CHAPTER 1

Introduction

1.1 Background/Context

The waste collection process is an important aspect for the service providers. The traditional way of manually monitoring the wastes in waste bins is a complex, cumbersome process and requires more human effort, time and cost which is not compatible with the present-day technologies.

The concept of smart waste management is implementable in cities where waste production is domestically high but the effort put to control it is relatively very low. This idea is compatible mainly with the concept of smart cities. The smart waste management mainly avoids the congested collection of waste generated domestically which creates difficulty to manage its disposal.

All cities, regardless their size, their geographical location or their economic level, spend huge amounts of money every year for waste collection. The number of bins located in the streets and the number of vehicles used to empty them are generally estimated based on the number of citizens, but the resulting estimation is sometimes either too high or too low.

Waste management involves the activities and actions required to manage waste from its inception to its final disposal. This includes collection, transportation, treatment and disposal of waste together with monitoring and regulation. Waste collection methods vary widely among different countries and regions. Domestic waste collection services are often provided by local government authorities. Curbside collection is the most common method of disposal in most countries, in which waste is collected at regular intervals by specialized trucks. Waste collected is then transported to an appropriate disposal area. Nowadays, cities with developing economies experience exhausted waste collection services, inadequately managed and uncontrolled dumpsites and the problems are worsening. Waste collection method in such countries is an on-going challenge and many struggles due to weak institutions and API urbanization.

1.2 Relevance

Things (Embedded devices) that are connected to the Internet and sometimes these devices can be controlled from the internet is commonly called the Internet of Things.

Smart dustbins are interfaced with the android app to get the real time information of the smart dustbins. This smart dustbin is a mechatronics system and also a connected device.

1.3 Literature Survey

The tremendous growth of population has led to a world of unclean and unhygienic environment. Though the significance produces a great impact on the living species, it is highly essential to take utmost care of the waste being dumped.

The present scenario follows a traditional method of manually visiting the places of the bins and cleaning them. The overflow of waste in municipal regions leads to the creation of polluted environment which turns into hazardous for lives. It steers the development of numerous severe diseases. This will create a higher chance of the various diseases that are likely to be spread. Evacuating the trash and to maintain the sanitation necessitates a smart waste management system.

Many days, garbage is left unattended and unnoticed for a longer period of time. These wastes include left over wastes from the Publics, industries etc. In the modern era of technology driven society, we are in need to implement a system to automate the process of cleaning away the garbage. [1]

Internet of Things (IoT) has attracted widespread applicability not only limited to smart cities and communities but also in water, waste management and so on. Its strength lies in the high impacts it created in the daily life and the potential user's behavior. In the perspective of waste management, several different IoT-enable solutions have been proffered with each having its own strengths and weaknesses that requires improvements.[2]

Shortcomings of existing waste management practices are highlighted and a conceptual framework for a centralized waste management system is proposed, where three interconnected elements are discussed: [1] an infrastructure for proper collection of product lifecycle data to facilitate full visibility throughout the entire lifespan of a product, [2] a set of new business models relied on product lifecycle data to prevent waste generation, and [3] an intelligent sensor-based infrastructure for proper upstream waste separation and on-time collection.[3]

1.4 Motivation

Today, the Indian Government is running cleanliness programs like 'Swachh Bharat Abhiyan'. All major cities of India are taking measures for garbage collection and distribution. The purpose behind this project is to help civil bodies in garbage management with modern technology

solutions like IOT and Android App.

1.5 Aim of the Project

It is seen that a number of times the dustbins are getting overflown and concern people don't get the information within a time and due to which unsanitary conditions formed in the surroundings sometimes leading to spread of harmful diseases, also the bad smell spreads due to accumulation of waste over a long period of time. In order to overcome all these problems, a smart waste management system can be helpful in auto-management of waste without human interaction in order to maintain a clean environment.

1.6 Scope and Objectives

The smart, sensor-based dustbin will judge the level of waste in it and send the message directly to the concerned garbage collection truck. The Smart Bins can sense all the types of waste material either it is in the form of solid or liquid. According to the filled level of the dustbin, the garbage collection truck will choose the shortest path to reach the location of the Smart Bin in order to collect the garbage with the help of the android app, which will save their time, petrol and will significantly help in minimizing the air pollution. Smart Bin emphasizes on 'Digital India', if there is any problem with any component in the future, that component can be easily replaceable with new one without any difficulty and delay. The main objectives are as follows:

1. Monitoring of waste management effectively.
2. Providing smart technology for the waste system.
3. Minimizing human intervention.
4. Reducing human time and effort.
5. Resulting in a healthy and waste ridden environment.

1.7 Technical Approach

Technical approaches used for this project include Arduino microcontroller and GSM on the dustbin side and Android based mobile app for garbage truck drivers. The app uses google maps API for maps integration and SMS receiver API for reading SMS. The app also uses firebase which is an online, real-time database for data storage. This project falls under the category of embedded systems and android applications.

1.8 Advantages

- Less time and fuel consumption as the trucks go only to the filled containers.
- Decreased noise, traffic flow and air pollution as a result of less trucks on the roads.
- Our smart operating system enables two-way communication between the dustbin deployed in the city and service operator. Therefore, the focus is only on collection of route-based fill level of the containers.
- The sensors installed in the containers provide real time information on the fill level. This information helps determine when and where to prioritize collection.

CHAPTER 2

Theoretical Description of Project

2.1 Theoretical Background

Timely clean-up of bins is vital for disinfection to prevent spread of harmful diseases and clean surroundings. The smart, sensor-based dustbin judges the level of waste in it and sends the message directly to the android application which is carried by garbage collection truck drivers. As the dustbin is filled a notification will be sent to the app, the truck driver can simply click on the popped notification and will be guided to the location of Smartbin through google maps.

2.2 Resources Required

Following are the hardware and software resources used in the project: -

2.2.1 Hardware Resources:

- Arduino Uno microcontroller
- Ultrasonic sensors for level and person detection
- DC motor for automatic operation of lid
- L293D motor driver
- Limit Switches for sensing lid movement
- GSM module for communication
- 12V DC power supply
- Wooden container

2.2.2 Software Resources:

- Android Studio 3.1.3 for App development
- Arduino IDE 1.8.12 for firmware development
- Firebase Database for online, real time database
- Eagle 9.6.1 for PCB design

2.3 Flowchart /Algorithm

Flow chart for this project can be divided into two parts. The first flow chart is for the Smart Bin and the second for the App.

2.3.1 SmartBin Flowchart

- The program flow of the dustbin is shown above. The garbage level in the dustbin is constantly monitored using an ultrasonic sensor.
- Then the proximity sensor checks the presence of any person in front of the dustbin. If someone is present at a certain distance in front of the dustbin, the motor is actuated and the lid opens for 30s and the person can throw garbage into the dustbin, after that it closes automatically.
- If garbage level is 70%, an SMS is sent to the controller indicating the dustbin unique ID of respective dustbin.
- After the dustbin is full i.e. the garbage reaches 70% of the level, the lid will not open even if someone wishes to use it.
- Once the garbage is collected from the dustbin then any person now can use the dustbin until the garbage level is below the threshold level.

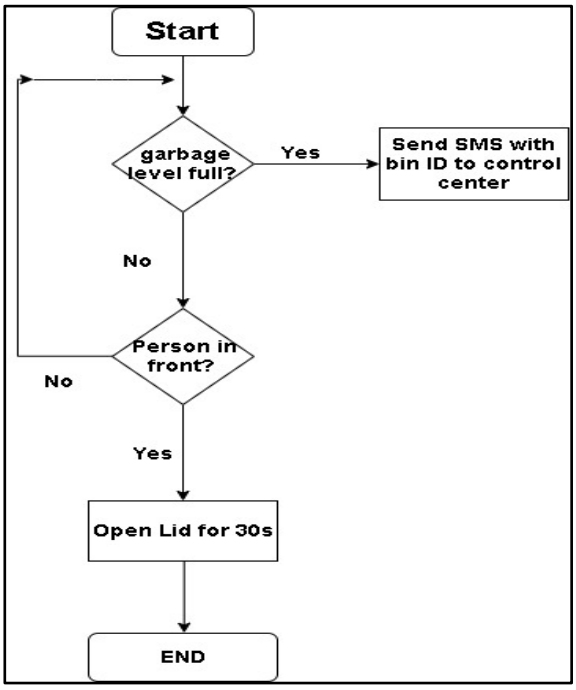

Figure 2.1 Smart Bin Flowchart

2.3.2 Garbage Collection App Flowchart

- Each garbage collection truck has a mobile app that is responsible for taking care of dustbins in a particular area. The truck driver has to register and login the app.
- Android app fetches the SMS received from the respective dustbin and then checks if the received unique ID is present in the database.
- If the ID is present then the app fetches the location of that dustbin from the database and notification pops mention the message “Collection Required” along with the dustbin ID.
- By clicking on the notification, the driver is redirected to google maps and the driver is guided to reach the location of the dustbin by taking the fastest route.

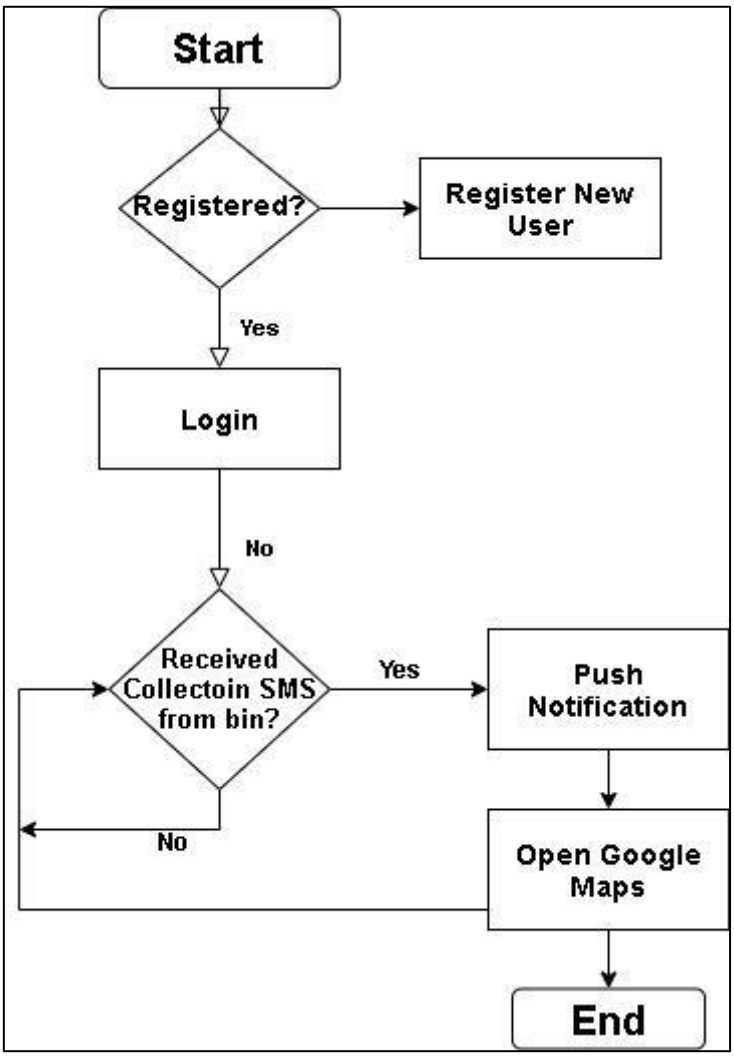

Figure 2.2 App Flowchart

CHAPTER 3

System Design

3.1 Block wise Design

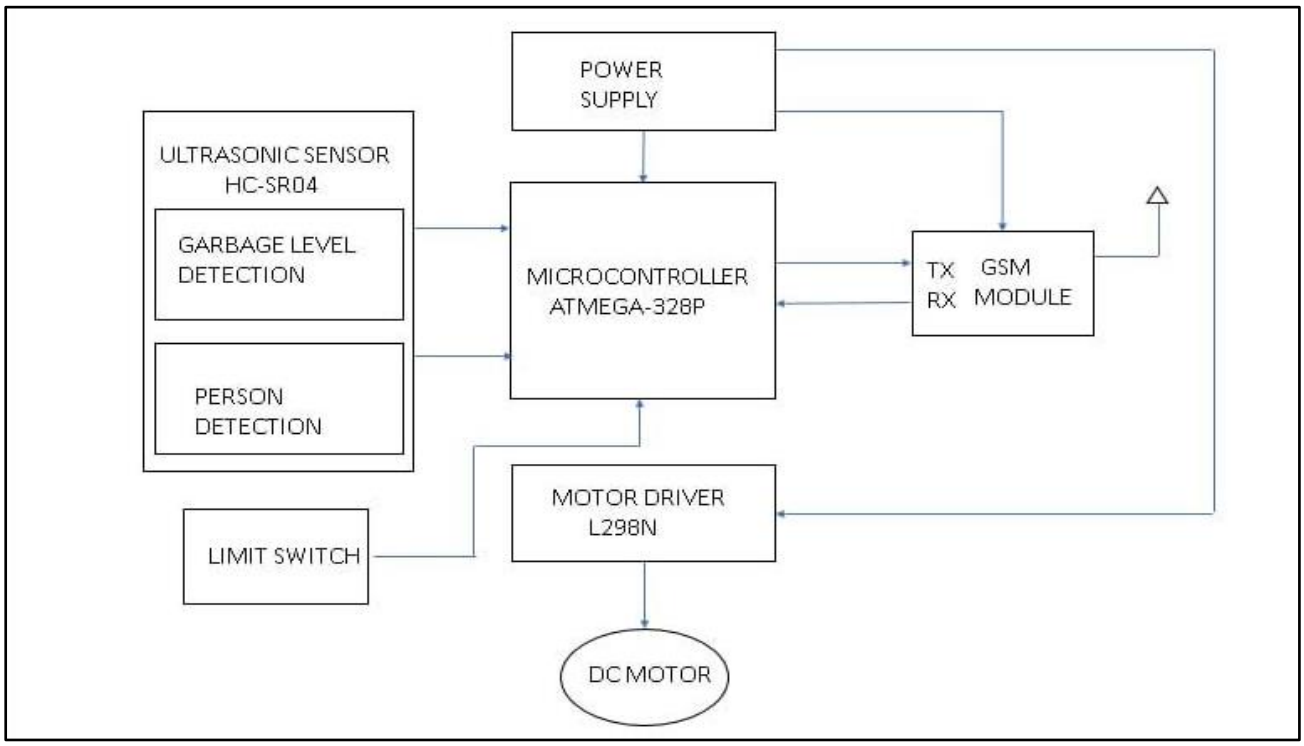

Figure 3.1

3.2 Function of Modules

3.2.1. Garbage Container

A waste container is a container for temporarily storing waste, and is usually made out of metal or plastic. The curbside dustbins usually consist of three types: trash cans (receptacles made of metal or plastic), dumpsters (large receptacles similar to skips) and wheelie bins (light, usually plastic bins that are mobile). All of these are emptied by collectors, who will load the contents into a garbage truck and drive it to a landfill, incinerator or consuming crush facility to be disposed of.

Figure 3.1 Dustbin

3.2.2 Arduino Board

Arduino is a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices [3]. The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an IDE based on a programming language named Processing, which also supports the languages C and C++.The first Arduino was introduced in 2005, aiming to provide a low cost, easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors

Figure 3.3 Arduino Uno

Microcontroller	ATmega328P – 8-bit AVR family microcontroller
Operating Voltage	5V
Recommended input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

Table 3.1 Arduino Specifications

3.2.3 Ultrasonic Sensor

A special sonic transducer is used for the ultrasonic proximity sensors, which allows for alternate transmission and reception of sound waves. The ultrasonic waves emitted by the transducer are reflected by an object and received back in the transducer. After having emitted the sound waves, the ultrasonic sensor will switch to receive mode. The time elapsed between emitting and receiving is proportional to the distance of the object from the sensor. Ultrasonic sensors generate high-frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object.

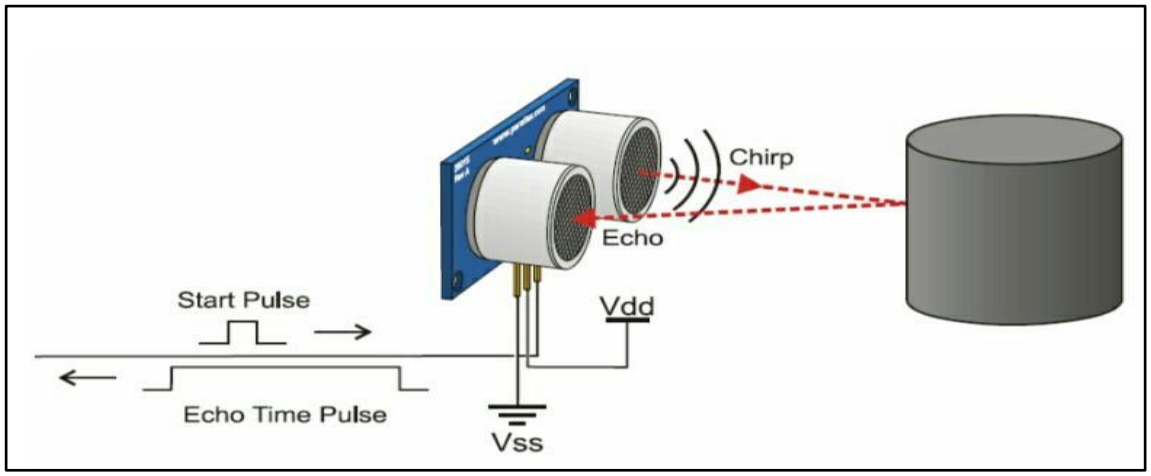

Figure 3.4 Ultrasonic Sensor Working

Working Voltage	DC 5 V
Working Current	15mA
Working Frequency	40Hz
Max Range	4m
Min Range	2cm
Measuring Angle	15 degree
Trigger Input Signal	10uS TTL pulse
Echo Output Signal	Input TTL lever signal and the range in proportion

Table 3.2 Ultrasonic Sensor Specifications

3.2.4 GSM Module

GSM (Global System for Mobile Communications, originally Groupe Special Mobile), is a standard developed by the European Telecommunications Standards Institute to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in July 1991. As of 2014 it has become the default global standard for mobile communications - with over 90% market share, operating in over 219 countries and territories.

GSM networks operate in a number of different carrier frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G), with most 2G GSM networks operating in the 900 MHz or 1800 MHz bands. Where these bands were already allocated, the 850 MHz and 1900 MHz bands were used instead (for example in Canada and the United States). In rare cases the 400 and 450 MHz frequency bands are assigned in some countries because they were previously used for first-generation systems

Figure 3.2 GSM Module

Supported Bands	850/900/1800/1900MHz.
Bluetooth	compliant with 3.0+EDR.
Control via	AT commands

Table 3.3 GSM Module Specifications

3.2.5 L298N Driver

The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time. The module can drive DC motors that have voltages between 5 and 35V, with a peak current up to 2A.

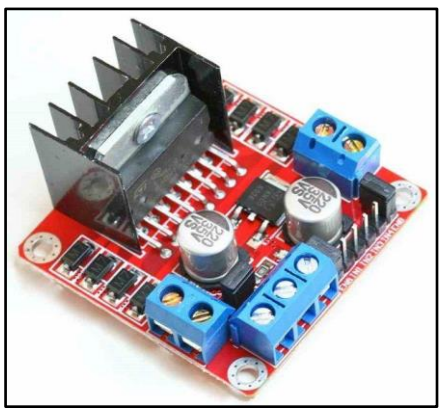

Figure 3.5 L298N motor driver

Motor Driver	L298N
Motor channels	2
Operating voltage	46V
Min logic voltage	4.5V
Max logic voltage	7V
Peak output current	2A
Package	Multiwatt 15

Table 3.4 L298N Specifications

3.2.6 Limit Switch

Limit switch is an electromechanical component that is used to detect physical presence of an object. This switch is used to limit the motor movement. As soon as the lid of dustbin closes, limit switch will send signal to the controller to stop motor movement.

Figure 3.6 Limit Switch

3.2.7 DC Motor (Johnson)

The dc motor is used to operate the lid of dustbin automatically when a person is standing in front of it. It is driven by L298N motor driver which can run the motor in both the directions. A mechanical assembly linked to the shaft of motor will convert rotational motion of motor into linear motion of bin lid.

Figure 3.7 DC Motor

RMP	100
Shaft Diameter	6mm
Torque	25 kgcm
Voltage	6 -24V
No load current	800mA

Table 3.5 DC motor Specifications

CHAPTER 4

Implementation, Testing and Debugging

4.1 Implementation of Android Application

This application is developed in Android Studio v3.1.3. This app starts with the registration page. Firebase is used for registration and login purposes. It is required to download and add google-services. Son file to app to configure the firebase database. It is also essential to include com. google.firebase.auth.FirebaseAuth package into the project file. If the user is not registered then he has to register by filling the required information. Once the user is registered each user is allotted an unique ID which along with the user details is stored in firebase database. If the user has already registered or after completion of registration process user can login by his email ID and phone number. After successful login users can use various features of the app. User also has to grant the permission for receiving the SMS by using android.permission.RECEIVE_SMS.

List View is available at the home page of the app which is used for news feed. The control unit can add various updates to the news feed to inform various users about operations, repairs, damage, etc. of the Smart Bin and other services. List View can be added by using the android.widget.ArrayAdapter function of android studio.

Navigation drawer is used to give access to various features of the app. Navigation drawer holds the buttons View Smart Bins, Objective and About Us for information to the user. androidx.drawerlayout.widget.DrawerLayout and com.google.android.material.navigation.NavigationView packages in android studio provide the usage of navigation drawer.

In View SmartBins all the SmartBins deployed are displayed by the markers along with their unique ID on map. User can simply click on the marker and is redirected to google maps which gives the fastest and shortest route to reach that SmartBin. To use google maps com.google.android.gms.maps.GoogleMaps API is essential to add into the project file. Also it is necessary to grant permission to use google maps for which it is required to add android.permission.ACSESS_FINE_LOCATION and android.permission.INTERNET.

Whenever SMS is received, the app pops notification indicating the message “New Collection Required” along with the unique ID of that SmartBin. Users can click on that notification and are automatically redirected to google map which shows the fastest and shortest route to reach the destination.

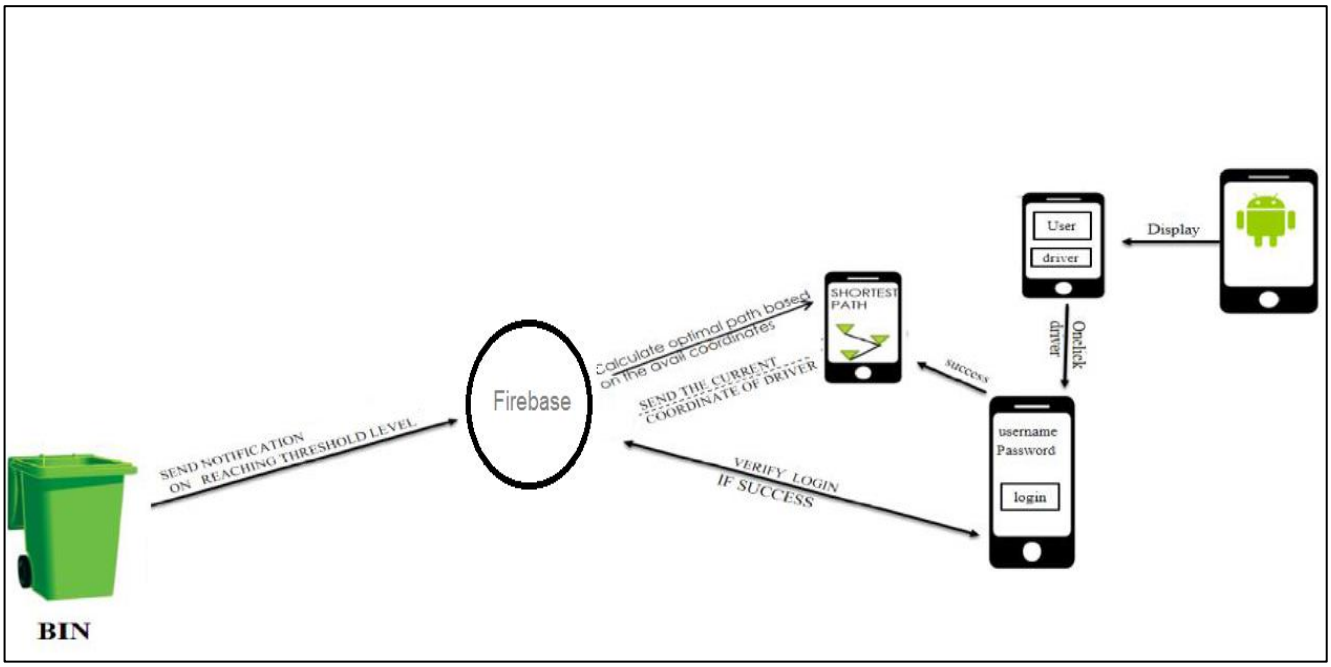

Figure 4.1 Implementation of App

4.2 Implementation of Dustbin

For the dustbin body, plywood material is used. At the rear side of the dustbin, a housing is made to properly secure and enclose electronic components.

At the front side of the bin, one ultrasonic sensor is mounted in such a way that it can sense people standing in front of it. Thus, it detects the presence of people in order to open the lid of the bin.

Another ultrasonic sensor is placed beneath the lid which monitors the garbage level inside.

For lifting the lid, a pulley-based mechanism is being used. The DC motor is attached at a slightly higher position than the lid to reduce torque requirements of the motor.

A string connects the pulley and the opening end of the lid. As pulley starts winding the string, the lid starts lifting gradually. Similarly, an unwinding action causes the lid to shut.

In order to limit lid movement beyond the physical limits, one limit switch each is mounted at the extreme ends. Once the lid reaches either end, the respective limit switch is triggered. It informs the microcontroller to stop the motor

The GSM module is housed in the hind enclosure. It sends SMS to a predefined number when garbage level raises above threshold.

4.2.1 Testing & Debugging

- All the individual sensors, motor driver and GSM module were interfaced with the microcontroller.
- Next, after the construction of the bin, all components were mounted and tested again to make sure that desired result is obtained.
- In the case of limit switches, trials were taken at different positions until desired process was achieved.
- Step by step additions were made in the firmware to add features to it.
- A PCB with all the components integrated on it was designed.
- A final test was carried out after connecting the components to the PCB. A dummy message was sent from the bin.
- In this way reliable functionality of the dustbin was achieved.

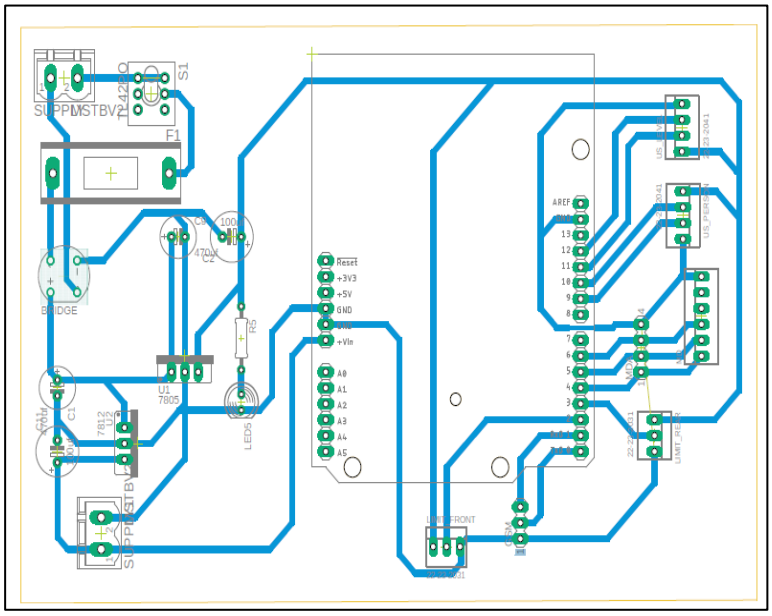

Figure 4.2 PCB Design

CHAPTER 5
Results and Discussion

- The first page of the app displays the registration and login page. User has to enter his credentials to login.

- Second page displays the feed. It is used to provide various news and updates to the user.

- Third page displays all the Smart Bins deployed in the area. The markers represent Smart Bin location along with unique ID of respective Smart Bin.

- Fourth page is an outcome of the popped notification after receiving SMS from Smart Bin. This notification displays the unique ID of the Smart Bin for whom this notification is generated.

- Fifth page is result of clicking the notification which redirects to google maps and shows the best possible route to reach the destination.

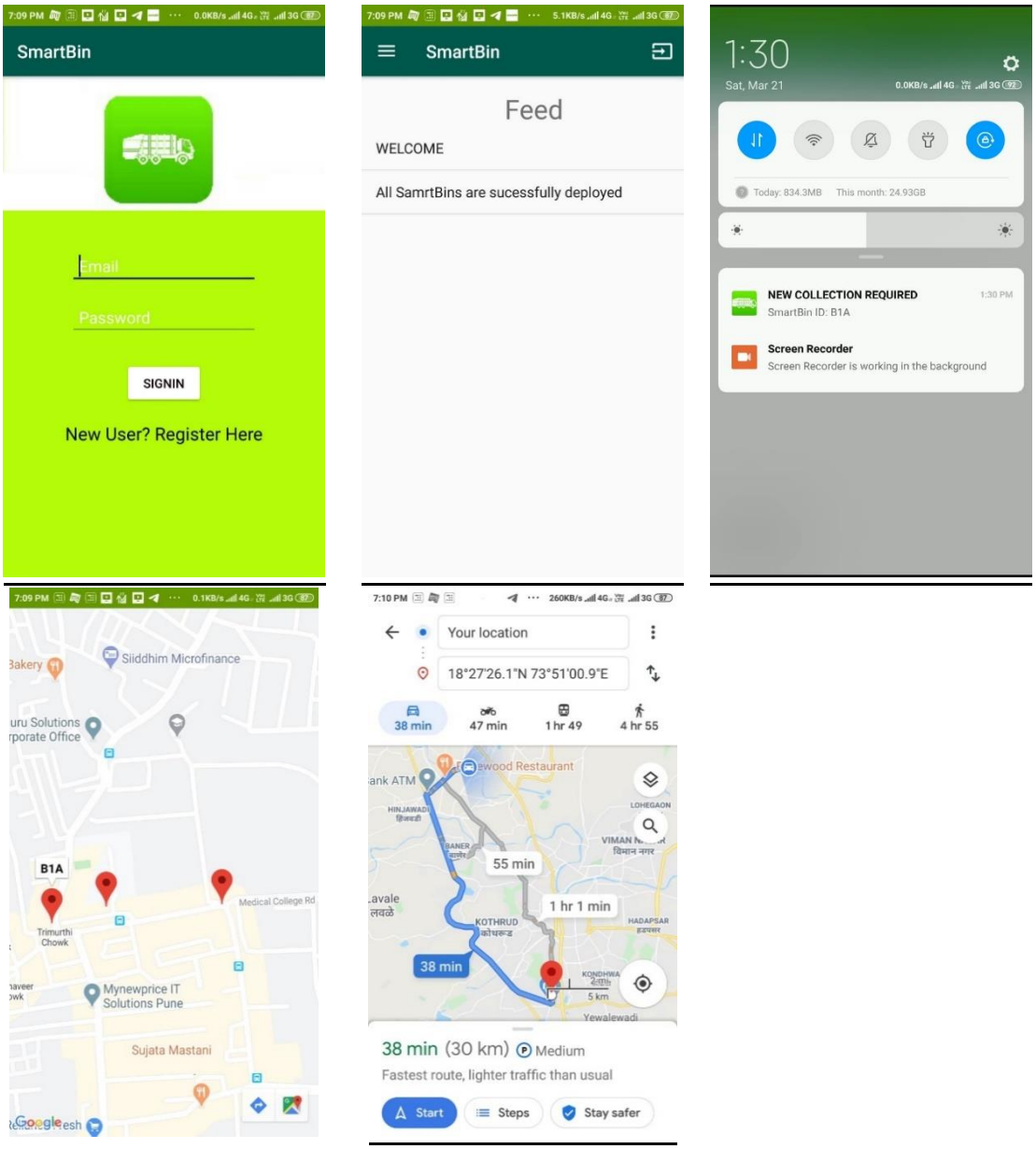

Figure 5.1 App User Interface

CHAPTER 6

Conclusions

By implementing this project, the stuffed-up dustbins can be determined and indication can be given to the garbage collection truck. It does not produce any user inconvenience caused by advanced discharge methods and odor nuisance. By using this method, the collection of waste in the city becomes easier. It helps in reducing air pollution, traffic flow, man power, time and money. With the help of GSM and android application it is possible to guide trucks in selecting the shortest path to reach a particular Smart Bin for garbage collection. This project can add an edge to the cities aiming to get smart and people-friendly. Timely clean-up of public dustbins will help abet the spread of diseases.

CHAPTER 7

Future Scope

As more and more cities are being developed as Smart cities, public Wi-Fi networks will be deployed all across the city. We intend to replace the communication mode from GSM to the internet via Wi-Fi using these urban networks. We can analyze the frequency at which dustbins are getting filled. It can be used to optimize garbage collection schedules and regional distribution. We can change the system of user's authentication and atomic lock of bins which would help in securing the bin from any kind of damage or theft. Therefore, future works can be made in the study of models that offer the best results in terms of decision-making.

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