Innovative Waste Management system using Wi-Fi for Smart IoT Solutions

Dr. Ch Ramesh Babu, P Venkatesh, P Lohitha, Dinesh Deeraj, Bharadwaj
Department of Electronics and Communication Engineering, Vignan's Institute of Information Technology(A), Visakhapatnam, Andhra Pradesh, India.
E-mail:venkatpondara667@gmail.com, rameshbabuchukka@gmail.com

Abstract*—Traditional waste management systems are inefficient and costly, the existing recycle bin usage methodology has also proved its ineffectiveness in the public as people does not recycle their waste properly. Our project introduces an innovative Internet of Things (IoT) based smart waste management system to address the inefficiencies and limitations of traditional waste management systems. Traditional approaches often face challenges like indiscriminate waste disposal and insufficient segregation. Our solution leverages Wi-Fi communication and integrates specially designed waste bins equipped with dual compartments for segregating metal and non-metal waste at the source. The key technology driving our system is the integration of inductive proximity sensors within the smart bins. The system seamlessly interfaces with the Blynk IoT platform, providing waste management authorities with real-time monitoring and notification capabilities. By promoting efficient waste segregation practices, our solution not only reduces environmental impact but also minimizes the risk of cross-contamination and pollution associated with mixed waste disposal.

INDEX WORDS- Internet of Things, Wi-Fi communication, Blynk IOT platform, Smart waste bins, Inductive proximity sensor, Real-Time monitoring.

I. INTRODUCTION

Everyday life is significantly impacted by the internet of things [1]. Improving automation, ease, and efficiency in many facets of daily life and business is the main objective of the Internet of Things. The term "smart city," which refers to a city with smart technology, clever people, and band smart teamwork, is one of our most well-known Internet of things products [2]. Wi-Fi connection technology is employed by an Internet of Things (IoT)-based smart garbage can system to enhance the efficiency of waste collection [3].

In recent years, there has been an increasing interest in using Internet of Things technologies to revolutionize waste management systems. These systems utilize sensors, wireless communication, and data analytics to monitor and optimize waste collection, disposal, and recycling processes. The implementation of IoT devices in waste management systems offers numerous benefits. These include improved efficiency in waste collection, reduced costs, decreased environmental impact, and enhanced public health and safety. IoT enabled waste management systems can monitor the fill-level of waste containers in real-time, allowing for more efficient collection routes and reducing the frequency of unnecessary trips. Furthermore, the integration of IoT technologies in waste management systems can enable the implementation of smart garbage systems. These smart systems can automatically detect and sort different types of waste, diverting recyclable materials from landfill and promoting sustainable waste disposal practices.By utilizing Wi-Fi communication, the smart waste management system can seamlessly connect all the devices and sensors involved in the process.This ensures smooth and reliable data transmission, allowing for real-time monitoring and analysis of waste collection and disposal activities. In order to store the data analysis, we used cloud platform for IOT technology so we interfaced our hardware system to Blynk application for real time monitoring and notify filling level of bins. Challenges achieving in waste management is insufficient technologies and facilities due to increasing rate of waste generation have resulted in the failure to cope with elevating.[4] In order to avoid these challenges in traditional waste management it can be solved by the advancements in IOT. Through the utilization of IoT technology, every device gains the ability to seamlessly engage with humans, fostering a smarter lifestyle. This interconnected network facilitates the exchange of data among devices, accumulate human tasks and enhancing overall efficiency. Utilizing IoT technology, a sophisticated waste management system is crafted to revolutionize how waste is handled, with the goal of fostering a pristine environment and minimizing human involvement in waste disposal processes. The growing issues in waste management faced by cities everywhere, we urgently require fresh ideas. One such idea is a wireless system for managing solid waste in smart cities. This solution aims to make waste management more efficient and keep our cities cleaner.[5] For IoT systems to function effectively,

devices must communicate seamlessly, which is made possible by using Wi-Fi technology as a reliable communication protocol. Moreover, Wi-Fi communication offers advantages such as widespread coverage, high data transmission rates, and low power consumption, making it an ideal communication technology for IoT-based waste management systems. Wi-Fi enabled sensors can seamlessly communicate with centralized management platforms, allowing for real-time monitoring, remote configuration, and efficient data management. Many smart systems have been established as a result of the advancement of contemporary technology, particularly in the area of waste management and disposal. These devices have made life easier and simpler overall. This evolution has continued to this day and has been the subject of several scientific research explains and studies to advance this topic in a systematic and effective way.

II. LITERATURE SURVEY

The literature survey encompasses an exploration of existing research, publications and projects pertaining to Internet Of Thing technologies, waste management system, Wi-Fi connectivity with IOT.

The rate of urbanization is increasing rapidly. The generation of waste is increasing in the meanwhile. One crucial aspect that has to be taken into account is waste management [6].

Waste management is a big issue in most nations in all over world. The recycling containers are overflowing with solid garbage, and some of it is seeping out, causing environmental pollution [7].

Since there has been a significant increase in garbage generation over the years, waste management received a lot of attention. Overflowing trash cans without official control have resulted in the spread of numerous diseases and other health risks [8].

These are networks composed of different devices with data-sharing capabilities that are connected to numerous sensors and actuators are known as big data analytics, the Internet of Things (IoT), and artificial intelligence (AI). The process of collecting and processing waste from different city trash cans is known as solid waste management [9].

The Internet of Things (IoT) is an extremely helpful instrument for garbage management. In a smart city, interconnecting all tools, cars, and infrastructure can lead to improved quality of life and well being [10].

The Internet of Things (IoT), which includes sensors, actuators, and connected objects that gather data from the environment, is used to share data for processing, raising awareness, and making data-driven decisions. This is necessary for the efficient management of a smart city [11].

The Internet of Things, or IoT, is rapidly developing and providing unique solutions to the challenges that people encounter on a daily basis. One such implementation that aims to improve human lifestyles is the "smart city." Solid waste management is a significant challenge in most cities, and efficient solid waste management is essential to the development of smart cities [12].

Smart Bins are a worldwide innovation that cities are implementing to improve the efficiency of public waste collection management [13].

When the waste is close to breaking down or when the bins are full, the smart bins alert us. It can reduce human labor costs and increase the efficiency of the garbage collection system. Converting conventional garbage cans to smart ones requires an embedded sensor network. This embedded system is made up of sensors that gather the required information, such as filling levels [14].

The Internet of Things (IoT) presents new opportunities for municipal management as the infrastructure that is envisaged for the imagined Smart municipal concept. IoT vision provides practical and cost-effective ways to collect and analyze massive volumes of data, which may be applied to a range of industries to boost production [15].

III. HARDWARE AND SOFTWARE DESCRIPTION

A. Node MCU (ESP8266):

Node MCU ESP8266 is a compact, open-source development board combining Wi-Fi connectivity and Lua scripting. Ideal for IoT projects, it features an ESP8266 microcontroller, USB interface, and GPIO pins. Its unique blend of affordability and versatility makes it a popular choice for wireless applications, fostering innovation in the Internet of Things.

B. Wi-Fi Module:

NodeMCU ESP8266 incorporates a robust Wi-Fi module, enabling seamless wireless communication for IoT applications. This module empowers devices with reliable connectivity, facilitating data exchange and remote control. Its compact design, coupled with affordable pricing, makes Node MCU a standout choice for diverse and innovative Wi-Fi-enabled projects.

C. Sensors:
Sensors are intelligent data gatherers, transforming physical phenomena into digital insights. Their unique role lies in translating the real world into a language machines understand, crucial for smart technologies and automation. The various sensors used are:

i. Ultrasonic Sensor: In smart waste management, ultrasonic sensors serve as the eyes of efficiency. These sensors accurately measure bin fill levels, optimizing waste collection routes. By wirelessly transmitting data to a central system, they enable timely pickups and fostering a sustainable, cost-effective waste management ecosystem.

ii. IR Sensor: In smart waste management, IR sensors play a pivotal role by detecting bin access. Triggered when lids are opened, they monitor disposal activity. This real-time data not only enhances operational transparency but also aids in optimizing collection schedules, promoting resource efficiency, and contributing to a smarter, more sustainable waste management infrastructure.

iii. Inductive Proximity Sensor: Inductive proximity sensors revolutionize smart waste management by identifying metal content in disposed items. By recognizing metallic objects, these sensors enhance recycling precision, separating recyclables from general waste automatically. This fosters an eco-friendly approach, streamlining sorting processes and promoting a more sustainable waste management ecosystem.

D. Servo Motors:
In smart waste management, servo motors dynamically control bin lids, optimizing disposal efficiency. Integrated with sensors, they respond to fill levels, ensuring timely lid movement and preventing overflow. This precision contributes to a cleaner environment, reducing litter and enhancing the overall functionality of waste collection systems with automated, responsive lid mechanisms.

E. Arduino IDE:
In smart waste management, Arduino IDE with ESP8266 orchestrates the intelligence of bins. Programmed to communicate sensor data, it facilitates real-time monitoring and data analysis. By connecting these devices, it forms a robust network, enabling remote management and enhancing operational insights, ultimately streamlining waste collection processes for a smarter, more efficient system.

IV. SYSTEM DESIGN AND IMPLEMENTATION

A. HARDWARE IMPLEMENTATION:

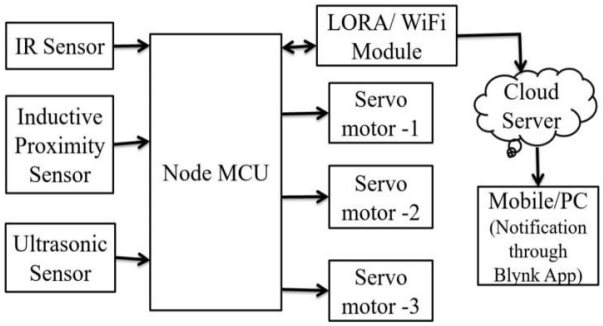

Fig. 1. Block Diagram of Hardware Implementation

Fig. 1., is the block diagram of IoT based Smart Waste Management System outlines the framework which is comprised of various hardware components such as Node MCU (ESP8266) as the main controlling unit, Ultrasonic sensors, IR Sensors, Inductive Proximity Sensor and servomotors integrated with the Wi-Fi module present in ESP8266.

B. SOFTWARE IMPLEMENTATION:

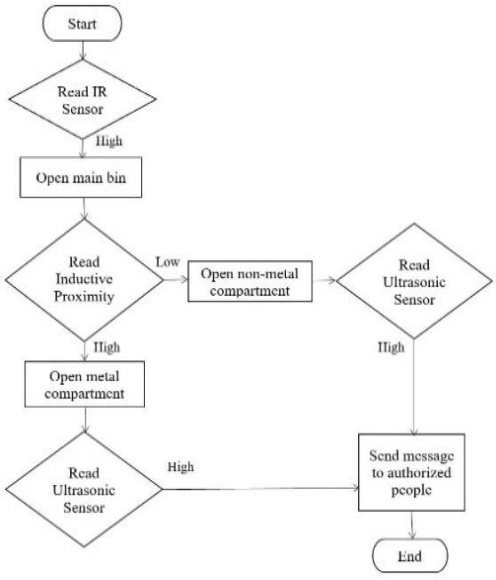

Fig. 2. Software Working flow Chart

Above fig-2 shows the workflow of the IOT Based Smart Waste Management System. When any waste material comes into the detection range with the IR sensor, it detects the presence of the waste and gives a high output by turning ON the LED. If the IR sensor's output is high,

then the lid of the bin gets opened and the waste material passes near to the inductive proximity sensor. If the waste material passing through the proximity sensor is a metal, then the proximity sensor triggers a high output. If the output of the inductive proximity sensor is high, then the lid of its corresponding compartment gets opened for the waste material to go inside the metal compartment. If the output of the inductive proximity sensor is low, it means that the passed waste material is a non-metal and hence the lid of the non-metal compartment gets opened. In this way, the waste materials get segregated in the bin itself. The ultrasonic sensors are integrated in each of the compartments of the bins so that whenever any of these compartments gets fille, it is indicated by the ultrasonic sensors. And thereby whenever the ultrasonic sensors get triggered due to overfilling of the bins, a notification is sent to the authorized people through the Blynk application so that the waste inside the bins can be cleared easily.

V. RESULTS AND ANALYSIS

After integrating all the hardware components as mentioned above, we can finally get the required output. The waste materials are being classified based on their composition such as metals and non-metals. The data collected from this system can provide valuable insight into waste generation patterns, helping authorities to make informed decisions about waste management policies and planning. The ultrasonic sensors integrated in this system helps in garbage level monitoring with the help of real-time data visualization through integration with IOT using Blynk application, remote controlling and monitoring the system from anywhere with an internet connection, long-term performance, cost benefit analysis and helps in effective recycling processes.

Fig. 3. & Fig. 4. Hardware implementation and top view of the bin

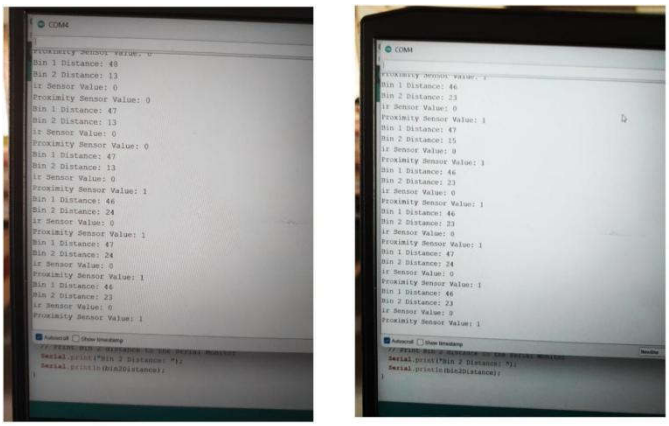

Fig. 5 & 6. Outputs of Inductive Proximity Sensor and Ultrasonic Sensors at different time periods

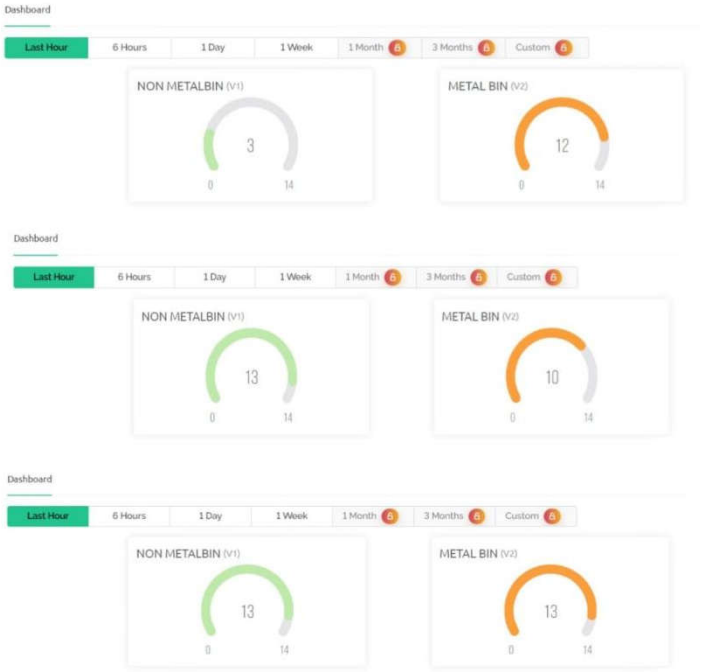

Fig. 7. Filling levels of metal and non-metal compartments of the bin

VI. CONCLUSION

In conclusion, The Internet of Things Based Smart Waste Management System Using Wi-Fi Communication gives valuable data insights for waste collection patterns, provides real-time data visualization, allows in remote controlling and monitoring the system at any place and anytime using internet connectivity. This system of waste management minimizes unnecessary waste collection trips which in turn reduces carbon emissions from collection vehicles, contributing to environment sustainability efforts. And overall, it is a low-cost smart bin which gives long-term performance.

VII. REFERENCES

1. Jasim, A. M., Qasim, H. H., Jasem, E. H., &Saihood, R. H. (2021).An internet of things based smart waste system.*International Journal of Electrical and Computer Engineering(IJECE)*,*11*(3),2577. https://doi.org/10.11591/ijece.v11i3.pp2577-2585

2. Kumar, S. V., Rethanya, S., Hussain, S., Sankar, S., & Sriram. (2023). Innovative waste management solutions for smart cities using IoT &NodeMCU. *2023 International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computational Intelligence (RAEEUCCI)*.

3. Meijer, A., & Bolívar, M. P. R. (2016). Governing the smart city: a review of the literature on smart urban governance. *International Review of Administrative Sciences*,*82*(2),392–408. https://doi.org/10.1177/0020852314564308

4. Sheng, T. J., Islam, M. S., Misran, N., Baharuddin, M. H., Arshad, H., Islam, M. R., Chowdhury, M. E. H., Rmili, H., & Islam, M. T. (2020). An internet of things based smart waste management system using LoRa and tensorflow deep learning model. *IEEE Access: Practical Innovations, Open Solutions*, *8*, 148793–148811. https://doi.org/10.1109/access.2020.3016255

5. Nirde, K., Mulay, P. S., & Chaskar, U. M. (2017). IoT based solid waste management system for smart city. *2017 International Conference on Intelligent Computing and Control Systems (ICICCS)*.

6. Chaudhari, M. S., Patil, B., & Raut, V. (2019). IoT based waste collection management system for smart cities: An overview. *2019 3rd International Conference on Computing Methodologies and Communication (ICCMC)*.

7. Radhika, D., Rukkumani, D., Devasena, & Ramya. (2019). Smart Waste Management System Using IoT. *International Journal of Research in Arts and Science*, *5*(Special Issue), 65–72. https://doi.org/10.9756/bp2019.1001/08

8. Nayak, S., Narayan, A., & Rout, J. K. (2022). IoT-Enabled Smart Dustbin. In *IoT-Based Smart Waste Management for Environmental Sustainability* (pp. 99–120). CRC Press.

9. Pradhan, A., Samal, S., Panda, B., & Acharya, B. (2022). Waste prevention: Its impact and analysis. In *IoT-Based Smart Waste Management for Environmental Sustainability* (pp. 19–36). CRC Press.

10. Rani,N.(2022).IoT-based smart waste management for smartcities. In *IoT-Based Smart Waste Management for Environmental Sustainability* (pp. 121–138). CRC Press.

11. Rajani, K. R., Gaddam, A., & Gaddam, J. (2022). IoT based smart waste management using deep reinforcement learning. In *Preprints*. https://doi.org/10.20944/preprints202211.0190.v1

12. Bharadwaj, A. S., Rego, R., & Chowdhury, A. (2016). IoT based solid waste management system: A conceptual approach with an architectural solution as a smart city application. *2016 IEEE Annual India Conference (INDICON)*.

13. Emmanuel, E., Cudden, J., & Mullarkey, M. (2021). When smart Bins meet a smart city. *Muma CaseReview*, *6*,001–035. https://doi.org/10.28945/4858

14. Haque, K. F., Zabin, R., Yelamarthi, K., Yanambaka, P., &Abdelgawad, A. (2020). *An IoT based efficient waste collection system with smartbins*. https://doi.org/10.36227/techrxiv.12455936

15. Iot based waste management in smart city using Ir. (2018). *International Journal of Engineering ResearchandAdvancedTechnology*.https://doi.org/10.7324/ijerat.2018.3246