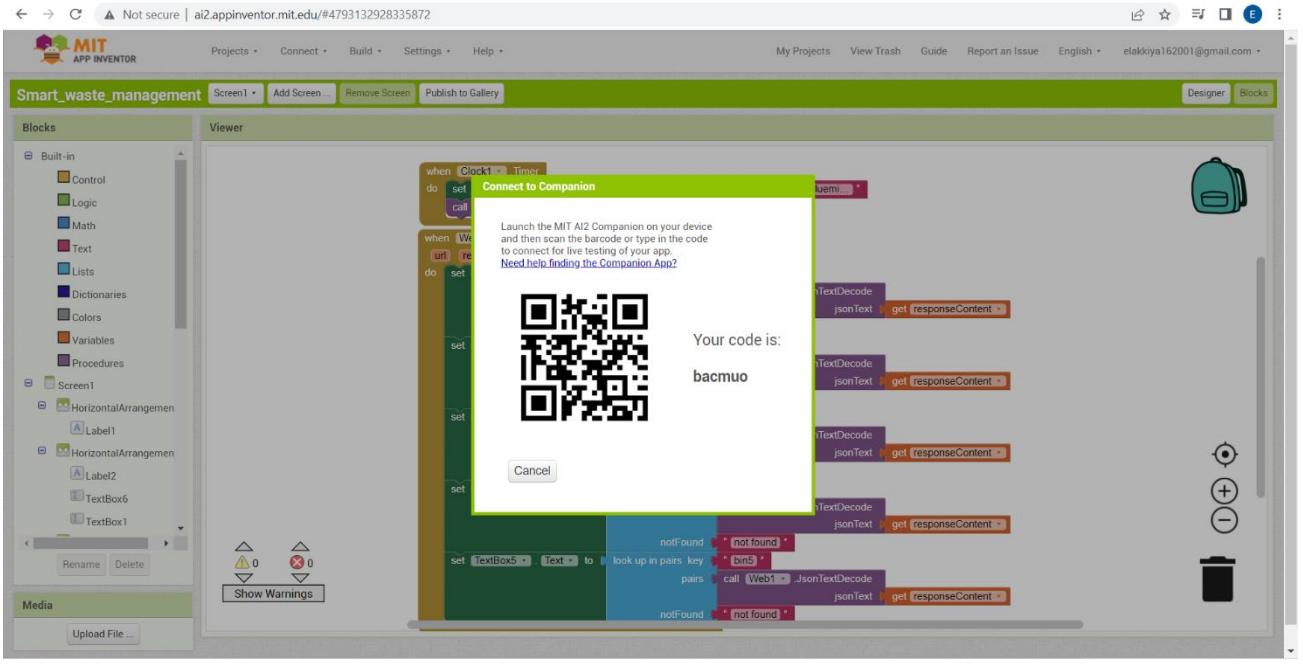

Fig 13.1.7 Sprint 4(3)

Fig 13.1.8 Sprint 4(4)

REFERENCES

1. Jain A, Bagherwal R, “Design and implementation of a smart solid waste monitoring and collection system based on Internet of Things” 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2017 (pp. 1- 5), IEEE.
2. Haribabu P, Kassa SR, Nagaraju J, Karthik R, Shirisha N, Anila M, “Implementation of a smart waste management system using IoT” International Conference on Intelligent Sustainable System (ICISS) (pp. 1155-1156), IEEE.
3. Kolhatkar C, Joshi B, Choudhari P, Bhuva D. “Smart E-dustbin”International Conference on Smart City and Emerging Technology (ICSCET), 2018 (pp. 1-3),IEEE.

4. Hayati AP, Emalya N, Munawar E, Schwarzböck T, Lederer J, Fellner J. “Analysis the potential gas production of old municipal solid waste landfill as an alternative energy source: Preliminary results.” IOP Conference Series: Materials Science and Engineering, 2018 (Vol. 334, No. 1, p. 012031). IOP Publishing.
5. K. F. Haque, R. Zabin, K. Yelamarthi, P. Yanambaka, and A. Abdelgawad, “An IoT Based Efficient Waste Collection System with Smart Bins,” IEEE 6th World Forum on Internet of Things (WF-IoT), 2020.