A Minor Project Report on

Smart Waste Management System

Submitted in Partial Fulfillment of the Requirements for the Degree of

Bachelor's Of Engineering In Computer Engineering under

Pokhara University

Submitted by:

Ashesh Shrestha, 161310

Wachaspati Arya, 161340

Alaka Shrestha, 161305

Under the Supervision of:

Er. Chandra Dev Singh

Date:

9-Jan -2020

Nepal College of Information Technology

Affiliated to Pokhara University

Acknowledgement

First of all, we are extremely thanks to the Department of Computer Engineering, Nepal College of information Technology for accepting our project proposal “Smart Waste Management System” and granting the opportunity for the completion of the work undertaken.

Our heartfelt gratitude goes to supervisor Er. Chandra Dev Singh, without whose support, invaluable guidance, patience and trust this paper would not have been produced in this shape. We would like to express our sincere gratitude to HOD Er. Resha Deo, for his encouragement and support. Our special appreciation goes to Dr. Roshan Chitrakar, Project Coordinator for his help and invaluable suggestions at various stages of this work.

Last, but not the least, it would be unfair on our part if we do not express our heartfelt thanks to all the staffs of the department and friends, for sharing their good collection of resources, discussing our ideas as well as mutual technical support.

Ashesh Shrestha

Wachaspai Arya

Alaka Shrestha

Abstract

With the increasing population and industrialization of nations throughout the globe, waste has become a great concern for all of us. Over years, researchers figured that only waste management is not enough for its proper treatment and disposal techniques to preserve our environment and keeping it clean in this era of globalization. With the help of technology research we have introduce "*Smart Waste Management System*" and initiatives that ensures reduced amount of time and energy required to provide waste management services. In the present day scenario, many times we see that the garbage bins or Dust bin are placed at public places in the cities are overflowing due to increase in the waste every day. It creates unhygienic condition for the people and creates bad smell around the surroundings this leads in spreading some deadly diseases & human illness, to avoid such a situation we are planning to design "*Smart Waste Management System*". In this proposed System there are multiple dustbins located throughout the city these dustbins are provided with low cost embedded device which helps in tracking the level of the garbage bins and an unique ID will be provided for every dustbin in the city so that it is easy to identify which garbage bin is full. When the level reaches the threshold limit, the device will transmit the level along with the unique ID provided. These details can be accessed by the concern authorities from their place with the help of Internet and an immediate action can be made to clean the dustbins

Keywords:- Smart, Dustbin, Waste, Unique Id, Tracking, Authorities etc.

Contents

List of Figure

List of Table

1 Introduction

Garbage consists of the unwanted material left over from Public area, Society, College, home. This system "Garbage Monitoring System" is motivated by Swachh Bharat Abhiyan Government of India. This System will help to minimize the garbage disposal problem. Garbage Monitoring is a very innovative system which will help to keep the cities clean. This system monitors the garbage bins and informs about the level of garbage in the garbage bins via Android Application. For this, the system uses ultrasonic sensors placed over the bins to detect the garbage level and compare it with the garbage bins depth. The system makes use of GPS and Node MCU Esp8266(wi-fi) for sending data to the cloud. An Android Application is used to view the level of waste in the bins. The Application gives the Location of the garbage bins and highlights the marker when the bin is full.

1.1 Problem Statement

A big challenge in the urban cities is solid waste management. The garbage collecting authority in traditional waste management system doesn't know about the level of garbage in dustbin, if the dust bins gets full by garbage then it gets overflowed as well as spelled out from the dustbin leading to unhygienic condition in cities. People throw garbage on that dustbin which is already overflowed. Sometimes due to unclean garbage bins bad smell arises also toxic and unhygienic gases are produced which is way to support to the air pollution and to some harmful diseases which are easily spreadable. It is very bad look of the city. Use of traditional system result in inefficient and time and money spending system.

1.2 Objective

- To automate the solid waste monitoring process and management of the overall collection process using IOT (Internet of Things).
- To design subsystems namely Smart Trash System(STS) and Smart Monitoring and Controlling Hut(SMCH).
- In the proposed system, whenever the waste bin gets filled this is acknowledged by placing the circuit at the waste bin, which transmits it to the receiver at the desired place in the area or spot.
- In the proposed system, the received signal indicates the waste bin status at the monitoring and controlling system.
- In the proposed system, it would be able to configure the smart(shortest) route for collecting the garbage from the container.

1.3 Significance of the study

With the web application, the administrator will be able to search for dustbins. The result will be based on the criteria the user inputs. There are several search criteria and it will be possible for the administrator of the system to manage the options for those criteria that have that. The result of the search will be viewed either in a list view or in a map view, depending on what criteria included in the search. The list view will have one list item for each dustbin matching the search criteria and show a small part of the dustbin information so the user can identify the dustbin. The administrator will be able to either select a dustbin as target destination or get information how to get there, or view the information of a specific dustbin.
The web portal will provide functionality to manage the system and the dustbin information. It will also provide information about the system

1.4 Scope and Limitation

1.4.1 Scope:

The scope of the proposed project is to maintain and monitor the solid waste of the town by the help of website dash board and also help to track the waste level of the city. And also provide the activeness of Waste management workers.

- This project helps to monitor the level of solid waste remotely and help to notify the worker for instance of waste level which provide greater accessibility to the dustbin.
- It provides location of dustbin to the user which are recorded in the database.
- It provides smart route for the garbage collector van which leads to reduction of fuel consuming and effective work.
- Provide work tracking platform for the workers.
- This project helps to maintain our city clean and minimize the pollution.

1.4.2 Limitations:

- Dustbin requires Wi-Fi network to upload the data to database. So Internet facility is required for each and every dustbin.
- Sometimes garbage indicator may indicate wrong value due to linear reading of ultrasonic sensor.
- Durability of the project is low on the hardware side.

2 Literature Review

There are different company and individual team which are contributing in the similar waste management project. Where some of the project has more functionality and some of the project has more limitation. After some research we found some similar task project and website which provide similar feature equipment.

2.1 Fohor Malai

FoharMalai is a Startup Based on Waste management & integrated environmental solutions in Nepal. We have invested in developing waste solutions for a changing world. Today, this includes not just disposal and recycling, but personal counseling to help customers achieve their green goals, including zero waste.

Fohor Malai recover the energy from the waste, called WTE(waste to energy).With the sensor based network of recycling facilities, our entire business can adapt to meet the needs of every distinct customer segment. As Startup, our motto is to maximize resource value while minimizing impact in order to further both economic and environmental sustainability for all human.

"From everyday collection, to environmental protection, think green. Think Waste Management."

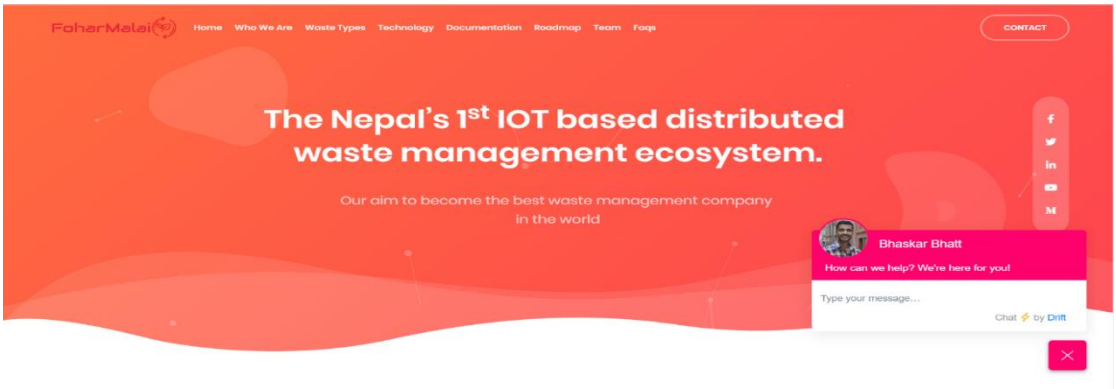


Figure 1 : Fohor Malai Website

2.2 Smartbin

SmartBin have established themselves as the leader of Intelligent Remote Monitoring Systems for the waste & recycling sectors. With over 100 clients across the globe, that include both private and public collectors of waste and recyclables and distributors of fresh oil and lubricants, SmartBin have the solution, expertise, and experience to optimize any manner of collection or distribution operation. In June 2016 SmartBin was acquired by OnePlus Systems Inc., a portfolio company of Parker Gale, LP, and the world leader of Intelligent Monitoring for the waste compactor industry.

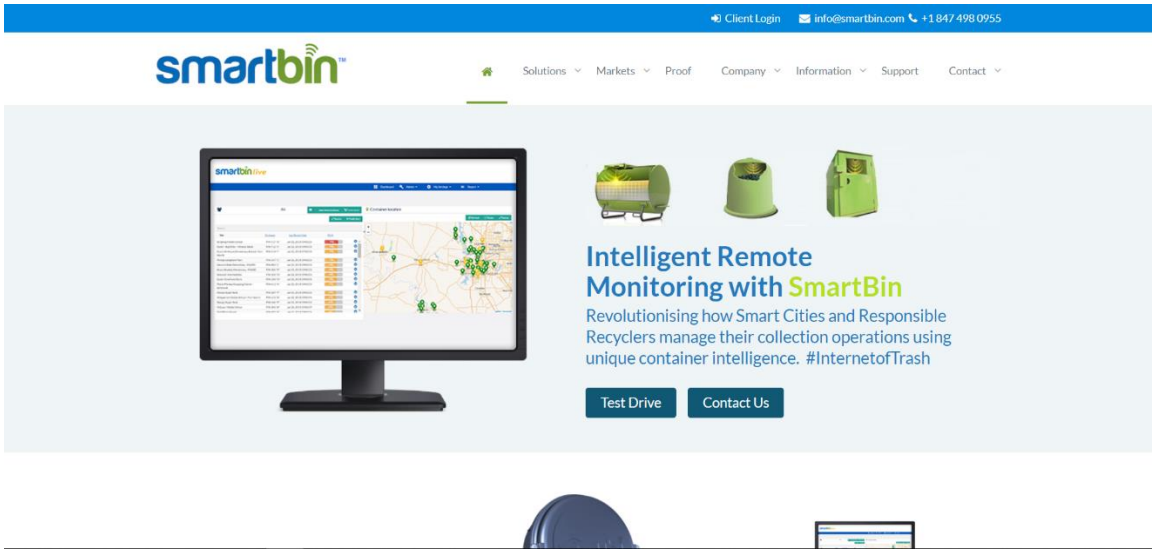


Figure 2:Smartbin website

2.3 SENSONEO(Manage Waste Smarter)

Sensoneo is a global enterprise-grade smart waste management solution provider that enables cities and businesses to manage their waste cost-efficiently, be more environmentally responsible and improve the well-being of people.

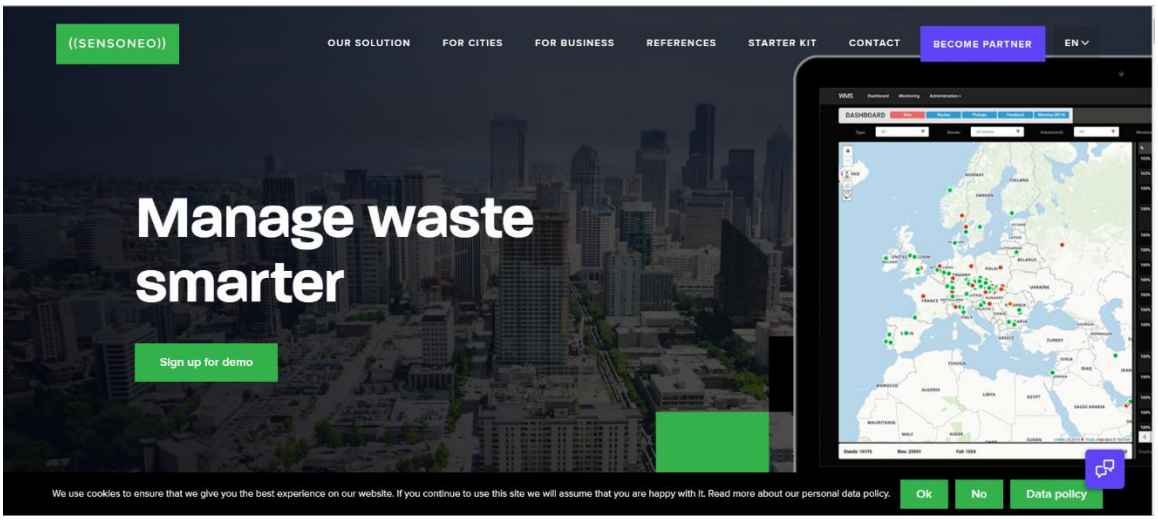


Figure 3:Sensoneo website

3 Methodology

3.1 Software Development Process:

The framework we propose in development of this software is "incremental model", i.e. a method for software development where the product is designed, implemented, and tested incrementally. This model combines the elements of waterfall model with iterative philosophy of prototyping i.e. multiple development cycles take place here, making the life cycle a multi-waterfall cycle. In Incremental Model the whole requirement is divided into various builds.

When an incremental model is used, the first increment is often a core product. That is, basic requirements are addressed, but many supplementary features (some known, others unknown) remain undelivered. The core product is used by the customer (or undergoes detailed review). As a result of use and/or evaluation, a plan is developed for the next increment. The plan addresses the modification of the core product to better meet the needs of the customer and the delivery of additional features and functionality. This process is repeated following the delivery of each increment, until the complete product is produced.

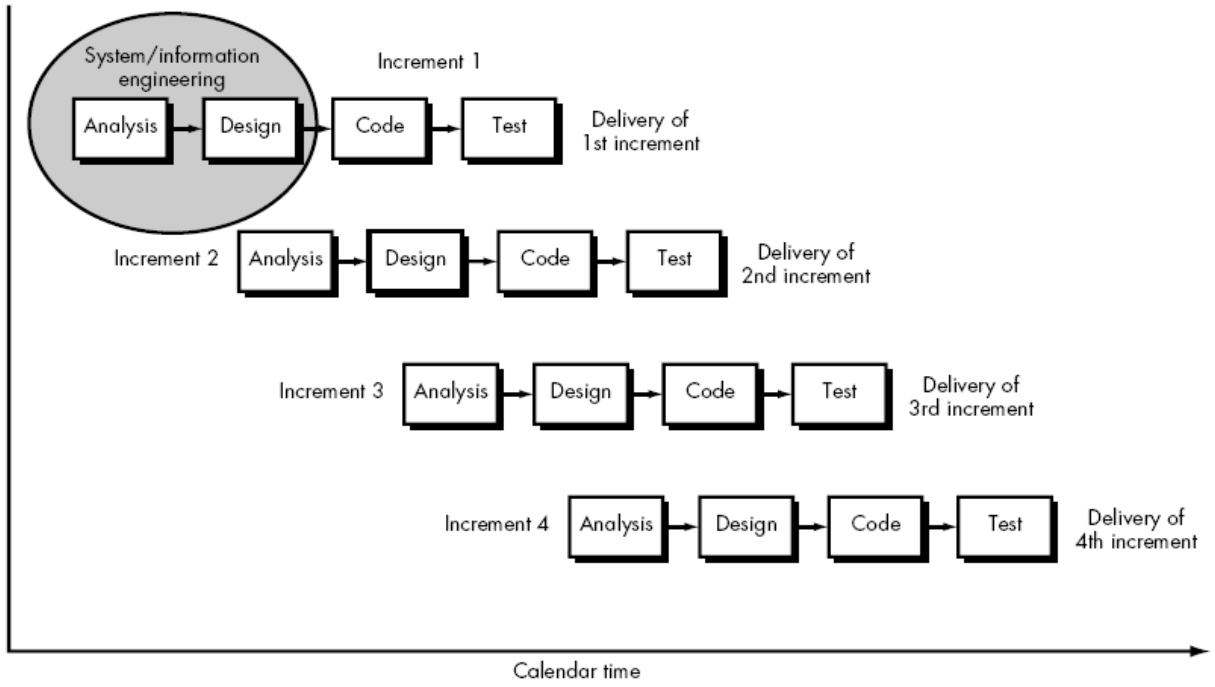


Figure 4:Incremental Model

3.2 Software Interface:

3.2.1 Arduino IDE:

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board. It contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus.

3.2.2 WebServer:

A Web server is a program that uses Hypertext Transfer Protocol to serve the files that form Web pages to users, in response to their requests, which are forwarded by their computers' HTTP clients. Dedicated computers and appliances may be referred to as Web servers as well.

3.3 Front end Technologies:

3.3.1 HTML5:

HTML5 is a markup language used for structuring and presenting content on the World Wide Web. It is the latest and most enhanced version of HTML.

3.3.2 CSS3:

Cascading Style Sheets (CSS) is a style sheet language used for describing the look and formatting of a document written in a markup language.CSS3 is a latest standard of CSS.

3.3.3 Javascript:

JavaScript is a full-fledged dynamic programming language that, when applied to an HTML document, can provide dynamic interactivity on websites.

3.3.4 JQuery:

JQuery is a cross-platform JavaScript library designed to simplify the client-side scripting of HTML. JQuery is the most popular JavaScript library in use today.

3.4 Back end Technologies:

3.4.1 Django:

The project is planned to make using Django which is a python web-based framework.

3.4.2 MySql:

MySQL is an open-source relational database management system (RDBMS).It is very fast, reliable, and easy to use.

3.5 Project Management Tools:

3.5.1 Trello:

Trello is the fun, flexible, and free way to organize plans, projects and more. Access from Anywhere. Connect Other Apps. Plan with Teammates

3.5.2 GitHub:

GitHub is a web-based version-control and collaboration platform for software developers. *GitHub*, which is delivered through a software-as-a-service (SaaS) business model, was started in 2008 and was founded on Git, an open source code management system created by Linus Torvalds.

3.6 Project Design Tools:

3.6.1 Draw.io :

It is the simple and powerful tools to design the system architecture and overview which helps the developer focused on the particular task.

3.7 Hardware Interface:

3.7.1 Arduino Uno:

Arduino Uno is a micro controller board. It has 14 digital input/ output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the micro controller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

3.7.2 Ultrasonic Sensor:

The Ultrasonic Sensor sends out a high-frequency sound pulse and then times how long it takes for the echo of the sound to reflect back. The sensor has 2 openings on its front. One opening transmits ultrasonic waves, (like a tiny speaker), the other receives them, (like a tiny microphone).The speed of sound is approximately 341 meters (1100 feet) per second in air. The ultrasonic sensor uses this information along with the time difference between sending and receiving the sound pulse to determine the distance to an object.

3.7.3 Wi-Fi Module – ESP8266:

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any micro controller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers.

Breadboard: A breadboard is a construction base for prototyping of electronics. In the 1970's the solder less breadboard (AKA plug board, a terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these. "Breadboard" is also a synonym for "prototype". Because the solder less breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design.

JUMPER WIRES: A jump wire is an electrical wire or group of them in a cable with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

4 System Architecture

A three-tier architecture is a client-server architecture in which the functional process logic, data access, computer data storage, and user interface are developed and maintained as independent modules on separate platforms. A three-tier architecture is a software design pattern and well-established software architecture. The three-tier architecture allows any one of the three tiers to be upgraded or replaced independently. The user interface is implemented on Android devices and uses a standard graphical user interface with different modules running on the web server. The relational database management system on the database server contains the computer data storage logic. The middle tiers are usually multi-tiered. It involves the client tier, application tier, and database tier.

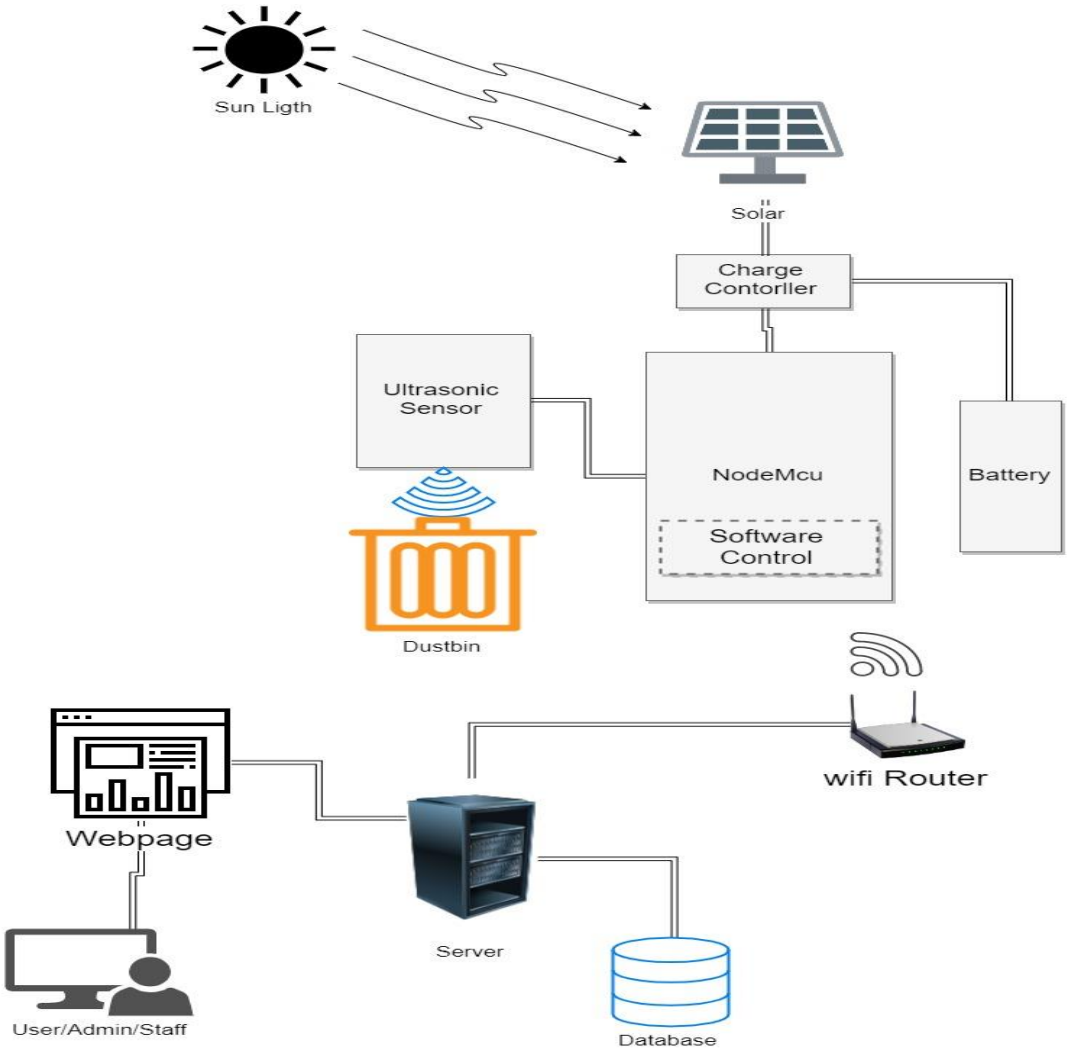


Figure 5: Architectural Design of Smart Waste Management System

4.1 How the system works?

The system monitors the garbage bins and informs about the level of garbage collected in the garbage bins via a web page.

Website is developed

Ultrasonic sensor is placed over the bin to detect the garbage level of the bin

This sensor feeds data about the status of the garbage to the Arduino/NodeMcu

ESP8266 SoC is connected to the Arduino (Inbuilt ESP8266 in NodeMcu)

Connection between the website and the Wi-Fi module Arduino is made so as to transmit information to the website through Internet connection

Whereas a web page is built to show the status to the user monitoring it

4.2 Dustbin Status indication:

4.2.1 Full Dustbin

Figure 6:Full Dustbin Image

Status: Full Dustbin

Height: <75%

Color: Red

4.2.2 Half Dustbin

Figure 7:Half Dustbin

Status: Half Dustbin

Height: 75> and <25%

Color: Orange

4.2.3 Empty Dustbin

Figure 8 Empty Dustbin Image

Status: Empty Dustbin

Height: <10%

Color: Green

4.2.4 Damage Dustbin

Figure 9:Damaged Dustbin Image

Status: Damage Dustbin

Height: >100%

Color: Black with Alert

4.3 Flow Chart of Dustbin Sensor

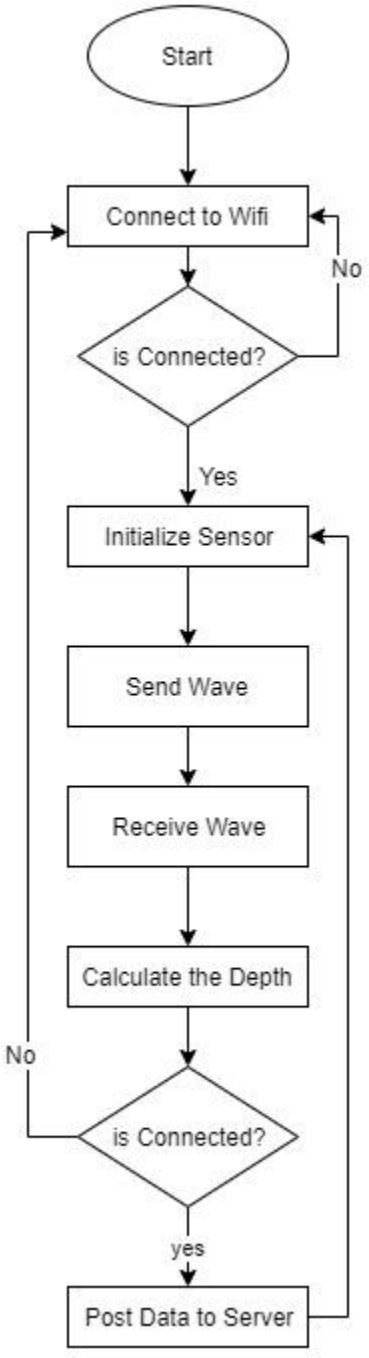


Figure 10: Flow Chart of Dustbin Sensor

4.4 Dustbin Sensor Working Principle

The ultrasonic sensor is used to check the level of waste inside the dustbins. A formula is used on the data collected by the HCSR04 (ultrasonic) sensor, to calculate the percentage fill of the dustbin. 3 cm is distance between sensor and the lid of bin maximum level can be considered as full. All calculations are in centimeter scale. *'G_c '*denotes the current garbage percentage (%) filled in respective Garbage bin. The Height of bin is a constant as per the dimension of the bin. The calculation of G_c(%) can be quantized as per the mathematical model given in (3) below:

$$Gc(\%) = \frac{[\,Height\ of\ bin - (distance - 3)]}{Height\ of\ bin} \times 100\% \quad \text{----------(3)}$$

The calculation of distance between the HCSR04 ultrasonic sensor and the surface level of garbage in the bin can be calculated by the mathematical model given in (4) as below.

$$\text{distance} = \left(\frac{Round\ Trip\ Time}{2}\right) \times \left(\frac{1}{Speed\ of\ Ultrasonic\ Wae}\right) \text{----------(4)}$$

The pseudo code for implementation is given as below: *Empty=d-3*

h-Empty=fill

*fill/h*100=Percentage of garbage filled*

duration = pulseIn(echoPin_G, HIGH);

distance = (duration/2) / 29.1;

*fillPercent= ((greenBin_height-distance)/greenBin_height)*100*

Figure 11 shows the ultrasonic sensor working. The trigger pin sends a very short 10 microsecond high pulse from TX and the RX receives that pulse with some delay after the ultrasonic signal bounce back from the surface of the waste bin. This round trip time (RTT) delay in time can be converted in to travelled distance by ultrasonic wave. This travelled distance when divided by 2 will give the distance between HCSR04 and the surface of garbage in waste bin.

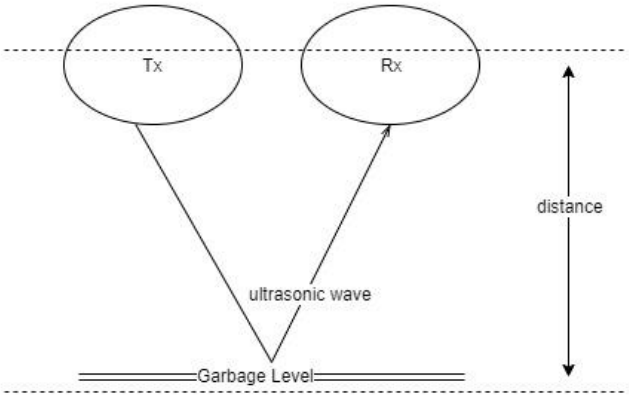


Figure 11 Finding the Garbage level using Trigger and echo signal HCSR04 Ultrasonic Sensor

This calculated percentage is sent to TrashCan cloud from where we can monitor the actual variation of data in graphical form graph and actual percentage of waste filled in the dustbin this monitoring helps to track and route the garbage collection trucks accordingly. The data gets updated on the cloud every 30 seconds.

4.5 Efficiency and Power Consumption of Dustbin Sensor

Not only working of the system is enough for the stable system. It should also durable and concrete on its architecture. By taking all the aspect of the system we should provide the long lasting sensor and long battery life of the sensor. To provide longer battery we have to calculate certain power consumption factor of the sensor.

Nodemcu power consumption = 0.1142 whr

For 24 hr a day = 0.1142*24=2.74whr

Ultrasonic Sensor consumption = 0.075whr

For 24 hr a day = 0.075*24 = 1.8 whr

Total load = (2.74+1.8) = 4.55 whr

Battery Voltage = 3.7 V

Battery Capacity = 3600mAh = 3.6mAh

Solar Charge controller = 4.5 V with 90% efficiency

Power Controller = 3.3V regulator with 85% efficiency

Charge Depth = 75%(maintain charge of battery)

Power Required = (0.90*0.85*0.75)*3.7*3.6 = 7.6423 whr

Cell Required = load/power = 4.55/7.6423 = 0.5953~1

Hence, from above calculation we can run our sensor all the year without draining its power below 75% we have to install 3.7 li-po battery to the sensor and 4.5 volt solar panel.

4.6 Hardware Cost

Parts	Cost(Rs)
NodeMcu x 1	500
Matrix Board x 1	10
Battery x 1	120
Solar Panal x 1	125
Ultrasonic Sensor x 1	225
Wires	80
Charge Controller x 1	120
Switch x 2	20
Others	100
Total	1300

Table 1:Hardware Parts Cost

4.7 Use Case Model

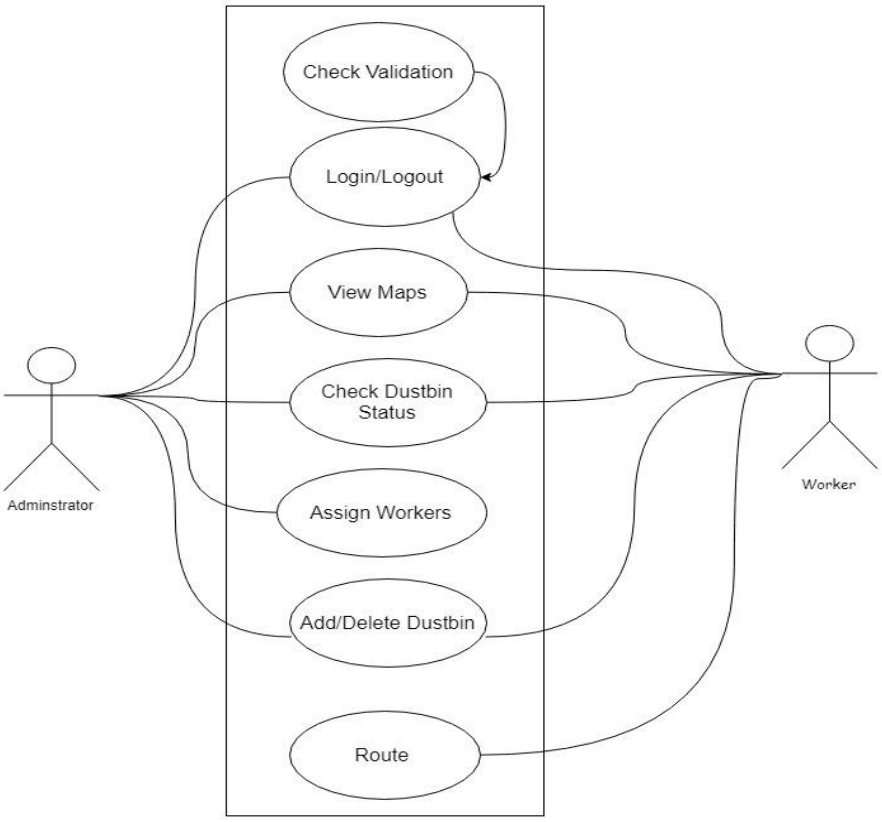


Figure 12: Use Case Diagram

Use Case 1: Login/Logout

Admin & Staff(worker) login and logout in the system. Only Admin can register and can alter the detail of any worker. Worker can only have permitted with their own profile.

Use Case 2: Validation

The admin can log in into the application by providing their username and password and if valid they can only use this web application and admin can register the sanitation staff details then only staff can log in into the application.

Use Case 3: View Map

Sanitation staff /admin able to view the map to get the level of garbage in the bin. This screen shows the garbage bin status.

Use Case 3: Check Dustbin Status

Sanitation staff /admin able to get the level of garbage in the bin. This screen shows the garbage bin status.

Use Case 4: Assign Workers

Sanitation staff /admin able to assign worker to particular area. And also can give the permission to worker to take care of the assigned area/street.

Use Case 5: Add/Delete Dustbin

Admin/staff both can install/create or delete the dustbin any place in his inherit location.

Use Case 7: Route

While doing his/her jobs to cleaning dustbins. Worker can create efficient route to track all full dustbin by the help of this system.

4.8 Data Flow Diagram

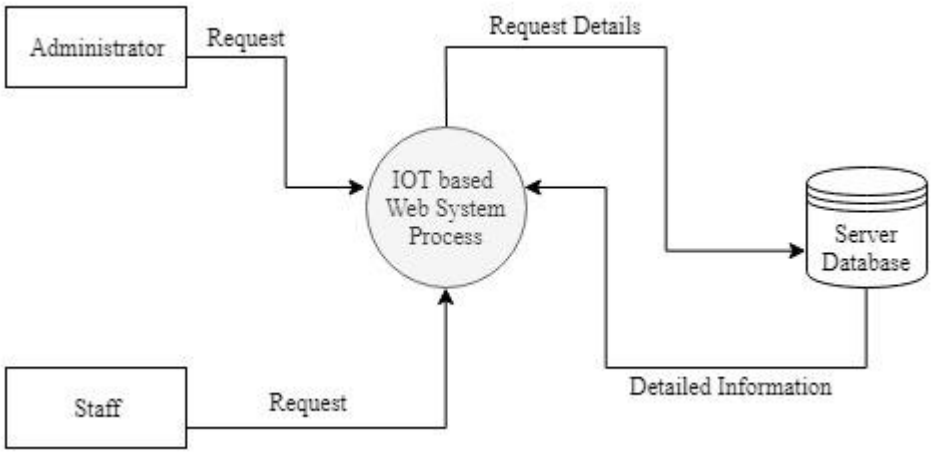


Figure 13: Level-0-DFD

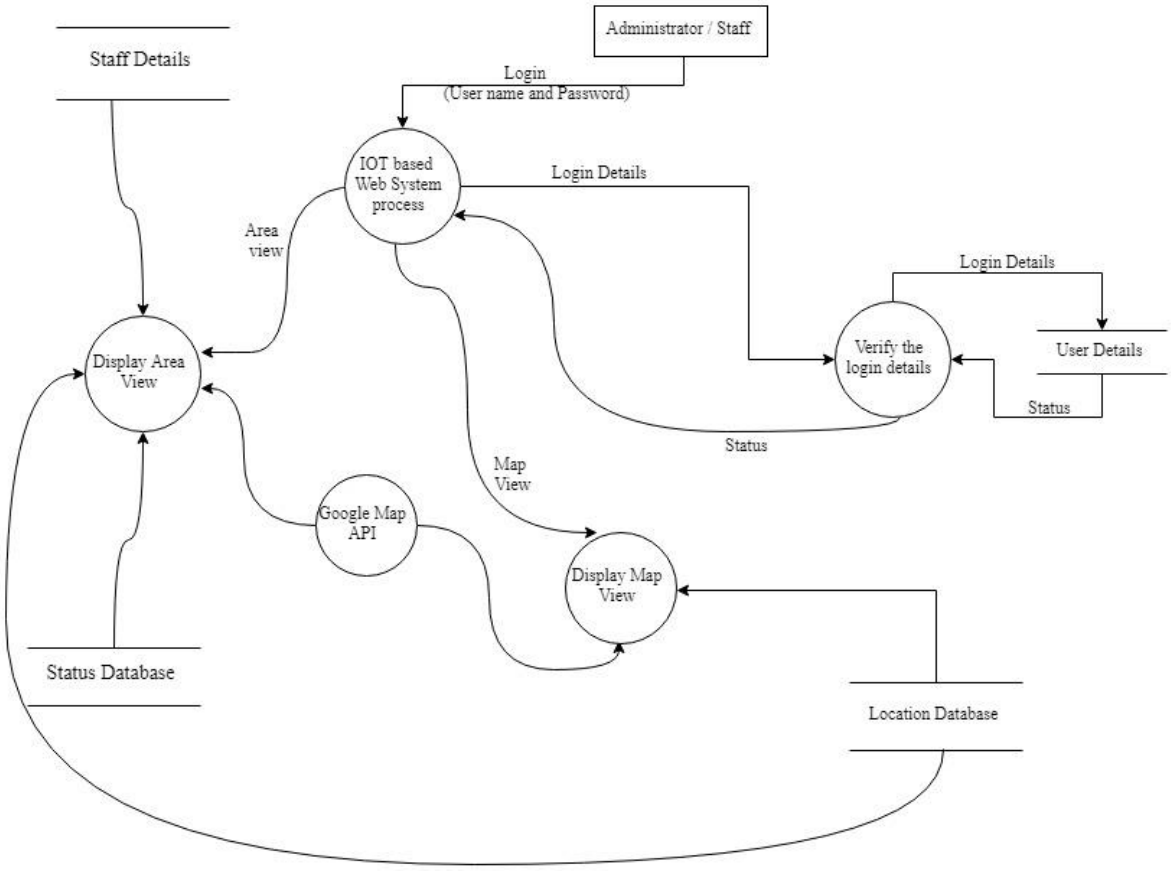


Figure 14: Level-1-DFD of Smart Waste Management System

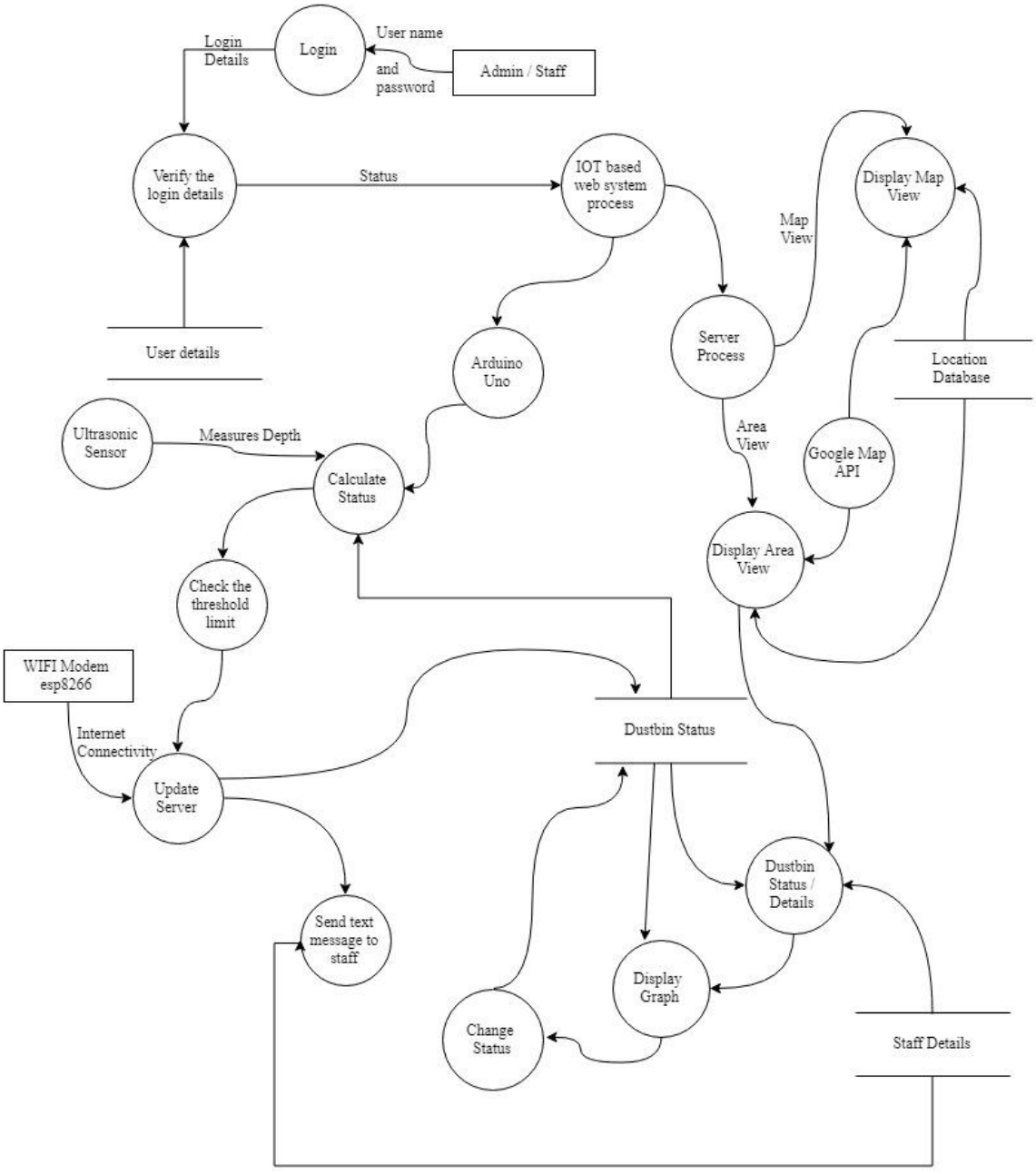


Figure 15: Level-2-DFD of Smart Waste Management System

4.9 ER Diagram

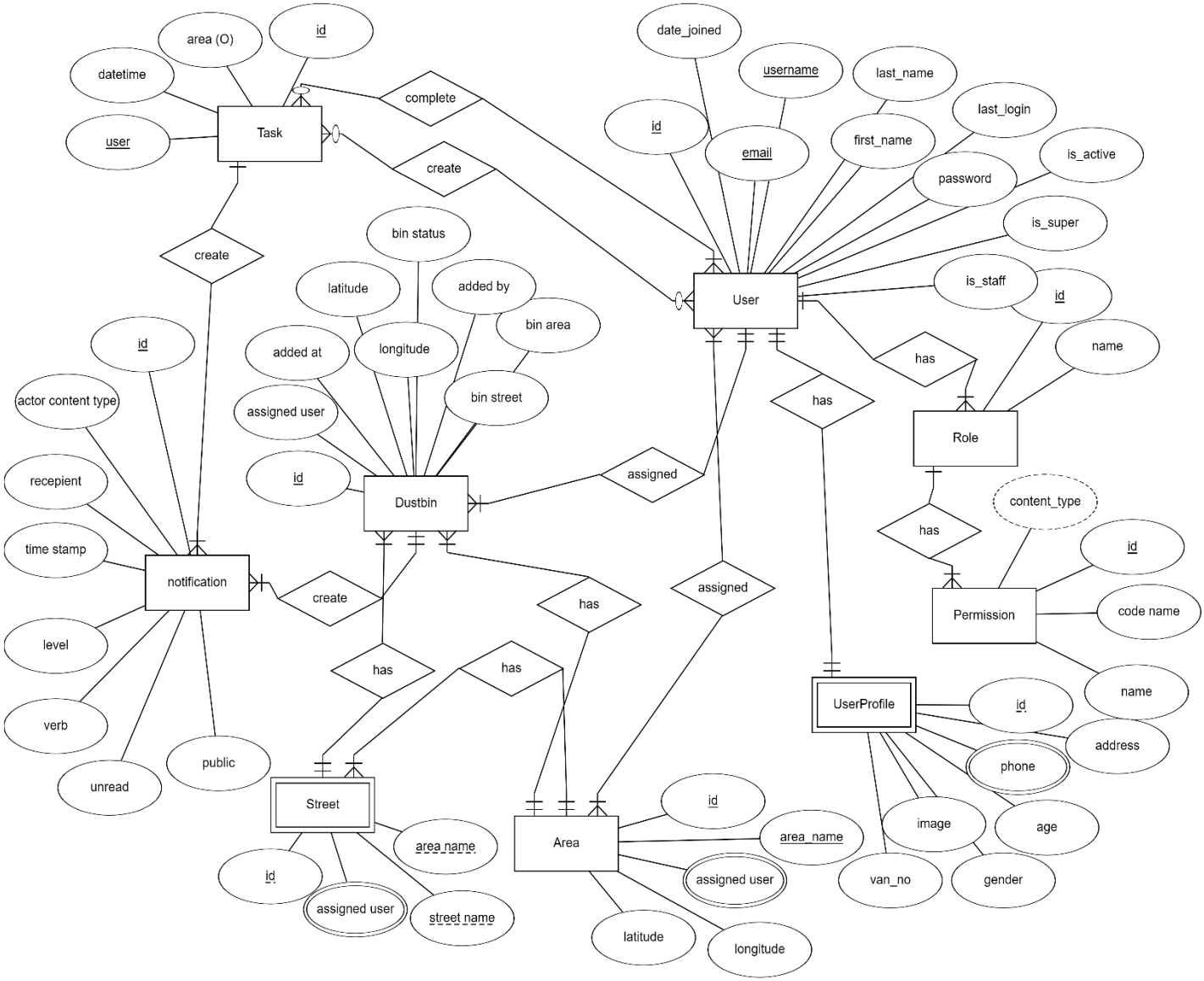


Figure 16:ER Diagram of Smart Waste Management System

4.10 Class Diagram

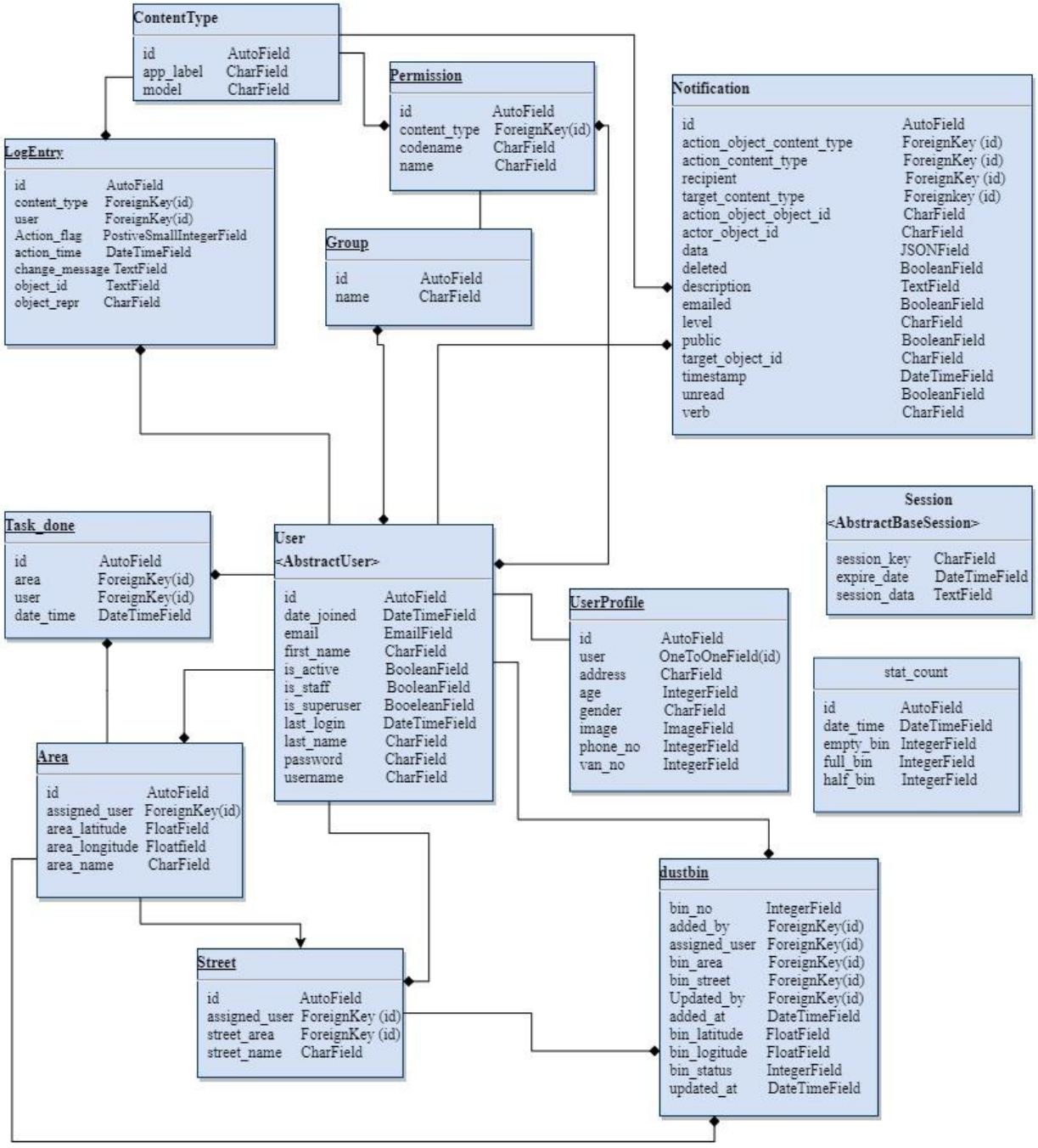


Figure 17: Class Diagram of Smart Waste Management System

5 Waste Monitoring System

5.1 How the information and the garbage in the dustbin is collected?

Here in Bhaktapur we have many sub-city and each sub city have a number of **areas**. In each area, there are N number of garbage collector bins. So, these garbage collector bins will send their status to the central database. For example, if one garbage collector bin is full in Lokanthali sub city in Bhaktapur-16, then this information is sent to the central database and the central database will send an full notification to the sub city regarding the status of the garbage bins in that lokanthlai . Because in one trip the garbage collector workers will visit those bins, around 25% to 100 % filled garbage bins.

In each sub city there is a dedicated person who have the duty to see his profile, each and every day.

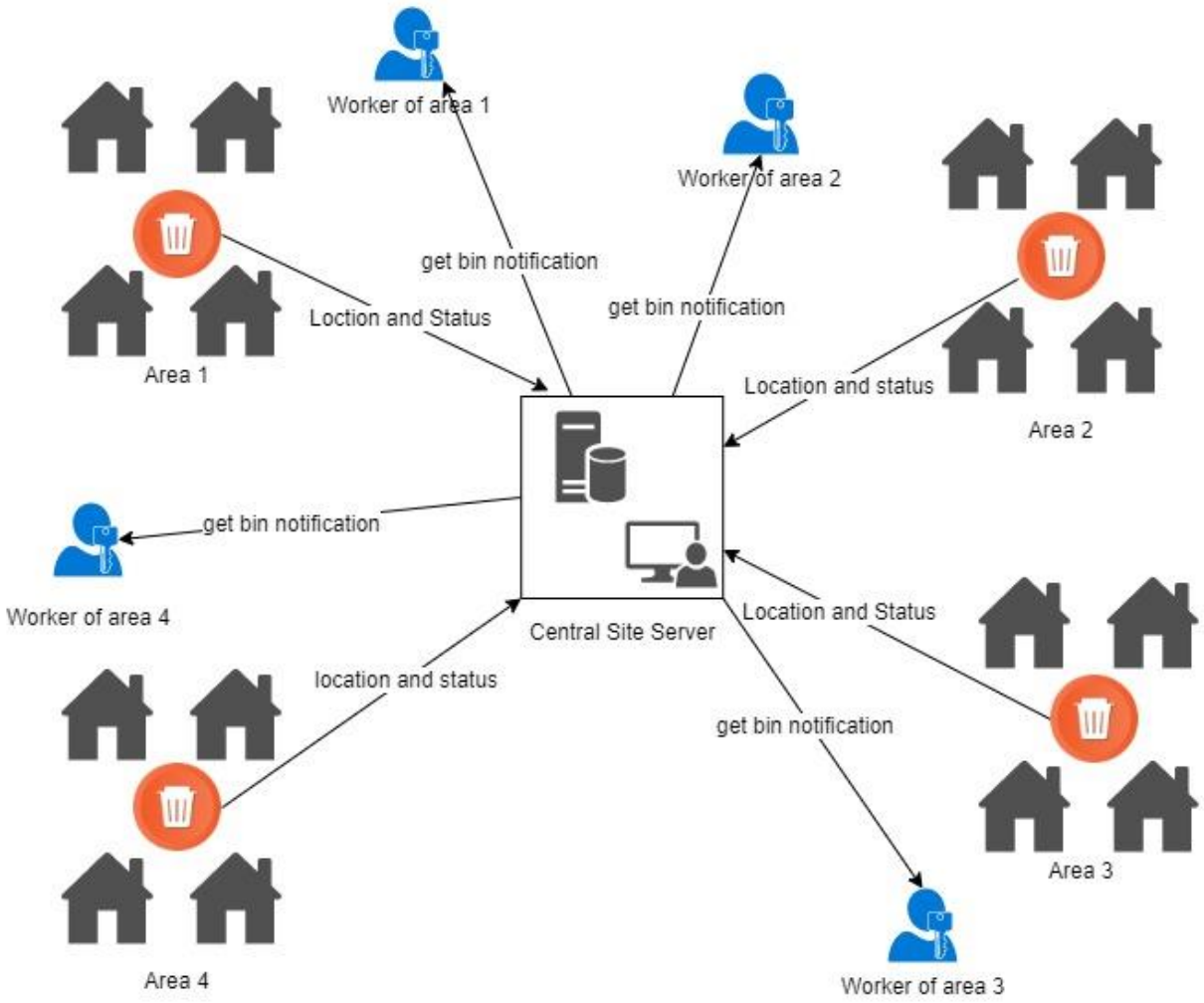


Figure 18 System Overview

5.2 Shortest Path Algorithm (Google Map API)

There are three major shortest path algorithms: Bellman Ford's Algorithm, Dijkstra's Algorithm, and Floyd–Warshall's Algorithm.

Google Map is based on this algorithm, Dijkstra's Algorithm which was invented by Edsger W. Dijkstra, Dutch essayist DescriptionEdsger Wybe Dijkstra was a Dutch systems scientist, programmer, software engineer, science essayist, and pioneer in computing science. A theoretical physicist by training, he worked as a programmer at the Mathematisch Centrum from 1952 to 1962.

Dijkstra is a greedy algorithm. What is greedy algorithm?

Greedy is an algorithmic paradigm that builds up a solution piece by piece, always choosing the next piece that offers the most obvious and immediate benefit. So the problems where choosing locally optimal also leads to global solution are best fit for Greedy.

A greedy algorithm is a simple, intuitive algorithm that is used in optimization problems. The algorithm makes the optimal choice at each step as it attempts to find the overall optimal way to solve the entire problem. Greedy algorithms are quite successful in some problems, such as Huffman encoding which is used to compress data, or Dijkstra's algorithm, which is used to find the shortest path through a graph.

However, in many problems, a greedy strategy does not produce an optimal solution. For example, in the animation below, the greedy algorithm seeks to find the path with the largest sum. It does this by selecting the largest available number at each step. The greedy algorithm fails to find the largest sum, however, because it makes decisions based only on the information it has at any one step, without regard to the overall problem.

With a goal of reaching the largest sum, at each step, the greedy algorithm will choose what appears to be the optimal immediate choice, so it will choose 12 instead of 3 at the second step and will not reach the best solution, which contains 99.

Dijkstra's algorithm (or Dijkstra's Shortest Path First algorithm, SPF algorithm) is an algorithm for finding the shortest paths between nodes in a graph, which may represent, for example, road networks. It was conceived by computer scientist Edsger W. Dijkstra in 1956 and published three years later. The algorithm exists in many variants; Dijkstra's original variant found the shortest path between two nodes, but a more common variant fixes a single node as the "source" node and finds shortest paths from the source to all other nodes in the graph, producing a shortest-path tree.

=> => → find the shortest path (minimum cost path)

```
function djakstra(graph,source):
    create vertex set q
    for each vetex v in graph:      //initialization
        dist[v] ← infinity          //unknown distance from source to v
        prev[v] ← undefined         //previous node in optimal path from source
        add v to q                  //all node initially in q(unvisited node)
    dist[source] ← 0                //distance from source to source
    while q is not empty:
        u← vertex in q with min dist[u]          //source node will be selected first
        remove u form q
        for each neighbor v of u:                //where v is still in q
            alt ← dist[u] + length(u,v)
            if alt<dist[v]:                      //a shortest path to v has been found
                dist[v] ←alt
                prev[v] ← u
    return dist[],perv[]
```

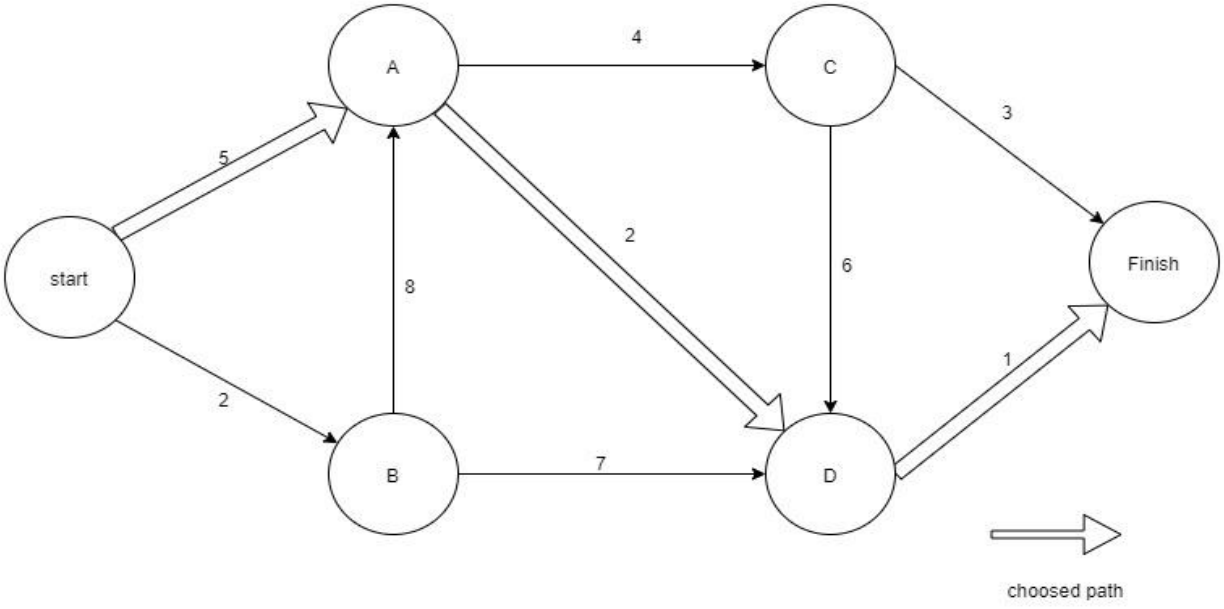


Figure 19:Dijkstra's Algorithm Implementation

5.3 System Permissions

In this system there is two layer of user one is Super user and other is staff(worker) user. They are assigned with different role and permissions in this system. The following activities can be done by the user according to their modes.

- **Super User:**
- Can create/update/delete the user.
- When the user created the credential (username, password and login url) is sent to the created user.
- Can add/delete/update Dustbins.
- Can add/delete/update Area and streets.
- It has permission to assign user to particular area and have all the permission to apply on the user(Staff).
- Cannot Delete other Superuser(Admin).
- Can add Superuser.
- Can track all the activity of Staff.

Staff:

- Can add/delete/update Dustbins
- Can add/delete/update Area and streets.
- Can Generate Route on areas.
- Perform Tasks.

6 Conclusion

On the final note, it can be inferred that, a real time waste monitoring system is the key to achieve a better waste management system. This would optimize logistics and human resources for any modern municipal agency. The above proposed waste management system would solve various scenario specific issues in modern cities when it comes to waste collection and disposal to ensure better community hygiene. As discussed, the submitted system would be cost effective solution to achieve a real-time waste bin level sensing by reliable and centralized cloud data integration. The prototypes and proof of concept shown in this paper can be upgraded to industry standard hardware and software for real world deployment. But point to be noted the concept, idea, systematic approach and technique used will remain unchanged. Further as discussed work has opened new opportunities to work in the domain of data analytics to further optimize the waste collection vehicle route by implementing better algorithms with more relevant and practical parameters, which may come in to picture in a real world scenario.

7 Project Task and Time Schedule

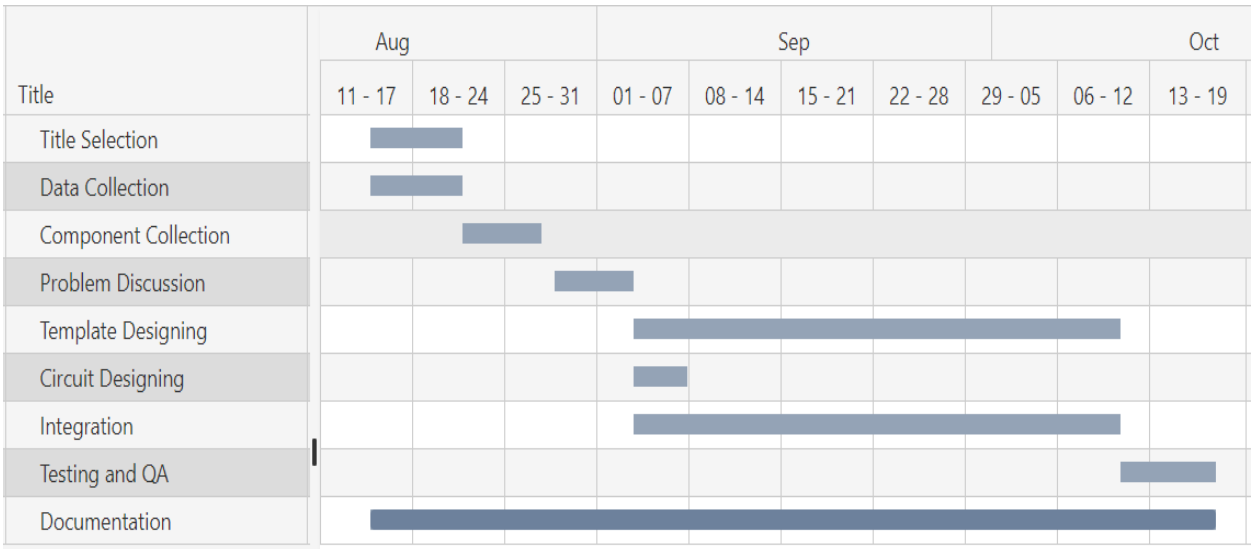


Table 2:Gantt Chart of Time Schedule

8 Bibliography

[1] Margaret Rouse, "IOT Agenda," [Online]. Available: https://internetofthingsagenda.techtarget.com/definition/drone.

[2] From Wikipedia, "Wikipedia,," [Online]. Available: https://en.wikipedia.org/wiki/Gimbal.

[3] T. E. RICKS, "FP," [Online]. Available: https://foreignpolicy.com/2015/12/10/5-big-problems-with-the-drone-programs/.

[4] D. D., "Prezi," [Online]. Available: https://prezi.com/w0ymgdksss6o/problem-statement/.

[5] M. LaFay, "Dummies," [Online]. Available: https://www.dummies.com/consumer-electronics/drones/popular-uses-for-drones/.

[6] BBC, "Academy," [Online]. Available: https://www.bbc.co.uk/academy/en/articles/art20151214151812855.

[7] S. A. HASSAN. [Online]. Available: http://docs.neu.edu.tr/library/6365457473.pdf.

[8] :. A. P.V.. [Online]. Available: http://www.kscst.iisc.ernet.in/spp/40_series/SPP40S/01_Seminar%20Projects/053_40S_BE_2142.pdf.

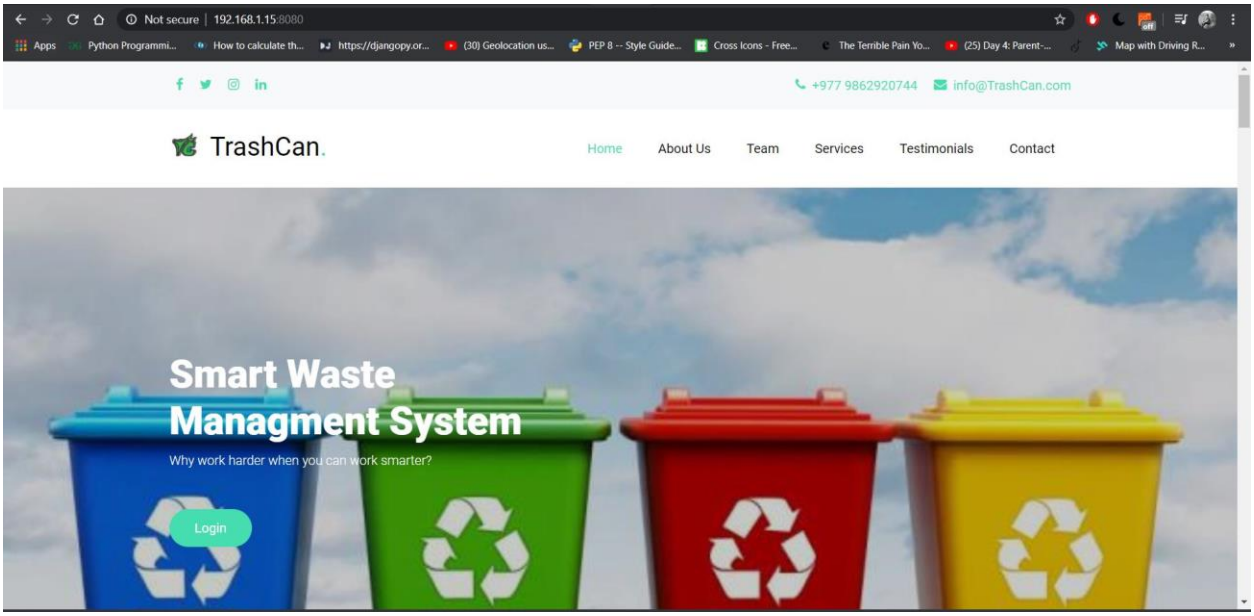
[9] Sneha Patil. [Online]. Available: http://ijarcsse.com/Before_August_2017/docs/papers/Volume_7/4_April2017/V7I4-0245.pdf.

[10] A. Siddharth. [Online]. Available: https://www.geeksforgeeks.org/project-idea-smart-waste-management-systems/.

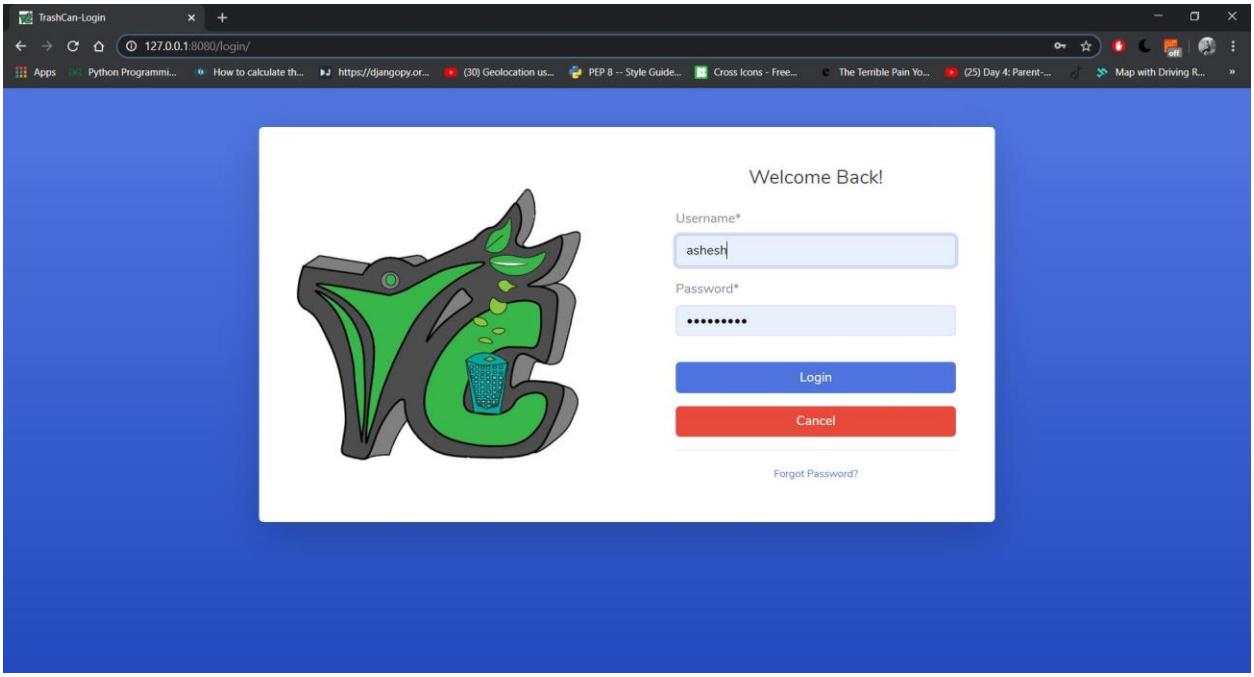
[11] "draw.io," [Online]. Available: https://www.edrawsoft.com/edraw-max.php?gclid=Cj0KCQjwkK_qBRD8ARIsAOteukBOwtNydDtPp_wthLOGKvQiAi48doDvPz4VFle1BMpsbyvNgrJIKSIaAsxNEALw_wcB.

9 Appendix

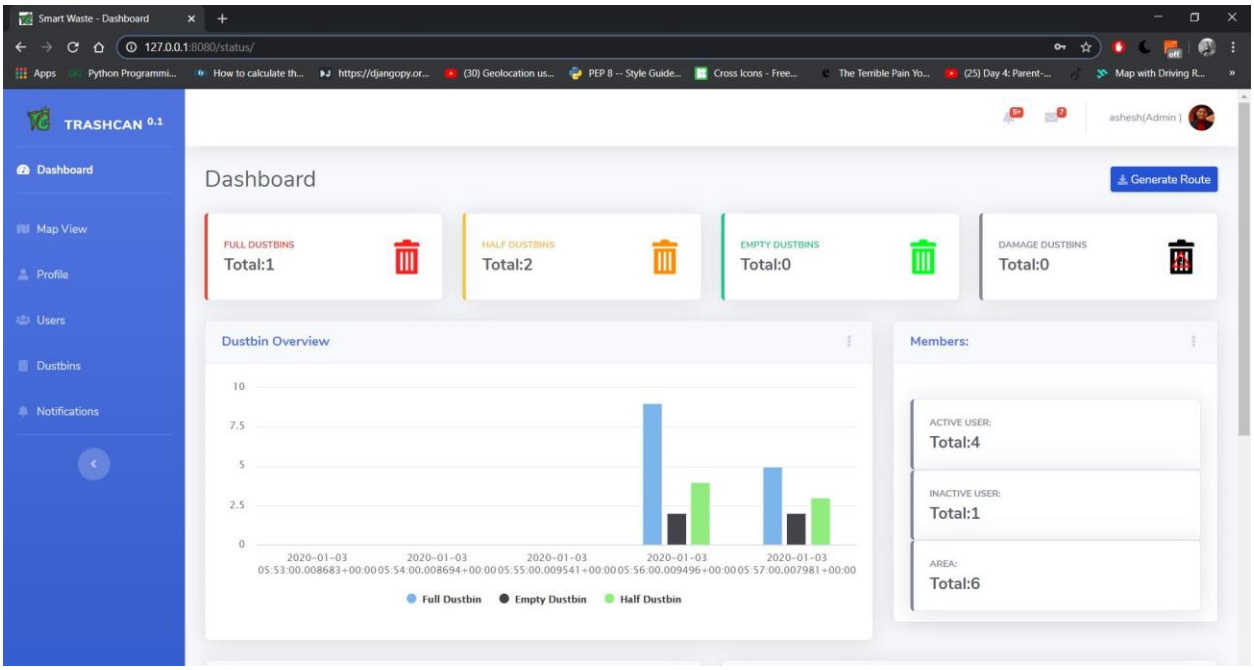
9.1 Home Page



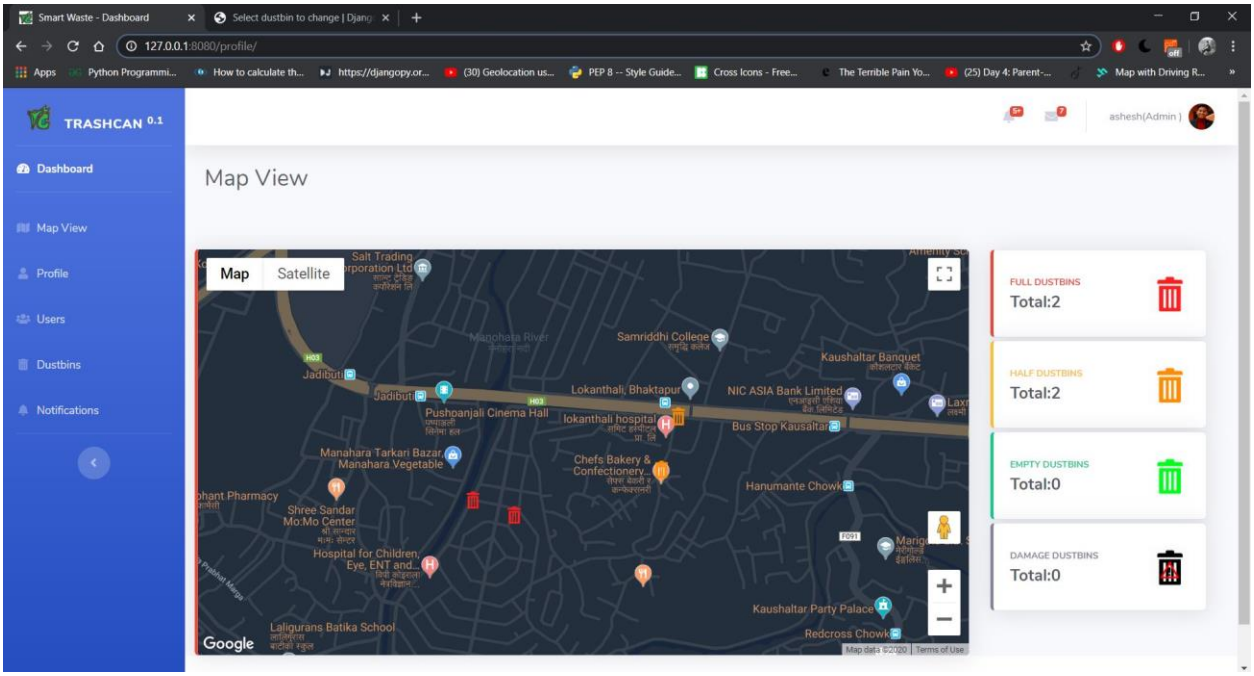
9.2 Login



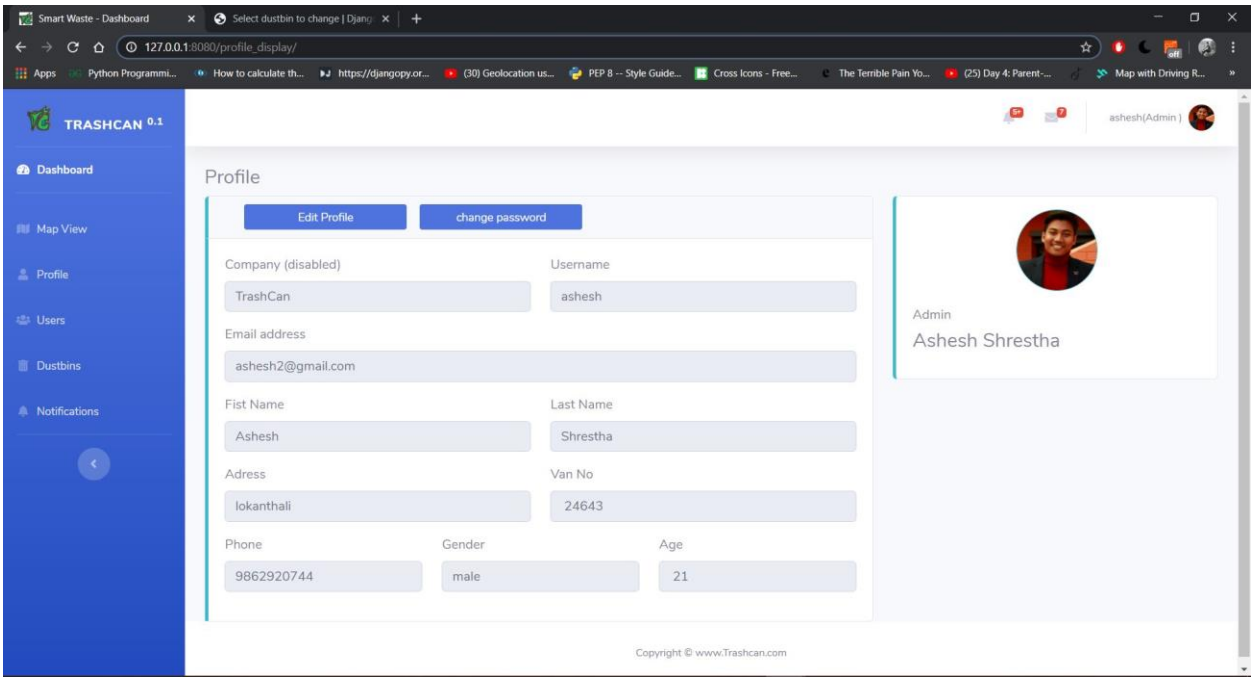
9.3 Dashboard



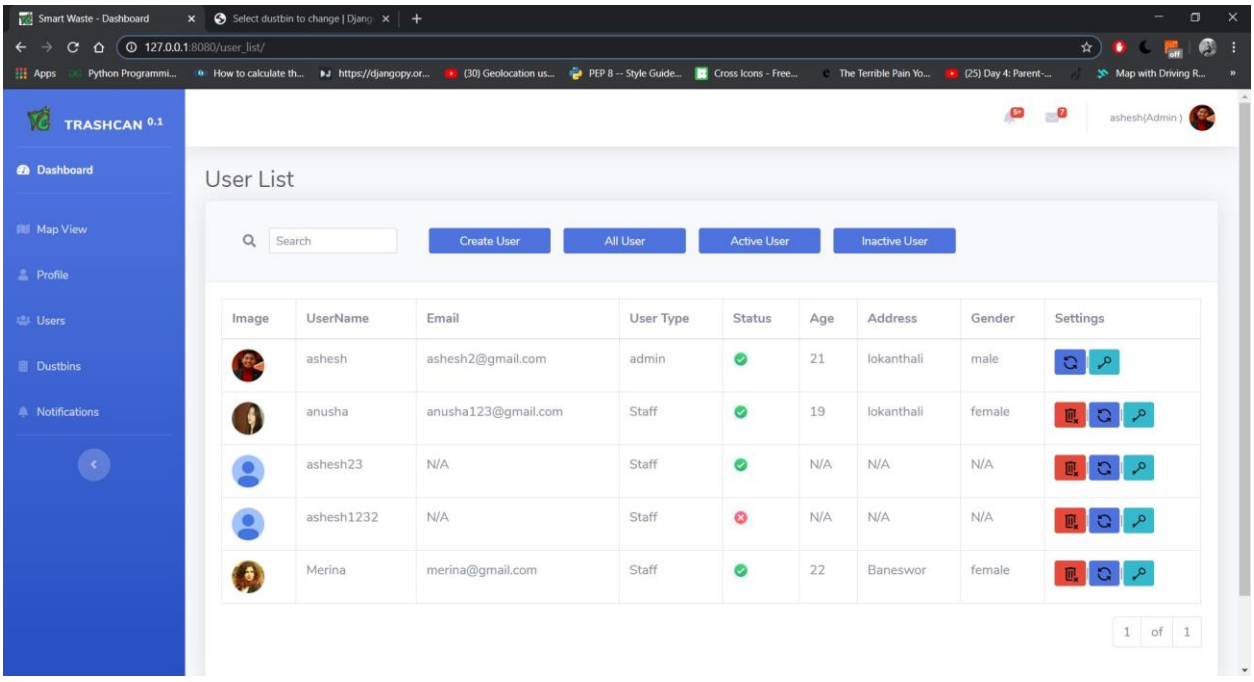
9.4 Map view



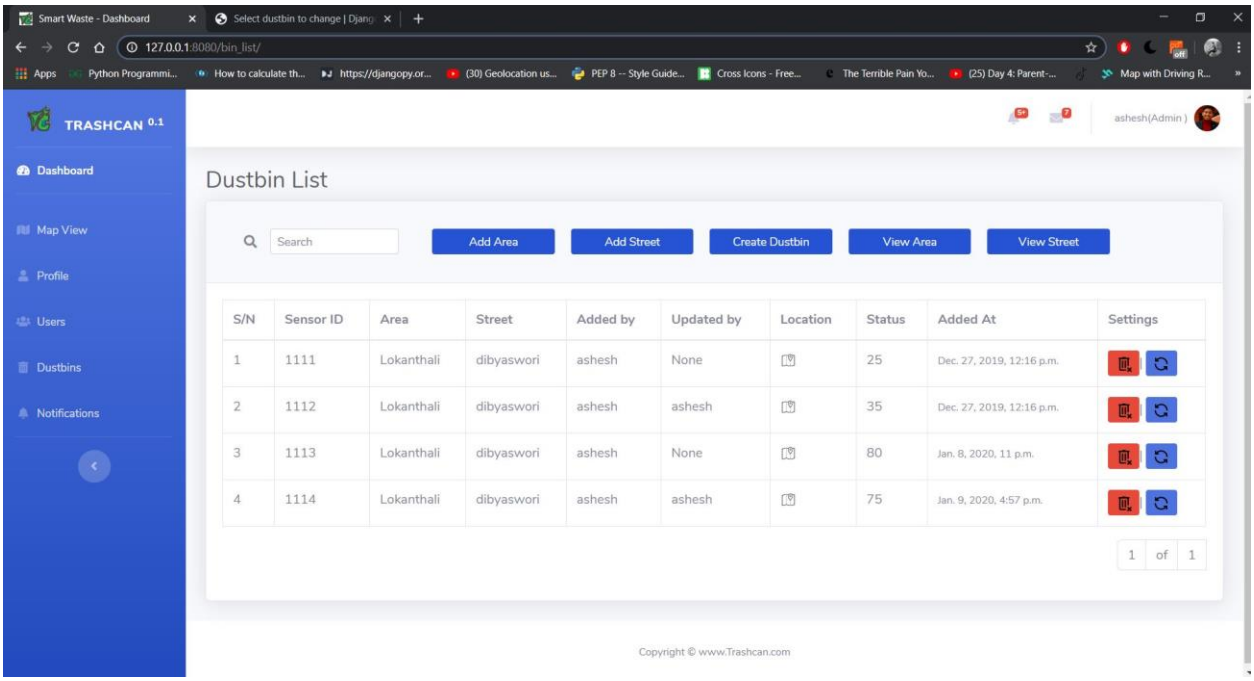
9.5 Profile



9.6 User List



9.7 Dustbin



9.8 Notifications