Vol. 03, No. 2,(2019),076–082, **ISSN:2581-3242**

IJMLNCE JOURNAL

International Journal of Machine Learning and Networked Collaborative Engineering

Journal Homepage: http://www.mlnce.net/home/index.html

DOI : https://doi.org/10.30991/IJMLNCE.2019v03i02.001

Cloudbin: Internet of Things based Waste Monitoring System

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Abstract

Nowadays, waste management has become a critical issue for the environment. Government and private agencies need to take certain action for proper management and cleanliness. The absence of systematic waste management system creates many issues for the environment and living creatures. Research on the Internet of Things (IoT) applications widely increased in many sectors. The waste management system is also one of the sectors. Therefore, in this study, IoT based waste monitoring system called Cloudbinis proposed to reduce the waste garbage from urban areas. In this system, Ultrasonic sensor is fixed on the top of the waste bin to monitor the level of garbage inside the bin and connected to the Blynk server. In addition, a GPS module is also employed to check the location of Waste Bin. Methane detection from garbage is an important feature in the system. Results show that the proposed system is suitable to monitor and control waste in cities.

Keywords

Internet of Things

Cloud Computing

IoT

Garbage Monitoring System

Artificial Intelligence

Blynk

1. Introduction

Since the last few decades, there is a ton of buildings and industries which have been constructed in urban areas [9]. The main cause behind this construction is to migrate a lot of people from rural areas to the urban cities for finding a job. In order to fulfill the need for shelter, the government constructed buildings for their accommodation. Many private and government sector based industries extended their branches in the urban areas to suffice the employment needs [10]. One of the major

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problems originated from this development is "Waste" which is depleting the environment quality day by day.

Waste can be divided into three categories: 1) Solid waste 2) liquid waste and 3) gas waste, all can be hazardous. Solid and liquid can be recycled, reused or some of it can be converted into organic matter. The main source of liquid waste is from dirty water from homes or hazardous waste from industrial processes. Whereas solid waste comes from homes or industrial garbage or solid waste left after industrial processes. The government takes appropriate actions to reduce this garbage, recycle the solid waste which helps to keep the environment clean.

In the Internet of Things(IoT) concept, things or objects are connected around a network [1]. Wireless technologies such as Bluetooth, Wi-Fi, Xbee and RFID make a communication bridge to overcome many challenges for the successful implementation of IoT system. Kevin Astron introduced the term 'IoT' in 1999 at MIT Lab [2]. In the initial findings, RFID was used for communicating, tracking and storing the data. However, RFID has a lot of barriers and limited use to fulfill many security challenges namely eave-dropping, jamming, replay attacks. Nowadays, IoT (see figure 1) performs data fetching, data gathering or storing and processing with artificial intelligence techniques to make the device smarter [3]. IoT extended its limited in various applications namely atmospheric monitoring [4], tracking system [5], traffic management system [6], healthcare industry [7] and smart buildings [8] to improve the quality of life.

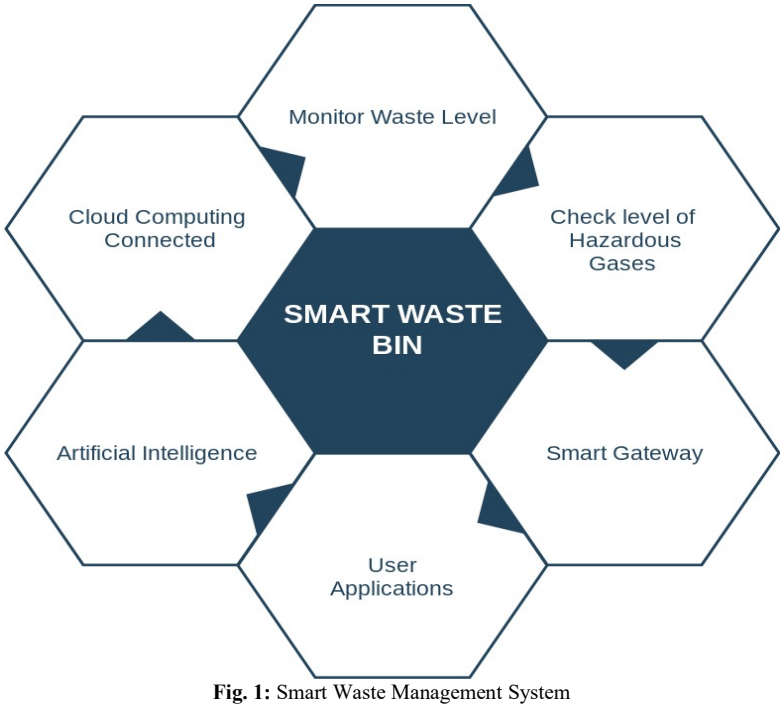

Fig. 1: Smart Waste Management System

IoT plays a vital role in controlling and monitoring the waste management system. Mustafa [11] designed and deployed a garbage monitoring based on the IoT. For monitoring purpose, Ultrasonic sensor and ARM microcontroller are used for the level detection and processing respectively. After monitoring and processing, the data is directly sent to the Thingspeak cloud server. Navghane [12] proposed a waste monitoring system based on the IR sensor. The sensor is used for detection of levels of Garbage and send to the cloud server for data storage and processing. Kumar [13] developed an IoT based monitoring system for the waste management system. GSM module is used to create connectivity between the sensors and cloud servers. User terminal namely Android application is used to display the processed data. The system is deployed in different locations and connected to one main server. Joshi [14] proposed a solution for waste management system called SMARTBIN which integrates wireless sensor network with cloud computing and machine learning techniques such as decision forest regression to improve the efficiency of garbage monitoring. Bharadwaj [15] proposed an IoT based smart monitoring system to monitor and manage solid waste. Data processing and Data sending is through the ATmega328 and LoRa technology. MQTT protocol

is used to share data between the electronic circuit and cloud server. Begur [16] discussed a mobile-based real-time innovative solution for illegal dumping, monitoring, and management of waste.

In our proposed work, we propose an IoT based Waste management system to monitor waste bin level and also monitor the methane gas generated from the solid waste. In addition, our proposed system also sends GPS location to the User terminal for checking the exact location of the waste bin. The proposed paper is discussed as follows: Section 2 explains Methodology, Section 3 discusses results and discussion, and Section 4 discusses the conclusion.

2. Methodology

2.1. System Architecture

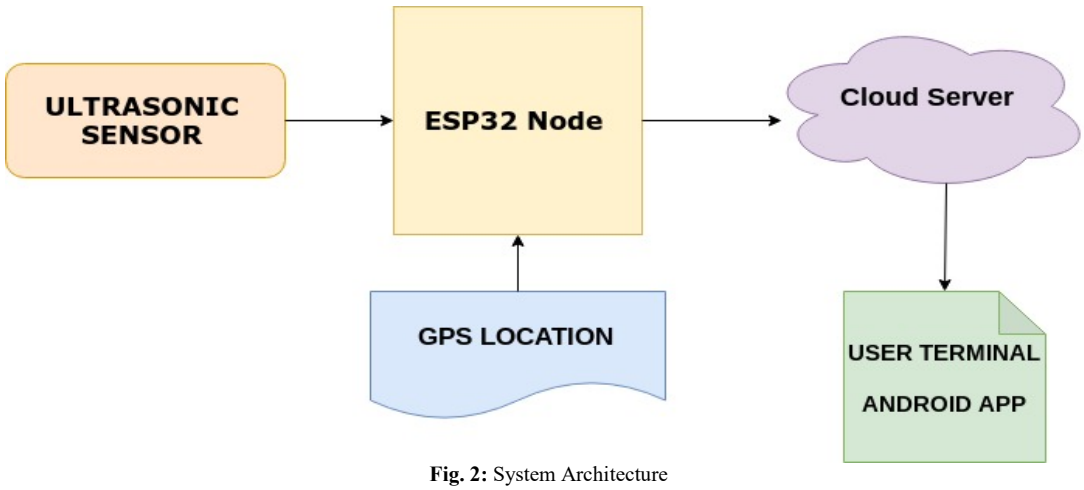

Fig. 2: System Architecture

Our proposed system is categorized into three different layers: 1) Sensing Layer 2) Processing Layer 3) Cloud Layer. Sensing layer consists of the sensor namely ultrasonic sensor which lends a hand to monitor the changes in the ultrasonic waves. These waves' frequency is too high for the human hears. The main working principle behind the sensor is to calculate the distance of the reflected wave. The formula for distance calculation of reflected wave is:

$$\textbf{Distance} = \tfrac{1}{2}\ \textbf{Time} * \textbf{Speed of sound} \qquad (1)$$

Speed of sound varies with the humidity and temperature.

The second layer is named as the processing layer which helps to fetch data from the sensor and applied algorithm for processing data. In our proposed system, NodeMCUis used for processing the data and is equipped with a Wi-Fi module. Moreover, GPS modules also interfaced with NodeMCU for waste bin location. Cloud layer in our proposed study is worked as the third layer. Blynk server employed to process different data and visualize with graphical effects on the user terminal.

2.2. Circuit Diagram

In the Proposed study, NodeMCU plays the major role. NodeMCU is an open source IoT platform integrated with the Wi-Fi module. It has 10 General Purpose Input/Output (GPIO) pins for connecting different modules or sensor. In our study, Ultrasonic sensor (HC-SR04) is connected to the NodeMCU with two different pins as follows: 1) one pin is used for input as ECHO 2) another pin used for output as TRIGGER. The ultrasonic sensor emits waves at a frequency of 40,000 Hz. If there is an obstacle or object between the waves, it reflects back to the sensor for measuring. The Object detection range varies from 2cm to 400cm. GPS module is also connected to the NodeMCU. NEO-6M GPS module is based on the serial communication pins which have in-built EEPROM and external antenna for better sensitivity. 9600 bps is by default baud rate of this module and operates between 3v to 5v. Table 1 represents the technical specification of NodeMCU.

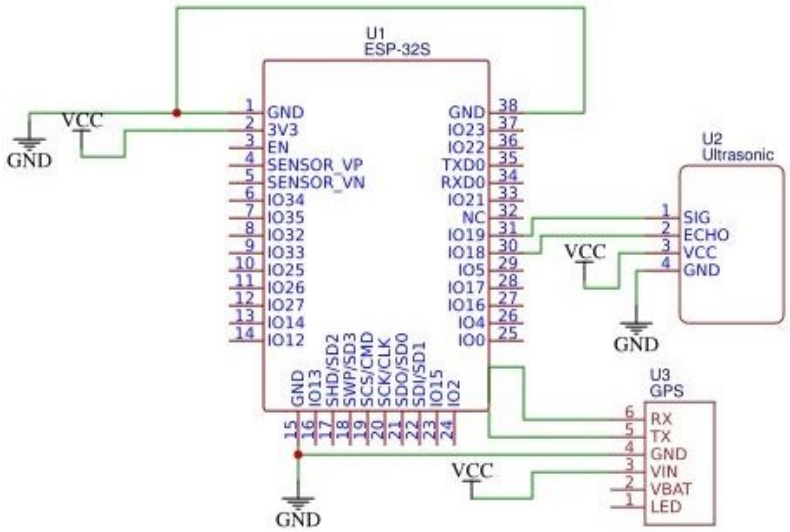

Fig. 3: Circuit Diagram

Table 1: Represents the technical specification of NodeMCU.

S.No	Parameter	Values
1	Firmware	Lua Scripting
2	Software	Arduino
3	Interface	USB_TTL
4	GPIO	10 Pins
5	In-built protocols	ADC, 1-wire, SPI, I2C
6	Power Supply	5-Volt
7	Antenna	In-Built
8	Network Interfacing	API

2.3. Cloud Server

Blynk is designed for the IoT application and also have the ability to control application remotely. It can store, process, visualize data, and graphical user interface for the Users. Blynkis categorized into three parts as follows:

1. **Application:** Android and iOS user-friendly application for smartphones and tablet having visual data with amazing graphics.
2. **Server:** It is responsible for all communication between the sensors and application. It is based on the Blynk cloud or local server. It can handle hundreds and thousands of devices at one time.
3. **Libraries:** It is already compatible with all types of hardware platforms and enabled communication with Blynk cloud

3. Result and Discussion

To evaluate the performance of our proposed study, location detection, level detection and methane in the garbage is employed in this study. Figure 4 represents the data shown on the Blynk server application

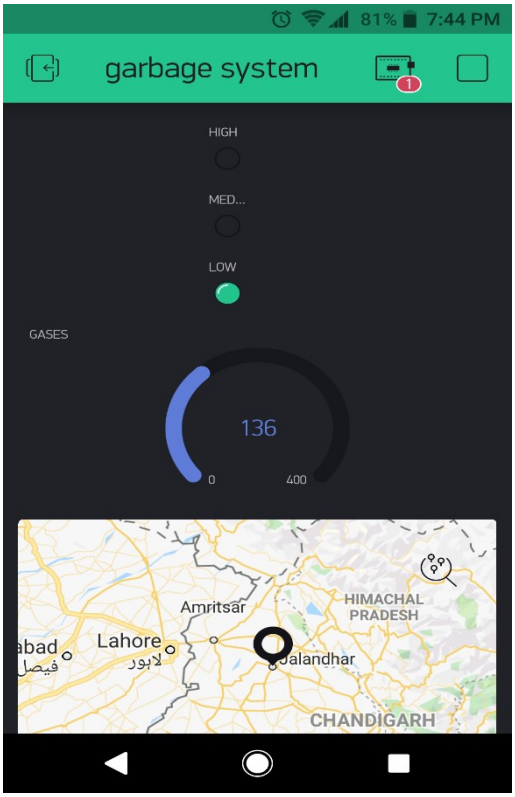

Fig. 4: Result of Proposed Work

For the level detection, three different levels are processed as low level, medium, and full level. When the level of the waste bin is full level, it sends information to the municipal authority to clear the waste bin. Methane detection is also an important parameter to check how much hazardous waste material is present inside the waste bin. GPS location is also stamped when it sent to the Cloud server (Blynk).

4. Conclusion

In this study, we have designed and developed an IoT based waste monitoring system to replace the existing waste monitoring systems. Due to the increase and migration of people from rural to urban areas, waste production has increased in the form of solid, liquid and gas. The main purpose behind the system is to maintain the cleanliness of urban areas. The basic architecture of our system is a centralized structure in which every waste bin is connected to the Blynk server for monitoring, tracking and processing the data value.

Our proposed system works on three different layers. One is to check the level of garbage inside the waste bin and the checking is based on the three different levels. Second is to check the hazardous gas, methane, inside the garbage through the use of a gas sensor. Last, we stamp GPS coordinates with the data to check the location of the bin. Nevertheless, the proposed system's performance is better as compared to the existing waste bin with respect to data transferring and accuracy. The system also decreases the usage of manual workers. Moreover, methane, being a hazardous gas for the workers, can be detected inside the bin before opening. In the future, we look forward to implementing Artificial Intelligence techniques for the bin to make it smarter.

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Author's Biography

Vikram Puri is a Researcher at the Center of Simulation and Visualization, DuyTan University, Da Nang, Vietnam and also Visiting Research Scholar at University of Nevada, LasVegas, USA. His research of interest is eHealth Technologies, Internet connected medical equipment, wearable health technologies. He has Bachelor of Technology in Electronics and Communication at Punjab Technical University, Punjab, India. He is currently pursuing his master and PhD in Computer Science at DuyTan University, Vietnam. He has total 3 years of Industrial experience. He has delivered many workshops and seminars regarding the new research development in collaboration with Intel. He was the Embedded Developer in Enjoin Technology (P) Ltd., 2014–2016 and Senior Embedded Developer in Ellen Infotech Pvt. Ltd., 2016–2017. He is also

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How to Cite

Puri, Vikram,Puri, Bhuvan,Jagdev, Sandeep Singh, Minh, Trí Tran Huu, "Cloudbin: Internet of Things based Waste Monitoring System", *International Journal of Machine Learning and Networked Collaborative Engineering,* Vol. 03, No. 2, 2019, pp. 76-82.

doi : https://doi.org/10.30991/IJMLNCE.2019v03i02.001.