IBM PROJECT REPORT

SMART WASTE MANAGEMENT SYSTEM

Batch: B1-1M3E

Team ID: PNT2022TMID47456

Team Leader: AKILA S

Team Members:

a. ASHWIN BHARATHI A
b. DHARSHINI K
c. SRINIVASAN S

CONTENTS

1. INTRODUCTION

1. Project Overview

The theme of the work is to develop a Smart intelligent garbage alert system for a proper Garbage management .This paper proposes a smart Alert system for garbage clearance by giving an alert Signal to the municipal web server for instant Cleaning of dustbin with proper verification based On level of garbage filling. This process is aided by The ultrasonic sensor which is interfaced with Arduino UNO to check the level of garbage filled in The dustbin and sends the alert to the municipal web Server once if garbage is filled .

2. Purpose

a. Public places gets overflowed well in advance before The commencement of the next cleaning process.
b. It In turn leads to various hazards such as bad odor & Ugliness to that place which may be the root cause For spread of various diseases.
c. To avoid all such Hazardous scenario and maintain public cleanliness And health this work is mounted on a smart garbage System

2. LITERATURE SURVEY

1. Existing problem
    i. The collection and disposal of garbage waste is in unordered, inefficient way which leads to overfilling of bins, rotting garbage smell and more fuel consumption of collecting trucks.
    ii. That waste in the bin was not dispose periodically, information about waste not reached to the collector properly.

2. References

a. Authors have considered Two garbage bins, for waste Segregation, and sensors are
   Attached to bins for garbage Data collection to avoid Overfilling. Overfilling of the bins Is prevented using Sensors, but no Mechanism for waste Collection is proposed

b. The proposed system uses Ultrasonic sensors to collect Real-time garbage level Which takes the garbage Readings every time the lid Of the bin is opened and Closed. Ease of the users is Taken into Consideration. But there Is no mechanism to Assign routes to

trucks For the collection Process.

c. This paper focuses on the Real time garbage level and The level of toxicity present In it and uses the air quality Sensor CCS811 for Measuring the toxicity level. The routes are generated Using Dijkstra's algorithm. The system rewards the Points in virtual wallets
   Based on waste Disposed to encourage People to keep the city Clean, but the algorithm Used for routing is not Explained in detail.

d. The system uses real-time Garbage data and calculates The shortest path using Google API.The capacity of the Truck is not considered While generating Shortest routes.

e. Waste collection problem is a set-covering and vehicle routing problem (VRP) involving inter-arrival time constraints, bi-level optimization formula to model the split delivery VRP with several trips to decide the shortest path. Developed an ACO algorithm for route improvisation. It lacked service for vehicles of a particular category to traverse small streets or bridges that have weight constraint.

f. Waste collection routing Problem is included in a Mixed-integer nonlinear Programming model after Which garbage is unloaded To find out the optimal route For all the garbage trucks. Aimed to avoid the Combined collection of Waste which differed in Quality. Instead, it Focused on the Collection of Homogeneous trash cans Owing to the same Quality of waste for Higher rate of recovery And lower rate of Disposal.

g. The primary components of IoT are accompanied with Intelligent Transportation Systems and surveillance Systems which enhance Quality of Service in waste Collection. It has proposed An advanced Decision Support System model. Covered an important Aspect of waste Collection which is Access to areas which Are not feasible to visit.

h. The paper discussed Different variations of Vehicle Routing Problem (VRP) and mainly focuses On the variation of VRP Which is used for reduction Of fuel The generation of Routes focuses on the Distance

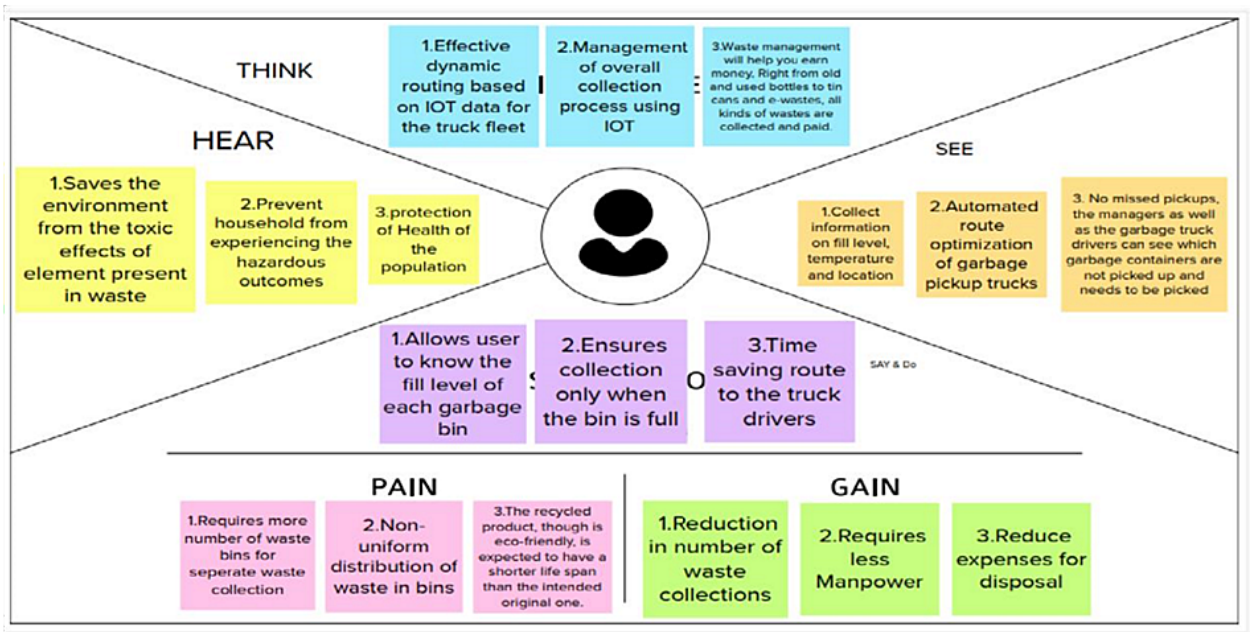
and fuel Consumption. The Vehicle capacities are Not considered.

Ø Problem Statement Definition

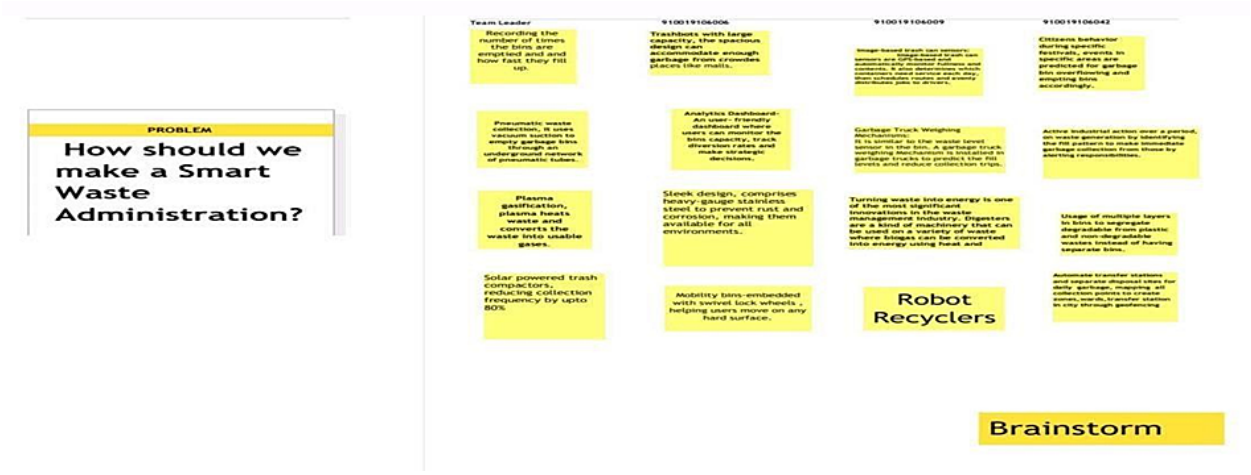
Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	A Resident	Dispose my domestic waste in trash	That waste in the bin was not dispose periodically	Unawareness of waste to the garbage collector	Cast down
PS-2	Entrepreneur	Dispose large amount waste material in safety manner	Sometimes dispose of waste by the truck is unpredictable per day	information about waste not reached to the collector properly	Obsessed

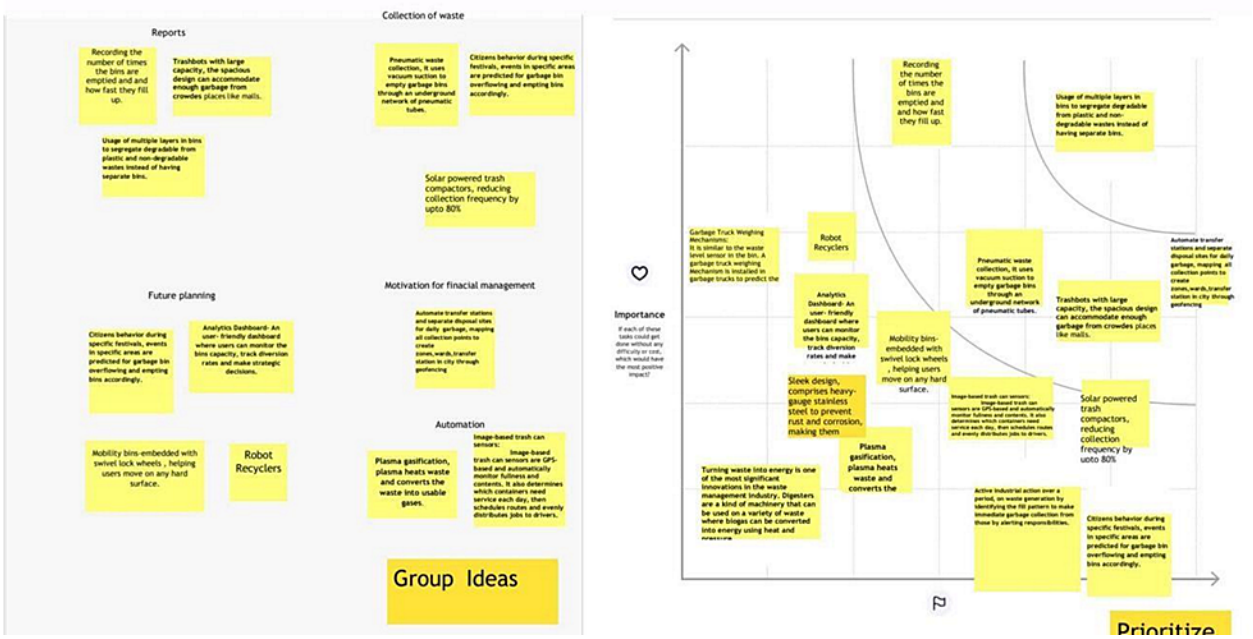
3. IDEATION & PROPOSED SOLUTION

1. Empathy Map Canvas



2. Ideation & Brainstorming



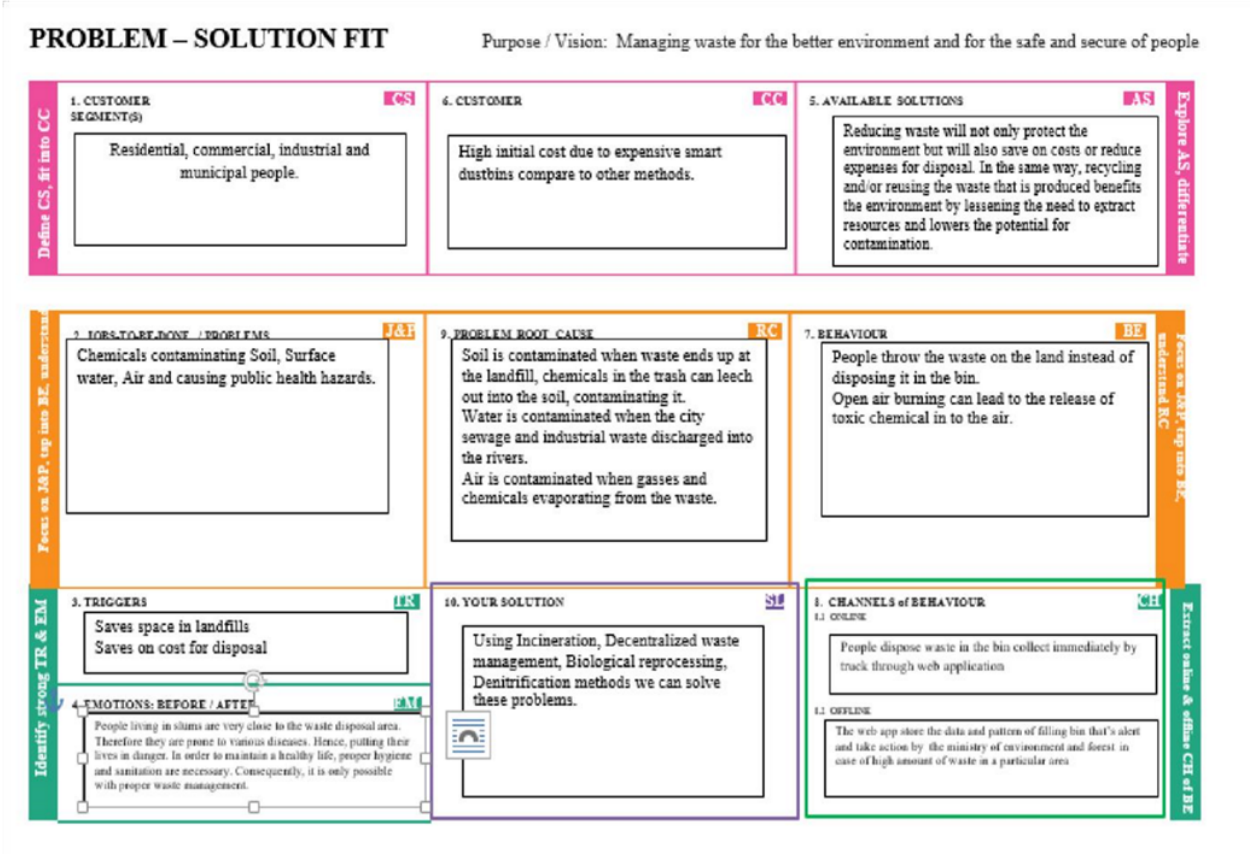


3. Proposed Solution

S.No.	Parameter	Description
1.	**Problem Statement (Problem to be solved)**	The collection and disposal of garbage waste is in unordered,inefficient way which leads to overfilling of bins, rotting garbage smell and more fuel consumption of collecting trucks.

2.	**Idea / Solution description**	Using sensors, weighing machine real time monitoring the level of waste in bins. The information get shared with appropriate authorities and fellow citizens through web application.
3.	**Novelty / Uniqueness**	Citizens & industries behaviour during specific festival, events at different seasons are monitored and are predicted for garbage overflowing. Also to find the shortest path to reach the destiny for trucks in basis of fuel and time consumption.
4.	**Social Impact / Customer Satisfaction**	Informative, effective management of waste in big cities reduces waste impacts over environment pollution
5.	**Business Model (Revenue Model)**	• Eco-friendly • Optimized route navigation system • Reduce fuel consumption
		Alerts authority by real-time monitoring Promote 3R's (Reduse,Reuse,Recycle)
6.	**Scalability of the Solution**	The need-driven waste collection eliminates unnecessary traffic blockage Generate important statistical data for monitoring for waste collection Recycling is promoted between residents, results in clean & sustainable environment

4. Problem Solution fit



4. REQUIREMENT ANALYSIS

1. Functional requirement

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Detailed bin inventory.	The map shows all monitored bins and stands, and Street View from Google can be used to visit them at any time. Bins are shown as green, orange or red circles. The Dashboard shows bin details, such as waste type and last measurement. You can see bin details in the Dashboard – capacity, waste type, last measurement, GPS location and collection schedule or pick recognition.

FR-2	Real time bin monitoring.	Aside from displaying real-time data on fill-levels of bins monitored by smart sensors, the Dashboard also predicts when the bin will be full based on historical data, which is one of the most useful features. Sensors recognize picks as well; so you can check when the bin was last collected. With real-time data and predictions, you can eliminate the overflowing bins and stop collecting half-empty ones.
FR-3	Expensive bins.	We help you identify bins that drive up your collection costs. The tool calculates a rating for each bin in terms of collection costs. The tool considers the average distance depo-bindischarge in the area. The tool assigns bin a rating (1-10) and calculates distance from depo-bin discharge.
FR-4	Adjust bin distribution.	Ensure the most optimal distribution of bins. Identify areas with either dense or sparse bin distribution. Make sure all trash types are represented within a stand. Based on the historical data, you can adjust bin capacity or location where necessary.
FR-5	Eliminate inefficient picks.	Eliminate the collection of half-empty bins. The sensors recognize picks. By using real-time data on fill-levels and pick recognition, we can show you how full the bins you collect are.
		The report shows how full the bin was when picked. You immediately see any inefficient picks below 80% full.
FR-6	Plan waste collection routes.	The tool semi-automates waste collection route planning. Based on current bin fill-levels and predictions of reaching full capacity, you are ready to respond and schedule waste collection. You can compare planned vs. executed routes to identify any inconsistencies.

2. Non-Functional requirements

FR No.	**Non-Functional Requirement**	**Description**

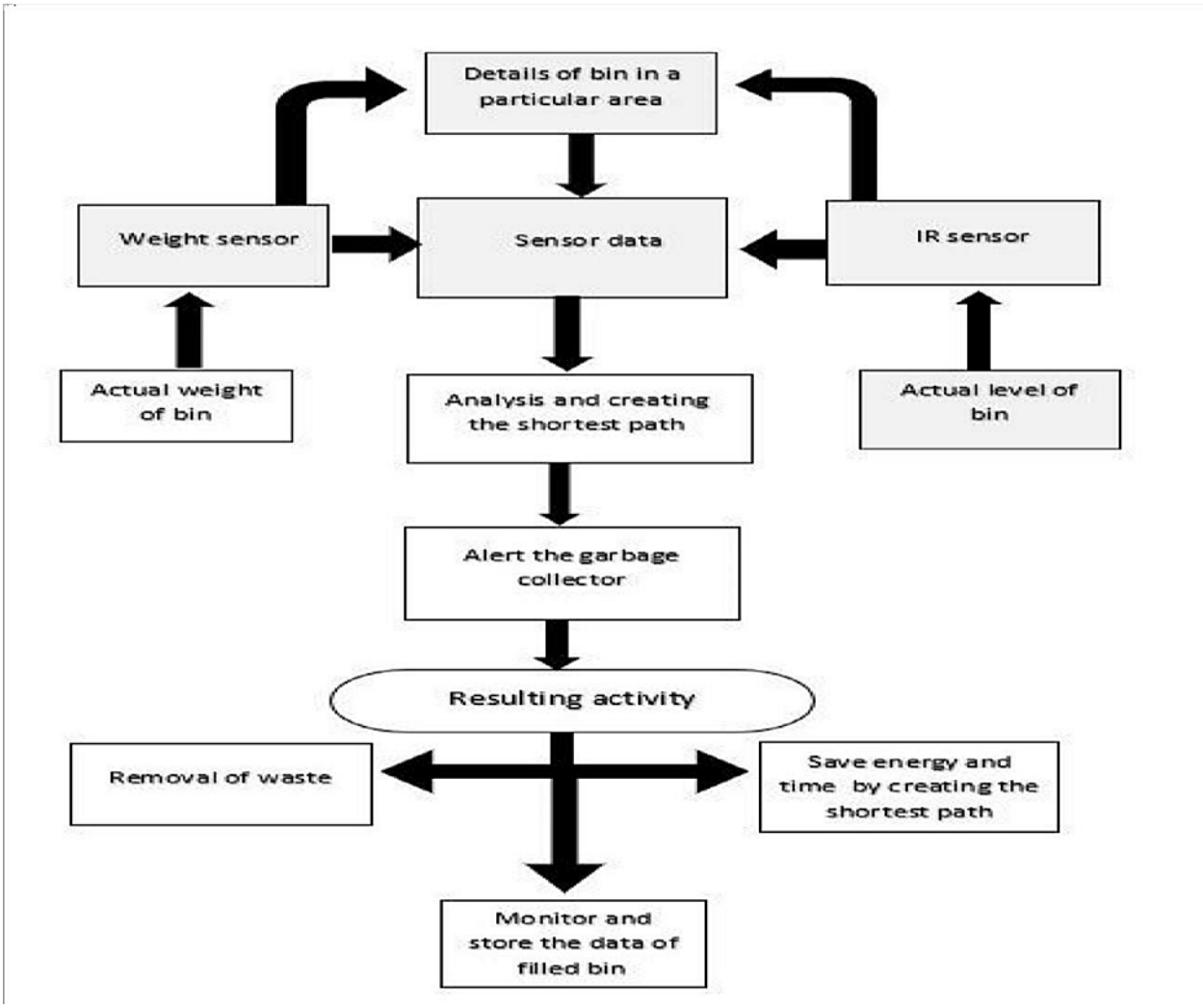
NFR-1	**Usability**	IoT device verifies that usability is a special and important perspective to analyze user requirements, which can further improve the design quality. In the design process with user experience as the core, the analysis of users' product usability can indeed help designers better understand users' potential needs in waste management, behavior and experience.
NFR-2	**Security**	Use reusable bottles Use reusable grocery bags Purchase wisely and recycle Avoid single use food and drink containers.
NFR-3	**Reliability**	Smart waste management is also about creating better working conditions for waste collectors and drivers. Instead of driving the same collection routes and servicing empty bins, waste collectors will spend their time more efficiently, taking care of bins that need servicing.

NFR-4	**Performance**	The Smart Sensors use ultrasound technology to measure the fill levels (along with other data) in bins several times a day. Using a variety of IoT networks ((NB-IoT,GPRS), the sensors send the data to Sansone's Smart Waste Management Software System, a powerful cloud-based platform, for data- driven daily operations, available also as a waste management app. Customers are hence provided data-driven decision making, and optimization of waste collection routes, frequencies, and vehicle loads resulting in route reduction by at least 30%.
NFR-5	**Availability**	By developing & deploying resilient hardware and beautiful software we empower cities, businesses, and countries to manage waste smarter.

NFR-6	**Scalability**	Using smart waste bins reduce the number of bins inside town, cities coz we able to monitor the

5. PROJECT DESIGN

1. Data Flow Diagrams



2. Solution & Technical Architecture

Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	Web Portal	HTML, CSS, NodeRed, Javascript.

2.	ApplicationLogic-1	To calculate the distance of bin location and show the real-time level in the web portal, information getting via ultrasonic sensor and the alert message activates with a python script to the web portal.	Ultrasonic sensor/Python.
3.	ApplicationLogic-2	To calculate the weight of the garbage and show the real- time weight in the web portal, this info getting via load cell and the alert message activate with python to web portal.	Load cell/Python.
4.	ApplicationLogic-3	Getting the location of the Garbage.	GSM / GPS.
5.	Cloud Database.	Database Service on Cloud	IBM DB2, IBM Cloudant etc.
6.	File Storage	File storage requirements	GitHub, Local file system.
7.	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, social authentication, notifications, or services, such as a real-time communication server.	Firebase.
8.	Ultrasonic Sensor.	To throw an alert message when garbage is getting full.	Distance Recognition Model.
9.	Infrastructure(Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: local host Cloud Server Configuration: local host ,Firebase	Local host, Web portal.

Table 2: Application Characteristics:

S.No	Characteristics	Description	Technology

1.	Open-Source Frameworks	Node Red, Python, IBM Simulator.	IoT
2.	Security Implementations	Raspberry Pi is connected to the internet and for example, used to broadcast live data, further security measures are recommended, and use the UFW(uncomplicated Firewall).	IoT
3.	Scalable Architecture	Raspberry pi: SpecificationsSoc: rsi ZERO W CPU: 32-bit computer with a 1 GHz ARMv6 RAM: 512MB Networking: Wi-Fi Bluetooth: Bluetooth 5.0, Bluetooth Low Energy (BLE). Storage: MicroSD GPIO: 40-pin GPIO header, populated Ports: micro HDMI 2.0, 3.5mm analogue audio video jack, 2x USB 2.0, 2x USB 3.0, Ethernet Dimensions: 88mm x 58mm x 19.5mm, 46g	IoT
4.	Availability	These smart bins use sensors like ultrasonic and load cells to send an alert message about the trash level recognition technology, and artificial intelligence, enabling them to automatically sort and categorize recycling litter into one of its smaller bins.	IoT.

5.	Performance	Many requests: RPI manages to execute 129- 139 read requests per second. Use of Cache:512MB Use of CDNs: Real time	IoT/Web portal.

3. User Stories

User Type	**Functional Requirement (Epic)**	**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
		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
		USN-3	As a user, I can register for the application through Gmail		Medium	Sprint-1
	Login	USN-4	As a user, I can log into the application by entering email & password		High	Sprint-1
	Dashboard	USN-5	As a user ,I can have user information ,data display, bin level		High	Sprint-2
Customer (Web user)	Login	USN-1	As a user, I can register for the application by entering my email and password	I can access my account or dashboard	High	Sprint-1
		USN-2	As a user ,I can confirm the captcha as I am not a robot.	Security prioritize	High	Sprint-1
Customer Care Executive	Resolving issues	USN-1	As a customer care executive ,I can resolve all the issues regarding to the user application.	I can access user login details	High	Sprint-1

Administrator	Managing and controlling	USN-1	As an administrator ,I can manage the application and control the issues in higher level.	I can access each and every details in the application of the particular user .	High	Sprint-1

6. PROJECT PLANNING & SCHEDULING

1. Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User StoryNumber	User Story / Task	Story Points	Priority	Team Members
Sprint-1		US-1	Create the IBM Cloud services which are being used in this project.	6	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN

Sprint-1		US-2	Configure the IBM Cloud services which are being used in completing this project.	4	Medium	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-1		US-3	IBM Watson IoT platform acts as the mediator to connect the web application to IoT devices, so create the IBM Watson IoT platform.	5	Medium	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-1		US-4	In order to connect the IoT device to the IBM cloud, create a device in the IBM Watson IoT platform and get the device credentials.	5	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-2		US-1	Configure the connection security and create API keys that are used in the NodeRED service for accessing the IBM IoT Platform.	10	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-2		US-2	Create a Node-RED service.	10	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-3		US-1	Develop a python script to publish random sensor data such as Loadcell, IR sensor and GSM/GPS to the IBM IoT platform	7	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint	**Functional Requirement (Epic)**	**User StoryNumber**	**User Story / Task**	**Story Points**	**Priority**	**Team Members**

Sprint-3		US-2	After developing python code, commands are received just print the statements which represent the control of the devices.	5	Medium	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-3		US-3	Publish Data To The IBM Cloud	8	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-4		US-1	Create Web UI in Node-Red	10	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN
Sprint-4		US-2	Configure the Node-RED flow to receive data from the IBM IoT platform and also use Cloudant DB nodes to store the received sensor data in the cloudant DB	10	High	S AKILA A ASHWIN BHARATHI K DHARSHINI S SRINIVASAN

2. Sprint Delivery Schedule

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

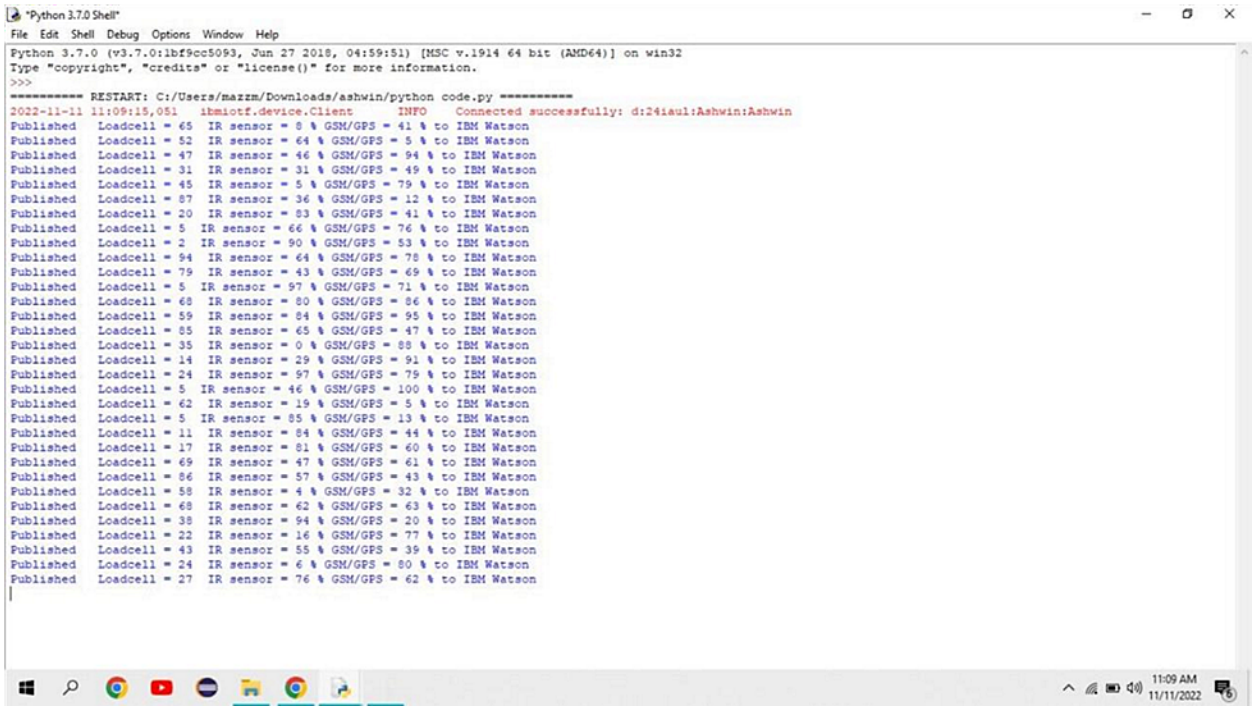
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

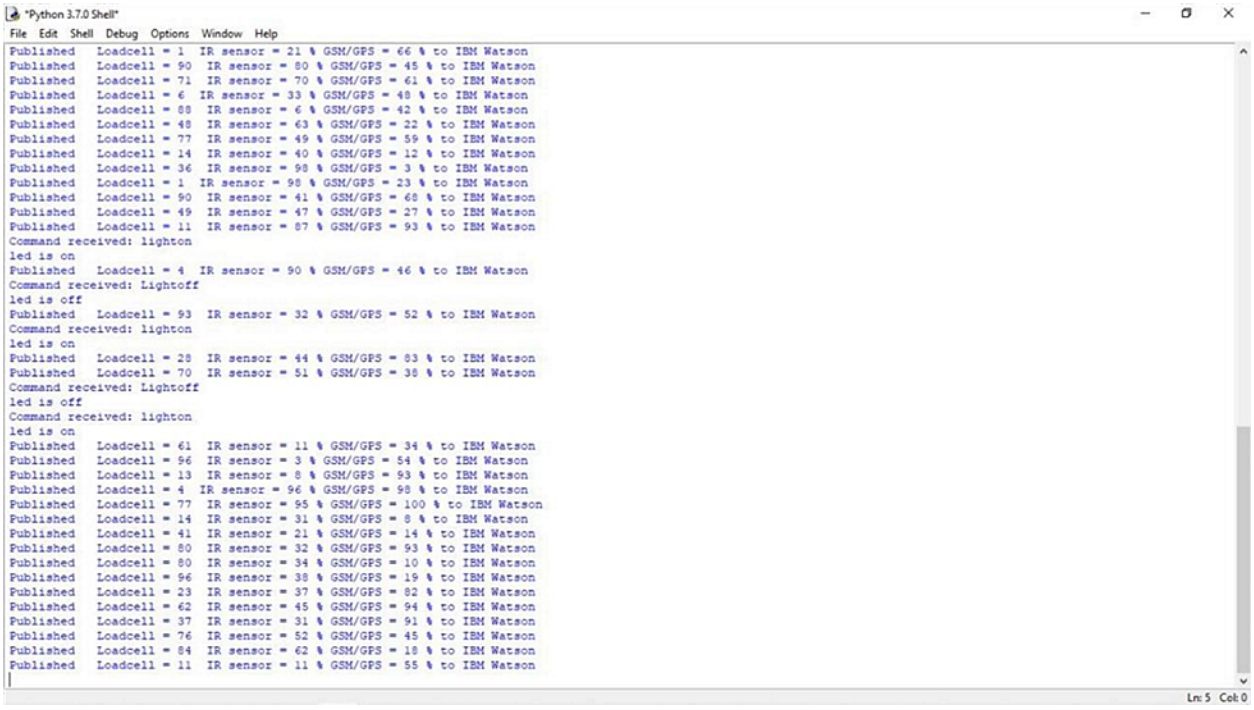
3. REPORT FROM JIRA

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

1. Feature 1: **python code**

2. Feature 2: python connect with IBM Watson iot-plotform





8. TESTING

1. Test Cases
2. User Acceptance Testing

9. RESULTS

Ø Performance Metrics

10. ADVANTAGES & DISADVANTAGES

Advantages:

1. The generation of routes focuses on the distance and fuel consumption.
2. Covered an important aspect of waste collection which is access to areas which are not feasible to visit.
3. To avoid the combined collection of waste which differed in quality. Instead, it focused on the collection of homogeneous trash cans owing to the same quality of waste for higher rate of recovery and lower rate of disposal.
4. The capacity of the truck is considered while generating shortest routes.
5. The need-driven waste collection eliminates unnecessary traffic blockage.

6. Generate important statistical data for monitoring for waste collection.

Disadvantage:

1. Installation cost is high.
2. Proper server maintenance is needed.
3. Real-time running errors can’t be neglected.

11. CONCLUSION

The system which has been proposed, promises to help the metropolitan government in minimizing the cost involved in the garbage collection drives of the city. Since the cost of extra fuel involved by following non-optimal routes can be minimized. The cost of the sensors and other hardware involved is a one-time investment for a long period. The web application for server-side are developed using simple technology with less maintenance and the mobile application has a user-friendly interface for the less qualified drivers to help them with the smooth usage of the application.

12. FUTURE SCOPE

This system can be made more eco-friendly in the future which will reduce the electricity cost involved. The distribution of bins can be done optimally by predicting the number of bins and the size of bins in a particular area. Also, waste segregation can be taken into consideration in future to dispose of the waste in a more eco friendly manner. The area-wise garbage level data is collected to improve the prediction in the future. The Waste Management Department of Municipal Authority generally lends the garbage trucks every day and is unaware of the exact number of trucks required for the waste collection. This problem can be solved by predicting the number of trucks for the given day as our system deals with the real time garbage levels. The internet is the basic dependency of the system which is not readily available in rural areas right now. However, in the new era of IoT and

Smart City Mission, the problem of availability of internet can be solved.

13. APPENDIX

1. Source Code
2. GitHub
3. Project Demo Link