



INTEGRATED AND EFFECTIVE WASTE MONITORING AND MANAGEMENT

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Abstract: In world, landscapes of rapidly growing urban areas generate large volume of solid waste. In the next decade, it is expected that more than 50% of solid waste will be increased. Effective and more integrated waste monitoring and management solutions using innovative technologies are required besides the traditional use of labour, dustbins, garbage boxes, vehicles, etc. This paper presents a solution for effective waste monitoring and management using IoT based smart waste bin. We have developed smart waste bin using Arduino hardware. The waste bin continuously monitors the level of waste in it through sensors. Developed smart waste bins and system have initially installed in the campus-sized area. The system is tested on various performance criteria. The solution gave promising results in effective waste monitoring and management.

Keywords: Internet-of-Things (IoT); waste management; waste monitoring; embedded system; sensors

1. INTRODUCTION

In world, landscapes of rapidly growing urban areas generate large volume of solid waste. More quantity of solid waste will be generated because of increase of population in this urban areas [1][10]. It requires efficient and effective solid waste management practices by the municipalities in this areas. This waste management service of the municipalities requires good amount of expenditures (i.e. operational and maintenance costs) along with large investment in the waste collection vehicles fleet. This service consumes around 30% of municipalities budgets in many developing countries [2][7]. It also increases air and noise pollution along with traffic congestions [2]. It also increases road accidents in major cities of country like India.

Effective and more integrated waste monitoring and management solutions using innovative technologies are required besides the traditional use of labor, dustbins, garbage boxes, vehicles, etc. It is essential to use smart waste bin for efficient and dynamic waste management system [2] [6]. Using this smart waste bins, we can have real time data of waste bin and vehicles [2]. It will reduce the operational cost (i.e. fuel and man power)

This paper presents solution for effective waste monitoring and management using smart waste bin. We have developed smart waste bin using Arduino hardware. The waste bin continuously monitors the level of waste in it through sensors. Developed smart waste bins and system have initially installed in the campus-sized area. The system is tested on various performance criteria.

The main contributions of this research paper are summarized next:

- We aim to enhance the existing waste controlling devices and system by having smart waste bin and container to control the waste with less human efforts.
- We aim at finding the eco-friendly solution for efficient waste management

One of the limitation of the system is requirement of the power supply, which may not available in the remote and rural areas. This limitation of power supply in remote or rural areas is solved by using the solar panels installed with the waste bins.

The rest of the paper is organized as follows. Section 2 presents literature reviews. Section 3 presents the solution for efficient waste monitoring and management. Section 4 explains the significance of the smart dustbin and the system. Section 5 describe the significance of the system. Section 6 concludes the paper.

2. LITERATURE REVIEW

A good number of researchers have proposed various solutions to manage the waste using various technologies [1][2][3][4][5][6][7][8][9]. Table-1 shows the technologies used by various researchers for waste monitoring and management.

Table I. Research related to Waste management

<i>Technologies/Solutions for waste monitoring and management</i>	<i>Proposed by</i>
Capacitive level-sensing model	[1]
Framework about the traceability technology	[2]

IoT prototype with sensors	[3]
Search space analysis for dynamic routing with time windows in waste collection.	[4]
Chaotic Particle Swarm Optimization in GIS based environments	[5]
Integrated sensing system and algorithm	[6]
IoT based	[7]
IoT based using RFID	[8]
IoT based (review)	[9]
Remote Sensing	[11]

3. DESIGN

In this section we present our solution for the problem of waste monitoring and management. It has 6 sections viz., i) Smart waste bin with sensor, ii) Arduino board, iii) Wi-Fi section, iv) Monitoring cell with data storage, v) GPS, and vi) GSM (See Fig.-1).

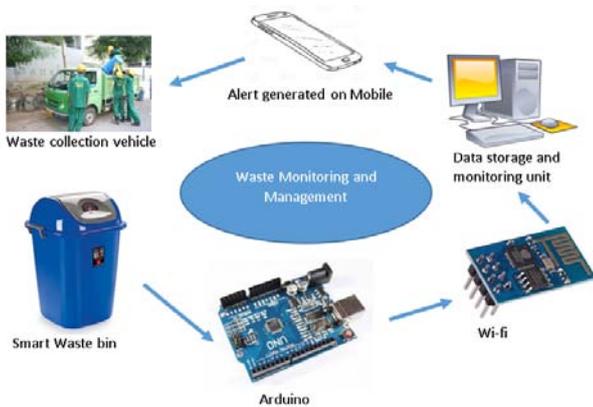


Figure 1. Schematic diagram of Waste monitoring and management solution

A. Smart Waste bin with Sensor

We have equipped our waste bin with ultrasonic sensor module to make it smart. It measures the distance from top to level of waste in the waste bin by using sound waves. For empty waste bin, it measures the distance from top to bottom of the waste bin (See Fig.-2).



Figure 2. Ultrasonic sensor module: HC-SR04

It detects the distance in the range of 2 cm to 400 cm (i.e. 0.02 meter to 4 meter). It measures the distance precisely with accuracy up to 0.3 cm. It sends the data. Distance is calculated using the Eq-1.

$$\text{Dist} = (\text{speed of sound} * \text{time taken}) / 2 \quad (1)$$

B. Arduino R3 UNO Board

Arduino Uno R3 ATmega328P CH340G board is used to collect the sensed data from sensors. It has USB connectors. The Arduino Uno is microcontrollers development board based on the ATmega328 (See Fig.-3). It is a reprogrammable electronics board having microcontroller. It works like a director and intermediary which govern the hardware based on the input given by sensors. It performs invoking task for different modules (See Fig.-4).

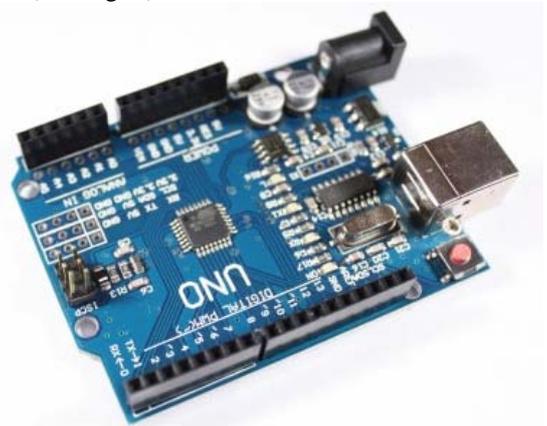


Figure 3. Arduino UNO R3 board

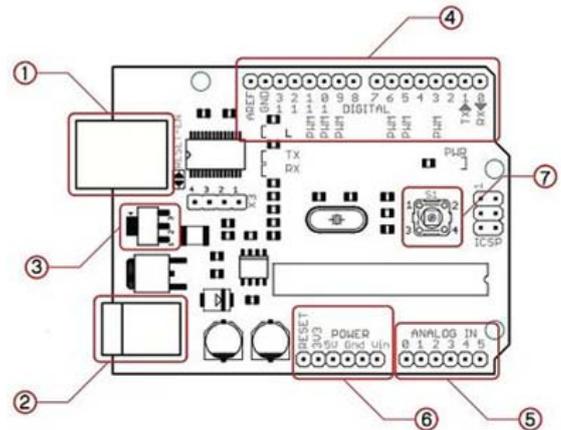


Figure 4. Pin diagram of Arduino UNO R3 (Here 1-USB connector, 2-Power connector, 3-Power switch, 4-Digital pins, 5-analog pins, 6-power pins, and 7-Reset switch)

C. Wi-Fi Section

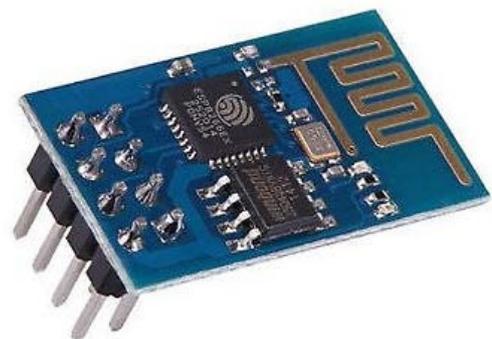


Figure 5. ESP8266 Wi-Fi Wireless Transceiver module

ESP8266 Arduino Compatible Serial Esp-01 Wi-Fi Wireless Transceiver Module (ESP-01 ESP-8266) is used to provide access of Internet or Wi-Fi to our waste bins (See Fig.-5).

D. Data Capturing Unit

Various data is captured in the system using wireless communication. It is viz., i) status of the waste bin/container, ii) location of the waste bin, iii) nearest dump location, iv) proximity of the vehicles, and v) status of vehicle.

E. Monitoring cell with data storage

All data is stored in the central database. Our system analyzes the data and generates proper instructional messages to various stockholders. Our system displays status of waste bins and status of waste collection vehicles graphically to the concerned persons. It sends the alert message to the vehicle drivers by considering the status of the vehicle i.e. waste level and distance from the waste bin.

F. GPS

This module having a NEO-6M GPS module which is been use for knowing exact location of waste bins and waste collecting vehicles (See Fig.-6). It is also helpful to the vehicle driver in finding route to reach the next waste bin to collect the waste with level of waste in the waste bin.

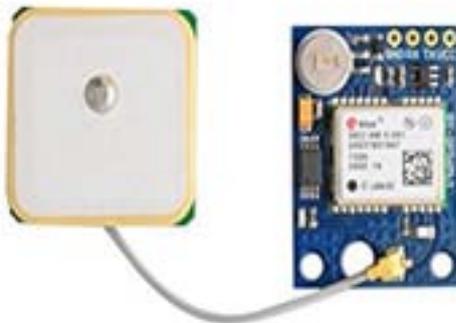


Figure 6. NEO-6M GPS Board

G. Global System for Mobile communications (GSM)

Global System for Mobile communications (GSM) is an open, digital cellular technology. It is used for transmitting mobile voice and data services. We have used SIM800A GSM module for sending text SMS/Alert to the concerned person and/or Authority (See Fig.-7). Based on data captured by the sensor /data capturing module controller module governing this module.



Figure 7. SIM800A GSM Board

4. IMPLEMENTATION

We have developed and evaluated our system of waste monitoring and management from the design. We have used Arduino IDE 1.8.5 (Integrated Development Environment for Coding) (See Fig.-8).

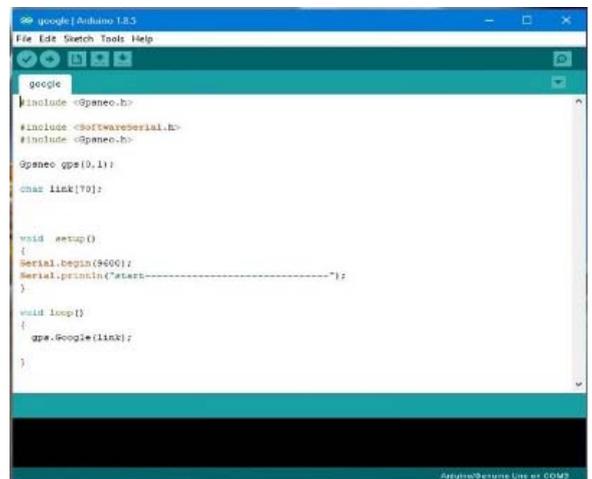


Figure 8. Arduino IDE

We have installed the system on the campus-sized area of CHARUSAT. We have installed 16 waste bins in various department of the university. Assembled panel is shown in Fig.-9 along with its circuit diagram in Fig.-10.

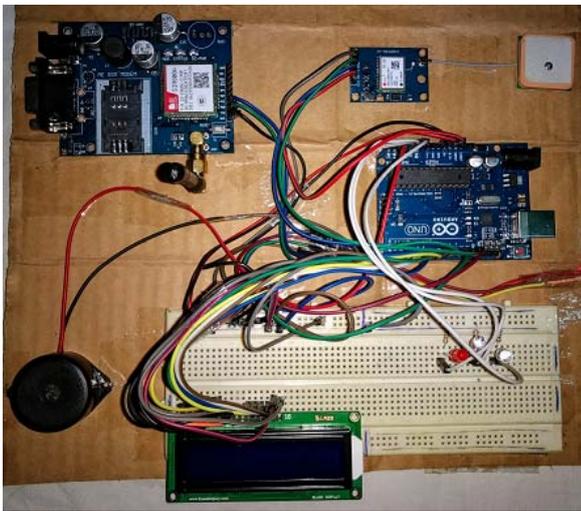


Figure 9. Developed panel for waste bin

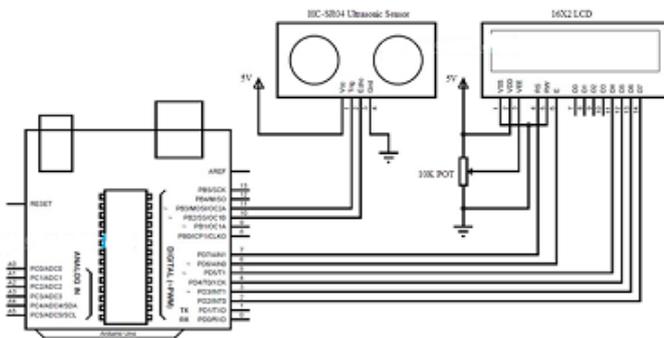


Figure 10. Circuit Diagram of Panel

LED panel is installed on the waste bin which shows the level of waste in the waste bin (See Fig.-11). LED panel display the various level of waste bin (see Fig.-12).



Figure 11. 16 x 2 LED display

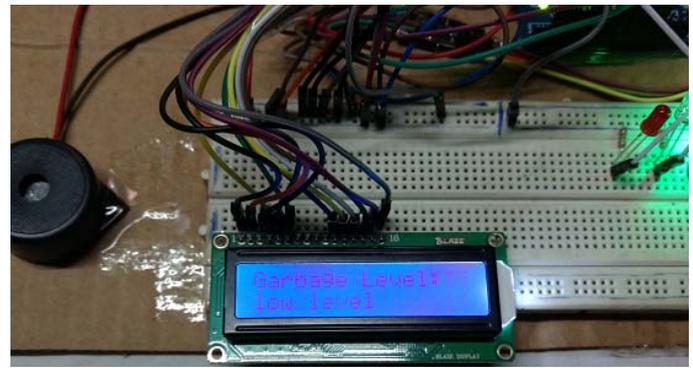


Figure 12. LED panel displaying status of waste bin

LED panel also display that SMS is sent to vehicle driver (see Fig.-13). Screen shot of vehicle driver's cell phone is shown in Fig.-14.



Figure 13. SMS is sent to Vehicle Driver

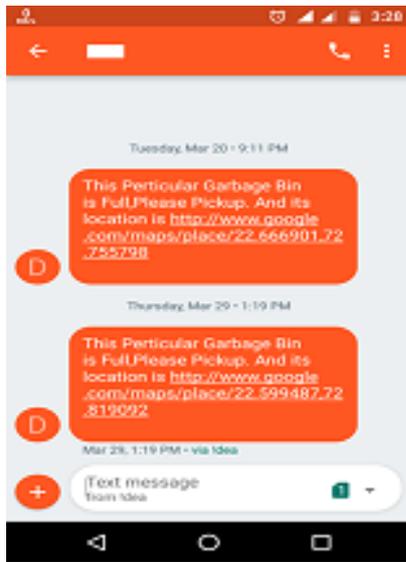


Figure 14. Screen shot of SMS on vehicle driver's phone

5. EVALUATION OF THE SYSTEM

We have evaluated our waste monitoring and management system with smart waste bin by storing following various data:

- Waste level in each Waste bin
- Position of waste collector vehicle
- Distance cover by waste collector vehicle

We have evaluated our system on following performance parameter:

- Accurate waste level
- Minimizing distance need to cover by the vehicle
- Time need to cover all the waste bins to collect the waste

6. SIGNIFICANCE OF THE PROPOSED SOLUTION

Following are the some of advantages and significances of the proposed solution:

- Efficient monitoring and controlling of waste

Our design provides efficient and effective solution for waste monitoring and management on the campus-sized area.

- Efficient time management

Using our system, we can minimize the time required by vehicle to collect the waste from the waste bins.

- Environment friendly or eco-friendly solution

Our solution uses low power battery to run the module installed on the waste bins. We use the solar panel with waste bin in

- Efficient fuel consumption

Integrating intelligence module send alert messages to the nearest vehicle for the nearest dump stations which ultimately saves fuel and time taken to collect the waste. In that sense our solution is save fuel consumption.

- Efficient use of man power

Our proposed solution saves the human hours to monitor and manage the waste on specified area of evaluation.

7. CONCLUSION

Efficient and effective waste monitoring and management solution is proposed using Arduino and sensors. Sensors provide the details of the status of waste bin. Smart bins transmit collected spatio-temporal data over the Internet to central repository. It is processed over there by intelligent optimized algorithms. We have achieved good results by combining Internet-of-Things (IoT) with intelligent system. Our solution can be used to dynamically manage waste collection and management process. It is planned to accommodate sensing technique to differentiate different kind of wastes viz., solid waste and biodegradable waste.

8. ACKNOWLEDGMENT

Authors are thankful to the management of CHARUSAT for providing support to implement the solution.

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