PROJECT REPORT

Team ID	PNT2022TMID42272
Project Name	Smart Waste Management System for metropolitan cities

1.INTRODUCTION

1.1 Project Overview

Rapid increase in population, has led to the improper waste management in cities resulting in increased pests and spreading of diseases. Nowadays, the Garbage Collecting Vehicle (GCV) collects the waste twice or thrice in a week. So, the problem is over flowing of wastages on the roads. Hence, to overcome this limitation, in this paper a scheme on smart waste management using Wireless Sensor Networks (WSN) and IoT (Internet of Things) is proposed. The garbage bins are deployed with sensors and are networked together using WSN. The sensors deployed in the garbage bins collect the data for every determined interval. Once the threshold is reached, it raises a request to the GCA (Garbage Collector Agent). This agent collects the requests of all the filled vehicles and communicate using IoT framework. The experimental simulation is done in proteus tool. A hardware prototype is developed for the proposed framework. Analysis of the proposed scheme provides better results in waste management.

1.2 Purpose

Most of the metro cities globally poses a challenge on effective solid waste management and maintenance of the waste bins. An IOT enabled Smart Waste Bin with real time monitoring is designed and implemented using ultra sonic sensor, parallel plate capacitance and status of the bins are communicated effectively using the cloud and Node MCU. The results prove the efficiency of the designed smart bins qualitatively. A smart waste management system incorporating robotic smart bins, where the smart bins has the mobility to move to the waste dockyard by localizing itself in the environment is proposed. This system could find an application in smart building where the waste management could be practiced autonomously in a smarter way. Our future work is to investigate the performance of the proposed traditional and robotic waste management system in outdoor and indoor environment respectively in our institutional campus

2.LITERATURE SURVEY

2.1 Existing problems

Internet of things and its applications have become an essential way part of today human life. It has turned into a fundamental tool in each angle. Regularly, the metropolitan or corporation specialists keep up clean garbage bins at particular places in the local zones where the occupants are told to arrange their family wastage. **In this system, a 24×7 monitoring system is designed for monitoring dumpsters, A smart and organized system is designed for selective clearing the ultrasonic sensor is used for measuring the level of waste in the dustbin, DC motor powered platform is used for segregating wet and dry waste, IR sensor and moisture sensor is used for separating wet and dry waste. The either of the containers is full then an alert message is sent from the dustbin to employees and the cloud. In turn, employees can clear the corresponding dumpster**. Smart City technology evolved together with the developments in wireless sensor networks (WSN) and the Internet of Things (IoT). Smart cities essentially combine the use of ICT to provide services for better living conditions inside cities. The everyday observing of waste gathering process utilizing android application is created. The vigorous method for dealing with the waste, help in diminishing time taken to gather and arrange strong waste. The essential objective of strong waste administration is decreasing and taking out unfavourable effects of waste materials on human good health and condition to bolster financial improvement and good personal satisfaction.

2.2 References

SI NO	TITLE	AUTHORS	ABSTRACT
1	Smart Garbage Dustbin	Shephali Rakhunde,Shreya Ghavghave,Shraddha Jagtap.	We have to develop an automatic dustbin which will detect the garbage is dry or wet then separate the garbage and informs about the level of garbage collected in the garbage bin to a person in the garbage collecting vehicle and by using vending machine coins comes out the smart dustbin. This system helps to city clean and green. There is a new garbage collecting way to dispose the waste by using the help of these sensors' authorities can get information about the bin is over flowing by the information given by sensor then they can easily find out the bin in which located and squash it as early possible. When garbage throw in dustbin. motor rotate according sensor and then wet and dry garbage is separated. A conveyer belt rotates and comes out coins.
2	Cloud-based Smart Waste Management for Smart Cities	Mohammad Aazam, Marc St-Hilaire, Chung-Horng Lung, Ioannis Lambadaris	With the increasing population, urbanization, migration issues, and change in lifestyle, municipal solid waste generation levels are

			increasing significantly. Hence, waste management becomes a challenge faced not only by the developing nations, but also the developed and advanced countries. The overall waste management involves three main types of entities: 1) users who generate waste, 2) waste collectors/city admin., 3) stakeholders. Waste management directly effects the lifestyle, healthcare, environment, recycling and disposal, and several other industries. Current waste management trends are not sophisticated enough to achieve a robust and efficient waste management mechanism. It is very important to have a smart way of managing waste, so that not only the waste status is notified in-time when to be collected, but also, all the stakeholders are made aware in timely fashion that what type of waste in what quantity is coming up at what particular time. This will not only help in attracting and identifying stakeholders, but also aids in creating more effective ways of recycling and minimizing waste also making the overall waste management more efficient and environment friendly. Keeping all this in mind, we propose a cloud-based smart waste management mechanism in which the waste bins are equipped with sensors, capable of notifying their waste level status and upload the status to the cloud. The stakeholders are able to access the desired data from the cloud. Moreover, for city administration and waste management, it will be possible to do route optimization and select path for waste collection according to the statuses of waste bins in a metropolis, helping in fuel and time efficiency.
3	Design a Smart Waste Bin for Smart Waste Management	Aksan Surya Wijaya,Zahir Zainuddin,Muhammad Niswar	In this paper, we presented the smart waste-bin that can managed the waste in a smart city project. The system consist of sensors to measure the weight of waste and the level of waste inside the bin. The system also adapt with network environment, to manage all information from waste management. As the result we proposed a prototype of smart waste-bin that suitable for many kind of conventional waste-bin.

4	Smart City Application: Internet of Things (IoT) Technologies Based Smart Waste Collection Using Data Mining Approach and Ant Colony Optimization	Zeki Oralhan1 , Burcu Oralhan2 , and Yavuz Yiğit3	Globally today, Living in urban areas is more preferred than in living rural areas. This situation creates many problem for urban living. One of the big problem is waste management in urban areas. Optimizing waste collection has become very important phenomenon for being smart city. In this study, we aimed to optimize waste collection for reduce both cost of collection and pollution effect of environment. We designed a garbage container integrated sensors for measuring fill level of container, temperature, and ratio of carbon dioxide inside the container. We transmitted all information to our waste management software based Internet of Things (IoT) technologies. According to the ant colony algorithm, most efficient waste collection route delivered to garbage truck drivers' cellular enabled smart tablet. We used data mining approach to forecast when garbage container can reach highest level, and the planning of garbage container placement. We applied this smart waste collection management system in a town where is in Kayseri, Turkey. In first step, we applied for 200 Items (garbage containers) in the town that has 548.028 population and urban living ratio is 100%. Before smart waste management system 200 garbage containers was collecting by garbage trucks in a static route. After we had applied smart waste management system, containers were collected by garbage truck in dynamic route. Smart waste management system significantly decreased the trucks' oil cost, carbon emissions, traffic, truck wear, noise pollution, environmental pollution, and work hours. The system presented approximately 30% with in direct cost savings in waste collection.
5	An IoT enabled Smart Waste Management System in concern	Pooja Devi, Wajge Shubham Ravindra, Sai Prakash S.K.L.V	The system is implemented by interfacing ultrasonic sensor, DHT22 sensor and air quality sensor to Wi-Fi enabled board

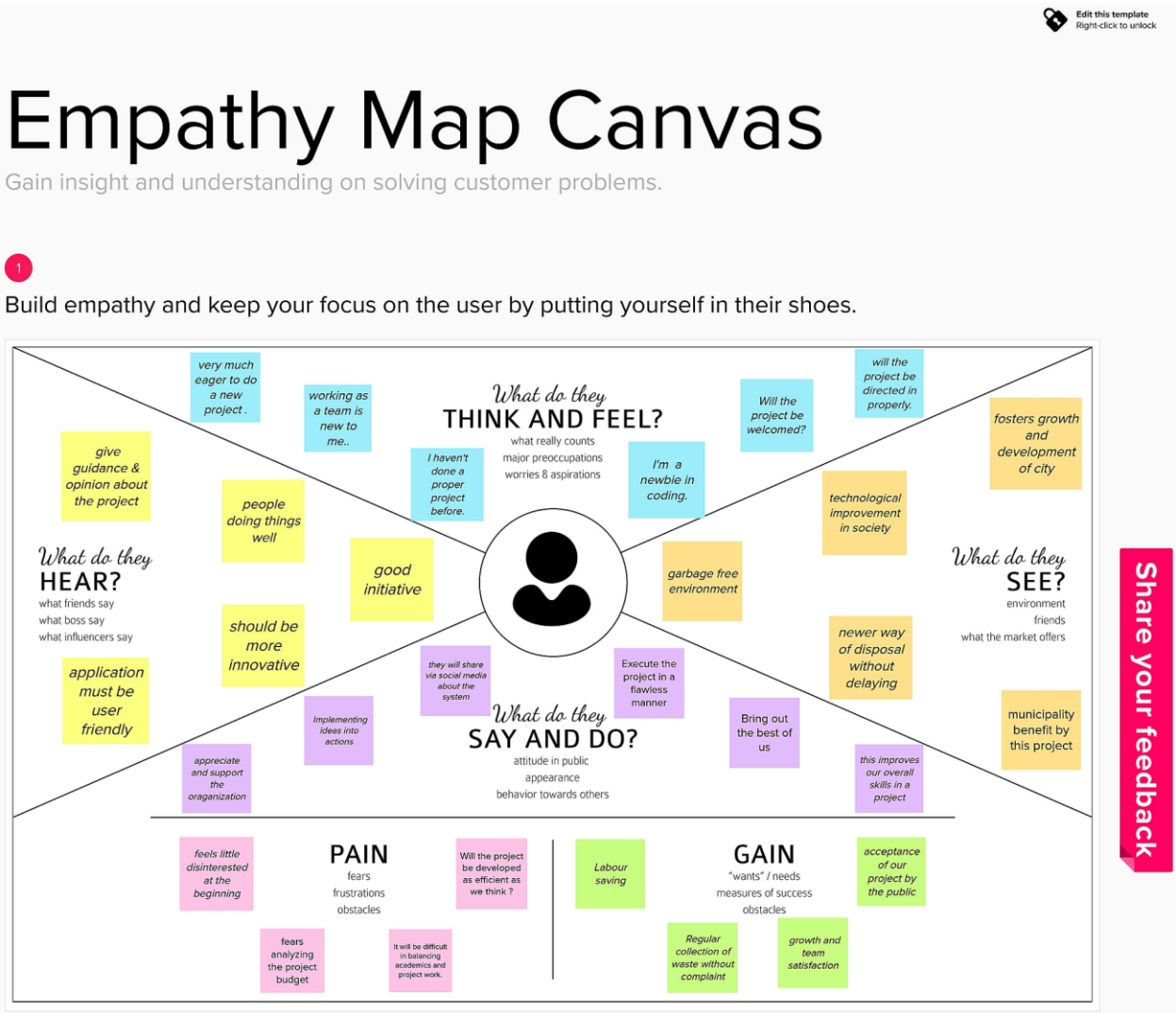
	with Indian Smart Cities 2018	978-1-5386-3570-4/18/$31.00 ©2018 IEEE	ESP8266. The ultrasonic sensor measures the distance between dust and top that is the level of a dustbin. The level measured is given to ESP8266 which as Wi-Fi enabled to put the data on the adafruit cloud. From the cloud, the user/municipality can get the information. The air quality in the surrounding area, temperature and humidity values also can be seen and accessed remotely. In this way, the level of waste in the bin can be identified and the problem of overflow can be avoided. Continuous air quality measurement is also guaranteed.
6	IOT Based Smart Waste Management System 2021 978-1-6654-0521-8/21/$31.00 ©2021 IEEE	Gayathri, Divagaran, Akhilesh, Aswiin, Charan	Each user has to scan their RFID to open the bin to pour the food waste inside the bin, RFID is used to monitor the food wastage of every individual as every RFID has its unique number. Load cell measures the amount of food wastage of each and every individual in the office premise and is displayed immediately on the screen fixed outside the bin for every time and then the amount of wastage is fed into the database. In the database all the records of every individual are gathered, and an analysis report is generated and the final report is shared to the display of the management website. Then finally management can take necessary measures based on the reports generated by the system.
7	Real -time smart garbage bin mechanism for solid waste management in smart cities 2021	Dominic Abuga, N S Raghava	This paper focuses on a real -time smart garbage bin mechanism for solid waste management in smart cities. The mechanism proposed accesses real - time information of any smart garbage bin deployed across the city and helps to resolve the problem of waste overflow from garbage bins and keep the smart cities clean. Fuzzy logic is applied in the strategic deployment of smart garbage bins across the smart cities. The system is implemented on Net -logo which is widely used in multi -agent modelling environments. The significant advantage of the system is its novelty in real - time decision - making and real -time monitoring using the fuzzy logic process.

2.3 Problem Statement

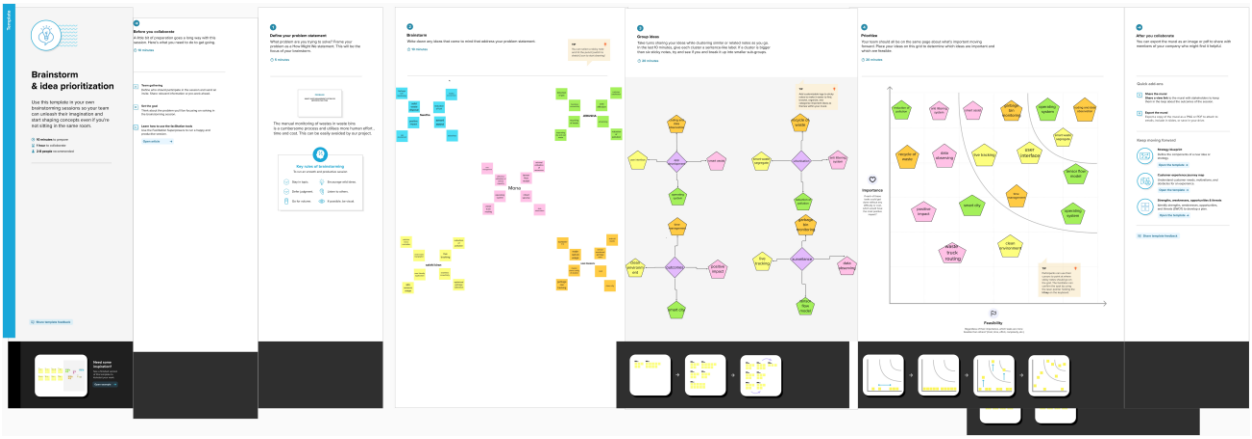
Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	Social Activist	Keep my surroundings clean and green.	The bins aren't collected regulary.	There is no proper schedule orpattern for garbage collection.	Frustrated
PS-2	Housemaker	Proper maintenance of house	I can't dispose thewastes when the bins are full.	The municipality hasn't takenany proper action	worried
PS-3	Employed Bachelor	Live by myself lonely and properly.	At the I leave my apartment theregarabage trucks neverarrives.	The time scheduled forthe garbage trucks are always irregular.	Odd about my living cleanliness.
PS-4	College studentliving alone as a dayscholar.	Make my living betterand to excelinmy career.	My living place often looks and smells untidy.	The municipality workers never come on timeand don't follow a regularity.	Feel distracted from my studies.

3.IDEATION AND PROPOSED SOLUTION

3.1 Empathy Map



3.2 Ideation And Brainstorming

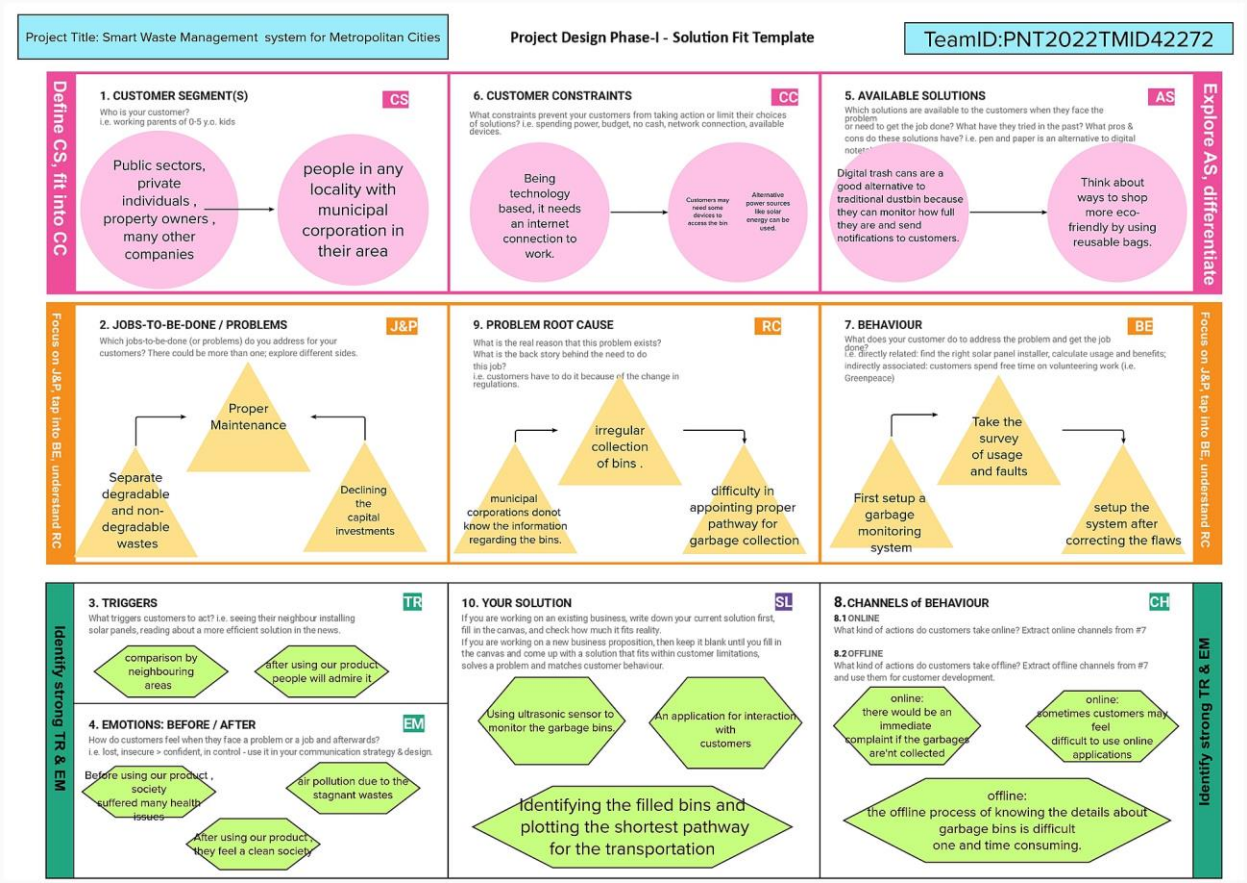


3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	• The manual monitoring of wastes in waste bins is a cumbersome process and utilises more human effort, time and cost. • Irregular disposal of wastes causing trouble to people. • Foul smell around the place with uncollected wastes or garbage.
2.	Idea / Solution description	• Creating an app, there by the corporation of a particular locality inside a metropolitan city can check the garbage bins whether they are filled or not. • This process is achieved by using a ultrasonic sensor to know the levels of garbage bin through cloud connection.
3.	Novelty / Uniqueness	• To reduce the human-effort and difficulty in monitoring the garbage bins. • Unlike the conventional methods for collecting garbage bins, this method tells us to use the transport only in required places.

4.	Social Impact / Customer Satisfaction	● People can experience a clean environment. ● Reduces the human effort involving in the garbage disposal process. ● This idea will be very much beneficial for a city corporation for monitoring the cleanliness of various parts of the city.
5.	Business Model (Revenue Model)	● This project aims to support the municipal corporations. ● Provide a clean environment. ● This reduces a huge fuel cost to the city corporations by reducing the unwanted transport expenses to unnecessary places.
6.	Scalability of the Solution	● There is no need of new establishment of things. ● Already present garbage bins are modified slightly. ● It can be updated to automated garbage collection through vehicles.

3.4 Problem Solution Fit



4. REQUIREMENT ANALYSIS

4.1 Functional Requirement

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	**User Registration**	Registration through Gmail
FR-2	**User Confirmation**	Confirmation via Email Confirmation via OTP
FR-3	**GPS Access**	GPS access to know the location
FR-4	**Bin level Analysing**	Acquire the levels of Waste bins in a regular interval of time.
FR-5	**Transport Router**	To make a efficient route for the collection of garbages around a area.

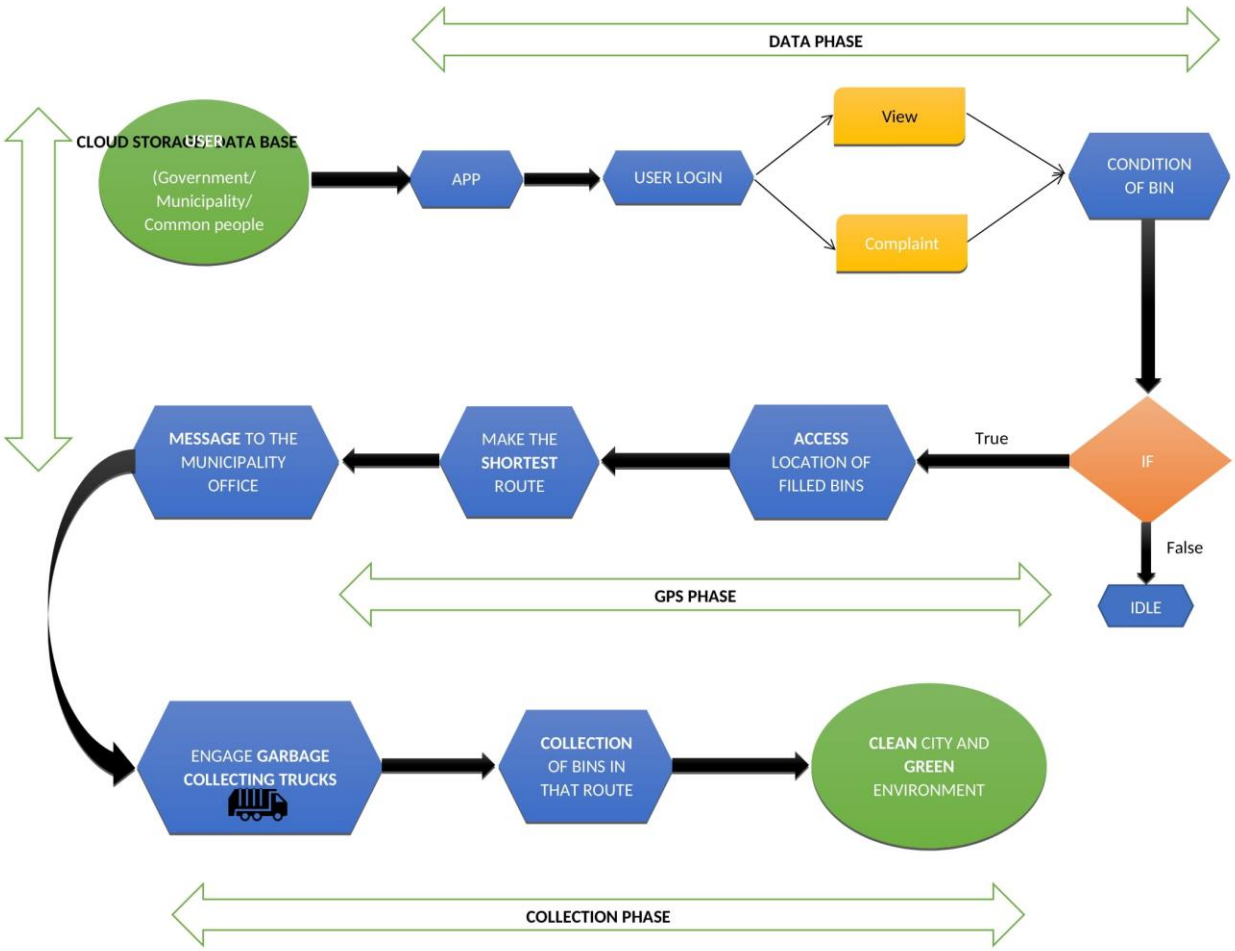
4.2 Non-Functional Requirement

FR No.	Non-Functional Requirement	Description

NFR-1	**Usability**	1. A smart solution has been proposed to make the waste sorting more simple and accurate , and improve the user experience, usability, and satisfaction. 2. It aims to optimize ease of use while offering maximum functionality.
NFR-2	**Security**	1. The information of the users will be highly secured,the accounts are verified with Gmail. 2. If the products are misplaced then the GPS driven sensor gives an alert.
NFR-3	**Reliability**	1. Operates in a defined environment without failure resulting in less manpower, emissions, fuel use and traffic congestion.
NFR-4	**Performance**	1. The system will provide accurate reports, thus increasing the efficiency of the system. 2. The real-time monitoring of the garbage level with the help of sensors and wireless communication will reduce the total number of trips required of Garbage collecting truck. 3. This will reduce the total expenditure associated with the garbage collection.
NFR-5	**Availability**	1. The smart waste bins are available in Convention centers, buildings, stadiums, and transportation facilities and captures high-quality waste data and informs staff when it gets full.
NFR-6	**Scalability**	2. A versatile scalable smart waste-bin system based on limited waste management could potentially lead to great improvements. 3. Once these smart bins are implemented on a large scale by replacing the traditional bins, the waste can be quickly managed to its efficient level as it avoids unnecessary lumping of wastes on roadside.

5. PROJECT DESIGN

5.1 Data Flow Diagrams

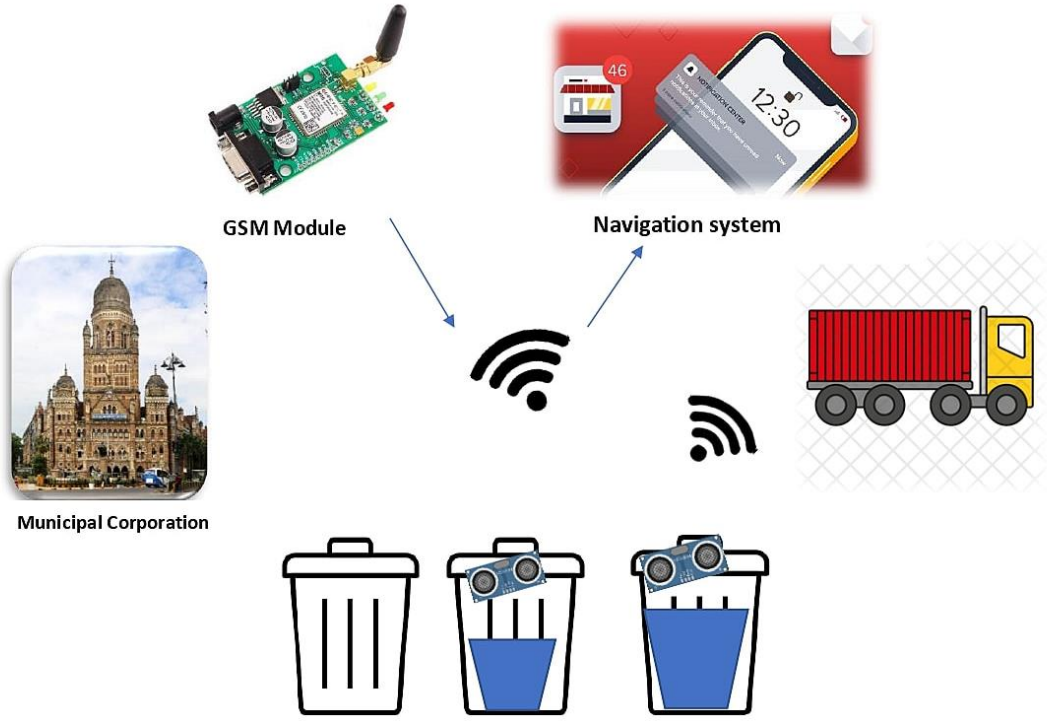


5.2 Solution and Technical Architecture

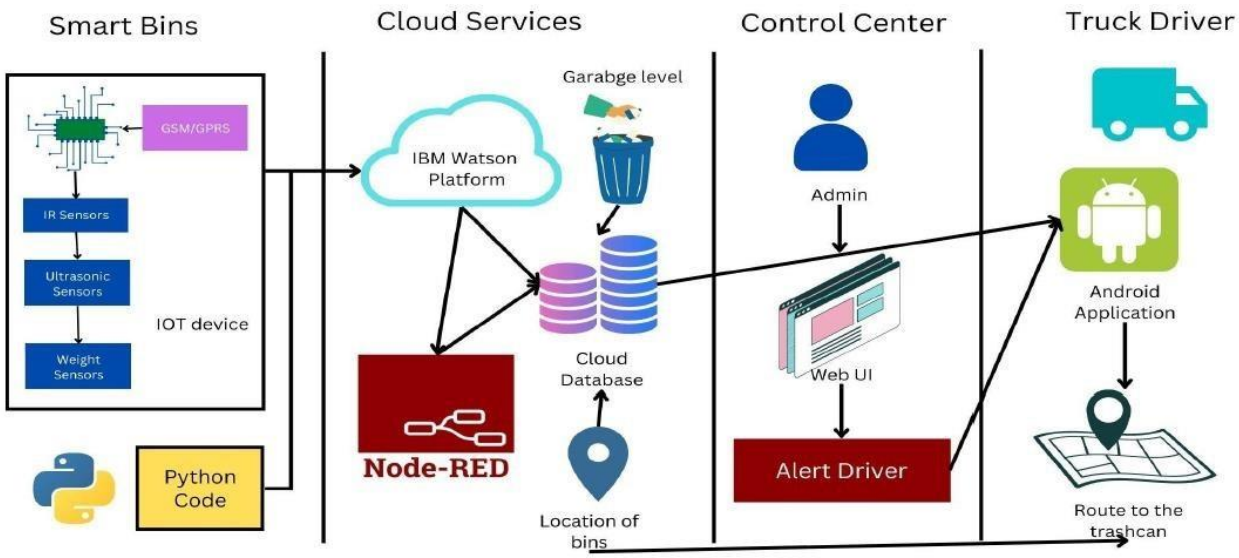
Solution Architecture:

- The general architecture which uses the cluster of smart waste bins connected through IoT in the outdoor environment. It uses a GPS to communicate the status of the smart waste bins enabling the effective waste management system.
- The proposed system could be considered as a robotic smart waste bin where the bins could mobilize, localize its location and communicate its status to the cloud.
- The smartness is achieved by having ultra sonic sensors, Node MCU, Capacitive sensors, servomotors, microcontrollers integrated to form an autonomous system.

Solution Architecture Diagram



Technical Architecture:



Components & Technologies:

S.No	Component	Description	Technology

1.	Application	It is the platform for interaction of user with the admin (municipality corporation)	HTML, Python
2.	Ultrasonic Sensor	It measures the distance of top of garbage to the base of it using ultrasonic waves.	a transducer to send and receive ultrasonic pulses
3.	GPS Sensor	They receive the data from the satellites regarding the location of garbage to be collected	GPS satellites
4.	Cloud Database	For the storage of user info, location of garbage bins etc.,	IBM DB2,IBM Cloud etc.
5.	Lithium Ion Battery	A lithium-ion (Li-ion) battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry.	the positive to the negative electrode
6.	Wifi Module	The ESP8266 WiFi Module is a selfcontained SOCwith integrated TCP/IP protocol stack that can give anymicrocontroller access to your WiFinetwork.	IEEE 802 protocol
7.	Transport	A vehicle for the collection of bins.	Garbage truck

Application Characteristics:

S.No	Characteristics	Description	Technology

1.	Open-Source Frameworks	Template for software development that is designed by a social network of software developers. These frameworks arefree for public use	Python
2.	Security Implementations	provides thetechnical security policies, requirements, and implementation details foreliminating the security weaknesses	GSM/GPRS.
3.	Scalable Architecture	scalable architecture supports higher workloads without any fundamental changes to it.	Node Red.
4.	Availability	The quality or state of being available trying to improve the availability of affordable housing.	Cloud, DB.
5.	Performance	The execution of an action	IBM Waston IoT Platform.

5.3 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 created an account in the application provided.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I registered using my gmail.	I can receive confirmation email .	High	Sprint-1
		USN-3	As a user, I successfully installed the app and login to see the bin level in my area.	I can register & access the dashboard .	Low	Sprint-2
	Login	USN-4	As a user, I login using my gmail and password easily.	The login process was easy and simple to access the dashboard.	High	Sprint-1

Customer (Web user)		WUSN-1	As a web user I can see whether the bins in the locality are filled or not only after loging in using my gmail account.	The website must work properly so that no error occurs in the info.	High	Sprint-2
Customer Care Executive		CCE-1	A customer care executive will always be available for the interaction with the customer to clarify the queries.	An executive will clarify the doubts and note down the complaints of the application if any .	High	Sprint-2

Administrator		ADMIN-1	I as a Admin can access the data or information provided by the customers to analyse their needs	The details of the locality of the user is provided to the municipal corporation when a complaint is received.	High	Sprint-1

6. PROJECT PLANNING AND SCHEDULING

6.1 Sprint Planning and Estimation

Title	Description	Date
Pre-requisites	Create IBM Cloud Services and developing Web application usingNode-Red	28 AUGUST 2022
Literature Survey & Information Gathering	Literature surveyon the selected project & gathering information byreferring the,technical papers, research publications etc.	17 SEPTEMBER 2022
Prepare EmpathyMap	Prepare EmpathyMap Canvas to capture the user Pains & Gains, Prepare list of problem statements.	16 SEPTEMBER 2022

Brainstorming ideas	List the ideas by organizing the brainstorming session and prioritizethe top 3 ideas based on the feasibility &importance.	16 SEPTEMBER 2022
Proposed Solution	Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc.	23 SEPTEMBER 2022
Problem Solution Fit	Prepare problem - solutionFitand submit for review.	2 OCTOBER 2022
Solution Architecture	Prepare solution Architecture and submit for review.	2 OCTOBER 2022
Customer Journey	Prepare the customer journeymaps to understand the user interactions & experiences with the application	11 OCTOBER 2022
Data FlowDiagrams	Draw the data flow Diagrams and submit for review.	11 OCTOBER 2022
Technology Architecture	Create an Architecturediagram.	16 OCTOBER 2022
Sprint Delivery	Prepare the Sprint delivery on Numberof Sprint planning meetingsorganized.	IN PROGRESS

Milestone &Activity List	Prepare the milestones & Activitylist of the project.	06 NOVEMBER 2022
Project Development Delivery of Sprint-1,2,3,4	Develop and submit the developed code after testing for no error	IN PROGRESS…
Final Deliveries	Develop theCode, Test and push it to GitHuband submit the project report	IN PROGRESS…

6.2 Sprint Delivery Schedule

Sprint	Functional Requirement	User Story Number	User Story/ Task	Story Points	Priority	Team Members
Sprint-1	Administrator	USN-1	As an admin, we need to give access to the drivers, users and other municipality workers.	2	High	Sakthi kiran M B, Swetha R
Sprint-1	Co-Administrator	USN-2	As an co-admin, we need to monitorthe garbage bin levels and sensors are used in the garbage bins.	5	Medium	Mona dhakshaya JK, Hariprasath K

Sprint -1	User Registration	USN -3	As an user, we can register the application by entering the email or mobile number, password and confirming the account.	5	Medium	Jerusha Jaisal J L, Sakthi kiranM B
Sprint -1	Login	USN -4	As an user, we can login the application using the mobile number or Email.	8	High	Swetha R, Mona dhakshaya JK

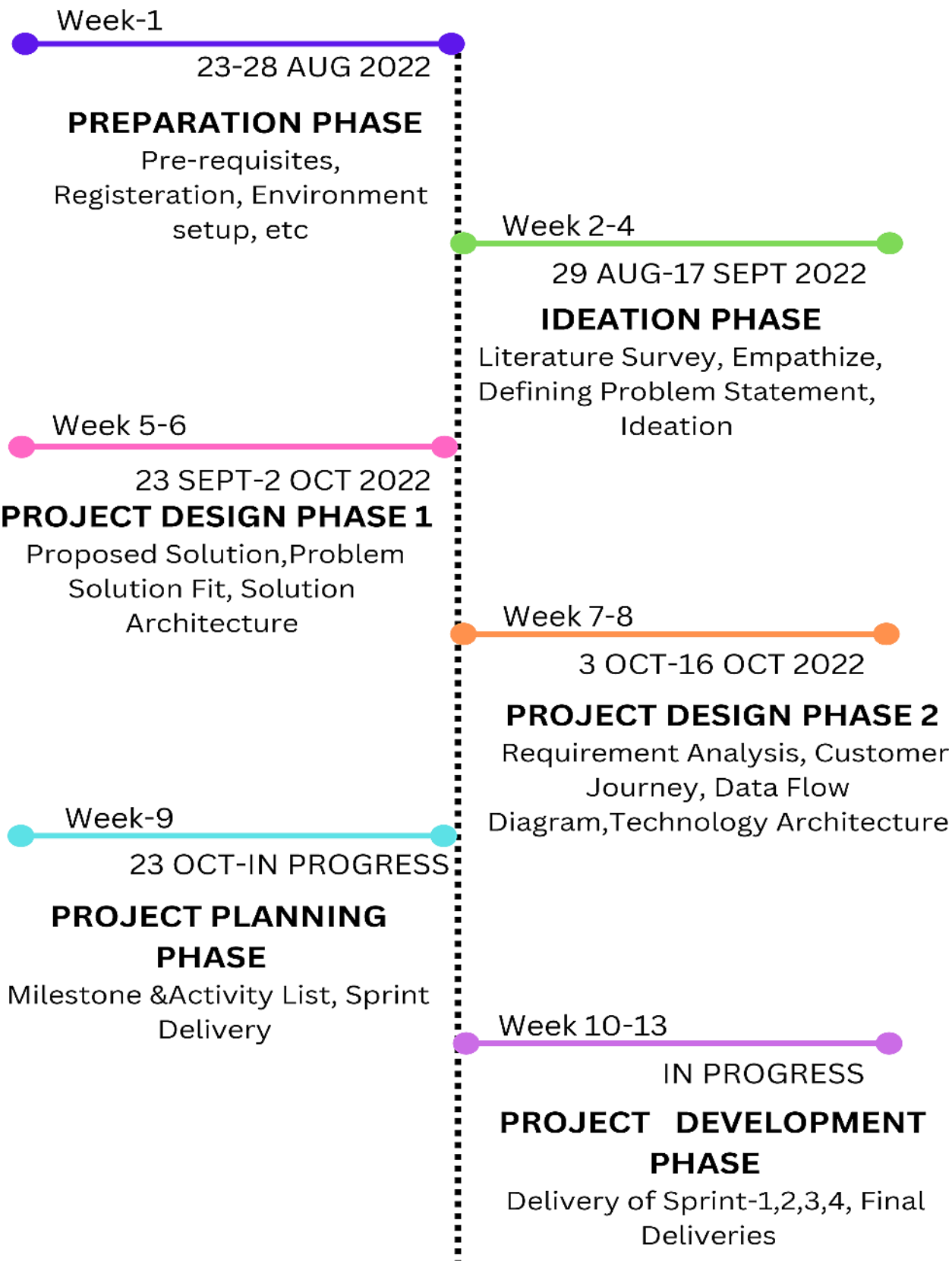
Sprint -2	User confirmation	USN -1	As an user, we can confirm my loginpage using OTP is sent to the Mobile number or Email.	2	Low	Hariprasath K, Jerusha Jaisal J L
Sprint -2	Data Sync	USN -2	The smart bins send their data to the cloud in the real time which is inturn updates in the web application and the administrator's dashboard.	13	Medium	Sakthi kiran M B,Swetha R

Sprint -2	User access	USN -3	As an user, We can access the information about the smart bin leveland the number of bins are filled in the area.	3	High	Mona dhakshaya JK, Hariprasath K
Sprint -2	Find Path	USN -4	As an user, I can access the mapthrough the web application to getthe shortest distance between twofilled in my areas.	2	High	Jerusha Jaisal J L, Sakthi kiranM B
Sprint -3	Notification	USN -1	As an user, we can receive a notification /message in the form visual notification.	5	Med ium	Swetha R, Mona dhakshaya JK
Sprint -3	SMS Notification	USN -2	As a user, we can receive a SMS notification when the smart bins are filled over75%.	1	High	Hariprasath K, Jerusha Jaisal J L

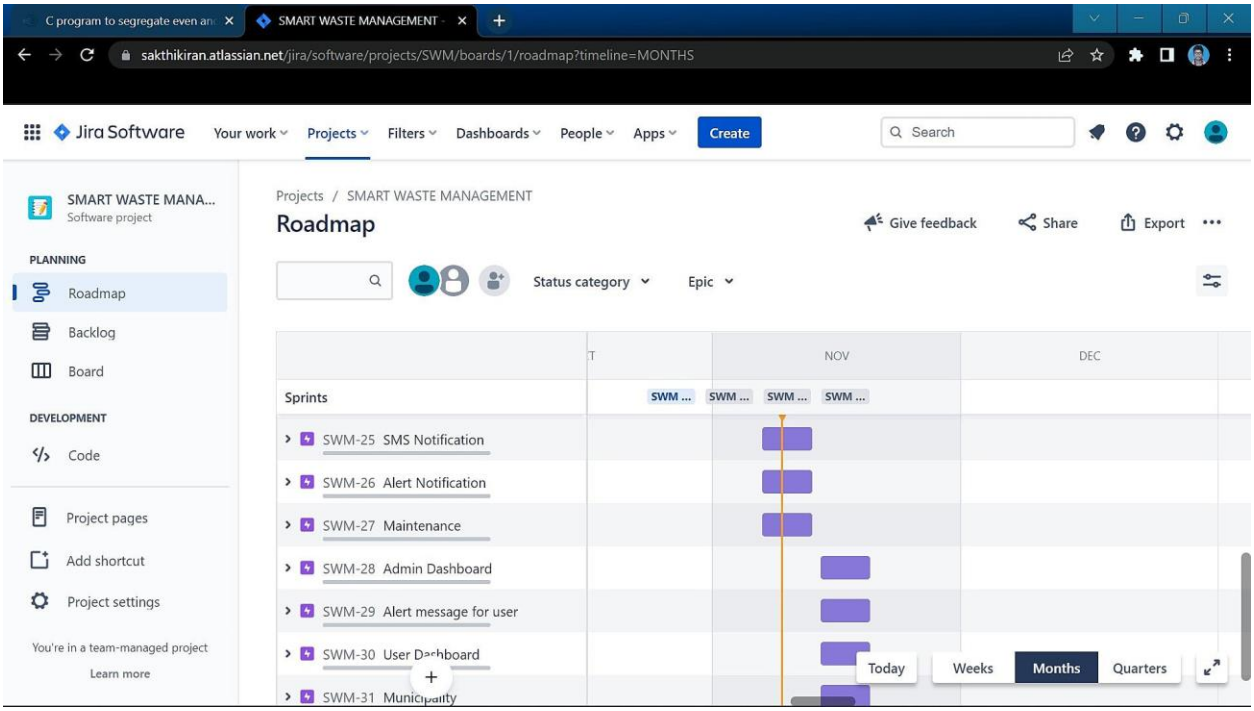
Sprint -3	Alert Notification	USN-3	As an user, We can get alert message if any smart bins caught fire or any kind of unusual things happened to thesmart bins.	13	High	Sakthi kiran M B,Swetha R

Sprint -3	Maintenance	USN -4	As an executive, I manage the teamof representatives offering customer support and maintenance.	1	Low	Mona dhakshaya J K, Hariprasath K
Sprint -4	Admin Dashboard	USN -1	As an executive, I can receive the information about that situation and can alert the concern people in authority.	2	Low	Jerusha Jaisal J L, Sakthi kiranM B
Sprint -4	Alert message foruser	USN -2	As an user, I can get notification about the filled smart bins in our area.	5	Medium	Swetha R, Mona dhakshaya JK

Sprint -4	User Dashboard	USN -3	As an user, I can acknowledge information about smart bins on my dashboard.	8	High	Hariprasath K, Jerusha JaisalJ L
Sprint -4	Municipality	USN -4	As a Municipal Corporation, I can check whether the work is happening efficiently or not.	5	Medium	Sakthi kiran M B,Swetha R



6.3 Reports from JIRA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Learn more
Projects / SMART WASTE MANAGEMENT
Roadmap
Give feedback
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SWM-25 SMS Notification
SWM-26 Alert Notification
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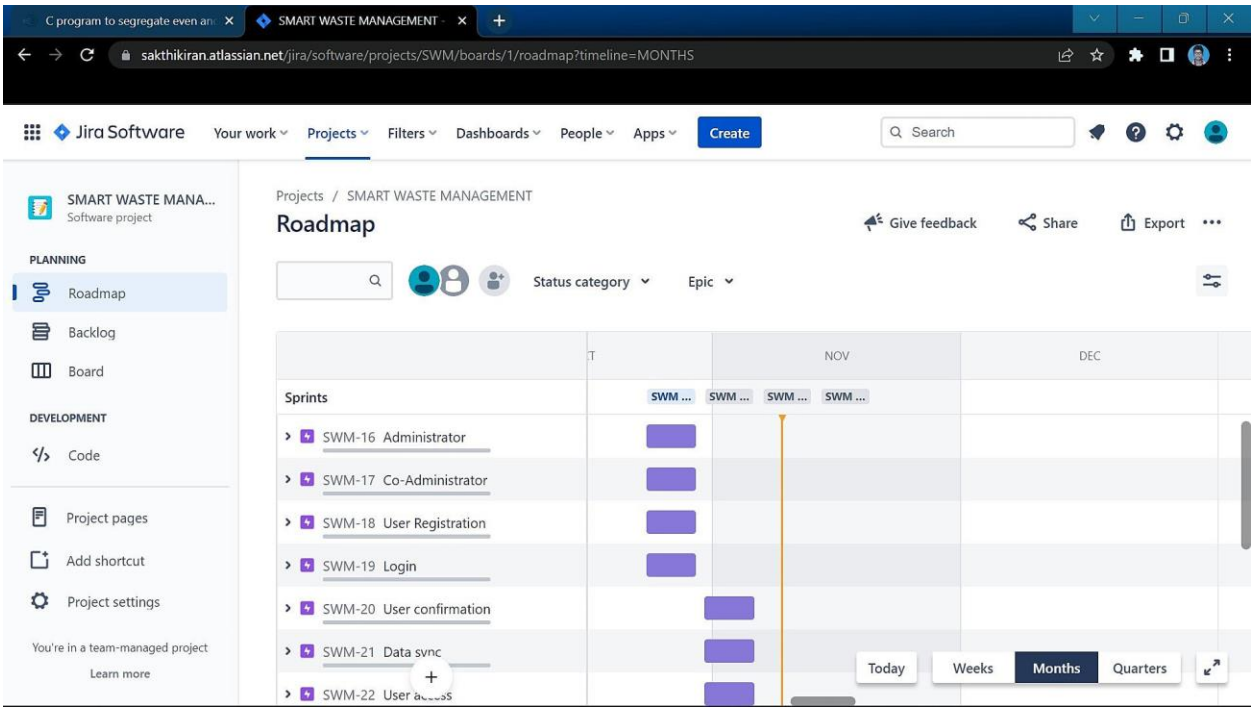
SWM-29 Alert message for user
SWM-30 User Dashboard
SWM-31 Municipality
Today
Weeks
Months
Quarters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Project pages
Add shortcut
Project settings
You're in a team-managed project
Learn more
Projects / SMART WASTE MANAGEMENT
Roadmap
Give feedback
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Weeks
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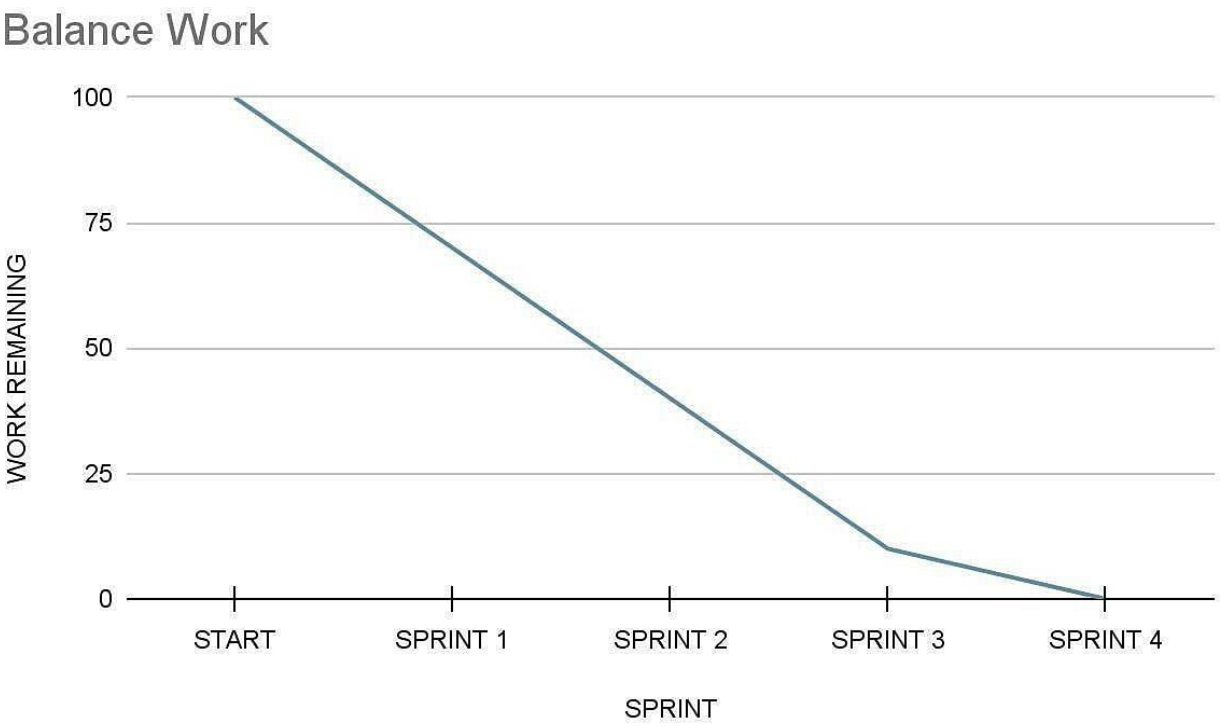
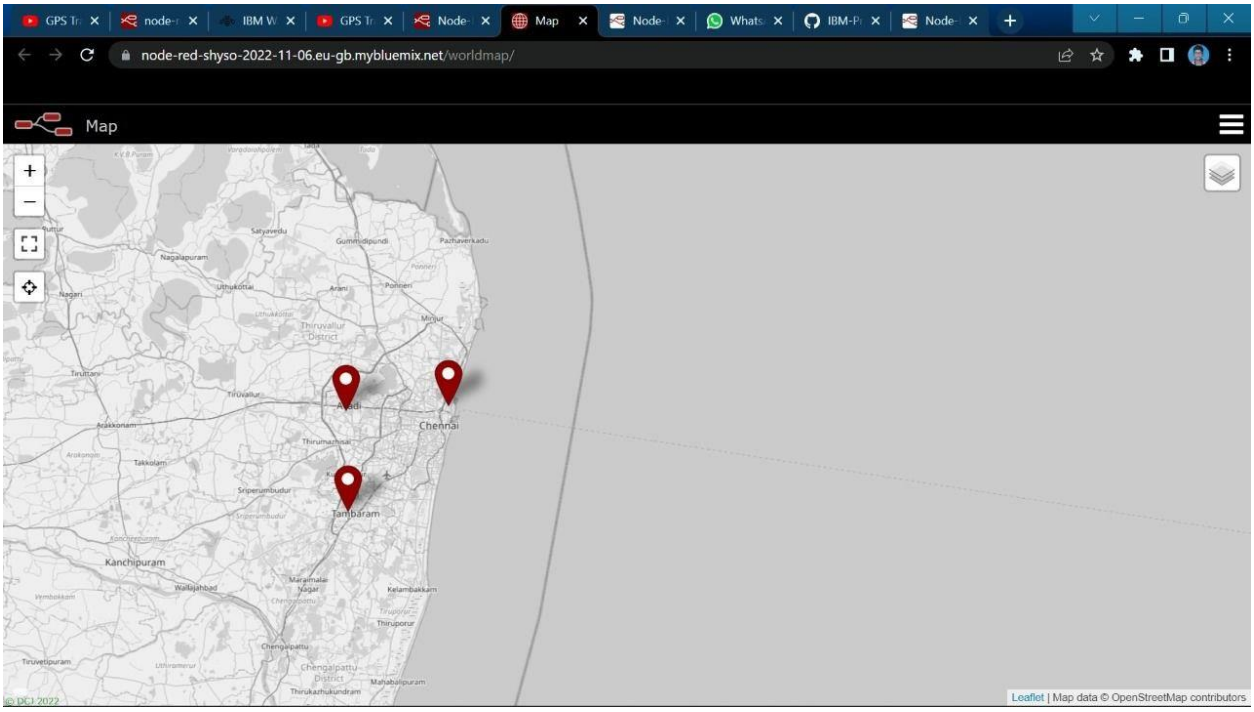
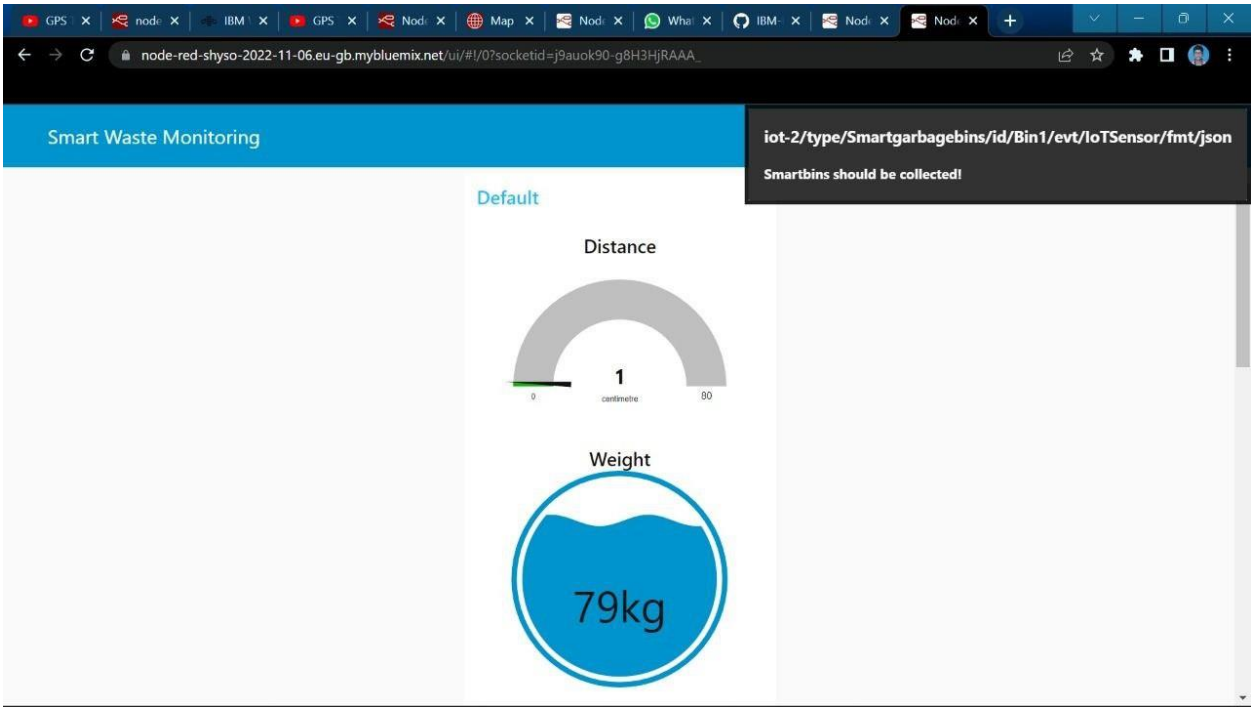


7. CODING AND SOLUTIONING

7.1 Feature 1



7.2 Feature 2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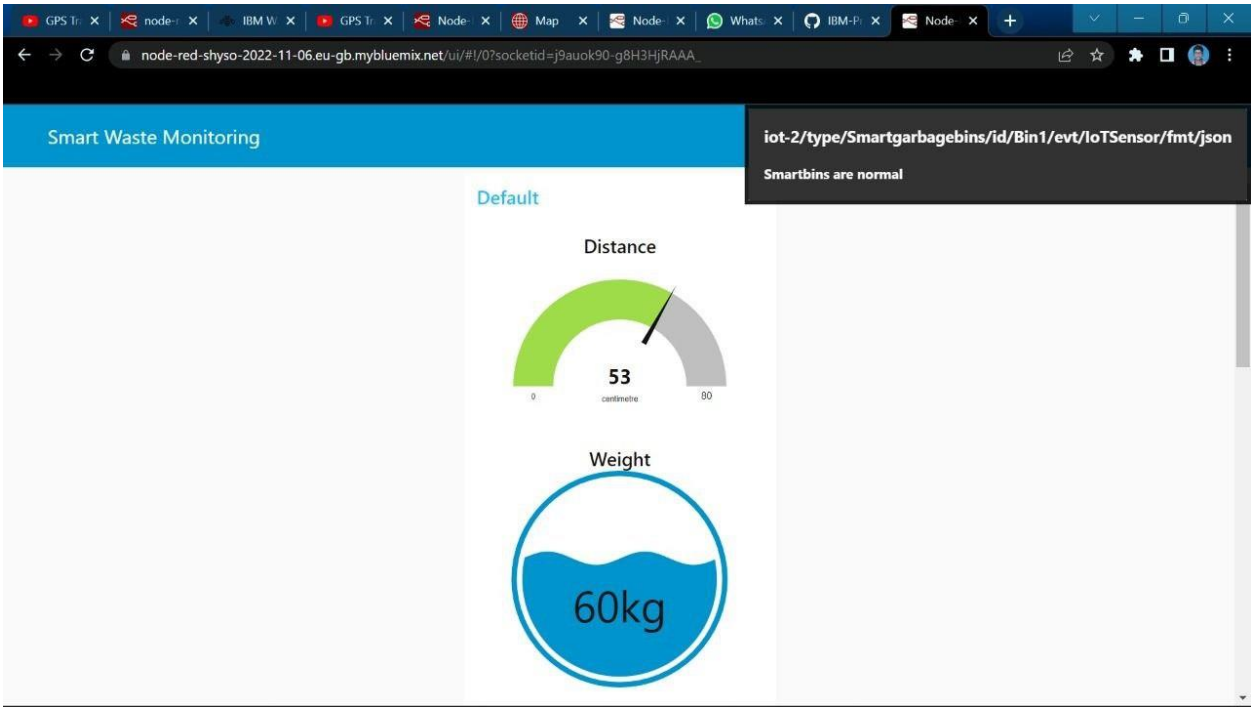
79kg


node-red-shyso-2022-11-06.eu-gb.mybluemix.net/ui/#!/0?socketid=j9auok90-g8H3HjRAAA_
Smart Waste Monitoring
iot-2/type/Smartgarbagebins/id/Bin1/evt/IoTSensor/fmt/json
Smartbins are normal
Default
Distance
53
centimetre
0
80
Weight
60kg

8. TESTING

8. Test Cases

Test case ID	Feature Type	Component	Test Scenario	Pre-Requisite	Steps To Execute	Test Data	Expected Result	Actual Result	Status	Commnets	TC for Automation(Y/N)	BUG ID	Executed By
LoginPage_TC_OO1	UI	Home Page	Verify whether user is able to access and notify	Notification	https://node-red-shyso-2022-11-06.eu-gb.mybluemix.net/red/#flow/c763b809dd8fc0b8	URL	No notification received	Failed to notify	Fail	Wrong browser selected	NO	101	Swetha R
LoginPage_TC_OO2	UI	Home Page	Verify whether user is able to access and notify	Notification	https://node-red-shyso-2022-11-06.eu-gb.mybluemix.net/red/#flow/c763b809dd8fc0b8	URL	Notification received	Notified	Pass	Able to access in selected browser	yes	102	Mona Dhakshaya J K
CloudStorage_TC_OO3	Functional	CLOUD	Verify the bin level and weight for efficient management of waste	CLOUD	As an user, We can access the information about the smart bin level and the number of bins are filled in the area	Smart bin level and weight in percentage	Garbage levels and range of visibility displayed dynamically	Does not change dynamically	Fail	Could not connected	NO	107	Hari Prasath K
CloudStorage_TC_OO4	Functional	CLOUD	Verify the bin level and weight for efficient management of waste	CLOUD	As an user, We can access the information about the smart bin level and the number of bins are filled in the area	Smart bin level and weight in percentage	Garbage levels and range of visibility displayed dynamically	Now it changes dynamically as per the factors	Pass	Could connected	YES	108	Jerusha Jaisal J L
Response_TC_OO5	Functional	IOT Device	Check for the bin level and notify them	IOT Device	1.Check whether the bins are empty or full 2.Displayed as per situation - Choose the shortest route to collect the garbage	If the bin is full Indicate -"BIN IS FULL!!" Or else "BIN IS IN NORMAL LEVEL"	Displayed Instructions	Does not displayed proper instructions	Fail	Check the inputs	NO	116	Sakthi kiran M B
Response_TC_OO6	Functional	IOT Device	Check for the bin level and notify them	IOT Device	1.Check whether the bins are empty or full 2.Displayed as per situation - Choose the shortest route to collect the garbage	If the bin is full Indicate -"BIN IS FULL!!" Or else "BIN IS IN NORMAL LEVEL"	Displayed Instructions	Now displayed proper instructions to users	Pass	Now verified	YES	117	Swetha R Jerusha Jaisal J L
Output_TC_007	Functional	CLOUD	Verify the location and indicates if any bins are full	CLOUD	1.Take the location data 2. Find the shortest route for the truck to collect the garbage	Garbage bin's location data	Indication for collecting the garbage as per pinned location	Does not included the location data	Fail	Smart bin - Garbage level should be below 50 cm Bin Weight - Weight should be below 75 kg	NO	129	Hari Prasath K Sakthi Kiran M B
Output_TC_008	Functional	CLOUD	Verify the location and indicates if any bins are full	CLOUD	1.Take the location data 2. Find the shortest route for the truck to collect the garbage	Garbage bin's location data	Indication for collecting the garbage as per pinned location	Location data included	Pass	Smart bin - Garbage level should be below 50 cm Bin Weight - Weight should be below 75 kg	YES	130	Hari Prasath K Mona Dhakshaya J K
TTS-TC_009	Functional	IOT Device	Indicate the message as per the factors	IOT Device and TTS	Take data's from all require factors and showed response in display	Displayed instructions as per the situation	Showed message for precautionary responses	Message displayed as per situations	Pass	Indication message displayed	YES	135	Sakthi kiran M B Swetha R
Final Output_TC_010	Functional	IOT Device	Verify all the responses are showed and dynamically changed in the single display	IOT Device and TTS	Take all the data's retrieved from cloud and Showed responses in display as per the data factors	Displayed all the type of instructions showed in a same display	Showing the indications and messages in a display and changes dynamically according to the situation	Indications and messages showed and dynamically changed	Pass	All factors showed in the display	YES	145	Jerusha Jaisal J L Mona Dhakshaya J K

9. RESULTS

9.1 Performance Metrics

NFT - Risk Assessment

S.No	Project Name	Scope/feature	Functional Changes	Hardware Changes	Software Changes	Impact of Downtime	Load/Volume Changes	Risk Score	Justification
1	Smart Waste Management System in Metropolitan cities	Existing	Moderate	Moderate	Low	Loss of users and delay in run time	>10 to 30%	ORANGE	Since there are moderate changes in function and hardware, it may add setup time in the long run

NFT - Detailed Test Plan

S.No	Project Overview	NFT Test approach	Assumptions/Dependencies/Risks	Approvals/SignOff
1	Managing the collection of trash in busy cities	LOAD, STRESS	May request advanced versions in software Requires speed test	Approval

End Of Test Report

S.No	Project Overview	NFT Test approach	NFR - Met	Test Outcome	GO/NO-GO decision	Recommendations	Identified Defects (Detected/Closed/Open)	Approvals/SignOff
1	Managing the collection of waste by using smart bins which alerts the garbage collector when it is full	LOAD, STRESS	MET	Opertates efficiently when the number of users is increased	GO	Recommended to have advanced browsers that enable gps tracking	Closed	Approval

10. ADVANTAGES AND DISADVANTAGES

Advantages

- The garbage will be collected on time-to-time basis.
- There would not be any bad smell around the bin.
- Real time notification to collect the garbage.
- Saving on fuel consumption, thus reducing the threat to the environment.
- It saves time and money by using smart waste collection bins and systems equipped with fill level sensors. As smart transport vehicles go only to the filled containers or bins. It reduces infrastructure, operating and maintenance costs by upto 30%
- It decreases traffic flow and consecutively noise due to less air pollution as result of less waste collection vehicles on the roads. This has become possible due to two way communication between smart dustbins and service operators.
- It keeps our surroundings clean and green and free from bad odour of wastes, emphasizes on healthy environment and keep cities more beautiful.
- It further reduces manpower requirements to handle the garbage collection process.

- Applying smart waste management process to the city optimizes management, resources and costs which makes it a "smart city".
- It helps administration to generate extra revenue by advertisements on smart devices.

Disadvantages

- It requires a well structured hardware.
- The onetime cost of installation will be higher than the present technique.
- System requires more number of waste bins for separate waste collection as per population in the city. 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.
- Wireless technologies used in the system such as zigbee and wifi have shorter range and lower data speed. In RFID based systems, RFID tags are affected by surrounding metal objects (if any).
- 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.

11. CONCLUSION

A Smart Waste Management system that is more effective than the one in use now is achievable by using sensors to monitor the filling of bins. Our conception of a "smart waste management system" focuses on monitoring waste management, offering intelligent technology for waste systems, eliminating human intervention, minimizing human time and effort, and producing a healthy and trash-free environment. The suggested approach can be implemented in smart cities where residents have busy schedules that provide little time for garbage management. If desired, the bins might be put into place in a metropolis where a sizable container would be able to hold enough solid trash for a single unit. The price might be high.

12. FUTURE SCOPE

The main aim of this project is to reduce human resources and efforts along with the enhancement of a smart city vision. We have often seen garbage spilling over from dustbins on to streets and this was an issue that required immediate attention. The proverb “Cleanliness is next to god and clean city is next to heaven” inspired us to conceptualized the project. Smart dustbin helps us to reduce the pollution. Many times garbage dustbin is overflow and many animals like dog or rat enters inside or near the dustbin. This creates a bad scene. Also some birds are also trying to take out garbage from dustbin. This project can avoid such situations.

And the message can be sent directly to the cleaning vehicle instead of the contractor’s office. Swatch Bharat Abhiyan (English: Clean India Mission and abbreviated as SBA or SBM for "Swatch Bharat Mission") is a national campaign by the Government of India, covering 4,041 statutory cities and towns, to clean the streets, roads and infrastructure of the country. In our system, the Smart dustbins are connected to the internet to get the real time information of the smart dustbins. In the recent years, there was a rapid growth in population which leads to more waste disposal. So a proper waste management system is necessary to avoid spreading some deadly diseases.

13. APPENDIX

SOURCE CODE

```
import time
import sys
import ibmiotf.application
import ibmiotf.device
import random
import sys
#Provide your IBM Watson Device Credentials
organization = "a7mbs7"
deviceType = "Smartgarbagebins"
deviceId = "Bin1"
authMethod = "token"
authToken = "Sakthi@2001"
# Initialize GPIO
def myCommandCallback(cmd):
    print("Command received: %s" % cmd.data['command'])
    status=cmd.data['command']
    if status =="lighton":
        print("led in on")
    else :
```

```
        print ("led is off")
try:
    deviceOptions = {"org": organization, "type": deviceType, "id": deviceId, "auth-
method":authMethod, "auth-token": authToken}
    deviceCli = ibmiotf.device.Client(deviceOptions)
#.....................................
except Exception as e:
    print("Caught exception connecting device: %s" % str(e))
    sys.exit()
#Connect and send a datapoint "hello" with value "world" into the cloud as an event oftype
"greeting" 10 times
deviceCli.connect()
while True:
    #Get Sensor Data from DHT11
    time.sleep(5)
    ult_son=random.randint(0,80)
    weight=random.randint(0,100)
    lat = round(random.uniform(12.03, 13.50), 6)
    lon = round(random.uniform(80.80, 85.90), 6)
    data = {'Ultrasonic' : ult_son, 'Weight' : weight , 'lat' : lat,'lon':lon}
    #print data
    def myOnPublishCallback():
        print ("Published Ultrasonic :%s Cm" %ult_son, "Weight:%s kg " %weight, "lat: %s" %lat,"lon:
%s" %lon)
    success = deviceCli.publishEvent("IoTSensor", "json", data, qos=0,
    on_publish=myOnPublishCallback)
    if not success:5
    time.sleep(1)
    deviceCli.commandCallback = myCommandCallback
# Disconnect the device and application from the cloud
```

deviceCli.disconnect()

WOKWI SOURCE CODE

```
#include <WiFi.h> // library for wifi
#include <PubSubClient.h> // library for MQTT
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 20, 4);
//---------------------- credentials of IBM Accounts ----------------------------
#define ORG "9gbe4w" // IBM organisation id
#define DEVICE_TYPE "SWMSMC" // Device type mentioned in ibm watson iot platform
#define DEVICE_ID "ibmproject" // Device ID mentioned in ibm watson iot platform
#define TOKEN "sUNA41tG6-Pq)0rk5X" // Token
//---------------------- customise above values ---------------------------------------------------
char server[] = ORG ".messaging.internetofthings.ibmcloud.com"; // server name
char publishTopic[] = "iot-2/evt/data/fmt/json"; // topic name and type of event perform and
format
in which data to be send
char topic[] = "iot-2/cmd/led/fmt/String"; // cmd Represent type and command is test format of
strings
char authMethod[] = "use-token-auth"; // authentication method
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID; //Client id
//-------------------------------------------------------------------------------------------------------------------
WiFiClient wifiClient; // creating instance for wificlient
PubSubClient client(server, 1883, wifiClient);
#define ECHO_PIN 12
#define TRIG_PIN 13
float dist;
void setup()
{
 Serial.begin(115200);
 pinMode(LED_BUILTIN, OUTPUT);
 pinMode(TRIG_PIN, OUTPUT);
 pinMode(ECHO_PIN, INPUT);
 //pir pin
 pinMode(34, INPUT);
 //ledpins
 pinMode(23, OUTPUT);
 pinMode(2, OUTPUT);
 pinMode(4, OUTPUT);
 pinMode(15, OUTPUT);

 lcd.init();
 lcd.backlight();
 lcd.setCursor(1, 0);
 lcd.print("");
```

```
 wifiConnect();
 mqttConnect();
}
float readcmCM()
{
 digitalWrite(TRIG_PIN, LOW);
 delayMicroseconds(2);
 digitalWrite(TRIG_PIN, HIGH);
 delayMicroseconds(10);
 digitalWrite(TRIG_PIN, LOW);
 int duration = pulseIn(ECHO_PIN, HIGH);
 return duration * 0.034 / 2;
}
void loop()
{
lcd.clear();
 publishData();
 delay(500);
 if (!client.loop())
 {
 mqttConnect(); // function call to connect to IBM
 }
}
/* ------------------------------retrieving to cloud----------------------------------------------------*/
void wifiConnect()
{
 Serial.print("Connecting to ");
 Serial.print("Wifi");
 WiFi.begin("Wokwi-GUEST", "", 6);
 while (WiFi.status() != WL_CONNECTED)
 {
 delay(500);
 Serial.print(".");
 }
 Serial.print("WiFi connected, IP address: ");
 Serial.println(WiFi.localIP());
}
void mqttConnect()
 {
 if (!client.connected())
 {
 Serial.print("Reconnecting MQTT client to ");
 Serial.println(server);
 while (!client.connect(clientId, authMethod, token))
 {
 Serial.print(".");
 delay(500);
 }
 initManagedDevice();
```

```
 Serial.println();
 }
 }
void initManagedDevice()
 {
 if (client.subscribe(topic))
 {
 Serial.println("IBM subscribe to cmd OK");
 }
 else
 {
 Serial.println("subscribe to cmd FAILED");
 }
 }
void publishData()
{
 float cm = readcmCM();
 if(digitalRead(34)) //pir motion detection
 {
 Serial.println("Motion Detected");
 Serial.println("Lid Opened");
 digitalWrite(15, HIGH);



if(digitalRead(34)== true)
{
 if(cm <= 60) //Bin level detection
 {
 digitalWrite(2, HIGH);
 Serial.println("High Alert!!!,Trash bin is about to be full");
 Serial.println("Lid Closed");
 lcd.print("Full! Don't use");
 delay(2000);
 lcd.clear();
 digitalWrite(4, LOW);
 digitalWrite(23, LOW);
 }
 else if(cm > 60 && cm < 120)
 {
 digitalWrite(4, HIGH);
 Serial.println("Warning!!,Trash is about to cross 50% of bin level");
 digitalWrite(2, LOW);
 digitalWrite(23, LOW);

 }
 else if(cm > 120)
 {
```

```
 digitalWrite(23, HIGH);
 Serial.println("Bin is available");
 digitalWrite(2,LOW);
 digitalWrite(4, LOW);
 }
 delay(10000);
 Serial.println("Lid Closed");
}
else
{
 Serial.println("No motion detected");
 digitalWrite(2, LOW);
 digitalWrite(15, LOW);
 digitalWrite(4, LOW);
 digitalWrite(23, LOW);
}

}
 else
 {
 digitalWrite(15, LOW);

 }
 if(cm <= 60)
{
digitalWrite(21,HIGH);
String payload = "{\"High_Alert\":";
payload += cm;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
[Forwarded from Sakthi kiran]
Serial.println(payload);
if (client.publish(publishTopic, (char*) payload.c_str())) // if data is uploaded to cloud
successfully,prints publish
ok else prints publish failed
{
Serial.println("Publish OK");
}
}
else if(cm <= 120)
{
digitalWrite(22,HIGH);
String payload = "{\"Warning\":";
payload += cm ;
payload += " }";
Serial.print("\n");
Serial.print("Sending payload: ");
```

```
Serial.println(payload);
if(client.publish(publishTopic, (char*) payload.c_str()))
{
Serial.println("Publish OK");
}
else
{
Serial.println("Publish FAILED");
}
}
else
{
Serial.println();
}
 float inches = (cm / 2.54); //print on lcd
 lcd.setCursor(0,0);
lcd.print("Inches");
lcd.setCursor(4,0);
lcd.setCursor(12,0);
lcd.print("cm");
lcd.setCursor(1,1);
lcd.print(inches, 1);
lcd.setCursor(11,1);
lcd.print(cm, 1);
lcd.setCursor(14,1);
delay(1000);
lcd.clear();
}
```

Github link

https://github.com/IBM-EPBL/IBM-Project-1915-1658420651

Project Demo Video Link

https://drive.google.com/file/d/1kh4wG0_1f7ALxM6t7AzfJ6DovJ-EpDG7/view?usp=share_link