SWACHH: An Effective Real Time Solid Waste Management System for Municipality

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ABSTRACT
Today, Indian Government agenda is to create smart cities. While promoting Swachh Bharat Abhiyan, solid waste management is most challenging problem for municipals, which are facing a serious pollution problem due to the huge quantities of solid waste. If solid waste is not managed effectively it may lead to lots of issue related to environment and human health. Thus, there is need of a system that gives information of the filling of the bin or garbage level in it. It can alerts the municipality so that they can collect the waste in bin on time and helps to clean the environment. This paper describe on technology like Zigbee, GSM etc. that enables the remote monitoring of solid waste bin in real time and which will inform the authorized person when the garbage bin is about to fill. These technologies are good enough to ensure the practical and perfect for solid waste collection and transportation monitoring and management for greener environment.

Keywords
Smart Bin, Solid Waste Management.

1. INTRODUCTION
At present situation the volume of generation of municipal solid waste is increasing at very fast rate due to increase in population, industrialization and change in habit and life style of urban population [1]. The solid waste is consider as household's refusal and non-hazardous solid waste is from industrial, commercial and institution like hospitals, market waste, yard waste and street sweepings . This waste thrown into municipal bins or waste collection centers and then it is collected by the area municipalities to thrown into the landfills or into dumping areas. However, either due to resource crunch or inefficient infrastructure and facilities, not all of this waste gets collected and transported to the final dumping sites. If at this stage the management and disposal is not done properly, it can cause serious impacts on health and the problems to the surrounding environment. The main problem of the existing solid waste collection and management system is that municipal office unaware of status on level of bin in the city. Garbage accumulated on the streets if bins are not timely cleaned. Waste collecting trucks are randomly moving throughout the city for waste collection. Increased prices of fuel disturbs the economic calculation.

Due to this a considerable amount of the total solid management budget is exhausted on waste collection and transportation.

2. RELATED WORK
Though large numbers of research have been done on different aspect of solid waste management, but a few works have been done on bin monitoring. Some researchers discussed about Radio Frequency Identification (RFID), Geographic Positioning System (GPS), transportation model, waste collection with bin monitoring application [2], [10]. The researchers collected bin data using GSM/GPRS communication from the bin to the server, which includes GSM/GPRS connectivity to each bin[5]. Selection of sensors for bin level detection is also a crucial task .In system [10] author Maher Arebey, M A Hannan uses camera fitted on bin to estimate level in bin. Author R.Narayanamoorthi [5], used multiple sensor such as load sensor, ultrasonic sensor for level estimation. When all waste collected, author proposed a method to separate the 5 types of plastic resins (which are not biodegradable) by using NIR spectroscopy. Author Ahmed imteaj, mahfuzulhoq [8], developed an android based application where person himself can contribute to clean his city, notify municipal cooperation about status of bin or any complaint. The user can also detect nearby dustbins location with path with this application.

The proposed system use wireless sensor network and can respond as soon as someone throw waste inside a bin. The aim of this work is to design a frame work that can collect data on bin status in real time which in turn helps to optimize waste collection route resulting reduced operation.

This paper is structured as follows: Section 2 highlights related work. Section 3 illustrates the generalized system architecture of real time smart waste management system. Section 4 shows the proposed model for waste management system. Section 5 outlines different technology used to build overall system. Section 6 describes the algorithm. Section 7 presents the results.

3. SYSTEM ARCHITECTURE
The framework of system is shown in fig. 1. It has three stages. Starting from the left, first stage is composed by waste bin equipped with sensor. Second stage is a communication module and third stage is control station which provide data storage and controlling actions.

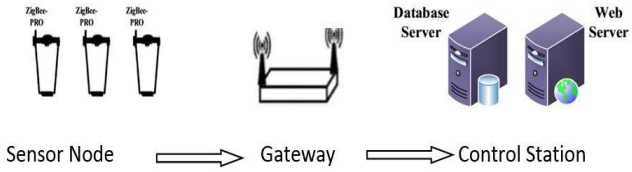

Fig. 1. Framework of the System

3.1 The Smart Bin
The smart bin is composed of sensor node mounted on it. It has an ultrasonic sensor for level measurement of garbage the data measured by the sensors are sent to the gateway through Zigbee communication [3].

3.2 Gateway

The smart bins send the data on bin status to the gateway. The gateway passes the data and stores to its local database at control station [6]. Considering different ways of wireless communication, the use of the Industrial Scientific and Medical (ISM) bands eliminate the need of telephone operator subscription. For this solution a cost reduction of 50% has been estimated [7].

3.3 Control Station

The control station receive real time data such as waste level in a bin through gateway and stored in into database. It contains the central server which hosts the database and DBMS. The central server has web based user interface for bin status monitoring and operator interaction with the system. Further these data can be used by control station to feed programs like optimization engines and routing and scheduling applications [6].

4. PROPOSED MODEL

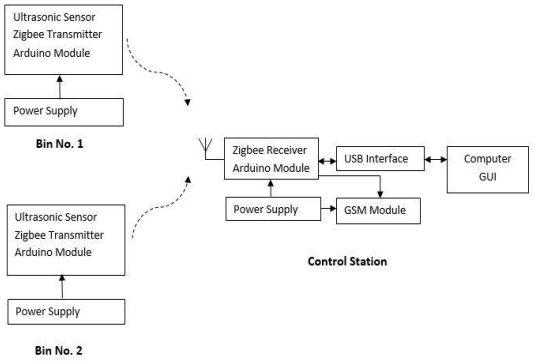

Fig. 2. Block diagram for proposed system model

5. INTEGRATED TECHNOLOGY

5.1 Sensor

A literature-based comparison in research and industrial efforts of various solutions with infrared proximity sensors, optical sensors and ultrasonic sensors, shows that ultrasonic sensors is best among them and it is suitable solution for the purpose of the presented architecture taking into account the harsh environmental conditions[9]. Ultrasonic sensors are used to detect the garbage level of bin. It is accurate to detect small objects. It is cheap, robust and can work in critical condition like dust and dirt. Further response of sensor is not depend on surface structure of object, colour of object etc. Considering all the parameters and requirement, ultrasonic sensors can be implemented for level detection. HC –SR04 is popular ultrasonic sensor module that can be detect level ranging from 2cm to 4m. It operate at frequency of 40 kHz. The number of sensor and range vary according to bin size. One or more ultrasonic sensor can be used in a bin for more accurate level estimation Sensors will be placed at the top of the bin in protecting box such that it cover entire area of bin[5].

5.2 Zigbee

Zigbee is high level protocol standard for communication using low power, low cost digital radios based on IEEE 802.15.4 standard. It allow to form ad-hoc mesh network to transmit data over a long distance. It can act as a router as well as co-ordinator to form network. This low cost transreceiver used in wireless control and monitoring applications and can best suited for continuous or periodic transmission of data. Low power operation allows longer battery life. It has defined rate of 250 kbps.

XBEE module manufactured by company Digi International is targeted for our application. The company has also developed software X-CTU that used to configuration of Zigbee and has many features. It allows to discover remote node from control station. It displays graphical representation of so formed network, signal strength and link quality. Remote configuration of node is also possible. Thus it is easy to monitor the network and detect any remote node failure from control station.

5.3 GSM

A GSM module is used to communicate with authorized person when the bin is about to fill. Communication is done via text massage that contain bin ID and location address. Thus person can collect waste from informed address. GSM module can also be used for two way communication. It is used as a complaint number for people. If cleaning of waste bin is not properly done then people can raise the complaint on these number to municipal office.

SIM900A is an ultra-compact, low powered wireless module manufactured by company SIMCom. It work on frequency 900/1800 MHz It is connected to microcontroller with RS232 interface. The baud rate of module configurable from 9600-11520 through AT command instruction.

5.4 Microcontrollar

Use of Arduino module simplifies the number of hardware and software required to build the system. It has already power and circuitry setup to program and communicate with microcontroller via USB. On software side, it has number of libraries to program the microcontroller easily. The module based on Atmega328 microcontroller. It is high performance, low power microcontroller clocked at 16 MHz It has 14 digital input/output pins out of which 6 can be used as PWM outputs, 6 analog inputs, one UART for serial communication. In our application, reception of data i.e. waste level in bin is not too much sensitive therefore it is programmed in such a way that it would control the power being wasted. Initially it first calculate depth of bin and set multiple distinct threshold level for it say 25, 50, 75, 90 percent. Microcontroller allows the sensor to sense waste level after certain period of time. Monitoring the bin at every interval will cause unnecessary waste of energy through sensors. Thus, the sensors will be activated only after certain intervals of time. If sensed level is greater than pre-determined threshold level, then the data will be send to control station through Zigbee network.

Therefore entire module can be used for any size of bin whose depth lies within sensor range.

6. ALGORITHM

6.1 At Garbage Bin

a. Start.

b. Initialize setup, Calculate depth(X) of bin and set multiple threshold level.

c. Set flag f = 0

d. Check real time level i.e. fulfilment of garbage in bin and flag status.

e. If level > 50% of X and f = 0 then send notification to control station, increase flag by 1 and go to step d.

f. If level > 70% of X and f = 1 then send notification

to control station, increase flag by 1 and go to step d.

g. If level > 90% of X and f = 2 then send notification to control station else go to step c.

h. Stop.

6.2 At Control Station

a. Start.

b. Initialize setup.

c. Receive available data, send it to computer.

d. Sort data coming from different bins.

e. Display level corresponding to each bin on graphic user interface.

f. Check bin status.

g. If bin is full then Alarm and send details of respective bin via SMS. Go to c.

h. Stop.

7. RESULT AND CONCLUSION

Prototype for solid waste management and monitoring system has been successfully implemented. In these two remote node and one control station is formed with integration of communication technology such as Zigbee. Graphic user interface was created in Matlab software that display real time bin level in graphical form. Two remote node send the bin level information to control station. Fill level estimation using ultrasonic sensor provide accurate results. Fig. 3 and fig. 4 shows the implemented hardware at bin (sensor node) and control station. At bin, entire harware is packed in protective case and mounted at the top of bin in such a way that waves of ultrasonic sensor strike exactly perpendicular to the bottom surface of bin. Based on different trial for mixed garbage it shows accurate level of bin. Fig. 5 shows the GUI build in Matlab software indicating real time garbage level at remote bin. Using software XCTU it is possible to monitor formed network from control station. Three node network topology formed i.e. Router(R)-Coordinator(C)-End device (E) as shown in fig. 6. Green link between R-C shows strong overall link quality whereas grey link between C-E shows link between them is broken. Thus in actual implementation, control station aware of these if any link of established network is broken.

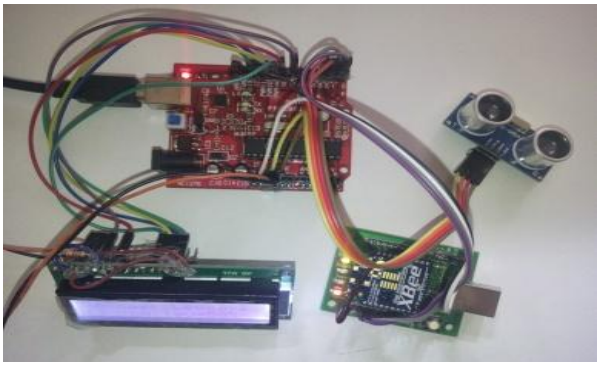

Fig. 3. Implimented hardware for transmitter(Bin)

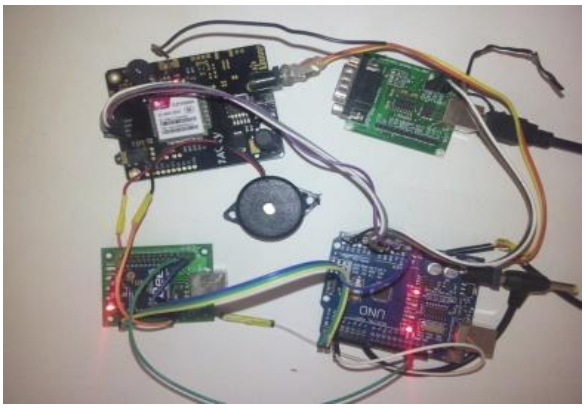

Fig. 4. Implemented hardware for Receiver(Control Station)

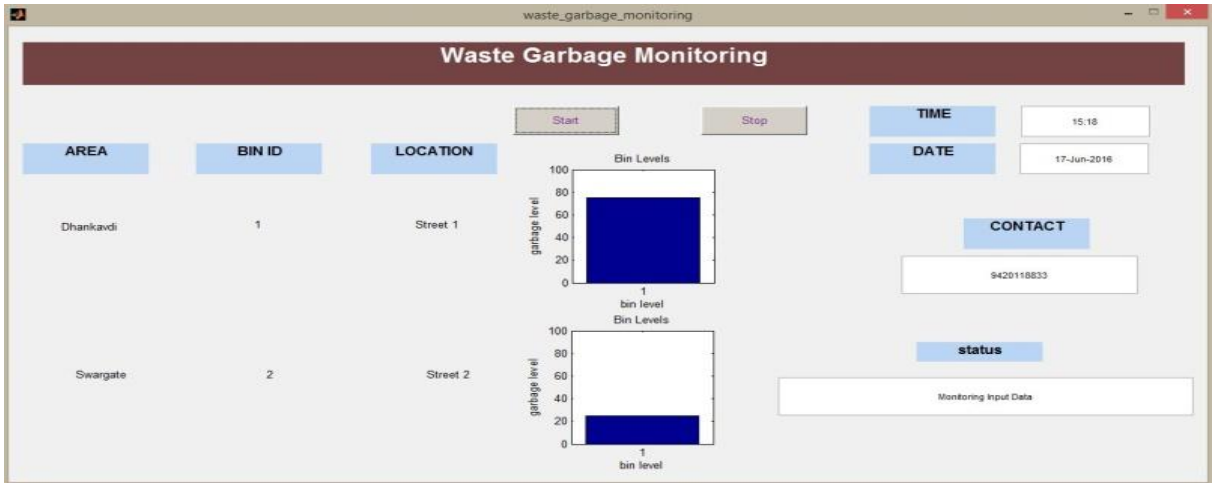

Fig. 5 GUI for real time waste bin level monitoring.

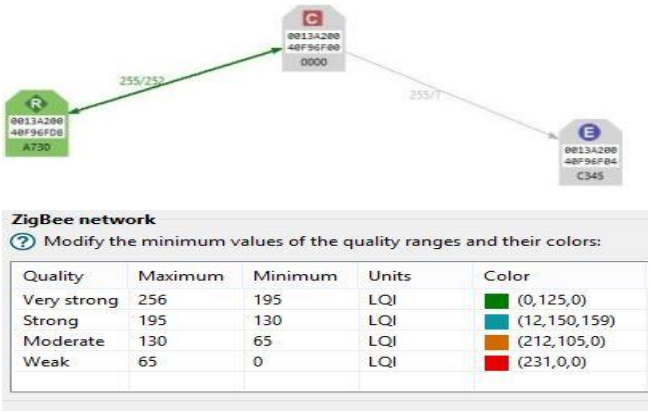

Fig. 6. Network monitoring and overall link quality indicator (LQI)

In real time application, delay is one of the important performance indicator of network. Many node act as a repeater to communicate over large distance. In our experiment, our interest is to find out relation between delay and payload size.

Consider two node A and B, the transmission of message from node A to B is activated at moment t_a and this massage is received by node B at moment t_b. The difference between two moments: $t_b - t_a$

Let T_A be the time inside the node activities associated with time required to access the communication medium and t_c is random time delay between source and destination due to active and passive disturbances. Thus approximated delay between transmission is $t_b - (t_a + T_A) - t_c$.

Fig. 7 shows the result of delay in network for topology (a) End device to coordinator (EC) (b) End device – Router-Coordinator (ERC). To measure transmission and reception time, software Docklight V 2.1 programmed to send packet consist of 10 bytes, then increase to 80 Byte with an increment of 10 bytes. The packet send at interval of 2 sec to remote end device. Each experimental trial is repeated twenty times and

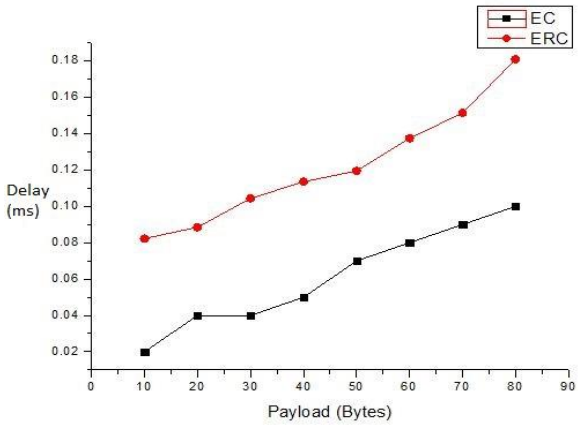

Fig. 7. Delay analysis

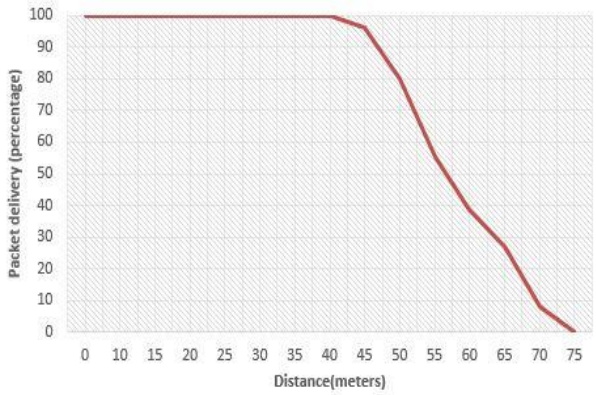

Fig. 8. Packet delivery analysis

its average is taken to eliminate any measurement errors due to fading and multipath phenomena. As observed from the graph, delay in network increase linearly with increase in payload size. It is less in case (a) of direct transmission. delay in case (b) of indirect transmission is more due to extra processing time at router. We have also analysed packet delivery ratio of Digi Zigbee s2 module. Practically range of module in line of sight communication is found to be 75 meters. Experiment is performed in a medium having WiFi interference. Graph fig. 8 shows the successful packet delivery as a function of distance. Signal strength between transmitter and receiver decrease a distance increase. Thus after 40m packet drop increases due to phenomenon like multipath propagation, diffraction and interference in medium.

8. FUTURE SCOPE

The management of solid waste is an important aspect in which everyone needs to put responsive and immediate action without any delay. For a future prospective web server can also build for effective graphic user interface of a system and controlling action. All bins are equipped with GPRS enabled embedded system. Central servers receive information from bins. It can store all necessary information such as bin level history, number of dispatched waste collecting vehicles etc. Thus based on prediction of collected data on bin level, it enables optimization of number of vehicles used. An application for smartphone will be developed, through which citizens can report to municipal office (fill level, photo, comment, etc.). When all such a technology integrated together a new way of waste management system emerges. This will led to reduction in amount of garbage in city and cost of transportation and realized clean and convenient environment.

9. REFERENCES

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