SMART WASTE MANAGEMENT IN METROPOLITAN CITIES

REPORT

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11/18/2022

1. INTRODUCTION

1.1 Project Overview

This project aims to design and implement a combination of IoT and Application Development based Waste Management Systems. The combination of IoT and Application Development has plenty of applications such as home security systems, payment technologies, intruder recognition systems, etc. This research utilizes the application for Waste Management. The kit consists of hardware and software parts. The hardware part comprises a sensor unit, which detects the volume of waste present in the bin, a weight-detecting garbage system, a GPS locator, and a GSM module to communicate with a mobile device. The software part uses Python codes and C codes.

1.2 Purpose

The purpose of this project is a small step to Reduce Air, Water, and Soil Pollution. The world faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment, and disposal. It is a matter of health safety. Tuberculosis, pneumonia, diarrhea, tetanus, whooping cough, etc. are other common diseases spread due to improper waste management. The toxic wastes can lead to different kinds of pollution - air, water, and soil. Our current systems cannot cope with the volumes of waste generated by an increasingly urban population and this has a huge impact on the environment and public health. It reduces manual labor, increases sustainable development, and reduces common health issues related to improper waste management techniques.

2. LITERATURE SURVEY

Waste management plays a crucial role these days. As environmental concerns grow, wastes are to be properly managed and recycled. Improper management will lead to air pollution, and soil erosion may even affect human health. Lisa Saffer, et al. enhance the point about the health impacts of incineration, landfill, composting, landspreading sewage sludge, and sewage discharges [1]. A step to reduce the risks is the proposed work of waste management using IoT. Gopal Krishna Shyam, et al. submitted a work that utilizes sensors and uses an IoT algorithm that can read, collect, and transmit a huge volume of data over the Internet. These data, when put into a Spatio-temporal context and processed by intelligent and optimized algorithms, can be dynamically handled by waste collection processes [2]. The published work by Tran Anh Khoa et al put forth a low-cost IoT architecture that efficiently achieves waste management by predicting the probability of the waste level in trash bins, using machine learning and graph theory, and determining the shortest path of waste collection. It also examines the data transfer on the LoRa module and demonstrates the advantages of the system, which is implemented through a simple circuit designed with low cost, ease of use, and replaceability [3]. "Challenges and Opportunities of Waste Management in IoT-Enabled Smart Cities: A Survey" by Theodoros Anagnostopoulos, et al. gives detailed information on various aspects of IoT in waste management [4]. With the above references, this project proposes a Smart Waste

Management System For Metropolitan Cities that detects the level of Garbage in bins, and the weight of the garbage in the bin and alerts the authorized person to empty the bin whenever the bins are full. With further advancements, the Garbage level of the bins can be monitored through a Web App through which we can view the location of every bin by sending GPS location from the device.

2.2 References

[1] Saffron, Lisa & Giusti, Lorenzo & Pheby, Derek. (2003). The human health impact of waste management practices: A review of the literature and an evaluation of the evidence. Management of Environmental Quality: An International Journal. 14. 191-213. 10.1108/14777830310470422.

[2] G. K. Shyam, S. S. Manvi and P. Bharti, "Smart waste management using Internet-of-Things (IoT)," 2017 2nd International Conference on Computing and Communications Technologies (ICCCT), 2017, pp. 199-203, DOI: 10.1109/ICCCT2.2017.7972276.

[3] Tran Anh Khoa, Cao Hoang Phuc, Pham Duc Lam, Le Mai Bao Nhu, Nguyen Minh Trong, Nguyen Thi Hoang Phuong, Nguyen Van Dung, Nguyen Tan-Y, Hoang Nam Nguyen, Dang Ngoc Minh Duc, "Waste Management System Using IoT-Based Machine Learning in University", Wireless Communications and Mobile Computing, vol. 2020, Article ID 6138637, 13 pages, 2020. https://doi.org/10.1155/2020/6138637

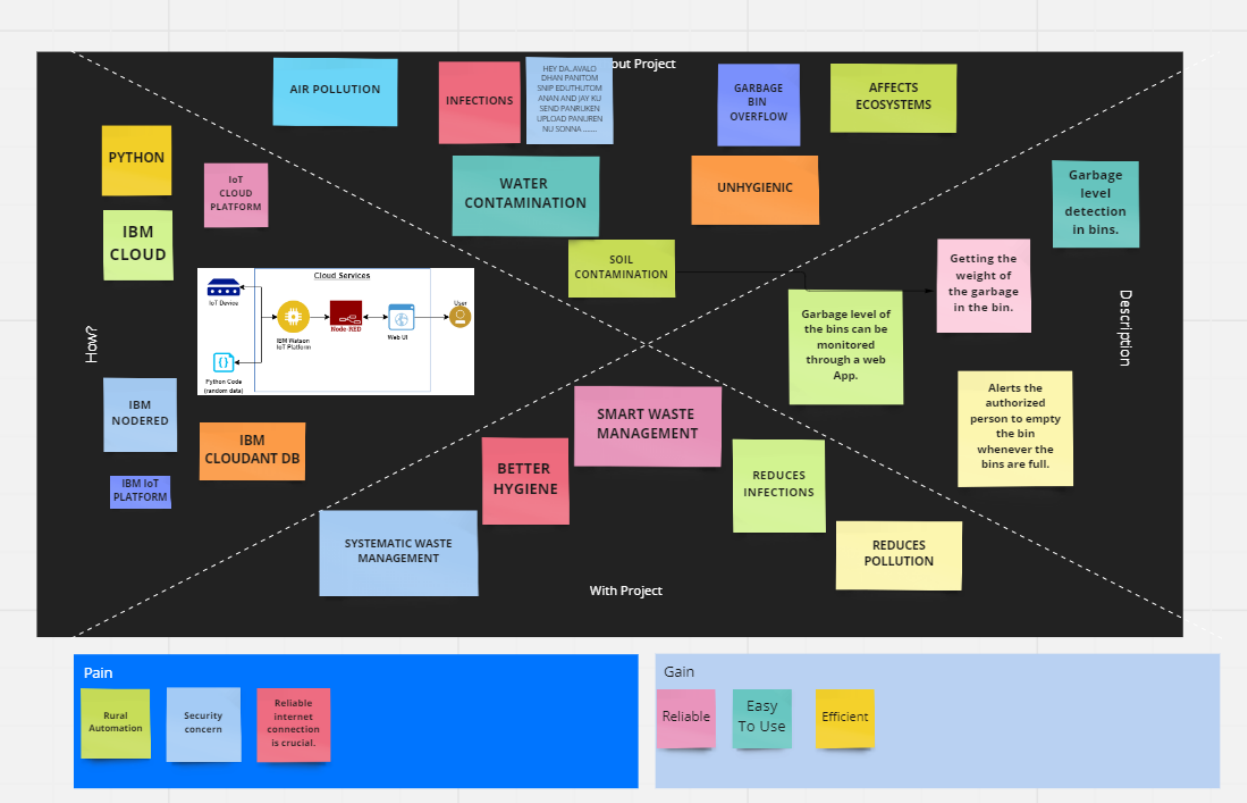
[4] T. Anagnostopoulos et al., "Challenges and Opportunities of Waste Management in IoT-Enabled Smart Cities: A Survey," in IEEE Transactions on Sustainable Computing, vol. 2, no. 3, pp. 275-289, 1 July-Sept. 2017, doi: 10.1109/TSUSC.2017.2691049.

2.3 Problem Statement

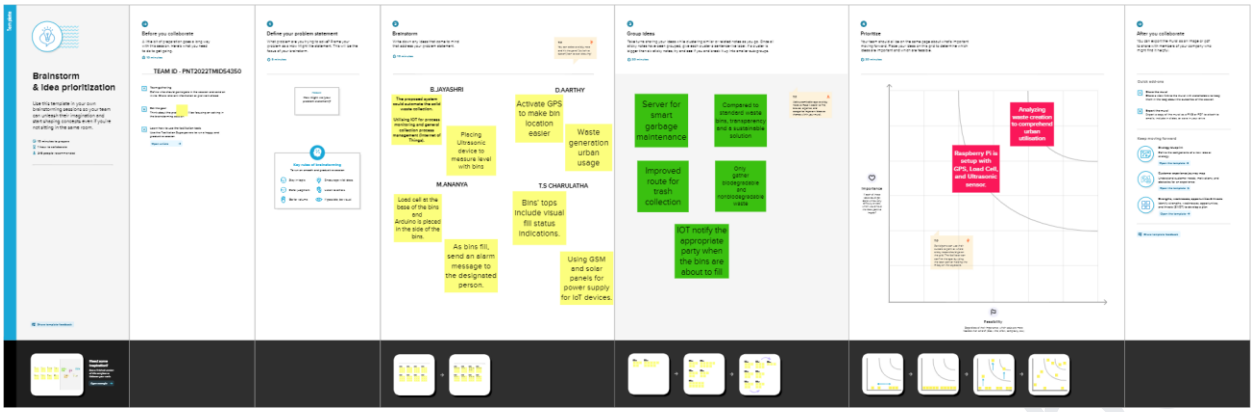
The world faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment, and disposal. It is a matter of health safety. Tuberculosis, pneumonia, diarrhea, tetanus, whooping cough, etc. are other common diseases spread due to improper waste management. The toxic wastes can lead to different kinds of pollution - air, water, and soil. Our current systems cannot cope with the volumes of waste generated by an increasingly urban population and this has a huge impact on the environment and public health.

3. IDEATION AND PROPOSED SOLUTIONS

3.1 Empathy Map



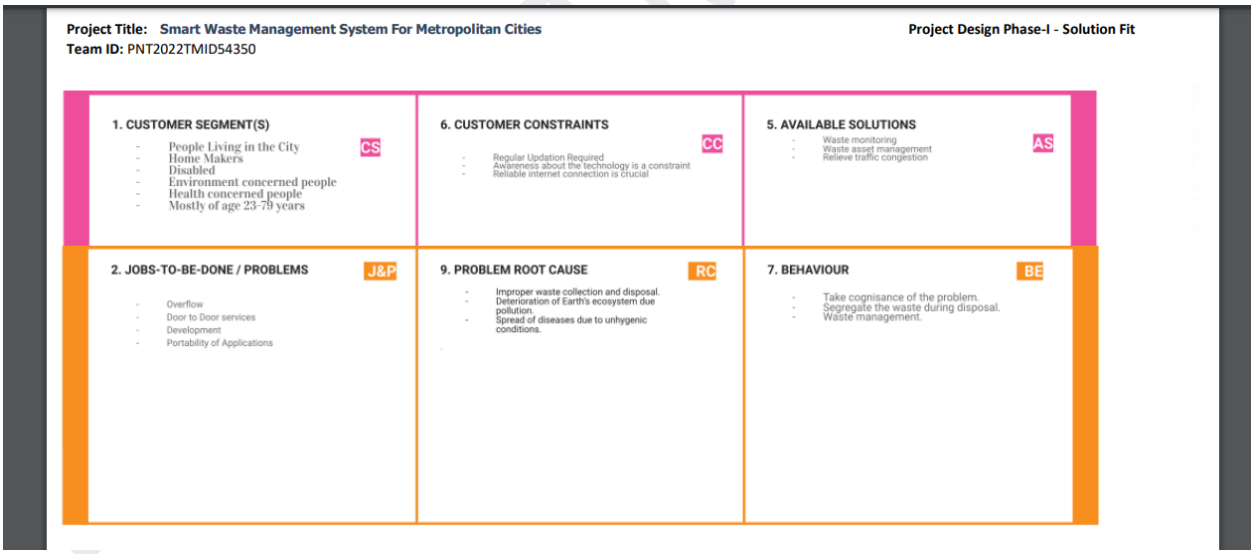
3.2 Ideation & Brainstorming

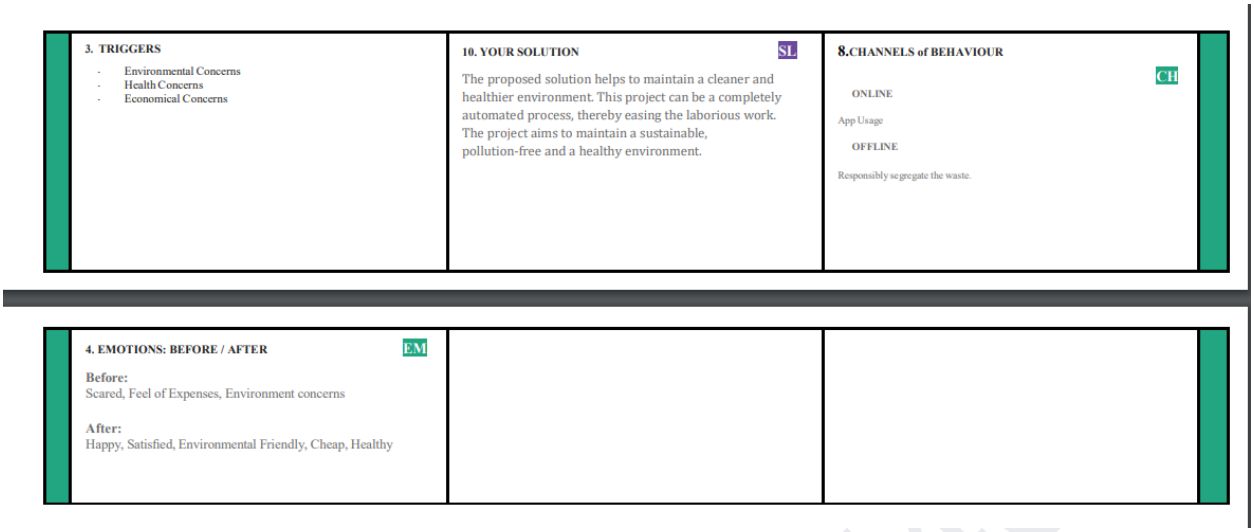


3.3 Proposed Solution

The proposed solution helps to maintain a cleaner and healthier environment. This project can be a completely automated process, thereby easing the laborious work. The project aims to maintain a sustainable, pollution-free, and healthy environment.

3.4 Problem Solution Fit





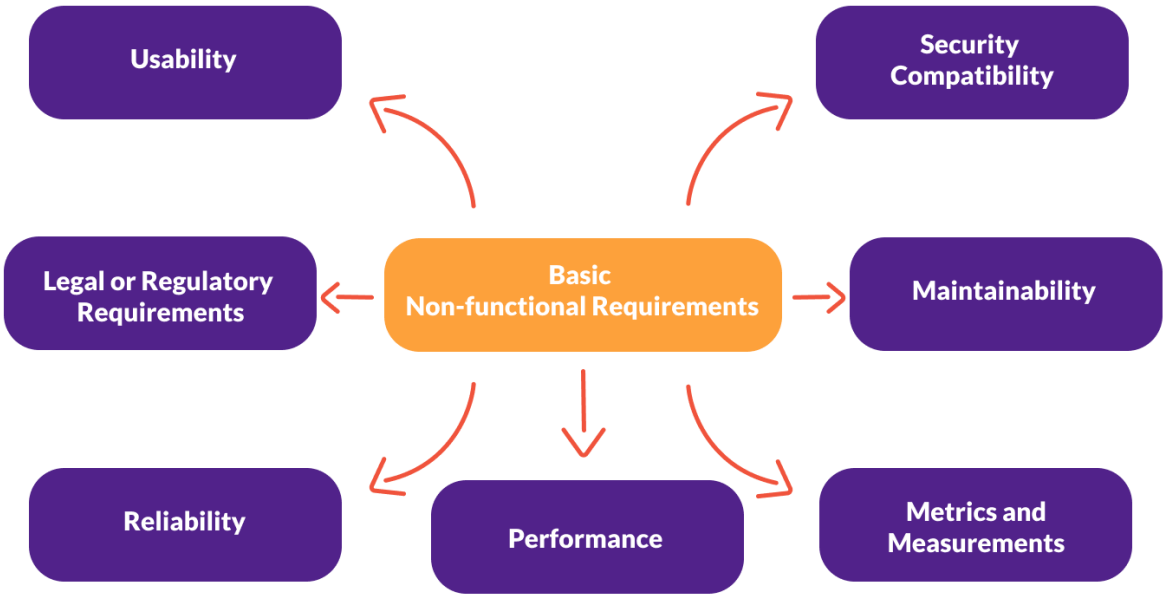
4. REQUIREMENT ANALYSIS

4.1 Functional Requirement

From the user's point of view, the functional requirement of the user has two most important dimensions, which are registration and confirmation. Users can register through their Mail ID and Phone number. User registration is confirmed via One Time Password and via E-mail. After the registration is confirmed, the user will be able to login into their account by entering the required data. If necessary, the required data like the username and password can be saved on the login screen. Based on the present map views, the system updates the real-time information using GPS and the user can view the status of the smart bin, and the location of the smart bin is also updated by the system. The location of the garbage truck can also be obtained by the user using this technology. The functioning of the system is predominantly based on the sensor circuit which detects the volume and transfers the data to the database. The data transferred is used to identify the garbage available for practically improving the waste collection and management method which satisfies our primary objective.

4.2 Non-Functional Requirements

The project was developed by considering the non-functional requirements such as usability, security, reliability, performance, availability, and scalability. The features such as portability and the provision of easy updates contribute to the usability requirement. When it comes to the security feature of the system, the registered mobile number or E-mail address gets the one-time password with which the system can be accessed. Reliability is ensured by identifying the level and volume of the garbage present in the bin. This project is environmentally responsible and sustainable. This technology is easily accessible and can be extended to each and every part of the country.

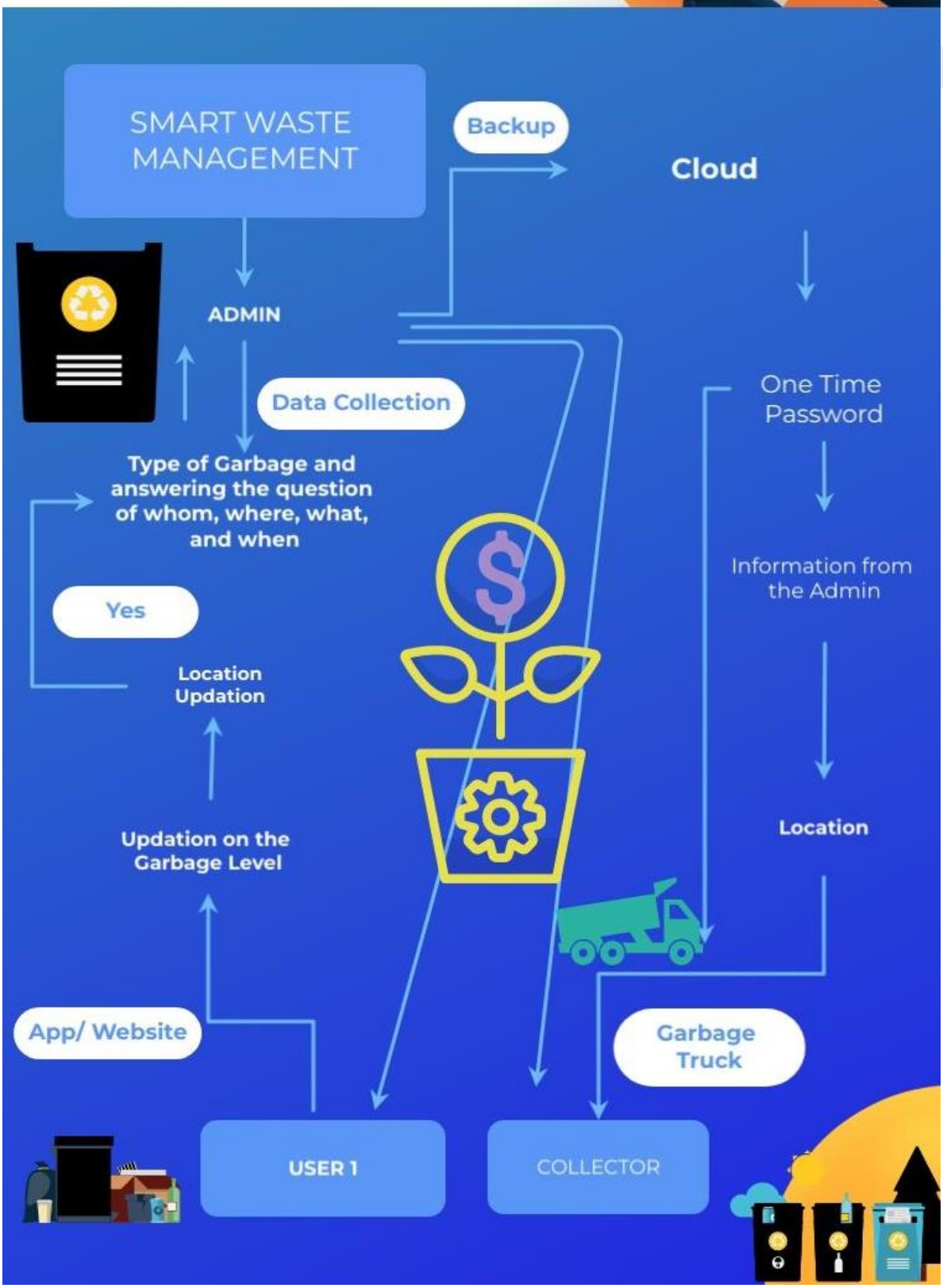


5. PROJECT DESIGN

5.1 Data Flow Diagrams

Smart Waste Management System in Metropolitan Cities

PNT2022TMID54350



5.2 Solution & Technical Architecture

5.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Resident(General Public User)	Login	USN – 1	As a Resident, I install the app, give in my information and segregate different kinds of waste in the entrance to make sure the collector takes it or notifies the collector in case of excess presence of wastes in a bin during segregation.	I segregate waste and update my app on a regular basis.	High	Sprint-1
Authorized Person (Manages Web app)	Login	USN – 2	As an Authorized Person, I give a **user id** and **password** for every worker and manage the overall technological work.	I can access main user information and use many other management of technical and administrative part of the webpage and Web-App.	Medium	Sprint-2

Admin	Login	USN - 3	As an Admin, I will manage **garbage level monitor**. When garbage gets filled alert, I will post the location and garbage Id to the trash truck.	I can manage monitoring the garbage in trash cans.	High	Sprint-1
Truck Driver	Login	USN – 4	As a Driver, I'll follow the route sent by the administrator/ app that notifies the full bin to reach the filled garbage **location**.	I can manage time and reach the required destination in the shortest route.	Medium	Sprint-2
Collector Service -Man	Login	USN – 5	As a Collector Service Man, I'll collect all the garbage from houses as a **door-to-door service man** and load it to the vehicle where the waste is segregated and send them to the required landfill.	I am able to pull a truck and collect trash.	Medium	Sprint-2
Local Authorities	Login	USN - 6	As a local Authoritative person, I'll check the process and it is happening in a correct and **well-disciplined** manner.	I will be able to keep the process to run smoothly.	High	Sprint-1

6. PROJECT PLANNING & SCHEDULING

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	Literature survey regarding the opted project & required information was gathered by referring technical papers, research publications, journals, etc.,	9 SEPTEMBER 2022
Prepare Empathy Map	Prepare an empathy map to identify and correct the constraints involved and increase the efficiency of the project.	11 SEPTEMBER 2022
Ideation	Team members' ideas were brainstormed and a solution arrived with a consensus.	19 SEPTEMBER 2022
Proposed Solution	The solution was framed by including the novelty, business(revenue) model, customer satisfaction and social impact, and several other parameters.	28 SEPTEMBER 2022

Problem Solution Fit	Problem's cause was identified and the solution was prepared by analyzing various parameters.	07 OCTOBER 2022
Solution Architecture	The architecture required for the solution model is prepared as a document.	10 OCTOBER 2022

Customer Journey	Customer journey document was prepared to understand the user interactions.	15 OCTOBER 2022
Functional Requirement	The functional and non-functional requirements of the proposed solution are defined.	16 OCTOBER 2022
Data Flow Diagrams	A data flow diagram is constructed to represent the information flow inside a system.	18 OCTOBER 2022
Technology Architecture	Technology architecture diagram was prepared.	20 OCTOBER 2022
Prepare Milestone & Activity List	Milestones reached and the activities performed were prepared as a list.	29 OCTOBER 2022

Project Development – Delivery of Sprint-1, 2, 3 & 4	Develop & submit the developed code by testing it.	14 NOVEMBER 2022

6.1 Sprint Planning & Estimation

Product Backlog, Sprint Schedule, and Estimation (4 Marks)

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Login	USN-1, USN-2	With an Executive's perspective, one would be giving User ID and a One Time Password for each and each and every registered worker. The waste is monitored and managed by real time control system and application. The volume is updated and notified.	20	High	Jayashri. B
Sprint-2	Dashboard	USN-3	With a Truck Driver's view, One would be following the Admin's Instruction to reach the filling bin and save time, hence producing a cheaper mode of collection.	20	Low	Charulatha. T. S
Sprint-3	Dashboard	USN-4	With a Local Collector's perspective, one would gather all the waste, load it into the truck, and deliver it to the required place.	20	Medium	Aarthy. D
Sprint-4	Dashboard	USN-5	With an Office's perspective, one would make sure everything is progressing as planned and makes sure it moves without any problem.	20	High	Ananya. M

6.2 Sprint Delivery Schedule

Project Tracker, Velocity & Burndown Chart: (4 Marks)

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

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

7.1 Feature 1

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

float temp;
int tempPin = A1;
int relayPin = 8;
int ledPin = 13;
int pirPin = 7;
int pirStat = 0;
#define fan 9

void setup(){
   pinMode(ledPin, OUTPUT);
   pinMode(pirPin, INPUT);
   Serial.begin(9600);
   pinMode(fan, OUTPUT);
   pinMode(relayPin, OUTPUT);

   lcd.begin(16, 3);

   lcd.setCursor(1, 1);
   lcd.print("PNT2022TMID54350");
   delay(1000);
   lcd.clear();
   lcd.setCursor(3,0);
   lcd.print("54350");
   delay(1000);
```

```
  lcd.clear();
  lcd.print("Lets Get Started");
  delay(2000);
  lcd.clear();
  lcd.print("Updating Collector and Admin");
  delay(2000);
  lcd.clear();

}
void poweronRelay()
 {
  digitalWrite(relayPin, HIGH);
  lcd.print("Updating Collector");
  delay(2000);
  lcd.clear();
 }

void poweroffRelay()
 {
  digitalWrite(relayPin, LOW);
  analogWrite(fan,0);
  lcd.print("Garb Fill-20%");
  delay(2000);
  lcd.clear();
 }
//only after signal is detected form pir sensor,
//the temp sensor will detect the temp and turn on the motor(fan)

void loop()
{
 pirStat = digitalRead(pirPin);
 if (pirStat == HIGH) {

  digitalWrite(ledPin, HIGH);
  Serial.println("Detected");
  lcd.setCursor(3,0);
  lcd.print("Recording");
  lcd.setCursor(2, 1);
  lcd.print("Garbage..");
  delay(3000);
  lcd.clear();
  lcd.setCursor(0,2);
  temp = analogRead(tempPin);
```

```
float voltage = temp * 5.0;
  voltage /= 1024.0;


  lcd.print(voltage); lcd.println(" volts");


  float temperatureC = (voltage - 0.5) * 100 ;

lcd.setCursor(0, 0);
lcd.print("Filled: 20 ");
lcd.setCursor(2,1);
//lcd.print(temp);
lcd.print(temperatureC); lcd.println(" Filled: 20%");
delay(3000);
lcd.clear();

if(temperatureC >= 20)
{
  poweronRelay();
  if(temperatureC >= 20 && temperatureC <= 25)
  {
    analogWrite(fan,51);
    lcd.print("Filled: 20% ");
    delay(2000);
    lcd.clear();
  }
else if(temperatureC <= 35)
  {
    analogWrite(fan,102);
    lcd.print("Filled: 40% ");
    delay(2000);
    lcd.clear();
  }
 else if(temperatureC <= 40)
  {
    analogWrite(fan,153);
    lcd.print("Filled: 60% ");
    delay(2000);
    lcd.clear();
  }
 else if(temperatureC <= 44)
```

```
    {
      analogWrite(fan,200);
      lcd.print("Filled: 80% ");
      delay(2000);
      lcd.clear();
    }
   else if(temperatureC >= 45)
    {
      analogWrite(fan,255);
      lcd.print("Filled: 100% ");
      delay(2000);
      lcd.clear();
    }
  }
  else if(temperatureC < 20)
  {
    poweroffRelay();
  }


 }
 else {
  digitalWrite(ledPin, LOW);
  Serial.println("Collector Notified");
  poweroffRelay();
}

}
```

8. TESTING

8.1 Test Cases

Section	Total Cases	Not Tested	Fail	Pass
Overall Process	4	0	0	4
Client Side	45	0	0	45
Security and User Information Protection	3	0	0	3
Outsource Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Report Output	5	0	0	5
Version Control and Updation	2	0	0	2
Adaptation	2	0	0	2

8.2 User Acceptance Testing

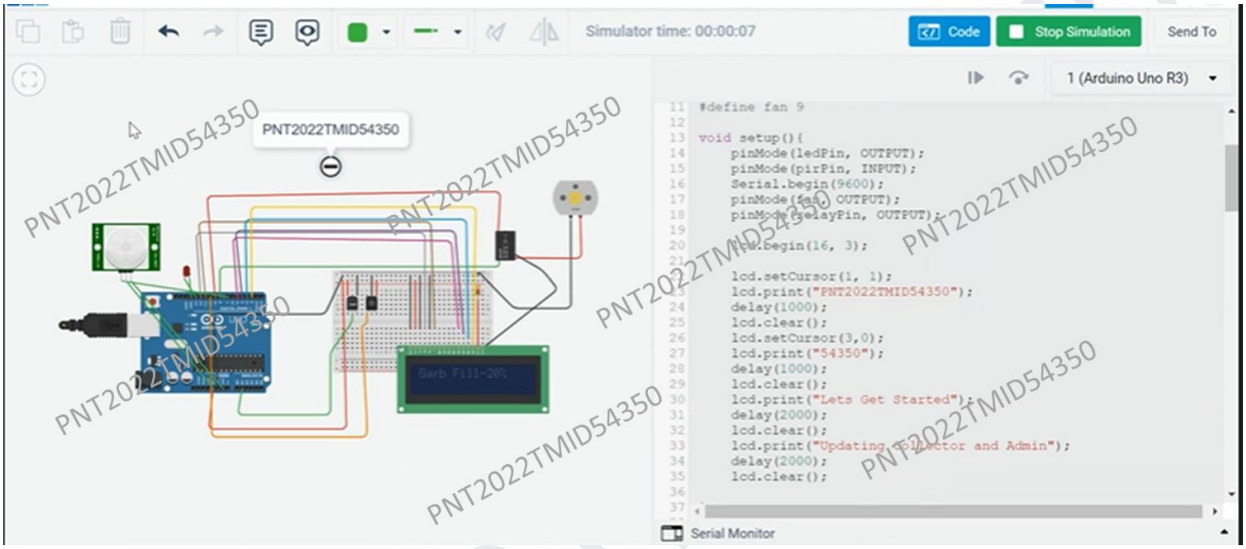
Survey was taken, the recording is attached with the video.

Section	Satisfied	Dissatisfied	No Comments	Score
Use - Easiness	7	1	2	10
Reliability	8	1	1	10
Security	8	2	0	10
Availability	3	2	5	10
Performance	9	0	1	10
Scalability	5	2	3	10

Adaptation	4	2	4	10

9. RESULTS

9.1 Performance Metrics



10. ADVANTAGES & DISADVANTAGES

Advantages

The advantage of using this system is that it overcomes the health and environmental hazards of improper waste management processes to a certain extent. This cannot be the only solution but one of the solutions to sustainable development. The use of solar panels to produce the required energy can be of great use as it is not a renewable resource, but it powers the sensor for detection and the IoT Devices present in the Truck for real-time GPS Tracker. This system is cheap and very efficient. The door - to door collection also helps the differently abled to manage the waste properly. The utilization of simple everyday gadgets makes it easy to understand for the customers to completely use the product. Anyone from age 5-90 can use the product. This is not the restriction that is mentioned but the ease and comfort of the app for all ages. One of the main advantages is that

awareness is created among the users. They come to know about the anthropocentric character that degrades the environment to a great level and in turn affects health. This acts as a change or at least a motivation to a certain extent to support, love and care for mother Earth which has done everything to satisfy our needs and all we do is degrade it. But it's time we repay it, help her and stop the antagonist's torture, and live happily.

Disadvantages

If something has a lot of positive effects there would be something negative. Nothing can be perfect or in an ideal condition. All we can do is satisfy a certain level and make it more advantageous than considering the disadvantages. One of these kinds is the adaptation to the new technology would take a lot of time to get accustomed to as a daily life habit. Another disadvantage is considering security. Well-secured information for the user will cost a lot and would make the project a more reliable one, as the user's personal information is collected, it is the owner's responsibility or the creator's responsibility to make it with a desirable or highly secured system. Considering the high competition in this market, the initial cost would be high. Investing in a good cause makes us satisfied. Investing in a profitable system makes us innovate more but the drawback is that in the initial stages a very high amount is expected or compelled to be spent to market or advertise the product.

11. CONCLUSION

A proper waste management system is essential for sustainable development. This would be a small step towards a developing nation overcoming the limitations of waste management. This step secures us from the environmental and health hazards that are being induced as a slow poison is interrelated. The technology in this period of the 21st century refines us and the surroundings to a better persona and a better place to live. It is the time when we have to bring in change and portray respect, love and care toward the beings that have helped us for our survival. There is a solution. And, this Project is just one very small part of it.

12. FUTURE SCOPE

There isn't any dead end for innovation. Either it branches out to a new one or it is sculpted for a particular application that adapts to the technology at the time. These are dependent on the trend of technology - The use of new software, and the utilization of new hardware that has come to the market. The future scope for this project is the use of an alternate source of energy. Even though the system uses solar energy, which is a renewable source of energy, but, during rainy days, constant energy support is required. The piezo-electric power supply can be one of the alternative energy sources to power up the instruments. The parallel recycling process means a way of collecting different types of waste - that is e-waste, plastic waste, medical waste, food waste, and many more. The biodegradable wastes can be used as compost. Vermicompost - compost that is made with the

help of earthworms. This can be distributed either to the area of residence or given to the farmers in need, in turn producing a sustainably developed model.

13. Appendix

GitHub Link:
https://github.com/IBM-EPBL/IBM-Project-40842-1660636576

Project demo link:
https://github.com/IBM-EPBL/IBM-Project-40842-1660636576/tree/master/Final%20Deliverables

Presentation Link:
https://docs.google.com/presentation/d/1jlu7F14S8wy3emO5gpaH3o6KGKJzS8YayGTs_7tgzDI/edit#slide=id.gf65337d18e_0_185