Cloudbin: Internet of Things based Waste Monitoring System

aVikram Puri, bBhuvan Puri, cSandeep Singh Jagdev, dTri Tran Huu Minh

a,d Duy Tan University, Da Nang, Vietnam
b D.A.V institute of Engineering and Technology, Punjab, India
c Ellen Technology(P) Ltd, Punjab, India

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 Cloudbin is 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.

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
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 eavesdropping, 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.

![Smart Waste Management System](image)

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

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:

\[
\text{Distance} = \frac{1}{2} \text{ Time} \times \text{ Speed of sound} \quad (1)
\]

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, NodeMCU is 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.
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. Blynk is 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.
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.

References

[1]. Gubbi, J., Buyya, R., Marusic, S., &Palaniswami, M. (2013).“Internet of Things (IoT): A vision, architectural elements, and future directions”. Future Generation Computer Systems, 29(7), 1645-1660.

[2]. Ashton, K. (2009). That ‘internet of things’ thing. RFID journal, 22(7), 97-114.
[3]. Hong, I., Park, S., Lee, B., Lee, J., Jeong, D., & Park, S. (2014). “IoT-based smart garbage system for efficient food waste management”. The Scientific World Journal, 2014.

[4]. Lazarescu, M. T. (2013). “Design of a WSN platform for long-term environmental monitoring for IoT applications”. IEEE Journal on Emerging and Selected Topics in Circuits and Systems, 3(1), 45-54.

[5]. Gama, K., Touseau, L., & Donsez, D. (2012). “Combining heterogeneous service technologies for building an Internet of Things middleware”. Computer Communications, 35(4), 405-417.

[6]. Foschini, L., Taleb, T., Corradi, A., & Bottazzi, D. (2011). “M2M-based metropolitan platform for IMS-enabled road traffic management in IoT”. IEEE Communications Magazine, 49(11), 50-57.

[7]. A. J. Jara, M. A. Zamora, and A. F. G. Skarmeta, “An internet of things-based personal device for diabetes therapy management in ambient assisted living (AAL)”. Personal and Ubiquitous Computing, vol. 15, no. 4, pp. 431–440, 2011.

[8]. Zhang, D., Shah, N., & Papageorgiou, L. G. (2013). “Efficient energy consumption and operation management in a smart building with microgrid”. Energy Conversion and Management, 74, 209-222.

[9]. Yusof, N. M., Jidin, A. Z., & Rahim, M. I. (2017). “Smart garbage monitoring system for waste management”. In MATEC Web of Conferences (Vol. 97, p. 01098). EDP Sciences.

[10]. Tikone, N., Zagade, P., Singh, G., & Cherian, M. (2018). “Smart Garbage Management”. Available at SSRN 3361515.

[11]. Mustafa, M. R., & Azir, K. K. (2017). “Smart Bin: Internet-of-Things Garbage Monitoring System”. In MATEC Web of Conferences (Vol. 140, p. 01030). EDP Sciences.

[12]. Navghane, S. S., Killedar, M. S., & Rohokale, V. M. (2016). “IoT based smart garbage and waste collection bin”. International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), 5(5), 1576-1578.

[13]. Kumar, S. V., Kumaran, T. S., Kumar, A. K., & Mathapati, M. (2017, August). “Smart Garbage Monitoring and Clearance System using Internet of Things”. In 2017 IEEE International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM) (pp. 184-189). IEEE.

[14]. Joshi, J., Reddy, J., Reddy, P., Agarwal, A., Agarwal, R., Bagga, A., & Bhargava, A. (2016, August). “Cloud computing based smart garbage monitoring system”. In 2016 3rd International Conference on Electronic Design (ICED) (pp. 70-75). IEEE.

[15]. Bharradwaj, A. S., Rego, R., & Chowdhury, A. (2016, December). “IoT based solid waste management system: A conceptual approach with an architectural solution as a smart city application”. In 2016 IEEE Annual India Conference (INDICON) (pp. 1-6). IEEE.

[16]. Begur, H., Dhawade, M., Gaur, N., Dureja, P., Gao, J., Mahmoud, M., & Ding, X. (2017, August). “An edge-based smart mobile service system for illegal dumping detection and monitoring in san jose”. In 2017 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computed, Scalable Computing & Communications, Cloud & Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI) (pp. 1-6). IEEE.

**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, Las Vegas, 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
working as consultant for the corporate. He has written research papers on SCI Q1, Q2 and Scopus indexed Journals. He is also acts as reviewers for the SCI journals and conferences.

**Bhuvan Puri** is a student of D.A.V institute of Engineering and Technology affiliated from the Punjab Technical University, Punjab, India. He is pursuing B.Tech in Mechanical Engineering. Currently he is working in field of IoT and its application as well as AutoCAD designing. He has experience of working under learned and experienced mentors.

**Sandeep Singh Jagdev** is a Senior Embedded Engineer in Ellen Technology (P) LTD., Punjab, India. He has Bachelor of Technology in Electronics and Communication at Punjab Technical University, Punjab, India. He has total 2 years of Industrial experience. He has delivered many workshops and seminars regarding the new research development. He has written research papers on Scopus indexed Journals. His research area is IoT and its applications, digital circuit designing and computer vision.

**Trí Tran Huu Minh** is an IoT Engineer in Duy Tan University, Da Nang, Vietnam. He has Master of Science in Control Engineering from Bach Khoa University, Vietnam. He has total 1 years of experience in Duy Tan University. He has developed products using Internet of Things. His research area is automation, IoT.

**How to Cite**

Puri, Vikram, Puri, Bhuvan, Jagdev, Sandeep Singh, Minh, Tri 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.