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Smart Monitoring and Collection of Garbage System Using Internet of Things

M. Srilatha
Assistant Professor, Department of ECE.
Vardhaman College of Engineering
Hyderabad, India
ma_srilatha2@yahoo.co.in

C. Abhinav
Student, Department of ECE.
Vardhaman College of Engineering
Hyderabad, India
abhi02111999@gmail.com

M. Balaram
Student, Department of ECE.
Vardhaman College of Engineering
Hyderabad, India
medibalaram44@gmail.com

A. Sanjana
Student, Department of ECE.
Vardhaman College of Engineering
Hyderabad, India
ananthulasanjana@gmail.com

***Abstract*—Waste management system includes monitoring of garbage, collection, transport, sorting, recycling or disposal, and waste material monitoring. The system usually denotes to the materials created by human activity and is generally used to decrease their influence on health, the atmosphere or aesthetics. Whenever the garbage bins are full, it also appears to overwhelm individuals and it allows waste to spill from dustbins. So one of the critical issues that is becoming difficult to lead hygienic life is an efficient waste management system. A smart garbage monitoring framework based on IOT that uses web application PHP programming, Kodular, NodeMCU, Ultrasonic sensors and GPS for communication is proposed to ensure this problem. In the proposed method, the ultrasonic sensor tracks and tests the amount of garbage in the garbage bins, and if a person wants to throw the garbage, an android app is programmed to direct the user to the bin that is not complete using GPS and also sends a warning message to the municipal department authorities concerned about bin status using cloud (Firebase), NodeMCU. The proposed system is more effective than the current system as it simplifies the human effort, saves time and is more cost-effective.**

Keywords— Waste management system; Internet of things; NodeMCU; Ultrasonic Sensor; GPS.

I. INTRODUCTION

In today's environment, waste management is very important concept. Due to the population rise, the production of waste is become double day by day. In turn, the rise in waste is impacting many people's lives. People who live in these areas appear to suffer a great deal from the detrimental effects of poor sanitation. Waste management is one of the biggest problems facing many countries in the world, with 2.01 billion tons of waste produced annually worldwide and rising to 3.40 billion tons by 2050 [1]. The statistical graph is shown in Fig. 1. If this waste is not properly disposed of, the ecosystem and, in turn, the human lifestyle would be severely affected. So, proper waste monitoring and collection needs to be undertaken.

Most of the natural resources are being polluted by the waste disposal openly into the soil and freshwater resources which needs to be take care. Now a Days urban garbage monitoring is being problematic. Though they are providing bins in areas and doing activities like Swachh Bharath, there are many cases where garbage cans are being over filled and people tending to dump their garbage over the bins which causes them to spill over by the air on to the roads. The main problem is that the trucks that are ordered to empty those bins need to visit each and every bin taking long journeys and huge time loss for them. In today's world most of the devices used by the people are connected to each other by using the concept of Internet of Things due to tremendous growth in the internet. Things in IOT refer to a hardware device which has sensing ability and will communicate with other devices or base stations via IP address [2]. Majority of the devices are linked with the internet servers and operate simultaneously even if they are far away from each other. The concept of IoT is used to design the garbage monitoring system for efficient collection of waste in urban areas.

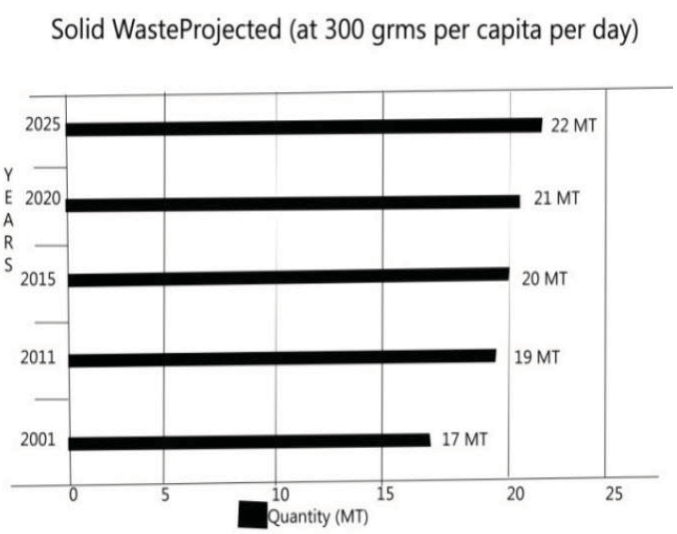

Fig. 1. Statistics of Solid Waste (gathered from [22])

The proposed system using NodeMCU, Ultrasonic Sensor and Kodular app is made a realistic monitoring and cleaning the garbage bins when the level crosses the threshold in waste management system. Using the software installed on the phone, the user can track the amount of the garbage at any time and

when the garbage in a specific bin reaches the threshold, then the google map automatically shows the location of the bin whose garbage is not complete and at the same time an SMS will be sent to the authority concerned. The proposed framework can be used by individuals who are willing to take one step forward to improve cleanliness in their valued areas as a benchmark. The paper is organized as chapter 2 discuss the Review of Literature, chapter 3 explains Implementation and Design, Results and Discussion is done in chapter 4 and Conclusion & Future enhancement in chapter 5.

II. LITERATURE REVIEW

Waste management system is one of the major problem faced by the world. It should be solved efficiently to save the natural resources and environment in turn the lives of the human being. Various authors [3] has come up with different solutions but none of them is an efficient one. Waste management system can be remodified and efficiently utilized by adopting innovations happening in the latest technologies. The existing research which solves the problem to some extent has been surveyed. Minhaz Uddin Sohag and Amit Kumer Podder [2] designed an IOT based system which identifies the status of garbage bin and intimate the level to the user and also to the concerned authority with the help of Arduino UNO and Ultrasonic sensor, but this design will solve the problem for small-scale garbage bin only. Authors in [4] has designed garbage system for urban cities using Android application through which user and authorities can know the status of bins.

Authors in [5] proposed a system which differentiates biodegradable and non-biodegradable waste by using ultrasonic sensor to measure the level of bin and MQ4 sensor to measure the odour level and the measured information will be sent to authorities using NodeMCU web server. Author also proposes SOS operation in app, so that if IOT system fails then an individual can send the message to the authorities using app for cleaning the bins. Shashank Mithinti, Aman Kumar, Suryansh Agarwal and Isha Malhotra [6] proposes a selection algorithm which is based on level of percentage, date and time, based on this shortest path algorithm calculates the path and selected bin to be disposed. Authors uses various technologies like Arduino [7, 8], Zigbee [10], wifi-enabled microcontrollers [13, 21], Wemos D1 mini [14], AVR microcontroller [15], NI myRIO [16], Raspberry Pi [19], VANET [22], NodeMCU [24, 25], different sensors like Ultrasonic sensor, IR sensor, Rain sensor, gas and smoke detection sensor, carbon monoxide and methane detection sensor, flame sensor, intimating through buzzer and GSM/GPS and different languages like HTML and Embedded C.

In [9], an Intelligent waste container is designed by using microcontroller, blynk IOT android, wifi module. In this ultrasonic sensor will detect the level of garbage in bins and once the bin is full then using wireless sensor nodes real time information will be transmitted to waste container, which then collects the waste from bins. In [11], author proposes neural network concept to classify the waste into digestible and indigestible and smart disposal boxes to monitor the real time data using IOT. Raspberry pi is used to classify the waste and sends an information to servo motor, so that corresponding waste will be dumped into respective disposal box. In [12],

TABLE I. COMPARISON OF RESEARCH WORK BY VARIOUS AUTHORS

Ref No.	Similar work compared to proposed system	Technology used	Benefits	Shortcomings
[2]	Checks the garbage amount sends an SMS to the authority concerned.	Arduino UNO, Ultrasonic Sensor, Servo motor, LCD(16x2), GSM SIM800L.	• Lid of the garbage will open automatically. • Sends an SMS to authority when bin fills 100%	Real time condition of the bin cannot be known.
[4]	• Checks the level of waste using sensor. • Alert the authority using GSM/GPS	Android Application, LEDs, GSM Module, Web server	User can find nearby bin using android application.	It is designed as a demo only. Automatic opening of bin lid is not provided
[5]	• Separation of waste into biodegradable and non-biodegradable. Notification through app	MQ4 sensor, Ultrasonic sensor, NodeMCU, Thingspeak Server, MIT appinventor2	For biodegradable waste, lid will open automatically.	For Non-biodegradable waste, lid will not open automatically.
[6]	Notification and collection of garbage based on weight, date and	Arduino UNO, Ultrasonic sensor, Load cell HX711, NodeMCU	Reducing the cost and time.	Automatic opening of lid and display is not proposed

	time.			
[7]	• Reduction in time and cost. • Notifying SMS using GSM	Arduino UNO, Ultrasonic sensor, GSM, MySQL database, Java netbeans, Buzzer	Collecting waste and trip management is possible	Positioning of the bin is not automatic
[8]	• Level testing is done • Automatic notification is possible	Arduino UNO, IR sensor, Ultrasonic sensor, Rain sensor, Buzzer, Relay, Motor	Monitoring by humans is reduced.	Lid closing is not done when it rains
[11]	Separates waste into digestible and indigestible	Deep learning Technique (CNN), Raspberry pi, Bluetooth, Camera, Ultrasonic sensor, Android application.	Measures level of garbage using weights and threshold.	It cannot work for all indigestible waste.
[12]	• Notification of message. • Monitors the level of garbage	Machine Learning technique (KNN), MQ4 gas sensor, IR sensor, Ultrasonic sensor, Raspberry pi, Adafruit IO free web service using wi-fi	Segregation will be happened at two different levels. Lid closes automatically.	Line follower concept is used.
[13]	• Monitoring fire in dump yards. • Monitoring the garbage level. Notification is possible.	Wi-fi microcontroller, sensor for gas and smoke detection, GPS module, sensor for carbon monoxide and methane detection, flame sensor, Ultrasonic sensor, Machine learning algorithm (SVM)	Fire detection is happening automatically	Multiple stations which monitor the complete dumping yard are used.
[14]	Monitoring the garbage level.	WeMos, Ultrasonic sensor, Wi-fi module	Cost is less, system is more efficient and saves time.	Automatic opening of lid and display is not proposed

author proposes a smart dustbin which is used to separate waste from household and reuse that waste to make bio compost using machine learning technique called KNN and IOT technology. In this paper based on the three parameters called level of biodegradable, non-biodegradable and poisonous gas concentration, a message will be sent to authorities.

In [17], author developed a sensor node which will monitor the garbage bin level and routes the information related to orientation sensor, distance/height sensor and real time clock module to central database using Arduino Nano microcontroller, then collected data from sensors will be displayed on webpage so that concerned authorities can make a route plan to collect the garbage. Umar Draz, Tariq Ali, Jamshaid Ali khan, Muhammad Majid and Sana Yasin [18] proposed monitoring the dumpsters and when it is full, collecting the garbage from respective dumpster. Authors used IOT technology to calculate the status of garbage based on threshold and its location with the help of GPS, so that concerned authorities can take action to clean the dumpster. To achieve this, components used are Arduino UNO, GSM module, LCD, IR Flame sensor, Ultrasonic sensor, GPS and Opt couplers. Authors [20], proposed smart bins forming a network and communicate through cloud-based techniques which is used to monitor, and analysis of data collected from smart bins to decide the shortest route for garbage trucks to collect the garbage from concerned bin. Authors [23], has given a solution for waste management system by integrating Wireless sensor network concept with IOT and also to improve garbage monitoring efficiency, machine learning technique called decision forest regression method is applied. Research work of various authors is compared with the proposed system is shown in table 1.

III. IMPLEMENTATION AND DESIGN

A. Block Diagram

The collection of information in the proposed system is done by ultrasonic sensors where the information is being fed to the NodeMCU and updated into the firebase database using the Wi-Fi-connectivity provided by ESP8266 SoC and at the same time the information is being updated to the user and the authorities using android application that is being made from using Kodular (a modern app making without heavy coding) which also sends the SMS alerts to the authorities without usage of separate GSM modules as shown in Fig 2.

B. Flow Chart

Fig. 3 shows the proposed system flow of execution.

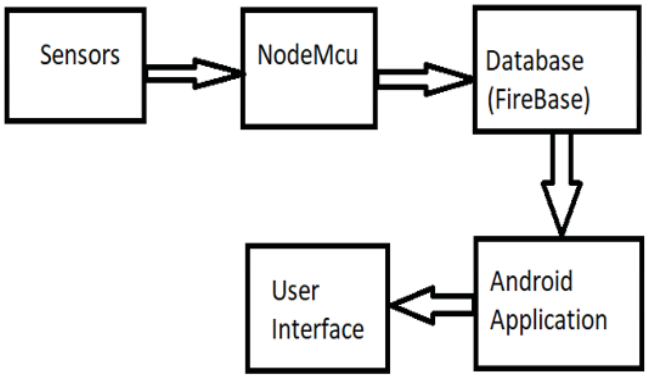

Fig. 2. Proposed System Block Diagram

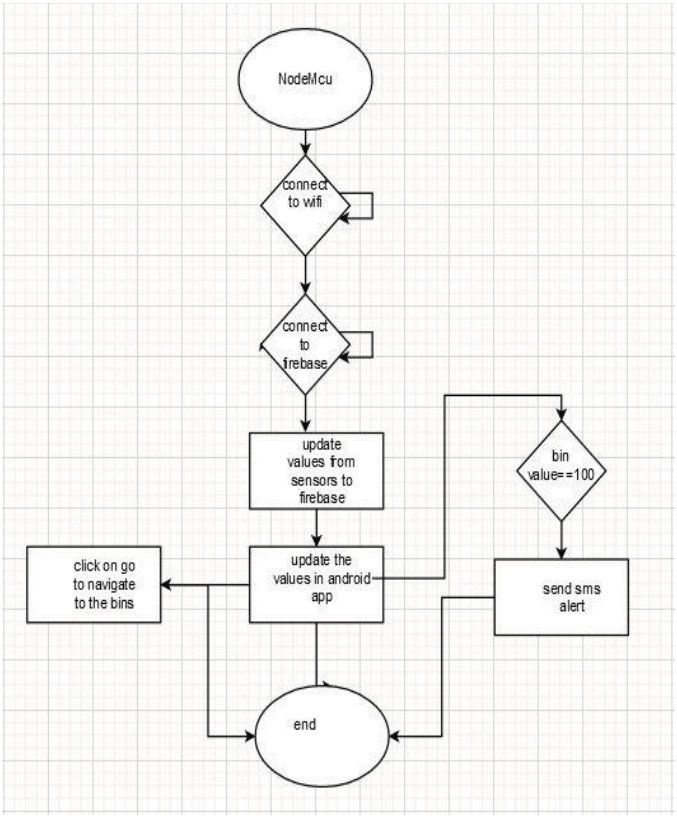

Fig. 3. Proposed System Flow of Execution

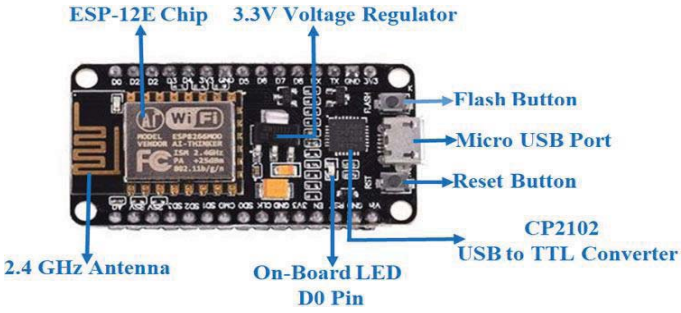

Fig. 4. NodeMCU

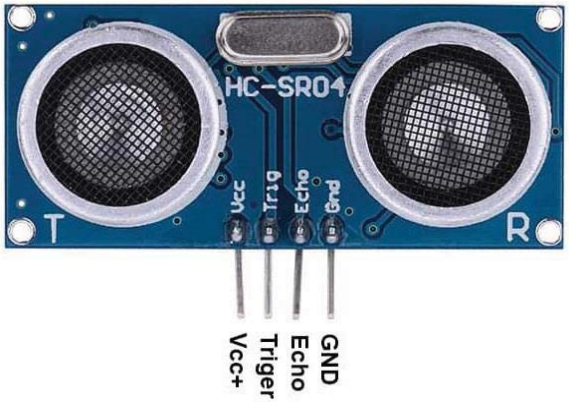

Fig. 5. Ultrasonic Sensor (HC-SR04)

C. Hardware Implementation

I. NodeMCU

The NodeMCU (Node Micro Controller Unit) is an open-source environment for the development of software and hardware designed around a cheap System-on-a-Chip (SoC) called ESP8266. The ESP8266, developed and manufactured by Espressif systems, as shown in Fig. 4, comprises the key components of a computer: CPU, RAM, WiFi, and even a modern operating system and SDK, making it an outstanding option for all sorts of Internet of Things (IOT) applications.

II. HC-SR04 Ultrasonic Sensor

The ultrasonic (or transducer) as shown in Fig. 5 operates on the same radar system concept. Electrical energy can be converted into acoustic waves by an ultrasonic sensor and vice versa. An ultrasonic wave travelling at frequency above 18KHz is the acoustic wave signal. Ultrasonic waves are produced at the 40KHz frequency by the popular HCSR04 ultrasonic sensor.

D. Software Implementation

I. Kodular

With each individual component being used for a particular purpose, the apps in Kodular are constructed as a combination of different components. Blocks are used to configure the component's actions, as shown in Fig. 6.

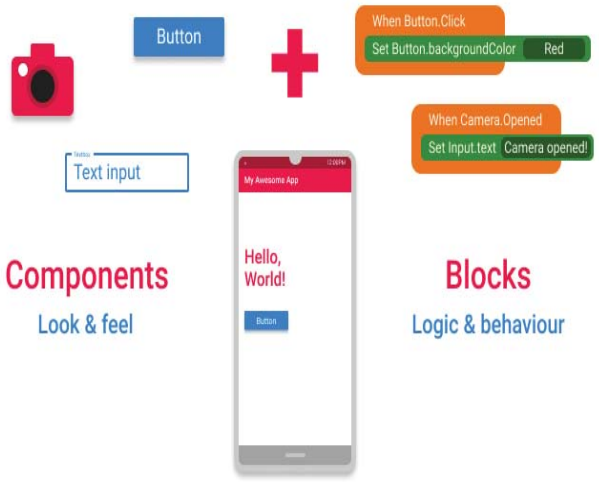

Fig. 6. Components and Blocks

In Kodular, components are the basic building elements. With the assistance of one component or the other, everything in the app is finished. For various purposes, various components are used. One feature, such as a button component, can be used to design the app's user interface (UI), while others can be used to perform actions such as interfacing with a database, saving an image to the Android device's folder etc. for example the *FirebaseDB* component.

Blocks are those that are used to explain how a job can be completed. Blocks are often constructed in the same way as how the components respond to different actions and events in the app. Foe example, when a button is pressed, how the app should react, what information to communicate to the database using the FirebaseDB part, etc. are all configured using the block. Thus, an app is "koded" in Kodular by using the various components and by configuring its behavior and response to user actions with the aid of blocks.

II. Firebase

Firebase as shown in Fig. 7 is a google's mobile platform that provides the developers with various tools and services for development of high-quality apps. Firebase database is a cloud-hosted sql database that lets the users to store and upload data dynamically.

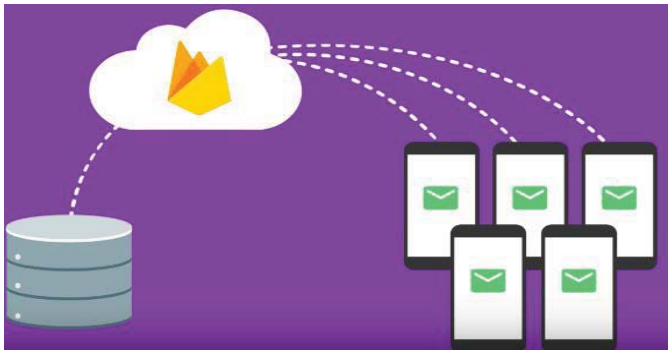

Fig. 7. Firebase Cloud Messaging

E. Algorithm

- Start.
- Include required libraries and define pins.
- Define the pinmodes of the pins and check for the wifi connectivity.
- Check the level of garbage in the bins with Ultrasonic sensors.
- Send the data to the firebase real time database.
- If level of the garbage updated in bins, update the information in Database.
- If the level of the bin is 100%, send the alert SMS to the concerned authority.
- If the user clicks on "GO" in application, navigate to the selected bin through gmaps.
- Stop.

F. Internet of Things (IOT)

The Internet of Things (IOT) is a broad network of related gadgets that gather and store information based on how they are used and the world in which they function. For all devices, IOT offers a common forum. IOT is an advanced technology that uses the internet to monitor or track internet-related computers, cars and other physical objects. IOT research is never ending and will be beneficial to humanity with the great possibility of linking more and more gadgets to the cyber world. The proposed system uses NodeMCU which links to the internet, where the data will be collected from the sensors and send them to the real-time Firebase database to access the information anywhere the internet is accessible. This enables the user to use the internet to track the smart garbage monitoring system.

G. Firebase Realtime Database

The Realtime Database Firebase is a cloud-hosted database. In the firebase database, information is stored in the form of a JSON (JavaScript Object Notation). For data saving and sending, JSON is a lightweight format. The real-time firebase database allows us to create rich, collaborative applications by allowing safe access to the database directly from the developed user-side code. In our project we have choose firebase cause of its vast facilities to create real time applications. In our project we are sending information collected from sensors through NodeMCU to the firebase real time database.

H. App Development

Kodular is used for developing the android application for our project. Kodular uses blocks and components to create apps. Kodular allows anyone to create perfect android apps easily without writing any line of code. Kodular allows us to concentrate on ideas for creating apps. In our project the user-side application is developed by Kodular where it fetches the data from the firebase real time database and displays it to the

end-users it also provides the google maps extension for navigating to the garbage bins.

I. Model of our work

Fig. 8 shows the proposed system model.

J. Pseudo Code

1: Program starts

2: Initialize Variables

3: Enter firebase authorization

4: Enter Wifi authorization

5: While Wifi status = = not connected

6: Continue

7: End while

8: Loop

9: If bin level = = 100

10: Send SMS to authorities

11: End if

12: Else

13: Update bin level in firebase

14: End else

15: If "GO" button clicked

16: Open gmaps to navigate

17: End if

18: Else

19: Continue

20: Go to loop

21: Program end.

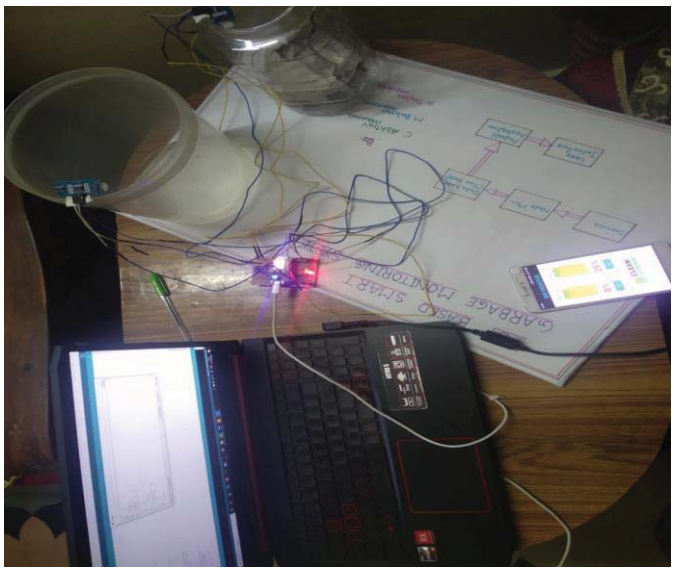

Fig. 8. Proposed System

IV. RESULTS AND DISCUSSION

The working model for the proposed system is designed and implemented. The performance of the system was analysed for different conditions. All the sensors are checked in such a way that their values are above and below the threshold values. All the hardware components ought to be connected with proper connections and ensure that wifi module is connected to internet as the values will update into "firebase database in real time. The output on the monitor is observed as shown in Fig. 9.

After ensuring that the android phone is connected to the internet, the application will open the first screen as shown in Fig. 10, then a second screen will appear as shown in Fig. 11 which shows the values of level of a garbage of different bins.

Whenever the user clicks on "GO" button on one of the bins in the application then it will navigate to the maps screen, where the location of bins will be displayed and when user clicks the direction then the app will navigate in google map screen as shown in Fig. 12. When the level of the garbage reaches the threshold value then an SMS alert will be sent to the authorities as shown in Fig. 13.

The main advantages of the proposed system over existing system are:

- Location of the bins whose level of garbage reaches threshold can be easily communicated to authorities.
- For sending SMS, instead of GSM module a fire base is used which leads to low-cost maintenance.
- Data will be periodically processed in the cloud so that data can be used for future predictions.
- Cost and effort will be less which makes environment clean and green.

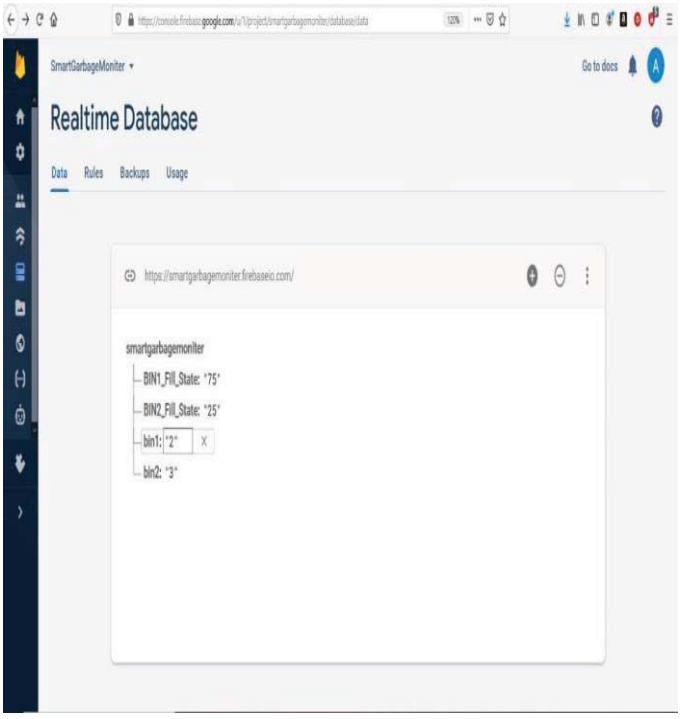

Fig. 9. Output on Firebase Real-time Database

Fig. 10. Screen 1

Fig. 11. Screen 2

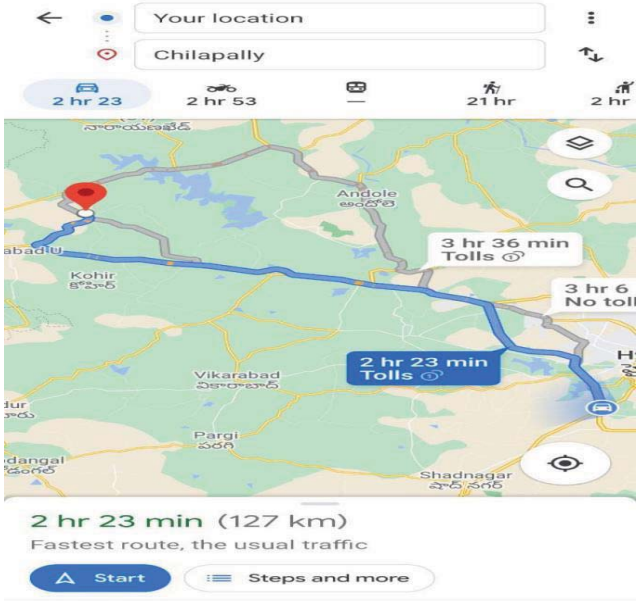

Fig. 12. Google Maps

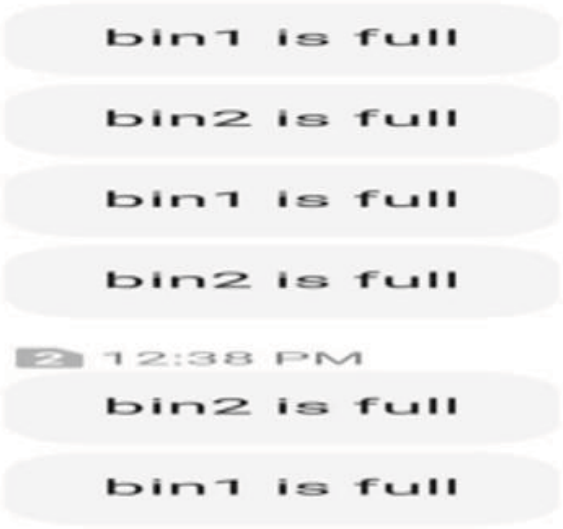

Fig. 13. SMS Alert

V. CONCLUSION AND FUTURE ENHANCEMENT

The main aim of the proposed scheme is to preserve the standard of cleanliness in the city and create a healthier living atmosphere. We can continuously check the amount of the garbage in the dustbins that are located in different parts of the city by using this device. If the maximum level has been reached by a specific dustbin, the the employees can be informed and they can take certain actions immediately to empty it as soon as possible. Employees can verify the status of these bins on their cell phones at any time. When used properly, this can prove to be a very useful system. The system can be used by people who are willing to take a step further to increase cleanliness in their respected regions as a benchmark. Further the proposed system can be extended by using infrared sensor and weight sensor which are used for precisely monitoring the garbage in bins. It can also be extended to classify the dry waste or a wet waste by using machine learning techniques.

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