SMART GARBAGE MANAGEMENT AND MONITORING SYSTEM

A minor project report,

submitted in partial fulfillment of the requirement for the award of
B.Tech. degree in computer science and engineering

by

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ABV INDIAN INSTITUTE OF INFORMATION TECHNOLOGY AND MANAGEMENT GWALIOR-474 015

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CANDIDATES DECLARATION

We hereby certify that the work, which is being presented in the report, entitled **SMART GARBAGE MANAGEMENT AND MONITORING SYSTEM**, in partial fulfillment of the requirement for the award of the Degree of **Bachelor of Technology** and submitted to the institution is an authentic record of our own work carried out during the period *May 2019* to *July 2019* under the supervision of **Prof. Aditya Trivedi** and **Dr. W Wilfred Godfrey**. We also cited the reference about the text(s)/figure(s)/table(s) from where they have been taken.

Date: Amal Shaji Sanchit Bansal

. Signatures of the Candidates

This is to certify that the above statement made by the candidates is correct to the best of our knowledge.

Date: Prof. Aditya Trivedi Dr. Wilfred Godfrey

. Signatures of the Research Supervisors

ABSTRACT

Efficient garbage management and monitoring is a huge challenge in this growing world where the population is increasing at a rapid rate. People are moving to new lands in search of better opportunities and with this increase in population and population density arises the problem of garbage management. Improper management of waste causes environmental pollution which leads to various health problems. The garbage is usually collected from the community dustbins in a manual way. The workers doing this job don't know when the dustbins would be empty or when the bins are filled and this leads to unhygienic living conditions. Suitable waste management frameworks are necessary for improving the quality of health and prosperity of occupants.

Internet of things can provide an efficient solution to this problem. Internet of things is a network of devices with software and sensors and network connectivity which enables us to collect data. Internet of Things (IoT) can be defined as the expansion of internet connectivity to devices equipped with sensors, enabling the devices to communicate with other devices using internet connectivity, and thereby controlling and monitoring these devices real-time from remote locations.

An efficient garbage management and monitoring system is proposed. We propose a model which can take care of human, logistic and scenarios of overflow by the power of IoT. The bins are equipped with ultrasonic sensors and methane sensors to detect the levels of waste and forward real-time information to Arduino board attached to a GSM Module and Wifi Module (ESP 8266). Waste levels are updated and recorded continuously which helps to determine efficient waste collection strategies. The main idea is to alert the authorities about garbage overflow and help them understand the social timetable of a community while formulating an efficient strategy for garbage collection.

Keywords: Arduino Uno Microcontroller, GSM Module, Wifi Module (ESP 8266), Internet of Things (IOT), Smart Garbage management system

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(Amal Shaji) (Sanchit Bansal)

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ABBREVIATIONS

ADC	Analog-to-Digial Conversion
API	Application Programming Interface
cm	centimetre
cms	centimetres
CO	Carbon Monoxide
EGSM	Extended Global System for Mobile communications
FAX	Facsimile
GHz	Giga-Hertz
GPIO	General Purpose Input/Output
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HTTP	HyperText Transfer Protocol
Hz	Hertz
I^2C	Inter-Integrated Circuit
IDE	Integrated Development Environment
IoT	Internet of Things
KBps	KiloBytes per second
LCD	Liquid Crystal Display
LPG	Liquified Petroleum Gas
m/s	metres/second
mA	milliAmpere
mm	millimetre
ppm	parts per million
PWM	Pulse-Width Modulation
RS-232	Recommended Standard 232
RTC	Real Time Clock
Rx	Receive
SIM	Subscriber Identification Module
SMS	Short Messaging Service
SPI	Serial Peripheral Interface
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
V	Voltage
WHO	World Health Organisation
WiFi	Wireless Fidelity
WPA	Wireless Fidelity Protected Access

NOTATIONS

$^\circ$	Degree
$^\circ C$	Degree Celcius
μ	Micro Units

CHAPTER 1

Introduction and Literature Survey

This chapter gives a brief introduction about the project and motivation behind selecting this topic.

1.1 Introduction

Internet of Things (IoT) can be defined as the expansion of internet connectivity to devices equipped with sensors, enabling the devices to communicate with other devices using internet connectivity, and thereby controlling and monitoring these devices real-time from remote locations.

HC-SR04 Ultrasonic sensor is used for measuring distance with high accuracy and stable readings. We also use an MQ9 sensor which is used for monitoring Carbon Monoxide and Methane gas and can measure their amount precisely. The hardware includes a Real Time Clock (DS1307 Real-Time Clock) which is a low power solution to measure and complete timekeeping functions.

This device continuously updates the status of dustbins in each area to the website designed for this management and continuously detects the level of garbage using ultrasonic sensor and as the dustbin gets full it will send notification via SMS (Short Message Service) to mobile by through the GSM module. We are also using a Wi-Fi module (ESP8266) to display garbage quantity on thingspeak.com along with methane sensor values and a buzzer to produce beep sound after increasing the methane above threshold value or if the bin has not been emptied for over two days. 16x2 LCD is used to displaying the values of MQ9 and Ultrasonic Sensors.

1.2 Motivation

Necessity is the mother of all inventions and motivation is what fuels it. Effects of waste not properly managed include serious health hazards such as Typhoid, Cholera as well as the spread of infectious diseases such as Malaria, Dengue which spread through flies, rats, etc. which act as carriers. According to a World Health Organization (WHO) report an estimated 12.6 million people died due to exposure to unhealthy environments which is nearly 1 in 4 global deaths.

Every day thousands of people are directly affected by improper garbage management. Current garbage collection is carried out according to fixed schedules and routes at a set frequency. Major disadvantages include Time Wastage, High costs, unnecessary fuel consumption and increased air pollution due to more garbage collection vehicles. Hence, there is a need to optimize the garbage collection service in order to reduce infrastructure and maintenance costs as well as reduce contamination levels in the community.

1.3 Literature Survey

This work introduces the design and development of smart green environment of garbage monitoring system by measuring the garbage level in real time and to alert the municipality where never the bin is full based on the types of garbage.[2] In this proposed System there are multiple dustbins located throughout the city or the Campus, 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.[3]

1.4 Report Layout

The report has been divided into 5 chapters. Chapter 1 gives a brief introduction and motivation behind the project. Chapter 2 is about the objective of the project and the features of the device. Apart from that, the workflow of the device has been discussed in detail. It also gives a brief description of the development cycle and components used in the device. Chapter 3 contains code snippets of the project and gives an understanding of how programming was used to complete the tasks. Chapter 4 gives an insight into the results and how we tried to improve the efficiency of the existing system. Chapter 5 gives an understanding of what we have achieved and the scope for future development.

In the next chapter project objectives, features of the device, workflow, and design phases have been discussed in detail.

CHAPTER 2

DESIGN, WORKFLOW AND IMPLEMENTATION

In this chapter, project objectives, features of the device, workflow of the device, design phases, and hardware components have been discussed in depth.

2.1 Objective

The main objectives of this project are:

1. Keep a check on the amount of garbage at all times and the level of methane gas produced by the bin and monitor the state of the bin in real-time.
2. Adopt more efficient methods for garbage management, to improve the usage of human and logistic resources. To make sure that the garbage bins are never overflowing.
3. To reduce the fuel consumption, by plotting a map of priority bins for the garbage collection vehicle (shortest path). The route optimization is achieved through Dijkstra Algorithm.

2.2 Features of the device

The waste level is monitored in real-time using ultrasonic sensor which is used to detect the height of garbage in the bin. This device also uses a Methane Sensor which indicates levels of Methane gas inside the bin. The device has SMS (Short Message Service) feature where the user is informed in case the waste inside the bin is beyond critical levels. As the device is connected to the servers and one can see real-time data from anywhere. Also, the authorities can use route optimization techniques to save fuel and time by emptying only the priority bins that are in a critical state.

2.3 Workflow

2.3.1 Setting up the required Sensors and Arduino Uno

1. We use HC-SR04 Ultrasonic sensor to measure distance and MQ9 Methane Sensor to detect critical levels of Methane gas.

2. Pulseln() function is used to calculate travel time in an Ultrasonic sensor, it returns the time of the pulse in microseconds.

3. In Methane Sensor, we use AO pin and DO pin to check and monitor the gas levels.

2.3.2 Setting up ESP8266 WiFi Module

1. Initially, we turn on the WiFi Module using 3.3V regulator (AMS1117). The regulator is used to drop the Arduino Uno voltage from 5V to 3.3V.

2. Now, we use thingSpeak.com to make a HTTP request to send the values of Ultrasonic Sensors and Methane Sensors on the Channel for real time updates.

3. The command AT+CWJAP="WIFI_NAME","WIFI_PASSWORD" is used to connect to the WiFi module.

2.3.3 Setting up GSM SIM900A Module

1. First, we need to connect the serial pins of Arduino(Rx and Tx) to the GSM Module.

2. Now, we need to download SoftwareSerial library of Arduino. This library allows serial data communication on other digital pins of Arduino Uno.

3. The command "AT+CMGS= "PHONE_NUMBER"" is used to add the phone number on which the message is to be sent.

2.4 System Architecture

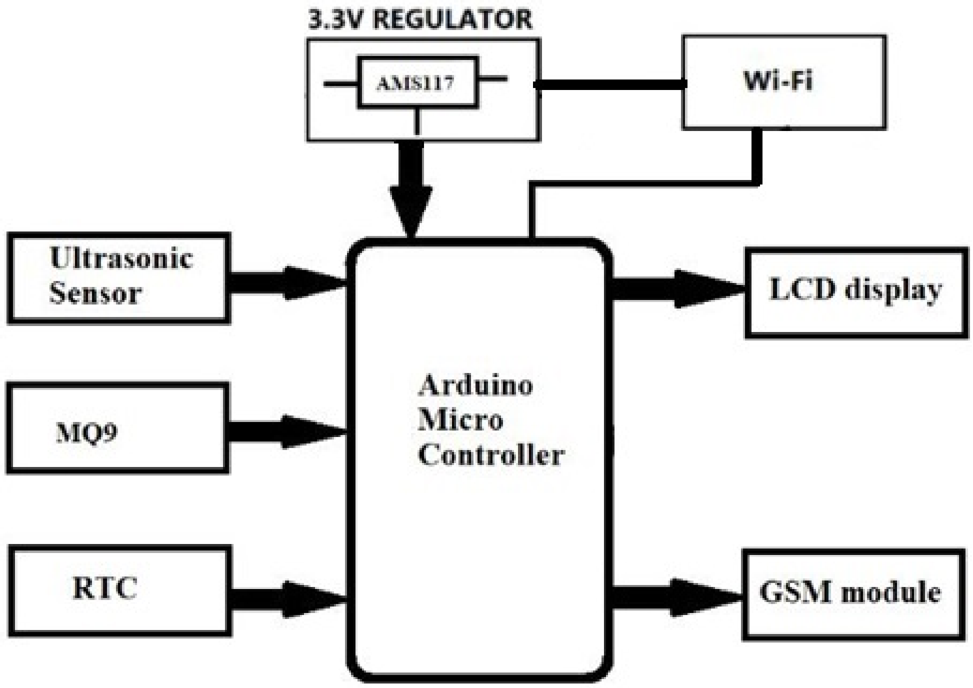

Figure 2.1: Hardware representation of IOT based Garbage Monitoring and Management Device

2.5 Design and Development Phases

The project is implemented in three phases. In the first two phases, the hardware circuit is set up using Arduino Uno Microcontroller, required sensors, communication modules such as GSM SIM900A and ESP8266 WiFi Module. In the third phase, we implement a local server where we can select the bins in a critical state and use route optimization to minimize the distance traveled.

2.5.1 First Phase

Initially, we set up the HC-SR04 Ultrasonic Sensor and Methane Sensor with the Arduino Board. The ultrasonic sensor returns a reading in microseconds. This value is then converted into distance using the given formula.
Distance = (Pulse Time x SpeedOfSound) / 2
Here, speed of sound = 340 m/s = 29.412 µs (microseconds) per centimeter
Distance = ((Pulse Time / 2) / 29.1) cms
The Ultrasonic sensors gives us the readings which are displayed on the 16x2 LCD

Module. According to the voltage supplied to the Methane Sensors, it senses the gases and displays the readings on the 16x2 LCD Module.

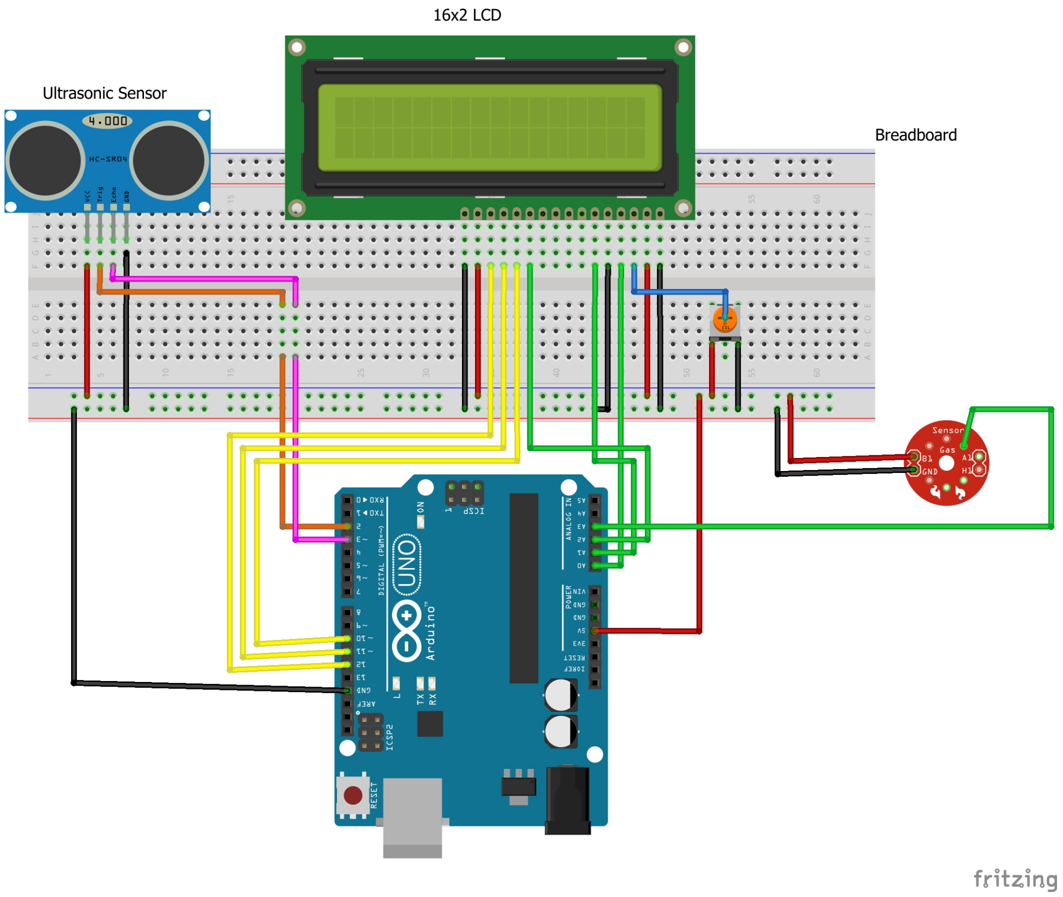

Figure 2.2: Circuit Diagram of First Phase

2.5.2 Second Phase

Here, we set up the ESP8266 Wifi Module and GSM SIM900A Module with the Arduino Board. First, we set up the ESP8266 Wifi Module using https://thingspeak.com/. We create a channel and generate the API key and add it to the code.
AT+CWJAP="WIFI_NAME","WiFi_PASSWORD" is used to connect to the WiFi.
This results in data being displayed on https://thingspeak.com/ with date and time. Now, we set up the GSM SIM900A module. After establishing connection, the LED will blink every 4-5 seconds. This confirms that the SIM card inserted has been connected. For this module we need an Arduino library SoftwareSerial.
AT+CMGF=1 sets the GSM Module in text mode.
AT+CMGS="PHONE_NUMBER" is the phone number on which SMS is sent.

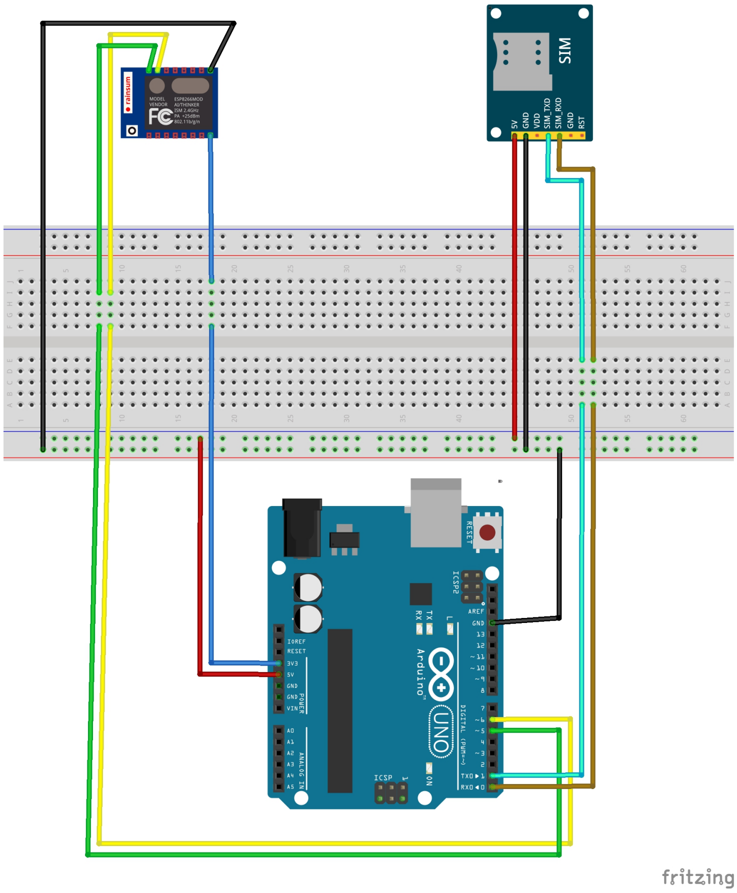

Figure 2.3: Circuit Diagram of Second Phase

After the completion of first and second phase of development, we integrate both the circuits to generate the final circuit.

2.5.3 Third Phase

In the final phase of development, we develop a local server where we can select the priority bins (bins which are in critical state and need urgent unloading) and devise an optimal path for the garbage truck. The optimal path is created using Dijkstra's Algorithm and API's provided by Google.

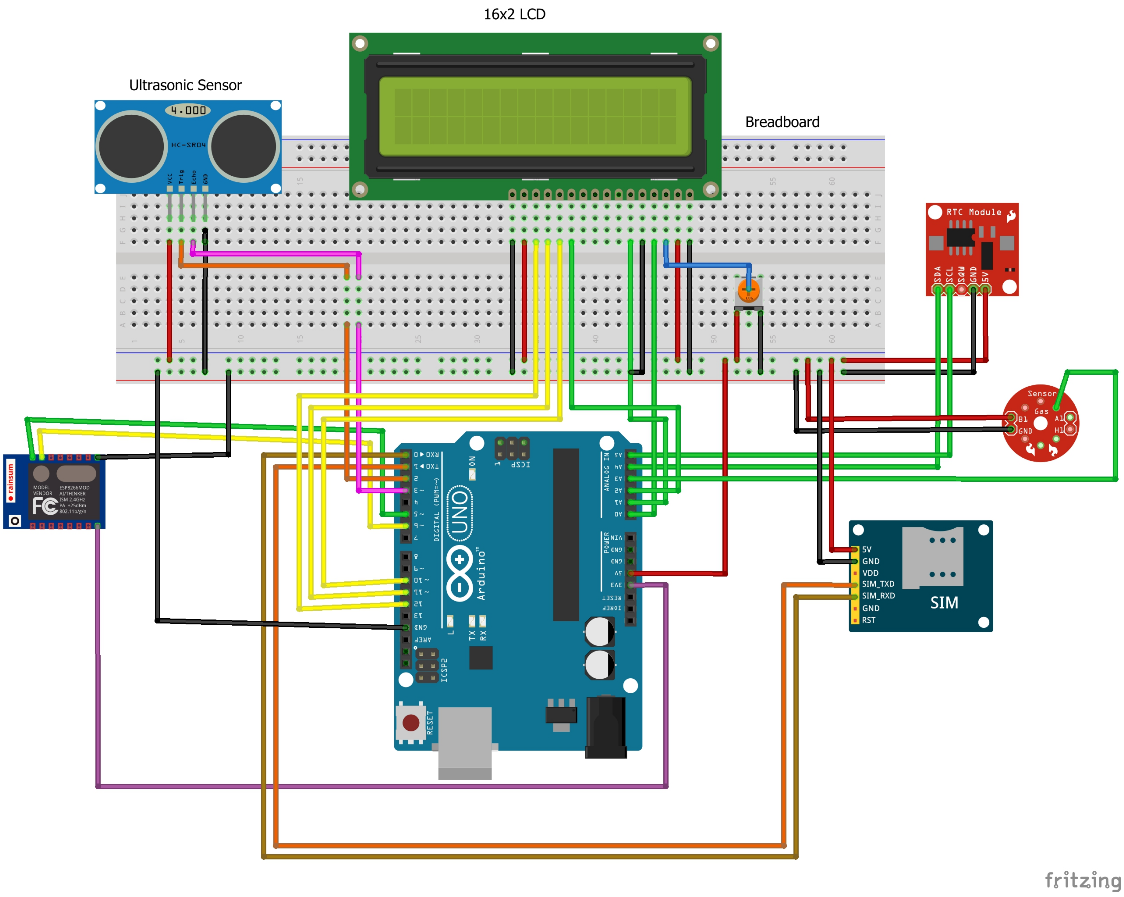

Figure 2.4: Final Circuit Diagram

2.6 Hardware Components

1. **Arduino Uno**

   Arduino Uno is a low cost microcontroller that can run one program at a time. It is a single board computer. Arduino IDE is a low cost software which can be used to configure an Arduino device. An Arduino can be programmed using C/C++ languages. An Arduino Uno uses Atmega328 microcontroller, 14 Digital input/output pins (D0-D13) and 6 Analog pins (A0-A5).

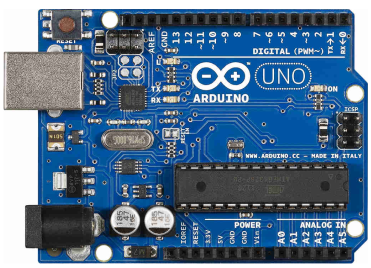

Figure 2.5: Arduino Uno Microcontroller
(Source: https://5.imimg.com/data5/JB/MK/MY-31027671/arduino-uno-r3-microcontroller-board-500x500.jpg)

2. **HC-SR04 Ultrasonic Sensor**

   The ultrasonic sensor is 4 pin module which measures distance or senses obstacles using ultrasonic waves. The ultrasonic sensor transmits an ultrasonic wave which when reflected back is received by the sensor. Now the time between emitted ultrasonic wave and reflected wave is used to measure the distance.

   Operating voltage: +5V
   Theoretical Measuring Distance: 2cm to 450cm
   Practical Measuring Distance: 2cm to 80cm
   Accuracy: 3mm
   Measuring angle covered: <15°
   Operating Current: <15mA
   Operating Frequency: 40Hz

Figure 2.6: HC-SR04 Ultrasonic Sensor
(Source: https://5.imimg.com/data5/BS/PN/MY-66278010/hc-sr04-ultrasonic-sensor-module-500x500.jpg)

3. **ESP8266 WiFi Module**

   The ESP8266 WiFi Module is used to provide wireless connectivity to Arduino and other microcontrollers. It is used extensively in IOT devices. This module works on 3.3V power supply and it works on I^2C (Inter-Integrated Circuit) serial communication protocol. ESP8266 comes with capabilities of:

   (a) 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2),
   (b) general-purpose input/output (16 GPIO),
   (c) analog-to-digital conversion (10-bit ADC),
   (d) Serial Peripheral Interface (SPI) serial communication protocol,
   (e) pulse-width modulation (PWM)

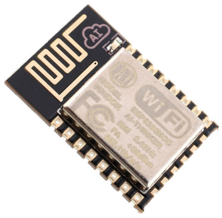

Figure 2.7: ESP8266 WiFi Module
(Source: https://5.imimg.com/data5/IY/OE/IT/SELLER-43948449/esp-01-esp8266-wifi-module-500x500.jpg)

4. **GSM SIM900A Module**

The GSM SIM900A Module supports communication through RS232 serial communication protocol and UART serial communication protocol. This module is used extensively in cellular communication, robotics and servers. Applications such as Audio call and SMS are supported. This module requires an external power supply of 12V.

GSM SIM900A Module features are:

(a) Frequency bands:SIM900A Dual-band: EGSM900, DCS1800. The SIM900A can search the two frequency bands automatically.

(b) DATA GPRS: download transfer max is 85.6KBps, Upload transfer max 42.8KBps

(c) Supports single SIM card

(d) Supports UART interface

(e) Supports SMS, FAX

(f) Operating Temperature: -30°C to +80°C

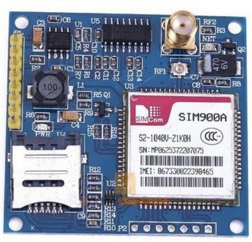

Figure 2.8: GSM SIM900A Module
(Source: https://5.imimg.com/data5/VD/PQ/MY-4500060/gsm-modem-500x500.jpg)

5. **MQ9 Methane Sensor**

MQ9 Methane Sensor is used to detect Methane gas from 100 ppm to 10,000 ppm. It is the same used in Gas Detectors. This sensor has high sensitivity to Methane, LPG and CO (Carbon Monoxide). It uses only one analog pin from the Arduino Uno microcontroller.

Figure 2.9: MQ9 Methane Sensor
(Source: https://4.imimg.com/data4/RU/NG/MY-19578709/methane-gas-sensor-natural-coal-co-methane-detector-arduino-250x250.jpg)

6. **16x2 LCD Module**

A 16x2 LCD Module has 2 rows and 16 columns and it has a total of 32 characters. This module is used to display alphanumeric values. It can work on both 4 bit and 8 bit mode and operates at a voltage of 5V.

Figure 2.10: 16x2 LCD Module
(Source: https://3.imimg.com/data3/UL/YP/MY-7984082/16x2-lcd-blue-250x250.jpg)

7. **DS1307 Real Time Clock Module**
   DS1307 Real Time Clock is an 8 pin Integrated Circuit (IC) which is to used to track time and opearate as a calender. RTCs are used heavily in embedded systems.

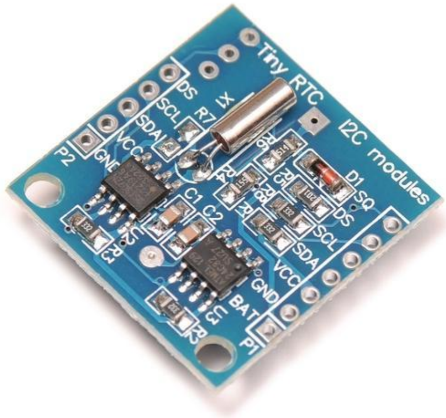

Figure 2.11: DS1307 Real Time Clock Module
(Source: https://5.imimg.com/data5/QB/JR/MY-41573657/ds1307-i2c-real-time-clock-module-250x250.jpg)

8. **AMS1117 3.3V regulator**
   AMS1117 3.3V regulator is a voltage regulator which is used primarily for the WiFi Module. This regulator, regulates voltage in the range of 4.5V-12V to 3.3V.

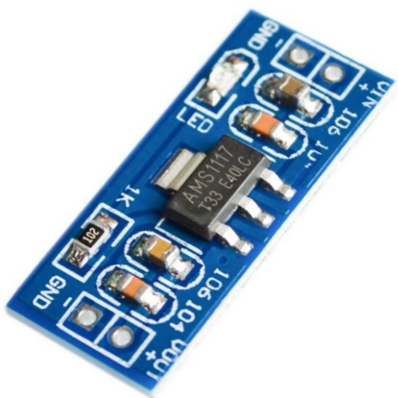

Figure 2.12: AMS1117 3.3V regulator
(Source: https://5.imimg.com/data5/AY/KE/MY-9380557/ams-1117-3-3v-voltage-regulator-500x500.jpg)

9. **Jumper Wires**

   Jumper wires are electrical wires with pins at both ends(or the opposite). It is mainly used to make connections to Arduino and Breadboard. It comes in different variants, male-to-male, male-to-female and female-to-female.

Figure 2.13: Jumper Wires
(Source: https://www.rhydolabz.com/images/1806.jpg)

In the following chapter, project code snippets have been provided to give an insight of the challenges that were resolved through programming.

CHAPTER 3

Code Snippets of Project

In this chapter, code snippets have been provided to provide an insight as to how various problems were resolved through programming.

```
#define trigPin 2//ultrasonic pins
#define echoPin 3
#include <LiquidCrystal.h>
#include <SoftwareSerial.h>
#include <Wire.h>
#include "RTClib.h"


int mq7;
char buf1[16];
String strmq7;

int i;
char buf2[16];
String stri;
// replace with your channel's thingspeak API key
String apiKey = "TBUZUXL8G360O9SY";

SoftwareSerial ser(5, 6); // RX, TX//esp8266 pin

char inchar; // Will hold the incoming character from the GSM shield

int count6 =0;
int timesTosend=1;
int numring=0;
int comring=3;
int onoff=0; // 0 = off, 1 = on


// initialize the library with the numbers of the interface pins
RTC_DS1307 rtc; //rtc variable


LiquidCrystal lcd(A0, A1, A2, 10, 11, 12);//lcd pin rs,en.d4,d5,d6,d7
```

Figure 3.1: Setting up the Microcontroller Arduino Uno

```
void loop()
{
  //Ultrasonic
  long duration, distance;
  digitalWrite(trigPin, LOW);  // Added this line
  delayMicroseconds(2); // Added this line
  digitalWrite(trigPin, HIGH);
  //delayMicroseconds(1000); - Removed this line
  delayMicroseconds(10); // Added this line
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration/2) / 29.1;//conversion formula
  delay(200);

  Serial.print("distance =");
  Serial.print(distance);
  Serial.println(" cm");
  delay(100);
  lcd.setCursor(0, 0);
  lcd.print("D =");
  lcd.setCursor(7, 0);
  lcd.print(distance);
  lcd.print("    ");
  delay(100);
```

Figure 3.2: Ultrasonic Sensor code

```
DateTime now = rtc.now();//rtc code for checking time
Serial.println(now.second());
if(distance<6)//if distbin is full
  {
if(now.second()==60){//if dustbin is full for about 1 minute


    digitalWrite(4,HIGH);
    delay(2000);
    digitalWrite(4,LOW);
    Serial.println("Dustbin Full");
    count6 = 0;
while(count6<timesTosend){// code for sending msg to the mobile number
delay(1500);
Serial.print("AT+CMGS=\"");//at commands for gsm
Serial.print("8076079529");
Serial.println("\"");
while (Serial.read()!='>');
{
Serial.print("Dustbin Full");  //SMS body
delay(500);
Serial.write(0x1A);  // sends ctrl+z end of message
    Serial.write(0x0D);  // Carriage Return in Hex
Serial.write(0x0A);  // Line feed in Hex


delay(5000);

}
count6=1;
}
}
  }
```

Figure 3.3: Configuring the GSM module in accordance with the Ultrasonic Sensor

```
  // TCP connection
  String cmd1 = "AT+CIPSTART=\"TCP\",\"";
  cmd1 += "184.106.153.149"; // api.thingspeak.com
  cmd1 += "\",80";
  ser.println(cmd1);
  if(ser.find("Error"))
  {
    Serial.println("AT+CIPSTART error");
    return;
  }

  // prepare GET string
  String getStr1 = "GET /update?api_key=";
  getStr1 += apiKey;
  getStr1 +="&field2=";
  getStr1 += String(stri);
  getStr1 += "\r\n\r\n";

  // send data length
  cmd1 = "AT+CIPSEND=";
  cmd1 += String(getStr1.length());
  ser.println(cmd1);
  if(ser.find(">"))
  {
    ser.print(getStr1);
  }
  else
  {
    ser.println("AT+CIPCLOSE");//when data is send need a notification
   // alert user
    Serial.println("AT+CIPCLOSE");
  }
  // thingspeak needs 15 sec delay between updates
 delay(6000);
}
```

Figure 3.4: Uploading data on thingspeak.com

```
const Map = compose(withGoogleMap((props) =>{
  let locationArray=[
    [ 21.14, 79.09 ],
    [ 21.17,79.14 ],
    [ 21.6, 79.00 ],
    [ 21.14, 79.09 ]
  ]
    let poly=polyline.encode(locationArray)


     let polyDecoded=polyline.decode(poly);
     let pathLoc=[];
      polyDecoded.map(stop => {
              pathLoc.push({lat:stop[0],lng:stop[1]})
              });
      const markers=pathLoc.map((element)=>{
          return <Marker position={element}></Marker>
      })
      let distanceArray=[];
      for(let i=0;i<locationArray.length;i++){
        if(i+1!==locationArray.length)
        distanceArray[i]=geodist({lat:locationArray[i][0],
        lon:locationArray[i][1]},{lat:locationArray[i+1][0],
          lon:locationArray[i+1][1]})
        else{
          distanceArray[i]=geodist({lat:locationArray[0][0],
            lon:locationArray[0][1]},{lat:locationArray[i][0],
              lon:locationArray[i][1]})
        }
      }
    return (
        <GoogleMap
          defaultZoom={4}
          center={ { lat:  20.59, lng: 78.96 } }
          >
            {markers}
            <Polyline
```

Figure 3.5: Generating the shortest path using Google APIs

In the next chapter, implementation results have been discussed.

CHAPTER 4

Implementation Results

In this chapter, we will share the results. Our main objective was to monitor and manage garbage efficiently.

4.1 Results

The system starts with connecting the Arduino Uno with a 5V power source. This activates the sensor modules as well as the WiFi module. Now, we need to connect the GSM module with an external power source of 12V and insert a SIM card into it. Once, connected we can log on to https://thingspeak.com/ to see real-time results of the system. Here all the sensory information will be updated in real-time.

When the Ultrasonic sensor gives output below a threshold value, an alert is sent in the form of SMS to the user's phone number. And the same is displayed online on the server. And, if the bin hasn't been emptied in over 2 days, another SMS is sent to the user.

Similarly, when the Methane sensor gives output above a threshold value, an alert is sent to the user's phone number. And the same is displayed on https://thingspeak.com/ server.

Now, we have set up a local server where one can select priority bins and implement efficient pick up of garbage through the optimal shortest path.

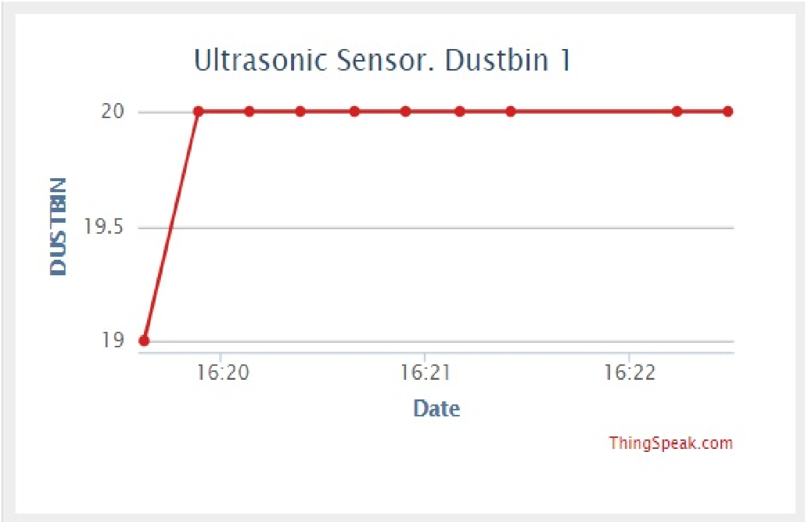

Figure 4.1: Results of Ultrasonic Sensor displayed on thingspeak.com

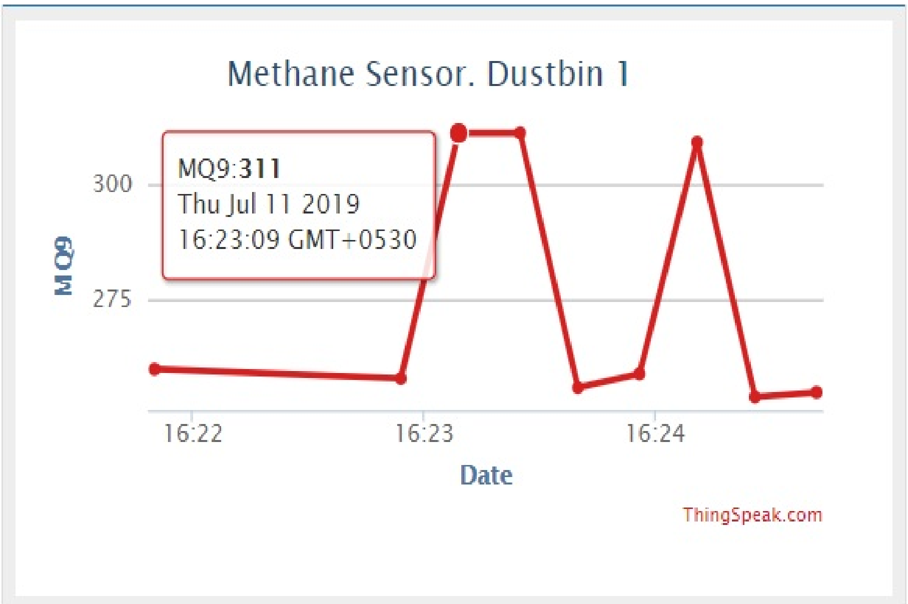

Figure 4.2: Results of Methane Sensor displayed on thingspeak.com

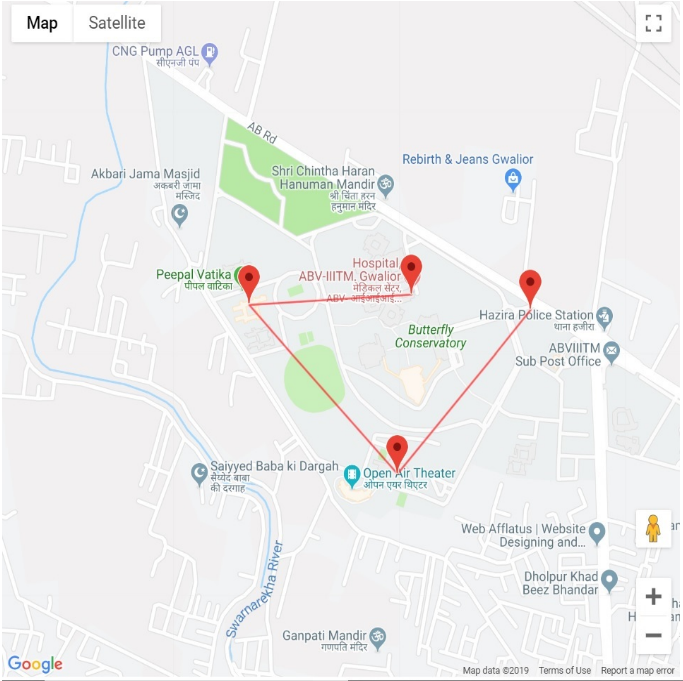

Figure 4.3: Map displaying shortest path

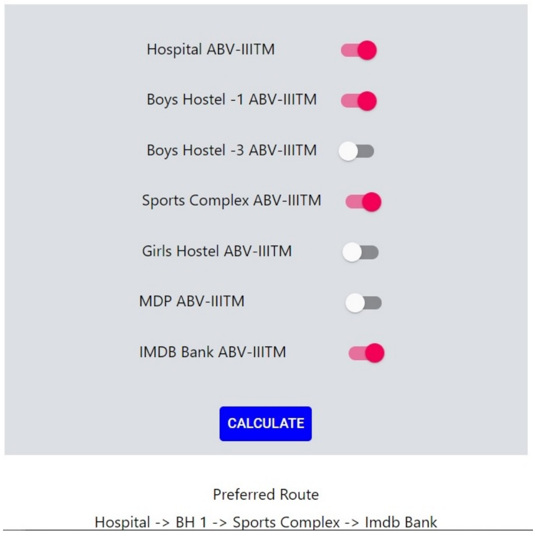

Figure 4.4: List of Bins and preferred route

In the next chapter, future developments and scope of the project have been discussed in great detail.

CHAPTER 5

Conclusion and Future Scope

In this chapter, we conclude our project report and discuss future developments and scope of the project.

5.1 Conclusion

In this project, we implemented a smart garbage management and monitoring system which increases efficiency when compared to the current system. The proposed system increases cleanliness and hygiene standards and reduces human time and effort, thereby helping the environment by lowering the fuel usage.

5.2 Future Scope

This section talks about future improvements, issues that need to be addressed in order to improve the project:

- **Scalability**
  The system can be implemented in large scale smart city projects where we can improve the cleanliness and hygienic conditions in an entire city.
- **Segregation**
  This system can be further extended to segregate biodegradable wastes and non biodegradable wastes, where the biodegradable wastes can be converted to manure.
- **Real Time Location**
  In order to track the location of smart bins, we can use GPS modules. This will give us real time location of the smart bins placed in an area.

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