Smart Garbage Bin: An IoT Platform for Smart Waste Management System

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***Abstract*—Internet of things (IoT) is an emerging field which is increasingly becoming influential instrument in daily life. It endeavors to provide comfort and easiness in doing day to day activities in life. Moreover, it has increased the effectiveness of tasks by reducing the time span of the activity and augmenting its accuracy. It is being done with the help of internet service. IoT connects the activities with internet where it becomes easier to watch and monitor the process and the progress of the activity. Internet, the most important phenomenon of the 21st century, has become a common norm in the society. Thus, IoT is making use of this dynamic feature of human innovation to add more innovative techniques to human lives. Besides all these innovation, human race has been subject to daunting and detrimental challenges which are putting its survival at risk. The problem of accumulating garbage is the most important one. The gigantic amount of waste material is also a big threat to climate of the earth. It is sine qua non to have a special mechanism to deal with the hectic task of collecting and transporting garbage in cities, however, recycling is another dimension of this huge problem. The focus of this research is to come up with a remedy for the problem of ever-increasing garbage. Here, an IoT based costeffective system has been developed. It has the capability to monitor the garbage in real time by using smart technology with the help of WeMos and Ultrasonic sensors. This system makes use of electronic devices and ThingSpeak platform to minimize the expenditures and time duration in the collection and transportation of the waste. This concept is unique in itself as it makes garbage bins able to communicate their status, periodically, to the authorities. This data can be seen on internet and it is not bounded by any specific location as internet is a global phenomenon and so do the proposed system.**

Keywords*—*IoT, cost efficient, WeMos, ThingSpeak, real-time.

I. INTRODUCTION

"If we could produce computers that knew everything about things; we would be in a position to locate and number everything, reducing waste and loss along with cost" says Kevin Ashton, [1] the man who introduced the term Internet of things. IoT is changing the dynamics of tackling such issues by developing a framework where objects will be able to communicate with each other without asking for any human intervention. They will also be capable of taking decisions based on the immediate data.

This is evident from the Gartner report which states that connected devices will reach to 50 billion in 2020. [2]. In this era of information and technology, everyone has smart phone and everyone is connected through the internet. Far gone are the days when only people use to communicate through internet, in this age of automation, devices are also capable to do that with sufficient efficiency and accuracy. Today, the new trend of communication is taking place that is device to device communication which introduces the term IoT. Looking at the advancement in the technology and present garbage collection system near homes and offices, surely, it creates unhealthy and unpleasant environment. Environmental pollution is endangering the lives of the people. It is mainly caused by the poorly managed waste. Overflow of bins and their untimely cleaning brings daunting consequences for life. Thus, keeping in mind the challenges that municipality faces in this hectic job, an IoT based system would serve the best.

Smart cities are the future where there are smart systems in place to tackle all such problems. These systems employ effective and efficient mechanisms to do the job with minimum cost being spent. IoT provides better solutions to the world for the most complex tasks. They bring the job and the service provider on a single platform, using internet at various stages of the process where devices can communicate their status with other devices or related authorities. Its applications are many and they are being used in every walk of life starting from home to office.

Pakistan, being a poorly managed country, has been unable to deal with the ever-rising levels of waste in the country. There is a lack of resources and the infrastructure which does not allow the waste to be collected and recycled properly. Study has found that more than 60% resources of the municipality go into the collection and transportation of the waste [3]. This situation is getting worse with every passing day. Waste management can be made easy and cheaper with the help of modern technology. It will ensure the optimum use of resources in right time and at the right place which reduce the cost of the entire process followed in the waste management. This study proposes a system that is cost effective and can monitor the garbage bins remotely by using ThingSpeak [4] platform.

Further, this paper discusses existing garbage monitoring systems in section 2 which is followed by the design of the newly developed system in section 3. Proposed system and Experimented setup are discussed in section 4 Results are discussed in section 5 and 6. Lastly, conclusion is shown in section 7.

II. EXISTING GARBAGE MONITORING SYSTEM

IoT and its application are vast. The intelligent machines are being developed every day. The technique has recently been applied in the area of waste management. It has raised the hopes for revolutionizing the techniques of the waste collection and its recycling.

Device to device communication has been experimented by Saadia Kulsoom and others [5] that is object to object communication using local area network, where devices are communicating with one another in a range of 20 foot, so the data access is limited. Murugaanandam and others [6] have equipped dustbin with ultrasonic sensor and ethernet shield for data transfer, where ethernet requires a wired internet connection. The paper [7] addresses a smart wirless mechanism, using GSM technology, for waste management. Chatterjee and others [8] made use of the arduino microcontroller in combination with CCTV camera for monitoring purpose. The paper [9, 10] enables RFID technology in the dustbins. The smart city guaranties for the development of economically strong city as reported in [11]. The device to device communication which enables the access of data over a limited range does not found any efficient solution. Ethernet shield being wired internet connection requires RJ45 connector for internet connectivity. Thus, it becomes very expensive and complex. However, CCTV camera is also very costly. Moreover, they cannot send alarm in order to ensure the fill level status of dustbin, unless such an efficient algorithm is utilized to detect waste using image processing and video processing. More importantly, it may not guarantee the accurate result. Besides this, it is likely to utilize more energy and time resources. Same is the case with RFID technology as it is unable to detect the waste level in the bin. It can be used to attach RF tags with waste bins to identify them and then carry them only after visiting the garbage collection point.

As per our investigation, in previous works dustbin monitoring systems are costly, consume more power, time resources and access of data is in a limited range, on the other hand, it does not guarantee the accurate results in garbage monitoring and collection. However, this work is solely developed for an IoT based real time monitoring of garbage that ensures the real time monitoring, saves time and money for garbage monitoring and collection.

III. PROPOSED SYTEM

A network of dustbins has been put under observation for this piece of work. An account of their monitoring and collection has been given in the research. Figure 1 shows the designed network of the dustbins of the proposed system, where dustbin is equipped with WeMos D1 mini [12-13] containing an advanced feature of built in WiFi capabilities and ultrasonic sensor. This system enables to transfer sensor data to garbage monitoring system. Through the monitored data, it informs to garbage collection truck drivers to collect garbage from that particular dustbin. The proposed system model can be implemented by following phases:

Fig. 1. Architecture for Garbage Monitoring and Collection System

A. Hardware Design

The ultrasonic sensor has been attached to each bin and they are fixed at the top of each bin and connected to the WeMos D1 mini, in order to monitor the garbage level.

Figure 2 shows the circuit diagram for the garbage monitoring sytem in which ultrasonic sensor is connected to WeMos D1 mini and the system is capable of transfering the information wirelessly and data is obseverved on thingspeak platform.

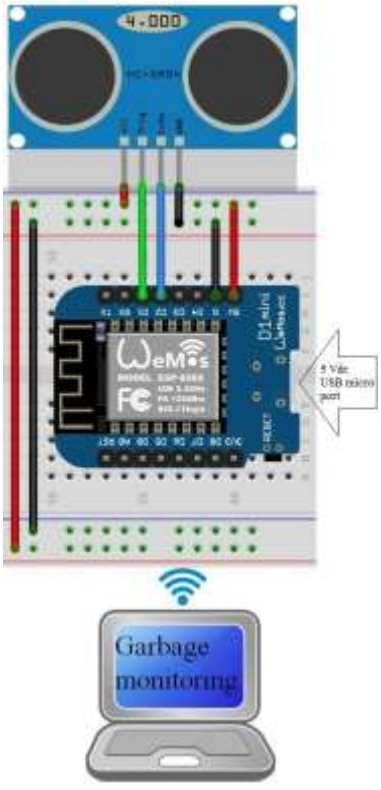

Fig. 2. Pin diagram of WeMos and connection with HC-SR04 and monitoring system

B. Software Design

The algorithm code for smart garbage monitoring and collection system has been written in arduino IDE [14]. The sensed data has to be sent through internet over ThingSpeak platform. Flow diagram for IoT based monitoring system in terms of code sequence is shown in Figure 3.

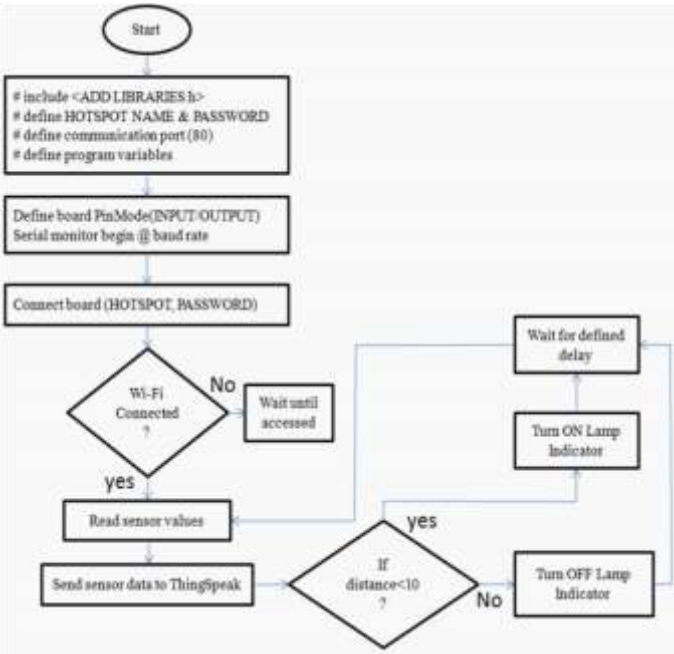

Fig. 3. Flow for garbage monitoring remotely

Initially, arduino code needs support of required libraries such as “ESP8266.h” to support Wi-fi and wireless communication related functionalities. Later, it connects with hotspot and starts redounding sensor data and then sends it to the ThingSpeak platform. If obtained data is below the defined threshold gap than indicator will turn on, otherwise it will remain off. The data is stored. No sooner does the client is disconnected, the system stops working in order to save energy.

C. Advantages of proposed system

- Waste level in the bin can be detected easily by waste management authorities in the smart city.
- Data can be accessed remotely from anywhere in the globe.
- Data can be transmitted and accessed in Real-time.
- This system proposes a cheaper solution and provides efficient monitoring and collection of garbage.
- Saves time, fuel and labor

D. Application areas of proposed system

- Restaurants
- Hospitals
- Colonies
- Shopping mall
- Airports
- Stations

IV. EXPERIMENTAL SETUP

This section depicts practical dimensions of the proposed system. This system is consisting of different technologies which include the processing unit and method of transferring data. With agglomeration of all these in an automated garbage monitoring system, smart dustbin has been developed.

We carried out experimental work by using multiple dustbins 20m distance apart with each other as shown in Figure 4. Each dustbin contains an ultrasonic sensor, and WeMos D1 mini with built-in Wi-Fi.

For further analysis, we are considering two dustbins whose total length is 100 centimeters each and for this setup we have defined the threshold level as 10 centimeters. The sensors have been fixed at the top of dustbins and the status of fill level is being obtained from the sensor according to the defined threshold. Thus, according to defined threshold; system decides whether the dustbin is full or not. If the distance is less than defined threshold, system considers the dustbin as full otherwise empty. The collected data sent over the internet and stored using ThingSpeak IoT platform and can be accessed from anywhere. ThingSpeak is an IoT analytics platform which is used for processing data streams in the cloud.

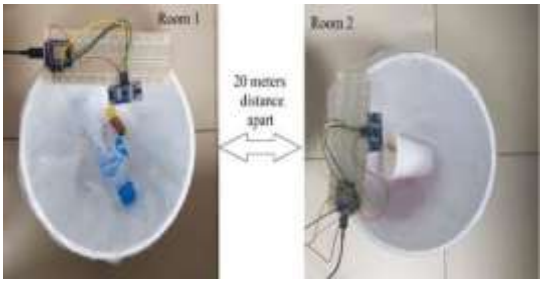

Fig. 4. Implemented system

V. RESULTS

The overall system was connected and observed over ThingSpeak platform in four different scenarios. In each case, the data being observed is according to the fill level status of dustbin. The lamp indicator turns ON only when the dustbin is full or fill level status is less than the defined threshold otherwise it remains off. The defined threshold is

10 cm as discussed in section IV. All four cases are being observed in real time where vertical axis represents distance in centimeters and horizontal axis represents current clock time in 24-hour format. In simulation results light color of indicator indicates OFF status whereas dark color of indicator indicates ON status.

Case A: When dustbin 1 and dustbin 2 are empty

In case A, the fill level status of both dustbins is greater than the defined threshold which means the dustbins are not filled yet. Hence, the lamp indicators of both the dustbins remain off as shown in Figure 5.

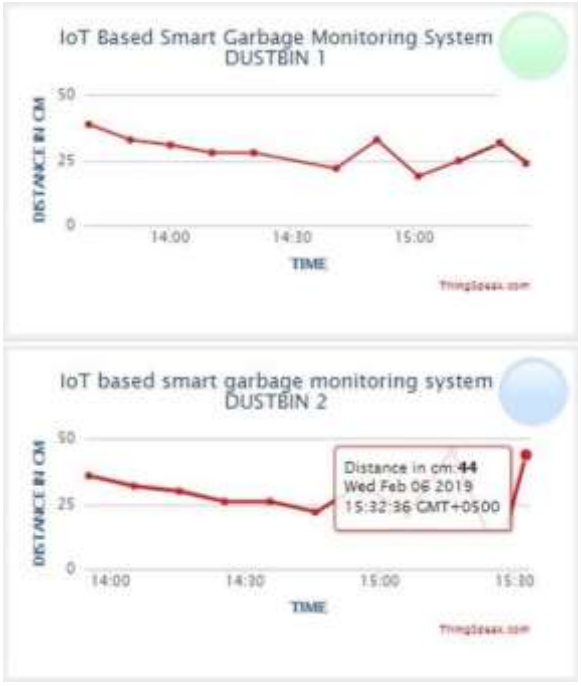

Fig. 5. Both dustbins are empty

Case B: When dustbin 1 is filled and dustbin 2 is vacant

In case B, when fill level status of dustbin 1 goes below defined threshold, then lamp 1 indicator turns on while the fill level status of dustbin 2 is greater than the definedthreshold, therefore, lamp indicator 2 remains off as shown in Figure 6.

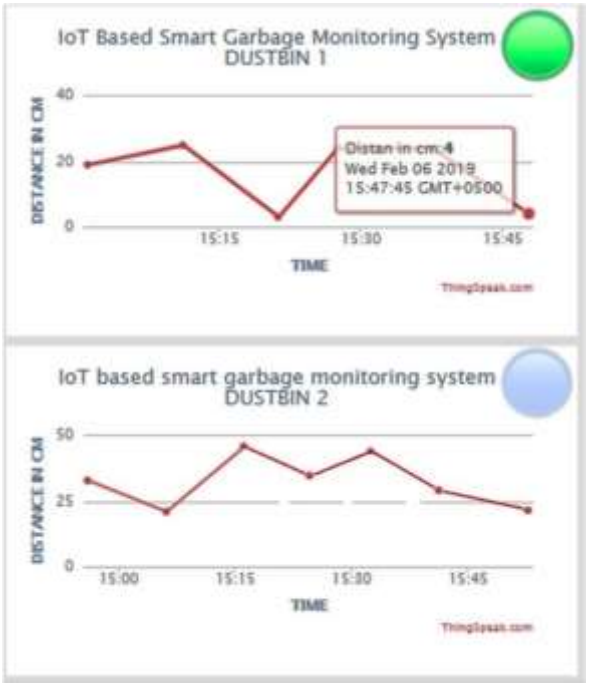

Fig. 6. Dustbin 1 is fill and dustbin 2 is vacant

Case C: When dustbin 1 is vacant and dustbin 2 is filled

In case C, the fill level status of dustbin 1 is greater than defined threshold, hence, lamp indicator remains off. On the other hand, the fill level status of dustbin 2 is less than defined threshold hence dustbin 2 lamp indicator turns ON as shown in Figure 7.

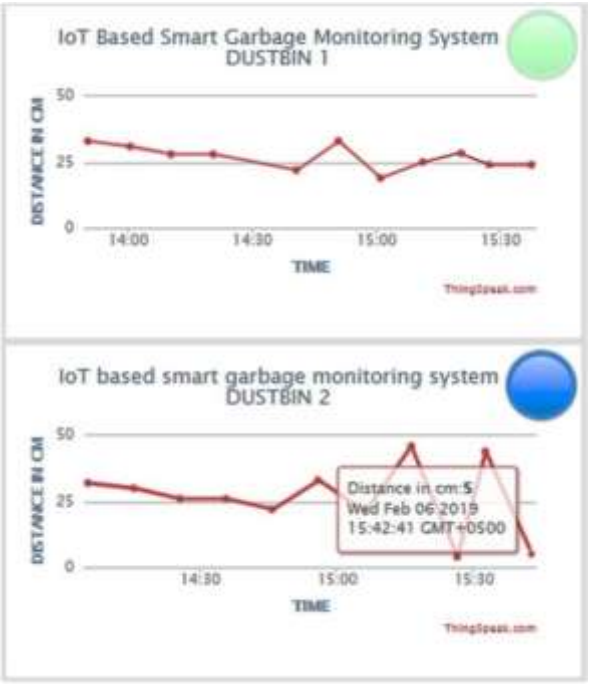

Fig. 7. Dustbin 1 is vacant and dustbin 2 is filled

Case D: When dustbin 1 and dustbin 2 are full

In case D, the fill level status of both dustbins is less than the defined threshold which means both dustbins are full. Hence, the lamp indicators of both dustbins are turned ON as shown in Figure 8.

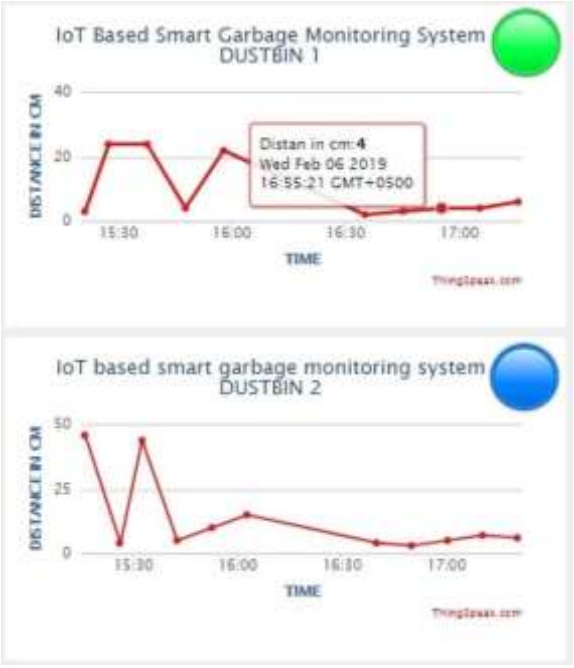

Fig. 8. Both dustbins are full

VI. Conclusion

This work describes implementation and monitoring of waste management system over internet. Monitoring was done in real time and it is cheaper and efficient. In proposed system, ultrasonic sensors detect bin level and sends it to ThingSpeaks, via WeMos di mini with the help of internet, where data is further processed for action. The collected data is saved in cloud sever and can be accessed by both waste management authority and truck drivers at any interval of time. This system can be used to automate the waste collection of entire city and bins can be affixed with solar systems and other sensors to process the waste further.

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