BREATHE SAFE: A SMART GARBAGE COLLECTION SYSTEM FOR DHAKA CITY

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering.

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APPROVAL

This Project titled **"BREATHE SAFE"**, submitted by **MD JUNAYED SIDDIQUE** and **MOHAMMAD AYNUL ISLAM** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering (B. Sc) and approved as to its style and contents. The presentation has been held on March 2018.

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **DR FERNAZ NARIN NUR, Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

In our city, sometime we see overloading dustbins near public place and beside road. This it creates unhygienic environment. To avoid this ugly situation, we are going to implement a project called “Breathe Safe: A smart garbage collection system for Dhaka City”.

All dustbins are interfaced with microcontroller based system having Ultrasonic sensor for waste level detection and Wi-Fi module to connect to the internet. Real-time status of all dustbins will be shown on an Android application and also shortest direction will be provided on map. Main goal is of this project is to maintain a healthy environment in our city and reduce human sufferings.

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CHAPTER 1

Introduction

1.1 Introduction

In our daily life we produce much more waste than we consume. And as we live in an overpopulated megacity whose population is increasing in a daily basis. So, the overflowed population is creating not only household garbage but also industrial wastes. Because the more the population grows, more factories, mills are going into production to accommodate the needs of the population with commodity or employment. So, this huge pile of waste is poisoning the air, water and surroundings. But these wastes need to be collected regularly on time because it makes the environment vulnerable to live and breathe.

There City Corporation is responsible organization for collecting waste. They collect waste following a routine but there is no emergency collection service as they don't know real-time status of dustbins.

From now on, we will focus on developing a waste collection system using IoT by which the responsible persons will be notified about real-time status of every waste bins and make emergency waste collection. Beside this, our system will provide real-time status of dustbins, distance to the bins, duration to travel and direction on map. That will be helpful for efficient and smart waste collection.

1.2 Motivation

Bangladesh is known as a land of natural beauty. Its scenic beauty, beauties of rivers, seasonal cycle and sea shore is famous all over the world. Besides that according to recent studies, Dhaka is the world's second most polluted city [1]. There are many causes behind pollution and our existing garbage management system is one of them. As our Nation is growing up, we should deploy latest technologies to make our lifestyle better. In our project, we are using Internet of Things (IoT) concept to make our existing waste collection system more convenient. It will result less pollution and energy efficient.

1.3 Rationale of the Study

Bangladesh has crossed over from Least Developing Countries (LDCs) by achieving all the three conditions and going to be recognized as developing countries economically and socially [2]. The country is thriving through Information and Communication Technology (ICT). Government and private organizations are gradually developing with modern technology such as Industrial automation. Besides commercial and technological development, our lifestyle is also developing. We are engaging modern technologies in every aspects of our life for a smart and convenient life.

By using smart city concept in our city, we can contribute to the ongoing development of our country. Besides that, it will mitigate some bothersome problems our city. This study is intended to make garbage collection system of our city smarter to escape from coarse situation.

1.4 Research Questions

Current waste collection system of Dhaka city provides periodic waste collection following a fixed schedule. Dustbins are usually placed beside road and there is no emergency collection option as the responsible persons are unable to see the real-time status of dustbins. As a result, sometimes we have to experience awkward situation. However, this system will provide real-time dustbin status to the responsible employees along with other facilities.

Most important stakeholder of this system is the driver who drives waste collection truck. He needs to know current status of all dustbins. Using a Smartphone is more convenient for driving direction before the driver than any other device.

In addition, there are various other reasons too-

- Mobile apps provide ease of use.
- Has ability to work offline.
- Apps can work faster than browser.
- Apps also provide better personalization.

1.5 Expected Output

Our primary goal is to develop a real-time waste collection system that will help to avoid unwanted air pollution in public places as the dustbins are usually situated in public places and beside busy road. We also tend to make this system more efficient requiring less fuel consumption and less working hour by providing shortest direction to the bin. Beside these, there will be authentication to permit only authorized person, profile management and collection history for statistics.

1.6 Report Layout

This report consists of five chapters, and this section provides insight of all five chapters.

- Chapter one provides introduction, motivation and expected outcome of the study.

- Related research work is discussed on chapter two. It also provides problem scopes of the research.

- In chapter three, requirements of the proposed system, system architecture and system flow diagram is provided.

- Chapter four of this document describe our proposed system design, implementation and testing.

- Lastly, chapter five is on conclusion, limitations, comparison and future study.

CHAPTER 2
Background

2.1 Introduction

In this era of science and technology, we are involving internet with nearly everything from computer to mobile phone. Due to high demand and modernizing civilization, inventors and researchers are connecting more things to the internet. This tendency results a new concept called Internet of things [3].

Communication is now not bound to human to human involvement while IoT introduced machine to machine communication. A machine can interact with another machine without direct human involvement through the internet. This concept is still in its initial stage of commercial deployment, but many industries e:g: home and industrial automation, transportation are showing interest on this.

Now a days, we are connecting home appliances, vehicles to the internet using IoT concept so why not dustbins. This study aims to develop a smart garbage collection system by connecting smart dustbins to the internet.

2.2 Related Works

This is neither an original nor a new idea. There are many existing implementation like this system after Introduction of Smart City Concept. However, this is a new plan for designing a smart garbage collection system with navigation and real-time visualization on map.

The paper [4], proposed waste collection system where 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 a unique ID will be provided for every dustbin. The ID will help to identify which dustbin is full. They used 8051 microcontrollers, RF Transmitter and sensors for sensing waste level and sending to the server. IR sensor is used to detect the level in the dustbin. The sensor senses the content

of the dustbin and sends the signals or the data to the 8051 microcontroller and then the same data wirelessly transmitted to the Central system (Intel Galileo microcontroller) using RF Transmitted. RF Transmitter is to transmit the signal form 8051 microcontroller to the Intel Galileo microcontroller. RF Receiver is used to receive the data sent by RF transmitter to the microcontroller. The Intel Galileo Gen2 Microcontroller is used to receive the data sent by the multiple transmitters and process the data and the same data transmitted to the Client i.e., Web Browser.

In the paper [5], a garbage collection system is proposed with ultrasonic sensor for garbage level detection, Arduino microcontroller and Wi-Fi modem is for sending message to the server. If any dustbin becomes full, the system will send notification to municipal office via text SMS that will be sent from GSM module.

The paper [6] proposed a garbage collection system where garbage level inside dustbin is measured with weight sensor with the help of microcontroller. Garbage level is also shown in a display and sent to server via Wi-Fi module. An webpage shows graphical representation of dustbins.

The paper [7] proposed a system where the amount of garbage inside a dustbin will be measured with a pressure sensor using Arduino microcontroller. This amount will be sent to the cloud server using Wi-Fi module. Whenever a dustbin gets full of garbage, the system will send push notification to mobile application.

But showing status of dustbin is shown in a web page that is not feasible for driver who cleans dustbins with collection vehicle. This collection system can be made more efficient and user friendly by using map and direction. Besides, sending data using RF communication will be challenging for all the dustbins in whole Dhaka city.

Alert and visualization system for dustbins status can be made smarter as well as easier by placing those dustbins status on map and providing direction to reach the dustbin. Besides that, there is no implementation like this in Dhaka city.

2.3 Research Summary

In our study, we are intended to find a feasible solution of garbage collection system for Dhaka city considering current system available so that current system can accommodate it easily. We will also be focused on economical and overall condition of our country. It will be hard to make replace all dustbins with new smart bins in our city because of cost. So we will use existing dustbins in current system interfacing with ultrasonic sensor and microcontroller.

For internet connection, it will not be a feasible decision to use GSM, 3G or 4G because of high cost equipments as well as data charge. We will be using Wi-Fi network for connectivity purpose considering availability through the city. Equipments for Wi-Fi is comparatively less expensive than equipments for cellular network. We don't need any GPS sensor for dustbins because dustbins are situated in the same place thus location remains fixed.

2.4 Scope of the Problem

This study focuses on finding a way to develop a smart garbage collection system to reduce overall expenditure related to garbage collection as well as better air to breathe.

No Overloading Bins

This study aimed to ensure no overloading dustbin exists. This will help to maintain a fresh looking environment and pure air in this city.

Less fuel consumption and less working Hours

This study also works to provide options for drivers to find nearest dustbin that needs to be collected. He can compare distance and time to travel and take better decision that will save our resources.

Easy waste collection especially for new cleaner

In our system, we will provide graphical direction on map that will help cleaners to reach the dustbin easily even if it is unknown to him.

2.5 Challenges

Network Connectivity

In our city, dustbins are located beside road. In our study, we are implementing with Wi-Fi network connectivity. So availability of Wi-Fi for all dustbins will be challenging. Dedicated Wi-Fi router for every dustbin will be costly.

Amount of Waste Detection inside Dustbins

In this implementation, we are using ultrasonic distance sensor for detecting amount of waste inside dustbins. Maximum working angle of this sensor is 15 degree [8]. Hence for larger dustbin single sensor cannot cover whole dustbin, more than one sensor will be required to detect perfectly.

Power Supply

Since dustbins are located beside roads, supplying power via wire is not quite possible. We have to find alternative way to supply power to the system. Using solar panel may be a good solution.

CHAPTER 3

Requirements analysis for the Proposed System

3.1 Introduction

Requirement analysis is consist of some approaches taken to determine specific features, demands, expectation by communicating with the system users. It requires combination of hardware, software and human factors expertise.

3.2 Proposed System Architecture

In this proposed system, amount of garbage inside a dustbin will be measured with ultrasonic sensor. Then this message will be sent to firebase server. Whenever an update will be occurred in firebase serve, mobile application will retrieve that update and take action according to that.

In fig-3.1, smart bins consists of ultrasonic sensor, microcontroller and Wi-Fi module is a single board development board,

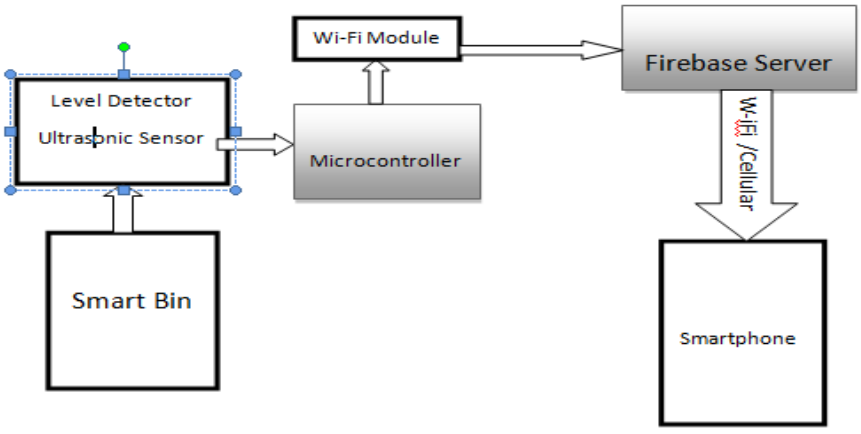


Fig-3.1: Proposed System Architecture

3.3 Program flow Diagram for the Proposed System

In fig-3.2, flowchart of this system is shown. Microcontroller will continuously measure the waste level of dustbin. Whenever it will detect any change in the amount of dustbin, it will send it to the server. If the amount reaches to 100 percent, the system will send an alert message to the server.

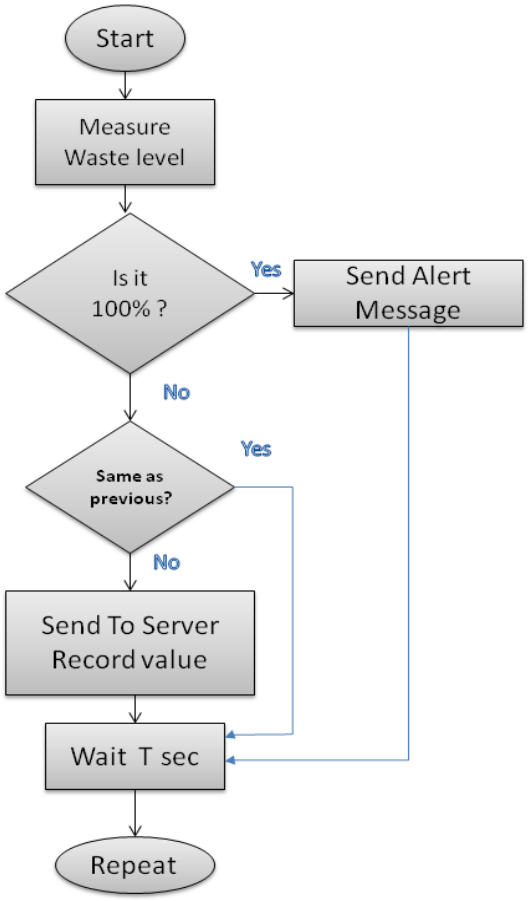


Fig-3.2: Flow Chart Diagram

3.4 Use case diagram

The following figure 3.3 shows use case diagram for mobile application. User can see the bins status on map, manage profile, get direction and he must be logged in to the system for that. Authority can track users location, bins status, collection history by logging in to the system.

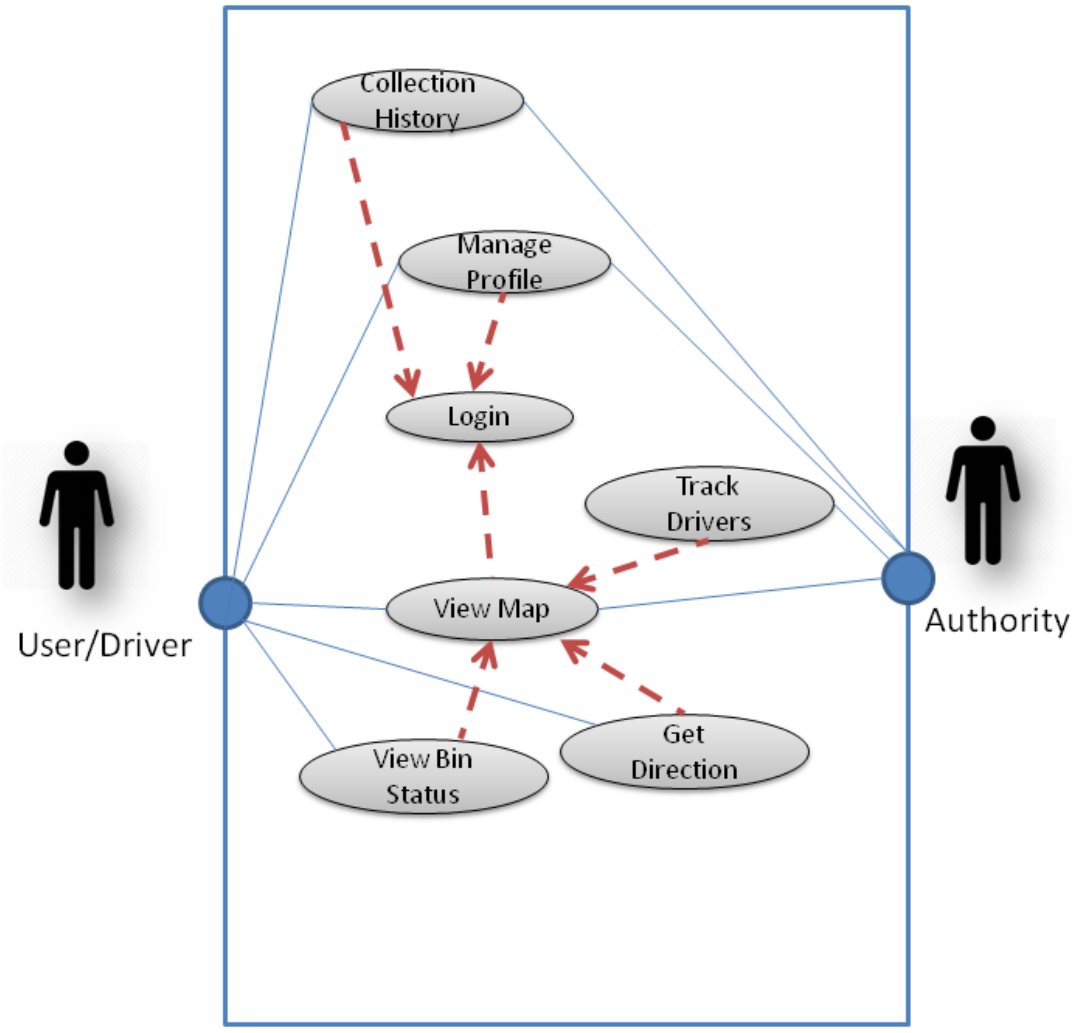


Fig-3.3: Use case diagram

3.5 Use Case Description

For Smart Bins

Table 3.1 shows use case description for waste level detection inside a dustbin using ultrasonic sensor with pre-condition and post-condition. It also provides trigger, basic path and exception path.

TABLE 3.1: USE CASE DESCRIPTION-WASTE LEVEL DETECTION

Use Case Name	Waste Level detection inside a dustbin.
Trigger	Waste is available inside the dustbin.
Pre-Condition	System Should be in Active state.
Basic Path	Microcontroller gets reading from ultrasonic sensor and calculates waste level in percentage.
Post Condition	Reading is stored for further need
Exception Path	Measured Waste level may be incorrect

Sending Update to Cloud

Table 3.2 shows use case description sending dustbin update to the cloud with trigger, pre condition, and post condition and exception path. This case will be triggered whenever amount inside dustbin become changed.

TABLE 3.2: USE CASE DESCRIPTION-SENDING UPDATE TO CLOUD

Use Case Name	Sending update to Cloud
Trigger	When the amount of waste in a dustbin become changed.
Pre-Condition	Smart bin must be connected to the cloud.
Basic Path	Microcontroller processes data and send it to the cloud.
Post Condition	Successfully updated.
Exception Path	Fails to update

For Mobile Application

User Registration

Table 3.3 shows use case description for User registration. In this case, user must have active connection and exception will occur if user provides invalid input.

TABLE 3.3: USE CASE DESCRIPTION-USER REGISTRATION

Use Case Name	New User Registration
Trigger	User Clicks on Sign-Up Button
Pre-Condition	User Must be connected to the internet.
Basic Path	Application shows a page with required fields to insert information of user.
Post Condition	User must click on Register button.

Exception Path	If any of the field contains invalid input, application will show a warning message to fix that.
Others	Only one user can register with one e-mail id.

User Login

Table 3.4 shows use case description for user login. This case will occur if user is not logged in to the application. If so, application will redirect to the main page. Otherwise shows a page for login credentials. Exception may occur upon invalid input.

TABLE 3.4: USE CASE DESCRIPTION-USER LOGIN

Use Case Name	User Login
Trigger	User Clicks on Start button
Pre-Condition	User must be connected to the internet and must have registered account before.
Basic Path	Application will show two fields for e-mai and password for user input.
Post Condition	User Must click on Login button.
Exception Path	If any of the field contains invalid input, application will show a warning message to fix that.
Others	If the user is logged in already, application will not show login page and redirect to main page.

Show Real-Time Dustbin Status on Map

Table 3.5 shows use case description for real-time dustbin status on map. In this case, user must be logged in to the system and also have active connection to the internet.

TABLE 3.5: USE CASE DESCRIPTION- SHOW REAL-TIME DUSTBIN STATUS ON MAP

Use Case Name	Show Real-Time Dustbin Status on Map
Trigger	User Successfully log in to the application.
Pre-Condition	Must have logged in. GPS of the device should be turned on.
Basic Path	Application will show a map page with icons for dustbins on their respective location. Those icons will be different in color e:g: red, green, black indicating amount of waste currently on that bin. Icons will be updated automatically in real-time whenever the amount of waste is updated.
Exception Path	Icon will not appear if there is no active connection.
Others	Icons will keep updating according to bin status.

Get Direction and distance To Desired Bin.

Table 3.6 shows use case description for providing distance and direction. In this case, user has to click on a icon and application will draw a path to the destination dustbin. Exception will occur if GPS is not enabled on user's device because source location will be user's current location.

TABLE 3.6: USE CASE DESCRIPTION- GET DIRECTION AND DISTANCE TO DESIRED BIN.

Use Case Name	Get Direction and distance To a Desired Bin.
Trigger	User clicks on a dustbin icon.
Pre-Condition	User logged in to main page and GPS of the device should be turned on.
Basic Path	Application will draw a path between user's current location and that desired dustbin's location. Application will also show the distance in Kilometer and required time to travel.
Post Condition	Not Applicable
Exception Path	If GPS of user's device is turned off, application will unable to acquire current location of the user. So no route will be drawn.

Adjust Map View

Table 3.7 shows use case description for adjusting map view. In this case, user must be logged in to map page and click on zoom-in and zoom-out button to adjust map view.

TABLE 3.7: USE CASE DESCRIPTION- ADJUST MAP VIEW

Use Case Name	Adjust Map View
Trigger	User Clicks on Zoom-in or Zoom-out button.
Pre-Condition	User must be logged in to main page.
Basic Path	Application will zoom in or zoom out map view for better fit of map view on display.
Exception Path	If system reaches to maximum or minimum zoom level, more adjustment will not happen.

Edit Profile

Table 3.8 shows use case description profile management. In this case, user must be logged in to his account. Exception will occur upon invalid input.

TABLE 3.8: USE CASE DESCRIPTION- EDIT PROFILE

Use Case Name	Edit Profile
Trigger	User Clicks on Edit profile button.
Pre-Condition	User must be logged in and have active connection.
Basic Path	Application will show a page with all editable fields.

Post Condition	User has to click on update button.
Exception Path	Application will show warning message for invalid field input.

Logout

Table 3.9 shows use case description for log out option. In this case, user must be logged in to his account. System will sign that user out from application and there is no exception path for this case.

TABLE 3.9: USE CASE DESCRIPTION- LOGOUT

Use Case Name	Sign Out From the Application
Trigger	User clicks on sign-out button
Pre-Condition	Must be logged in to the system
Basic Path	System sign out current user from application
Exception Path	Not Applicable

3.6 Equipments for Proposed System

- ESP 12-E Wi-Fi IoT Development Board
- HC SR-04 ultrasonic Distance Measuring Sensor

3.6.1 ESP8266 (ESP-12E) Wi-Fi Development Board

It is an microcontroller and Wi-Fi module built in a single board platform that is very easy to use to create projects with Wi-Fi and IoT (Internet of Things) applications. The board is based on the highly popular ESP8266 Wi-Fi Module chip with the ESP-12 SMD footprint. This Wi-Fi development board already embeds in its board all the necessary components for the ESP8266 (ESP-12E) to program and upload code. It has a built-in USB to serial chip upload codes, 3.3V regulator and logic level converter circuit so you can immediately upload codes and connect your circuits. This board contains the ESP-12E chip with a 4MB flash memory so no worries for long project codes. This microcontroller board can easily be programmed using the Arduino IDE programming software [9].

In figure 3.4, ESP-12E Wi-Fi Development Board. Microcontroller, Wi-Fi module, flash chip and logic level converter are integrated in a single board.

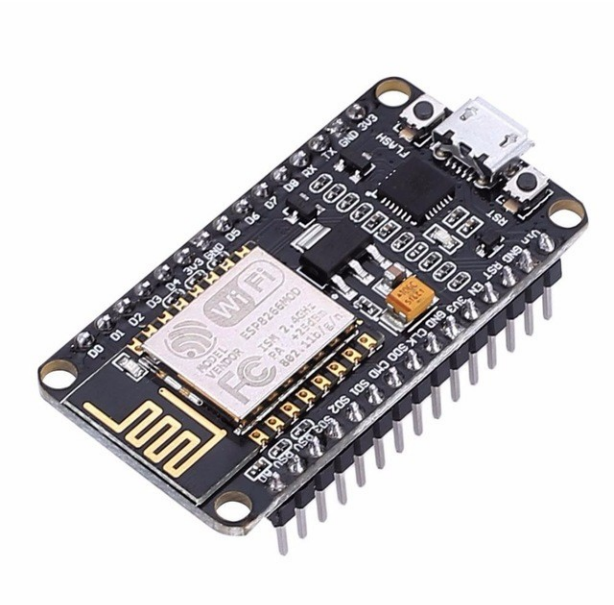


Fig- 3.4: ESP8266 (ESP-12E) Wi-Fi Development Board

3.6.2 Ultrasonic Sensor (HC-SR04)

This sensor is used to detect the amount of garbage inside a dustbin. It works on the principle of ultrasonic detection. It provides 2cm to 400cm non-contact measurement functionality and accuracy up to 3mm. It works on 5V 15mA current and has 15 degree of measuring angle [10].

In figure 3.5, Ultrasonic Sensor (HC-SR04) has four pins. Vcc and Gnd for 5v power supply. Trig and Echo pins for sending sound wave and receiving the reflected wave respectably.

Fig-3.5: Ultrasonic Sensor (HC-SR04)

Platform used for Smart Bins

Platform: Arduino

Language: C++

Tools: Arduino IDE,

Arduino IDE

In our project, we have used Arduino IDE to program microcontroller that is used on smart bins.

Fig-3.6: Arduino IDE

Arduino is an open-source platform used to develop electronics projects. Arduino consists of both programmable circuit board and a piece of software that is known as Arduino IDE (Integrated Development Environment). This IDE runs on computer and used to writing, compiling and uploading program to many varieties of physical board.

The Arduino Platform has become very popular among hobbyist and developers.

Arduino products are distributed as open-source hardware and software and are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL)[11].

Here are some reasons of using Arduino IDE:

- It is open-source and extensible software.
- It has a large community all over the world.
- It is a cross-platform IDE and very popular.

Platform used for Android Application

Platform: Android

Language: Java

Tools: Android Studio, Java SDK, Android Mobile Phone, Firebase App Platform.

Android Studio

In our project, we have used Android Studio IDE to develop Android Application

.

Fig-3.7: Android Studio

Android studio in official IDE (Integrated Development Environment) provided by Google for its operating system Android. It is a replacement of Eclipse Android Development Tool (ADT) as primary IDE for Android Development [12].

CHAPTER 4

System Design, Implementation and Testing

4.1 Introduction

In this section, we discuss our practical approach has been taken to solve the problem. Proposed system delivers expected result. As the amount of waste inside dustbin increase, reading from ultrasonic sensor placed on the top of dustbin decreases. The microcontroller runs this measurement process continuously and whenever it gets different value from the previous, it sends the reading to the server as percentage value from 0 to 100. In the user side, user application maintains continuous communication with the server. Whenever any change of value happens on database, it retrieves that value and updates graphical representation on map according to the value.

If a dustbin gets full of its capacity, microcontroller sends an alert message to the server and that message is immediately sent to cleaners mobile. All those process works very quickly without delay. When a cleaner make decision to clean a specific dustbin and he clicks on that icon, application draws a path to that dustbin as well as distance.

4.2 System Design

This study was focused on developing garbage collection of Dhaka city. We conducted an experiment in a prototype that covers Dhanmondi area of Dhaka city. Location coordinates of dustbins are manually measured using GPS sensor and then placed on database. These coordinates consist of latitude and longitude that is required to place icon for dustbins on map.

To represent dustbin status on map, icons of four color i.e: black, green, purple and red has been used for empty, low, medium and full status accordingly. An icon of garbage truck has been used to indicate current location of collecting vehicle.

In figure 4.1, Proposed model for IoT based garbage collection in a city is shown. Smart bins are places beside road near residential area. Garbage collection truck collects garbage from those dustbins whenever they get filled.

(a) Proposed garbage collection plan in a city

(b) Proposed garbage collection plan in a city

Fig-4.1 Proposed model for IoT based garbage collection in a city

In figure 4.2: a smart dustbin is shown. Every dustbin has an unique name, id and GPS coordinates set on database.

Fig-4.2: A smart dustbin.

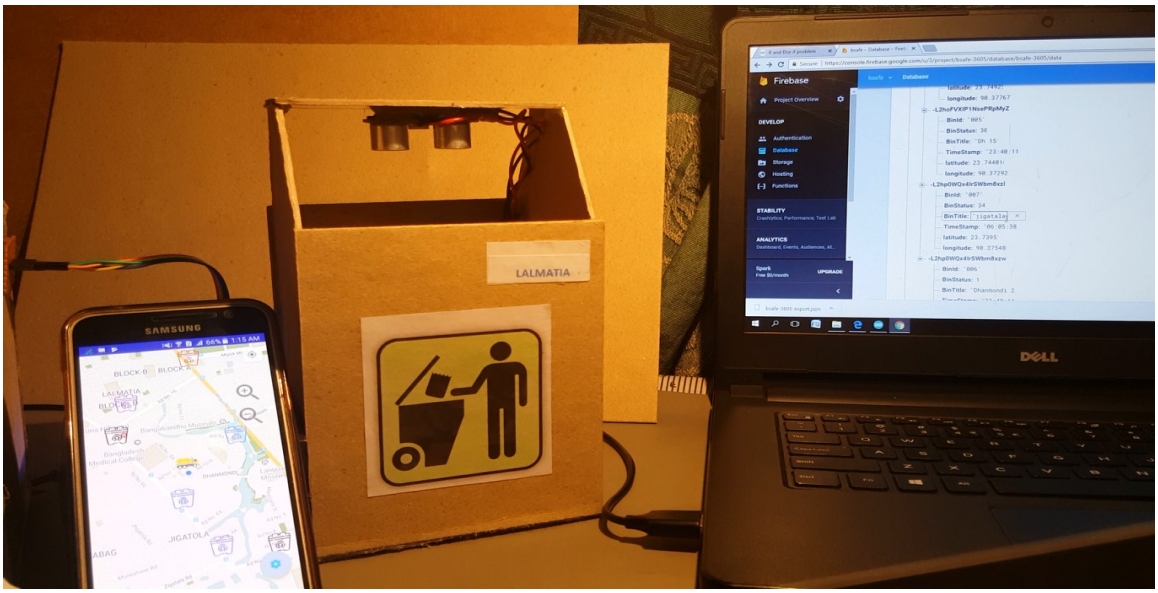
In figure 4.3: a smart dustbin with integrated distance sensor is shown. Ultrasonic distance sensor is integrated at top of the existing dustbin.

Fig-4.3: A smart dustbin with integrated ultrasonic sensor.

4.3 Implementation of the Proposed System

In figure 4.4: demonstration of dustbin status update is shown in both database and mobile application.

(a) Demonstration of real time dustbin status update on map



(b)Demonstration of real time dustbin status update on database

Fig-4.4 Overall demonstration of implementation for the proposed system

TABLE 4.1: STATUS OF DUSTBINS REPRESENTED BY COLOR OF ICONS.

Percentage	Color	Status
0-24	White	Empty
25-50	Green	Low
51-75	Purple	Medium
100	Red	Full

In figure 4.5, four different colors has been used to represent dustbin status on map.

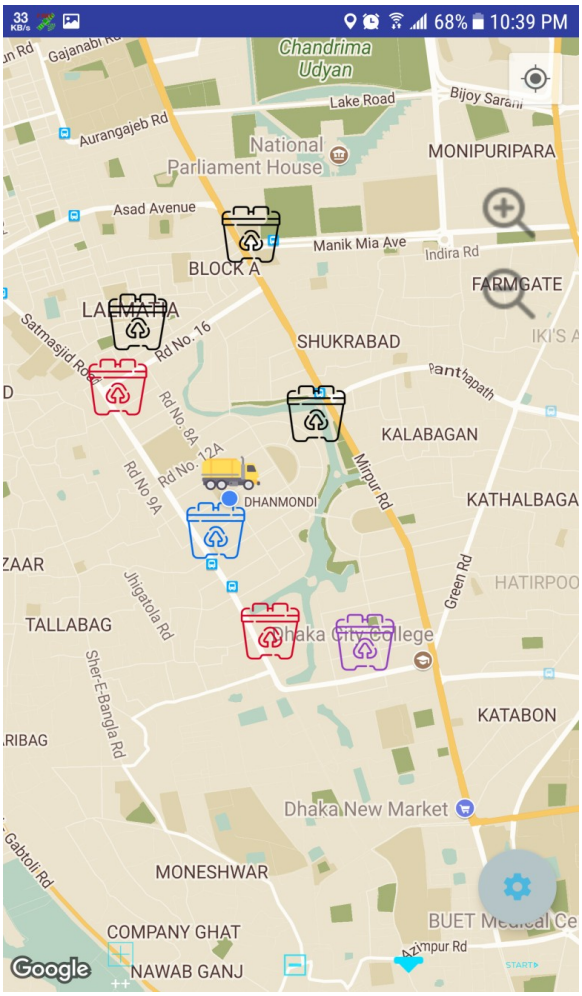


Fig 4.5: Representation of dustbins according to their status on map.

In figure 4.6, direction to a dustbin is provided. Here . Current location of collection truck is Cantonment and destination is jhigatala. Beside this, last percentage of dustbin as well as travel time is also provided.

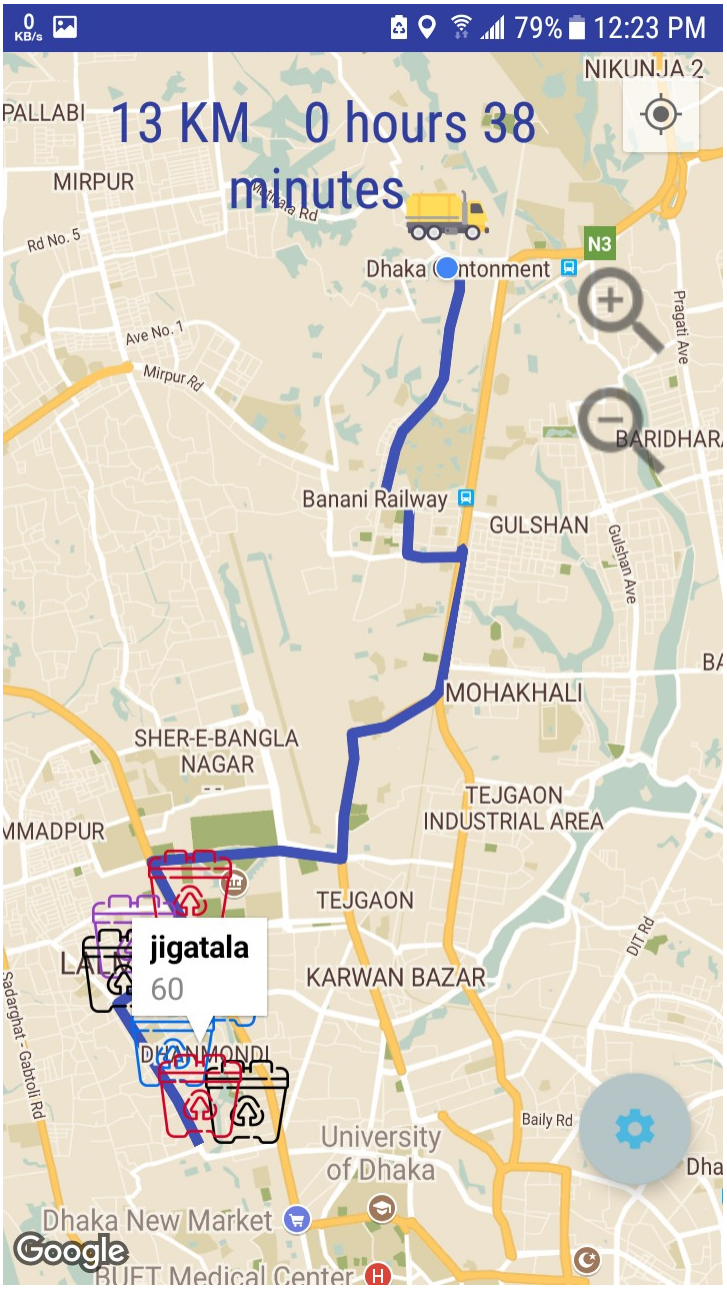


Fig4.6: Direction and duration provided on map.

4.3 Testing

Integration test

Integration testing is a level of testing where individual modules are combined and tested as a group. It occurs after unit testing phase. Purpose of integrated testing is to expose faults in the interaction between integrated units [13].

table 4.2 shows test cases, expected result and observed result for individual module of the system.

TABLE 4.2: INTEGRATION TEST

Test Case	**Expected Result**	**Observed Result**	**Test result**
Ultrasonic sensor should be able to detect waste level inside dustbins correctly.	Can detect level accurately.	Can detect level accurately.	Pass
GPS system of mobile should be able to detect vehicle location correctly.	Location should be accurate	Location is accurate.	Pass
Microcontroller should be able to send data to server using Wi-Fi module.	Can send data to the server.	Can send.	Pass
Application should be able to retrieve data from the server.	Can retrieve data.	Can retrieve data.	Pass

System test

System testing of software or hardware is conducted in complete and integrated system to evaluate its compliance with its the specified requirements. System testing takes all integrated modules that have passed integrated testing as its input. System testing aims to detect any inconsistence between the units integrated together [14].

Table 4.3 shows test cases, expected result and observed result of system testing.

TABLE 4.3: SYSTEM TESTING

Test Case	**Expected Result**	**Observed Result**	**Test result**
Users should be able to login to the system successfully.	Login to the system.	Can login.	Pass
User should see current location as well as all dustbins on map.	All dustbins and current location should be shown.	Current location and all dustbins are shown.	Pass
User should be able to update profile information.	Profile information can be updated.	Can update profile information.	Pass
Application provides different color for dustbin icon according to their status on Map.	Should show different colored icon accordingly	Shows different colored icon accordingly.	Pass
Application should provide direction, distance, as well as travel time to the desired dustbin.	Can provide direction, time and distance.	Can provide direction, time and distance	Pass

CHAPTER 5

Conclusion, Implication for Future Research

5.1 Conclusions

In this study, we proposed and implemented a waste collection system for Dhaka city. This system will ensure no overloading dustbin that we see around us. It will also provide an easy collection system by providing direction. Cleaner can make the right decision as he has all information in one page, thus it will reduce total number of trips of collection vehicle. Hence, it will reduce expenditure of garbage collection system. After all, we may hope for a better air as well as environment in this megacity.

5.2 Limitations

Firstly this proposed system can only work for solid waste. Secondly, detecting waste level using ultrasonic sensor may arise some issues because sound wave will be reflected from any object on its path. If there is a stick standing bellow the sensor, sound wave will be reflected from that. As a result, system will detect wrong level of waste.

5.3 Comparison with Existing Systems

TABLE 5.1: COMPARISON BETWEEN EXISTING SYSTEMS AND OUR PROPOSED SYSTEM.

Subject	Existing Systems	Our Proposed System
Visualization of dustbins.	Mostly on webpage those are not arranged according to their location.	On Google maps, arranged according to their actual location.

Real-time dustbin status on map.	Not present in currently available systems.	This system provides real-time dustbin status on map.
Direction to the Dustbins.	Not present in currently available systems.	This system provides direction and travelling cost to a specific bin whenever user clicks on that bin icon.
Showing Dustbin status	In a form of numerical or quantitive value.	Graphical representation for easy understand.
Cost Effectiveness	Somewhere not cost-effective because of using GSM devices, new dustbins.	Comparatively cost-efficient as we are using our existing dustbins, low cost Wi-Fi device as well as network.

5.4 Implication for Further Study

In our present scope we are using manual decision making approach to select next dustbin to collect, like we are first checking on the dump levels at each dustbin and then proceeding to its location. So, the decision is made from the truck driver. But we will consider implementing a learning algorithm to automatically check the dump levels and make decisions for us like which way will be optimal for us. Furthermore, we will work for power supply solution using solar panel, developing waste amount sensing system for liquid waste.

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APPENDIX

Appendix A: Global Positioning System (GPS)

We have repeatedly said in our document about GPS, now we are going to explain it in a brief. The Global Positioning System (GPS) is a network of about 30 satellites orbiting the earth. It was originally developed by US government for military navigation. But now, anyone with GPS device such as mobile phone or GPS device can receive the radio signal broadcasted from satellites.

At least four GPS satellites are visible from anywhere on the earth at any time. Each satellite transmitting their position with time at regular interval. GPS device intercepts these signals and calculates how far away those satellites are. A GPS device can detect its location when it can detect distances of at least three satellites. This process is known as Trilateration [15].

In figure A1: after calculating distances from a GPS device to satellites A,B and C, it detects its position from intersection of three circles. In practice it uses overlapping spheres rather than circle.

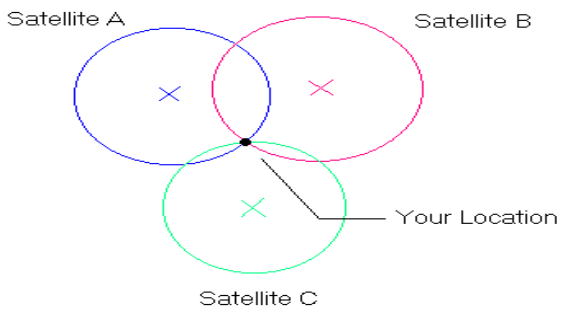

Figure-A1: Trilateration.

Appendix B: Plagiarism Report

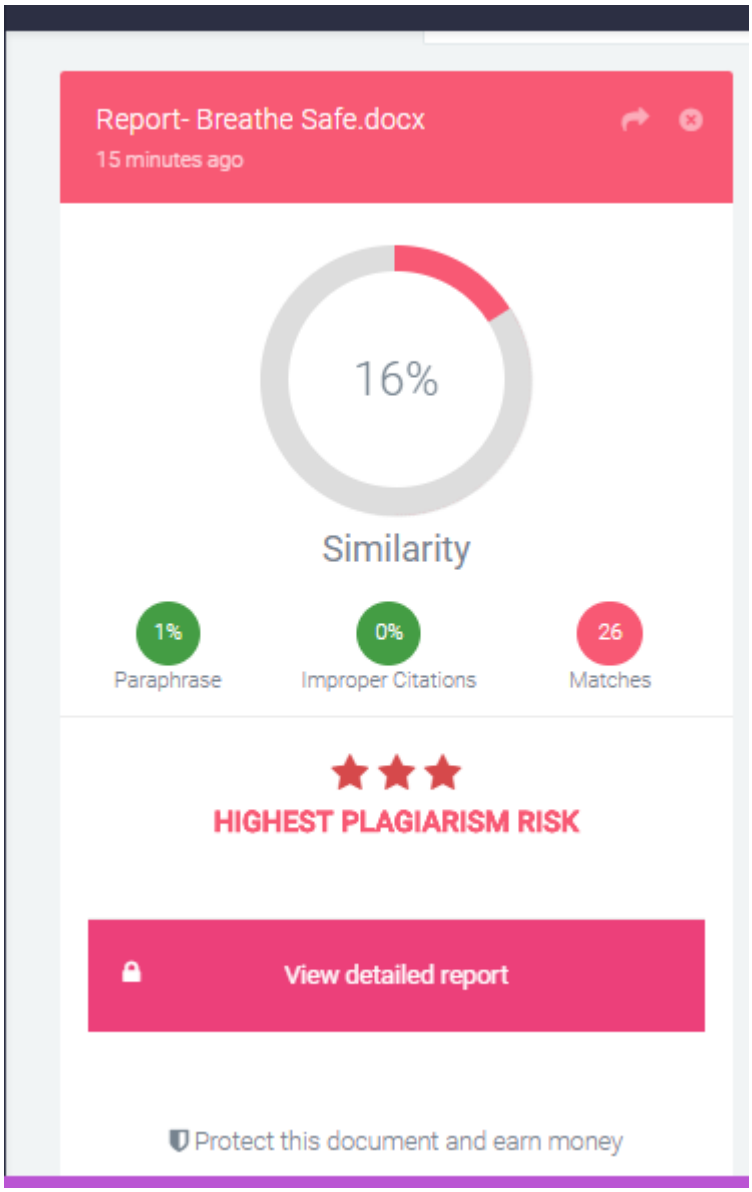

Figure-B1: Plagiarism Report.