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Network of Smart Waste Bin Management system and GPS enabled Waste collection Vehicles

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Abstract: With the increasing trend of a cleaner and greener country, modern and non-traditional techniques of waste collection and garbage management are required. For this, we present an apt solution in this paper. This paper focusses on automating the door-to-door waste collection process carried out by the Municipals of most cities in India. By means of some sensors that together constitute a module with each module fitted in a dustbin, the amount that the dustbin is filled up to will be displayed in real time at a website. The authorities can monitor the status of the dustbin and dispatch the collection vehicle accordingly. Also, the garbage collection vehicle is to be fitted with a GPS Module to monitor its location continuously and display the predetermined route and estimated time of arrival on the website for the user's convenience.

Keywords: Ultrasonic sensor, Wi-Fi Module, GPS Module, Server, Web Interface, Bins.

INTRODUCTION

The civic authorities of a city are constantly in pursuit of methods that aim to bring about revolutionary changes in the levels of cleanliness and hygiene in their area. After commencement of the "Swatchha Bharat Abhiyaan" it has become a primary focus of the local bodies to maintain the cleanliness in and around the cities.

The aim of the "Smart dustbin Network", as we like to call it is to modernize the trends in traditional garbage collection and waste disposal mechanisms to serve the citizens by collaborating with the civic authorities. This work provides a solution to the wastage of necessary resources by implementing the new idea of automation and monitoring of waste management operations [1]. With the help of the "Smart Dustbin Network", we embed technologies like Internet of Things, Sensor based micro controller functioning, GPS tracking System along with mobile and web application to improve and smoothen the ground level mechanisms for waste collection and efficient processing and re-cycling of waste which were earlier not used as an integrated system for waste management [2].

SYSTEM IMPLEMENTATION

The work is widely divided into three categories:

1. Network of Sensor based Waste Bins Management system for Commercial Zones.
2. GPS enabled door-to-door waste collection vehicles optimized especially for the consumers in Housing areas.
3. Full-fledged web interface for the users and administrator.

A. Sensor based Waste Bins Management system for Commercial Zones :

According to this segment of the work, the entire city is fragmented into zones and a waste bin is placed for every zone, i.e., one dustbin per zone. Each dustbin has an identification (ID) associated with it which is used to connect to the bin wirelessly from a monitoring station to know the status of the waste bins in any of the commercial zones of the city. If a zone has large garbage generation volume, several bins (4-5 in nos.) can be placed in a single zone to cater to the needs of about 6-7 shops in the vicinity of that particular bin. The real-time status of each bin, whether it is empty or filled, is monitored continuously from the central monitoring station for uninterrupted updating in a database stored at the server machine. This monitoring ensures customizable waste collection schedule according to the amount of garbage filled in the bin thereby reducing resource wastage and ultimately the cost of operation. The sensors mounted on top of the bins transmit accurate percentage filled information to the central monitoring station over wireless web access. Through this system, the information of all the bins can be accessed from anywhere and anytime.

The work also offers push notification service as soon as the bin gets filled beyond a certain level as set by the administrator. On arrival of the information, the concerned authority can dispatch the zone dedicated garbage collection vehicle to that particular zone only when the average fill in the dustbins in a particular zone is greater than a certain threshold value. By implementing this system, a major step in resource optimization, cost reduction and effective usage of bins can be taken. The frequency, quantity and average waste generation of a

particular area can also be measured accordingly for future aspects.

Technical Specifications:

The setup consists of a micro controller with a built -in Wi-Fi Module - Node MCU [7] and an ultrasonic sensor [3], as shown in Fig.1 (a). The Fig. 1(b) shows the actual module. The sensor senses the depth up to which the dustbin is filled which is sent to the back-end server using the Node MCU. The salient features like small size, low power consumption and a built-in capability to connect to a Wi-Fi network make it quite handy for use in applications of IoT. NodeMCU here is responsible for sending the data from sensor to the server. The server then processes the data and stores it into the database along with the current timestamp. This data is then used for various operations which can be performed by the user on the website. Here a rechargeable battery (8V) is used as a power supply which is regulated to 5V by means of IC 7805 [4] for power supply to the ultrasonic sensor.

Here, we use the ultrasonic sensor [3] as our depth sensor. Fig 2 shows a picture of the sensor used. It consists of a transmitter and a receiver. The transmitter emits an ultrasonic wave which after striking a surface is reflected back and is detected by the receiver. The sensor then sends a high pulse, at its output pin, whose duration is equal to the time taken for the sound wave to be received after it was sent. The time duration, on being received by the micro controller is divided by 2 and using the basic speed distance time relation, where the time taken by the sound and speed of sound (343 m/s) is known, and the distance is calculated. The range of the ultrasonic sensor is 2 cm to 400 cm. This calculated value is then sent to the server where it is subtracted from the total capacity of the particular dustbin. It is then stored in the database along with the current date time.

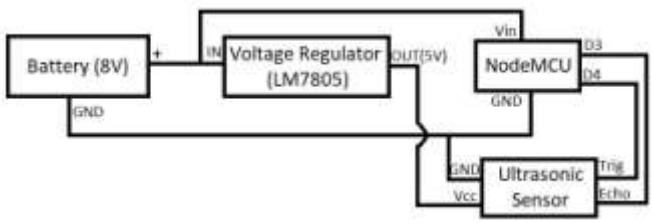


Figure 1 (a). Block diagram of the module.

Figure 1 (b). Actual module

Figure 2. Ultrasonic sensor

B. GPS enabled door-to-door waste collection vehicles optimized especially for consumers in Housing areas:

This segment of the work aims to optimize the present door-to-door garbage collection process by implementation of vehicular tracking on garbage collection vehicles. In the present scenario, a garbage collection vehicle is assigned for a particular locality, which collects garbage from the doors of the houses periodically. But, it has been observed that the fashion in which garbage is collected is highly irregular with the customers being unaware of the current precise location of the vehicle. To solve this problem we propose the concept of "Moving Bins". A moving bin consists of a GPS enabled vehicle which will be used for the collection of garbage from doors of the houses of a particular a Housing colony. The houses will have individual bins which will be periodically emptied in a large capacity GPS enabled garbage collection vehicle. The route and time of the Moving bin will be fixed and will be made available to the user so that they are aware about route map of the moving bin well in advance. Since the moving bin is GPS enabled, the current location of the vehicle will be continuously available to the consumers as well as the Waste Management officer who would be able to display notices, if required about maintenance/malfunctions, on a dedicated web page of the website if any delay is bound to be created in the arrival of vehicle. The GPS system sends information whether the moving bin has visited all the houses in the area or not and this can be used to determine the frequency of emptying of the moving bin. The GPS module fitted in the vehicle will be continuously transmitting information to the central monitoring system/server over wireless internet. By implementing this system, resource optimization, cost reduction and an effective usage of door-to-door garbage collection model can be done.

Technical specifications:

Fig. 3(a) shows the block diagram of this module. It consists of a microcontroller with built in Wi-Fi capabilities [7] - Node MCU and a GPS module [1] in order to get the coordinates of the location of the vehicle. Just like the previous module, here also we have used NodeMCU as our microcontroller [7] which acts as a source to connect to a Wi-Fi network and sends the coordinates of our vehicle to the server. The power supply here is taken from a car charger (DC 5V - micro USB) used in the vehicle. It is so because, unlike the previous module, this module has to continuously keep track of the coordinates and send it to the server which is a very tedious and power consuming task and hence rechargeable battery can't be used to solve the purpose.

We have used Neo 6M as the GPS module in our work. This module has a 25 x 25 x 4 mm ceramic antenna attached to it

(Figure 3(b)). This module is responsible for providing the vehicle's current coordinates to the microcontroller. It connects to 4 satellites at a time to calculate the exact coordinates in 3D, velocity and numerous other parameters.

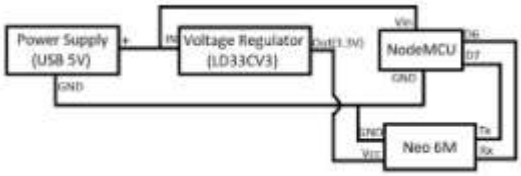


Figure 3(a). Block Diagram of Moving Bin Module

Figure 3 (b). Actual Module

C. Full fledged Web interface for users and administrators:

The third and the final module of this work is also the most important one. All the backend processing and storage of data at the server, as well as the frontend display of the data to the users is carried out at this level. This module can broadly be divided into the following sub-sections for better understanding of the structure and interactive ability of the website.

1) *Server*
2) *Database Management*
3) *Different Webpages*
4) *Notifications System*

Server:

The online server used for the website is 000webhost (Fig.4) and the live website can be accessed through the following link: http://smartdustbinnetwork.000webhostapp.com/. For offline testing, soft wares such as XAMPP are used which is a cross-platform local server of Apache, MySQL, and PHP & Perl [6].

Figure 4. Homepage of website on 000webhost.

Database Management:

The Database Management System used here is MySQL. The following tables have been created for the storage and management of different type of data within the website:

1. Complaint – This table consists of the complaints submitted by the user along with the date time stamp, contact details of the complainer and a serial no to identify the complaints.
2. Feedback – It is just similar to the previous table and in place of complaints, the feedback of the user is stored.
3. Current Location – It stores the latitude and longitude of the garbage collecting vehicle along with the date of time. There is one such table for each vehicle.
4. Details – It is a record for the details regarding all the details present in the system. It consists of the DustbinId, their capacity, the zone in which they are situated and some other variables which will be discussed later.
5. Dustbin – There is one such table for each dustbin in the system. Each table has a date-time stamp along with the value filled at that particular moment.
6. Route – This table consists of a well-defined list of coordinates along with a date & time. This is the proposed route of the vehicle along with its scheduled timeline.
7. Global Variables – This table consists of some variables which are used throughout the website.
8. Users – It stores the data of different users who have created an account for bill payment purposes.

Different webpages:

The different webpages you will see in the website are mentioned below:

1. Status - It shows the status (in percentage) of the dustbins whether filled or empty.
2. Statistics – It shows the past statistics of each dustbin, zone and the overall city in terms of graphs and pie-charts (Fig. 5(a), (b)).
3. Submit Complaint – It is the interface for the user to submit a complaint to the administrator (Fig. 5(c)).
4. Feedback – It is the webpage for the submission of feedback by the users (Fig. 5(d)).
5. Current Vehicle location – It shows the present location of the garbage collecting vehicle (Fig. 5(e)).
6. View Vehicle route – It is used to display the predefined route followed by the garbage collecting vehicle (Fig. 5(f)).
7. Pay Bill – This page allows users to pay pending monthly bills by integrating a gateway from PayU Money which offers various options for payment like credit card/debit card etc. (Fig. 5(g), (h)).
8. Administrator Section (Fig. 5(i)).

Figure 5 (a). Dustbin statistics

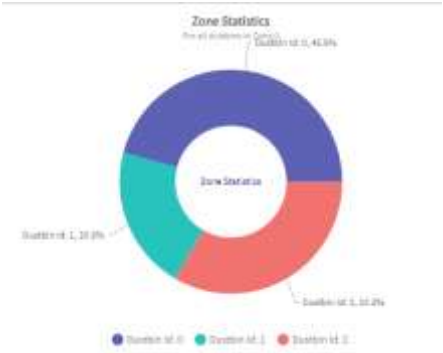


Figure 5 (b). Zone statistics

Figure 5 (c). Submit Complaint

Figure 5 (d). Feedback

Figure 5 (e). Current Vehicle Location

Figure 5 (f). Vehicle Route.

Figure 5 (g). Bill Payment

Figure 5 (h). Payment Success

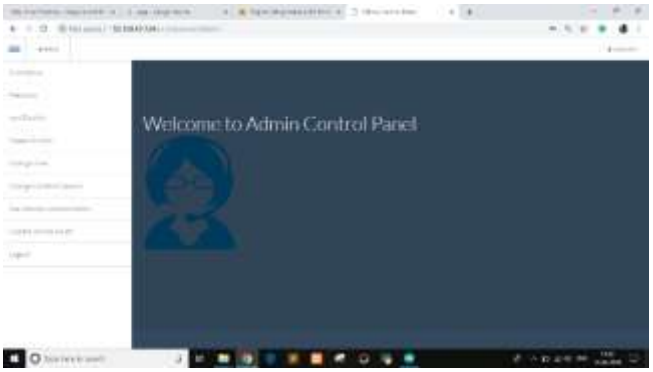


Figure 5 (i). Admin Section

The Administrator section has the following pages:

1. Complaints - This page enables the admin to view the complaints submitted by the user and to reply to the complaints via integrated e-mail service using Simple Mail Transfer Protocol (SMTP) [5] (Fig. 6(a), (b)).
2. Feedback – It is used to view the feedback submitted by the user and to reply to the same via e-mail as mentioned above (Fig. 6 (b), (c)).
3. Add Dustbin – This page is used to add another dustbin to a particular zone (Fig. 6(d)).
4. Delete dustbin – This page is used to delete a particular dustbin from any zone (Fig. 6(e)).
5. Change Zone – It is used to change the zone of a dustbin.
6. Change Dustbin capacity – This page is used to change the maximum capacity of any particular dustbin.
7. See Vehicle Location History – It is used to view the locations the garbage collection vehicle has visited in the past in order to keep a track of its activities (Fig. 6(f)).
8. Update Vehicle route – It is used to update the predefined vehicle route in case of changes, which is then displayed in the 'View Vehicle route' page of the website (Fig. 6(g)).

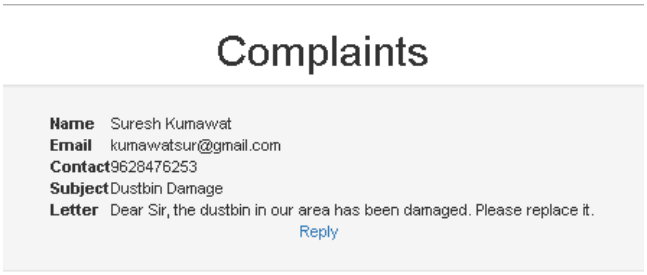


Figure 6(a). View Complaints

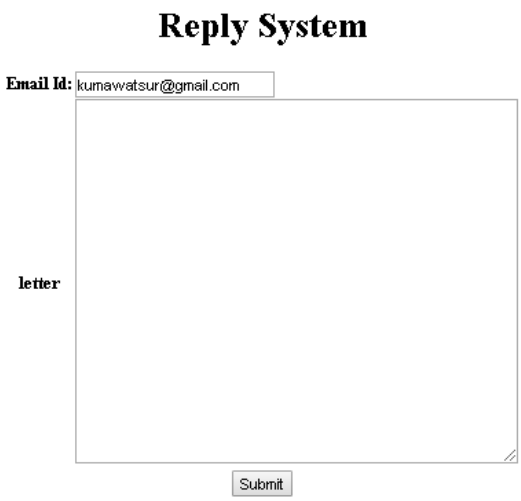


Figure 6(b). Reply System

Figure 6(c). View Feedback

Figure 6 (d). Add Dustbin

Figure 6 (e). Delete Dustbin

Figure 6 (f). Location History

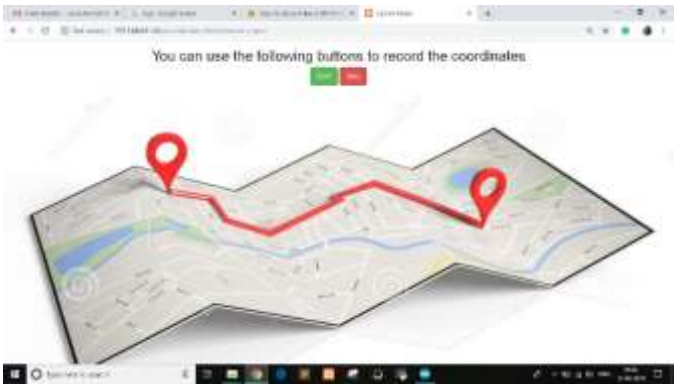


Figure 6 (g). Vehicle Route Update

Notification System:

The whole system and the website is connected to a well versed Notification System supported by Telegram. This enables the administrator to keep a strict watch on the garbage collection vehicles as well as the status of each and every bin in the zone. By means of this system, a push notification is sent to the mobile phone of the driver of the vehicle (Fig. 7(a)) and the administrator (Fig. 7(b)) as per the following status of the dustbins when filled to this level:

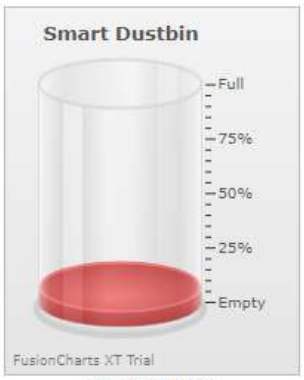
1. Notification to driver about Dustbin – 90%
2. Notification to Admin & Driver about Dustbin – 95%
3. Notification to driver about Zone – 70%
4. Notification to Admin & Driver about Zone – 80%

Figure 7 (a). Driver Notice

Figure 7 (b). Admin Notice

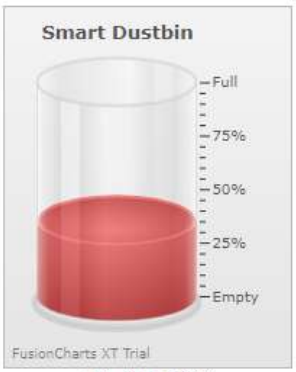
RESULT

The following are the results obtained when different amount of garbage was filled in a particular dustbin. The following figures show the amount of garbage filled in the dustbin and the corresponding change in the value of status of that dustbin on the status page of the website in real time.



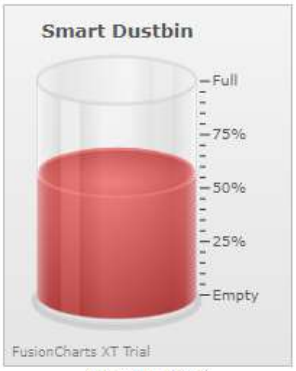
Dustbin Id: 2
Capacity: 14

Figure 8 (a). Empty Dustbin & corresponding status update.



Dustbin Id: 2
Capacity: 14

Figure 8(b). Quarter-filled bin & corresponding status update.



Dustbin Id: 2
Capacity: 14

Figure 8(c). Half-filled bin & corresponding status update.

CONCLUSION

This work is the implementation of smart garbage management system using Ultrasonic sensor, Wi-Fi module & GPS. If the dustbin is not cleaned in specific time, then the record is sent to the higher authority who can take appropriate action against the concerned contractor. This reduces the total number of trips of garbage collection vehicle and hence reduces the overall expenditure associated with the garbage collection. Overflow of garbage bins is a common sight and this work can avoid such situations and the notifications can be sent directly to the driver of the cleaning vehicle as well as the supervisor. There is a great scope for the modifications of the Smart Dustbin in future by adding new functionalities & can be very widely used in the Smart buildings of Smart cities.

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