WASTE MANAGEMENT SYSTEM

Mrs.K.Vidhya Assistant Professor,
Department of Electrical and Electronics Engineering, Velammal Engineering College, Chennai-600066.

Guru Vignesh A[2]
Student,
Department of Electrical and Electronics Engineering, Velammal Engineering College, Chennai-600066.

Purushothaman R[3]
Student,
Department of Electrical and Electronics Engineering, Velammal Engineering College, Chennai-600066.

Rahul R[4]
Student,
Department of Electrical and Electronics Engineering,
Velammal Engineering College,
Chennai-600066.

Anbarasan R[5]
Student,
Department of Electrical and Electronics Engineering,
Velammal Engineering College, Chennai-600066.

Abstract: ***In response to escalating environmental concerns, this paper presents a comprehensive waste management system comprising two pivotal phases. Phase 1 addresses the imperative need for efficient waste segregation. By harnessing a suite of sensors—IR, ultrasonic, and soil moisture sensors—coupled with the ESP32 microcontroller, our system autonomously segregates solid and liquid waste, addressing the contamination issue prevalent in conventional disposal methods. Real-time monitoring via the Thing Speak cloud platform offers remote access to waste levels, empowering responsible waste disposal practices. Phase 2 builds upon this foundation by introducing autonomous movement capabilities to the waste collection process. The integration of user-friendly interfaces enables seamless monitoring and control of the dustbin's movements, resolving traffic congestion issues associated with manual waste collection. This innovative approach not only revolutionizes waste segregation but also mitigates traffic and pollution concerns through a cloud-managed, systematically operated moving bin. The presented system stands as a beacon of sustainable waste management, offering a pragmatic solution to global environmental challenges***

Keywords: real time monitoring, sustainable waste management, user friendly

I. INTRODUCTION

In today's world, the imperative for effective waste management stands as a critical linchpin in combating escalating environmental challenges. Traditional waste disposal methods often lead to hazardous mixing of solid and liquid waste, exacerbated by contamination from oil and water residues. This paper presents a pioneering two-phase waste management system designed to revolutionize waste segregation and collection processes, addressing these critical issues head-on.

Phase 1 of the system tackles the pressing challenge of waste segregation. Utilizing an array of cutting-edge sensors—IR, ultrasonic, and soil moisture sensors—integrated with the ESP32 microcontroller, this phase autonomously segregates solid and liquid waste. By precisely identifying and separating waste based on moisture content, it circumvents the contamination issues inherent in conventional disposal methods. Real-time monitoring capabilities facilitated through the Thing Speak cloud application provide remote access to graphical representations of waste levels, fostering responsible waste disposal practices.

Phase 2 of the project introduces an innovative dimension to waste collection by enabling autonomous movement of the waste collection bin. Recognizing the logistical challenges and environmental impact of manual waste collection, this phase integrates user-friendly interfaces to monitor and manage the dustbin's movements. By extending the system's capabilities to include cloud-based management, it envisions a systematic operation of a moving bin, alleviating traffic congestion and streamlining waste collection processes.

This integrated waste management system represents a holistic and forward-thinking solution to the global issue of waste disposal. By amalgamating state-of-the-art sensor technologies, microcontrollers, and cloud-based platforms, this system not only addresses the critical challenge of waste segregation but also envisions a future where waste collection processes are streamlined, environmentally conscious, and sustainable. Through this paper, we delve into the intricate details and functionalities of this innovative

waste management system, highlighting its technological prowess, potential impact on environmental sustainability, and its role in fostering responsible waste disposal practices.

II. DESIGN AND DEVELOPMENT

The development of an integrated waste management system presented in this paper represents a comprehensive approach towards addressing the escalating challenges in waste disposal and environmental sustainability. The system architecture incorporates two pivotal phases: Phase 1 focuses on autonomous waste segregation by leveraging an array of sophisticated sensors (IR, ultrasonic, soil moisture) integrated with the ESP32 microcontroller. This phase achieves precise waste sorting and real-time monitoring through the ThingSpeak cloud application, offering a tangible solution to contamination issues. Building upon this foundation, Phase 2 introduces autonomous movement capabilities to the waste collection process. It envisions a system where waste bins autonomously navigate designated areas, incorporating user-friendly interfaces and cloud-based management to streamline waste collection processes and alleviate logistical challenges associated with manual collection. The implementation details encompass technical specifications, encountered challenges, and solutions devised, while performance evaluation includes accuracy metrics for waste segregation and the efficiency of autonomous bin movement. The seamless integration of both phases underscores their collective impact on environmental sustainability, offering a viable solution and paving the way for future enhancements and scalable implementations

III. HARDWARE SETUP

1. IR PROXIMITY SENSOR

An infrared (IR) proximity sensor is a type of sensor that detects the presence or proximity of an object by emitting and receiving infrared radiation. These sensors are commonly used in various applications, ranging from consumer electronics to industrial automation and robotics.

The basic principle behind an IR proximity sensor is relatively straightforward. It consists of two main components: an IR emitter and an IR receiver. The emitter emits a beam of infrared light, which is usually not visible to the human eye. The receiver, positioned nearby, is designed to detect the reflection of this emitted light.

When there is no obstacle in the path of the emitted IR beam, the receiver does not receive any reflected light, and the sensor registers this as an absence of an object or a far distance from the sensor. However, when an object comes within the sensor's detection range and reflects the emitted IR light back to the receiver, the sensor detects this reflection and registers the presence of the object.

Fig 3.1 IR PROXIMITY SENSOR

2. SOIL MOISTURE SENSOR

A soil moisture sensor is an electronic device designed to measure and monitor the moisture content of soil. These sensors are commonly used in agriculture, gardening, environmental monitoring, and irrigation systems to help ensure optimal soil conditions for plant growth. Here is a paragraph describing the soil moisture sensor:

A soil moisture sensor is a valuable tool for those seeking to optimize plant growth and conserve water resources. This small yet essential device is placed in the soil, where it measures the moisture content by analyzing the electrical conductivity or resistance between its probes. As soil moisture levels fluctuate, the sensor provides real-time data, allowing farmers, gardeners, and environmentalists to make informed decisions about when and how much to water their crops or plants. By preventing overwatering or under watering, these sensors help enhance plant health, increase crop yields, and reduce water wastage, contributing to sustainable and efficient land use. Furthermore, soil moisture sensors can be integrated into automated irrigation systems, enabling precise control over watering schedules, conserving water, and promoting environmental stewardship.

Fig 3.2 SOIL MOISTURE SENSOR

3. ULTRA SONIC SENSOR

An ultrasonic sensor is a versatile and widely used technology that plays a crucial role in distance measurement, object detection, and obstacle avoidance applications. This sensor operates by emitting high-frequency sound waves, typically in the ultrasonic range, and then measuring the time it takes

for those waves to bounce back after hitting an object. Here is a paragraph describing the ultrasonic sensor:

The ultrasonic sensor is a remarkable technology known for its ability to precisely measure distances and detect objects in various applications. This sensor employs the principle of echolocation, similar to how bats navigate in the dark. It emits short bursts of ultrasonic waves, which travel through the air until they encounter an obstacle. Upon hitting the object, the sound waves bounce back to the sensor, and the sensor calculates the distance by measuring the time it takes for the waves to return. This real-time distance information is invaluable in fields like robotics, where it enables robots to navigate and avoid collisions autonomously. It is also used in industrial automation, automotive parking systems, and even in everyday devices like automatic hand sanitizers, where it detects the presence of hands and dispenses sanitizer accordingly. The versatility and precision of ultrasonic sensors make them an indispensable component in numerous applications where accurate distance measurements and object detection are essential.

Fig 3.3 ULTRA SONIC SENSOR

4. DC SERVO MOTOR

A DC servo motor is a specialized type of direct current (DC) motor that offers precise control over its rotation and position. These motors are designed to respond to input signals and maintain a specific position or move to a desired position with a high degree of accuracy.

The DC servo motor stands as a remarkable engineering innovation, meticulously designed to deliver precise and controlled motion in a wide array of applications. It operates on the fundamental principle of converting electrical energy into mechanical motion with exceptional accuracy. What sets the DC servo motor apart is its ability to maintain and adjust its position based on feedback signals, making it a critical component in tasks demanding precise positioning and motion control. These motors are frequently employed in robotics, CNC machinery, industrial automation, and various mechatronic systems. When coupled with an encoder or resolver, DC servo motors can provide closed-loop control, ensuring that they reach and maintain specific positions with minimal error. This level of precision is invaluable in scenarios where accuracy and reliability are paramount, allowing for tasks ranging from guiding the movements of robotic arms in manufacturing to maintaining the alignment of telescopes for astronomical observations. DC servo motors represent an essential component in the realm of motion control, contributing to advancements across multiple industries.

Fig 3.4 DC SERVO MOTOR

5. NODE MCU ESP32S

Dual-Core Processor: The ESP32 features a dual-core Xtensa LX6 microprocessor, which can be independently controlled. This dual-core design allows for efficient multitasking and better performance.

Wireless Connectivity: The ESP32 includes built-in Wi-Fi and Bluetooth capabilities, making it suitable for IoT applications that require wireless communication. It supports various Wi-Fi security protocols, including WPA2, WPA3, and more.

Peripheral Support: The ESP32 offers a wide range of built-in peripherals, including GPIO pins, SPI, I2C, UART, PWM, and more. This extensive set of peripherals makes it versatile and suitable for interfacing with various sensors and devices.

Low Power Consumption: The ESP32 is designed to be power-efficient, making it suitable for battery-powered applications. It has different low-power modes, such as deep sleep and light sleep, to conserve energy.

Rich Development Ecosystem: There is a robust development ecosystem around the ESP32, including the Arduino IDE, Platform, and the Express if IDF (IoT Development Framework). This makes it accessible to both beginners and experienced developers.

Programming Languages: You can program the ESP32 using various programming languages, including C/C++, Python, and Micro Python, depending on your preferences and project requirements.

Security Features: The ESP32 includes hardware-based security features, such as secure boot, flash encryption, and cryptographic accelerators, to help protect your IoT devices from security threats.

Cost-Effective: The ESP32 is relatively affordable compared to many other microcontrollers with

similar capabilities, making it a popular choice for hobbyists and professional projects alike.

Community Support: The ESP32 has a large and active community of developers and enthusiasts who share knowledge, libraries, and projects, making it easier to find resources and solutions to common challenges.

ESP32 is a versatile and powerful microcontroller that is well-suited for a wide range of IoT and embedded system applications, thanks to its wireless capabilities, extensive peripheral support, and low power consumption.

It has gained popularity in the maker and IoT communities and continues to be used in various innovative projects**.**

Fig 3.5 NODE MCU ESP32S

6. BO MOTOR

The BO (Brushed DC) motor serves as a critical component within our waste management system, facilitating the autonomous movement of the waste collection bin. These motors are renowned for their reliability, simplicity, and versatility, making them ideal for our application. With precise control over speed and direction, the BO motor integrates seamlessly with our system's design, enabling smooth and controlled movements of the waste collection bin to designated areas. Its compatibility with the system's motor driver ensures efficient utilization, contributing to the reliability and effectiveness of the autonomous movement functionalities.

Fig 4.5 BO MOTOR

6. LITHIUM ION BATTERY

The inclusion of the Lithium-Ion Battery (3.7V, 2500mAh) within our waste management system provides a reliable power source essential for sustained system operation. These high-capacity batteries offer a balance between energy density and size, making them suitable for powering portable and autonomous devices. Within our system, these batteries ensure extended operational periods for the smart bins, supporting the autonomous movement and sensor functionalities. Their rechargeable nature aligns with sustainability goals, promoting efficient energy use in the context of waste management operations.

Fig 3.6 LITHIUM ION BATTERY

7. MOTOR DRIVER L293D

The L293D motor driver plays a pivotal role in our waste management system, acting as an interface between the microcontroller and the BO motors. This versatile motor driver facilitates bidirectional control of the motors, enabling precise control over their speed and direction. Its H-bridge configuration ensures efficient power delivery to the motors while offering built-in protection against back electromotive force (EMF) generated during motor operation. The L293D's compatibility with various microcontrollers, including the ESP32 utilized in our system, ensures seamless integration and reliable motor control, essential for the successful implementation of autonomous movement functionalities within the waste collection bins.

Fig 3.7 MOTOR DRIVER

IV. SOFTWARE REQUIREMENTS

1. THING SPEAK

ThingSpeak is an open-source Internet of Things (IoT) platform developed by Math Works, the company behind MATLAB. ThingSpeak is designed to allow users to collect, analyze, and visualize data from IoT devices or sensors.

Data Collection: ThingSpeak provides a platform where you can easily collect data from various IoT devices and sensors. It supports a wide range of data sources, including temperature sensors, humidity sensors, GPS modules, and more.

Data Storage: The platform offers cloud-based storage for the data collected from your IoT devices. This data is stored in channels, which act as data repositories. Each channel can hold a different type of data, and you can create multiple channels to organize your data.
Data Analysis: ThingSpeak includes built-in MATLAB analytics capabilities, allowing you to perform data analysis and visualization directly on the platform. You can create custom MATLAB scripts to process and visualize your data in real-time.
4. Visualization: ThingSpeak offers various built-in visualization tools, including charts and gauges, to help you create dashboards and displays for your IoT data. These visualizations can be embedded in websites or shared with others.
IoT Integration: ThingSpeak is compatible with a wide range of IoT hardware platforms, including Arduino, Raspberry Pi, ESP8266, and more. It supports common IoT communication protocols like MQTT and HTTP, making it easy to connect your devices.
Automation: ThingSpeak allows you to set up triggers and alerts based on the data you collect. You can configure actions to occur when certain conditions are met, such as sending notifications or activating other IoT devices.
Open Source: While ThingSpeak is a commercial product, it has an open-source version called "ThingSpeak Community Edition" that you can host on your own server. This allows for more control and customization of the platform.
API Access: ThingSpeak provides APIs that enable developers to integrate the platform with other services and applications. This can be useful for building custom IoT solutions and automations.
Community and Support: ThingSpeak has an active community of users and developers who share their projects, code, and solutions. There are also forums and documentation available for assistance.
ThingSpeak is a versatile platform for IoT data collection, analysis, and visualization. It's suitable for hobbyists, students, and professionals looking to build IoT applications and gain insights from their sensor data. Whether you're monitoring environmental conditions, tracking assets, or conducting scientific experiments, ThingSpeak can be a valuable tool for your IoT projects.

Fig 4.1

2. ARDUINO IDE

Arduino IDE is an open-source software, designed by Arduino.cc and mainly used for writing, compiling & uploading code to almost all Arduino Modules. It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.
It is available for all operating systems i.e. MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role in debugging, editing and compiling the code. A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino macros and many more.
Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code. The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.
The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

Fig 4.2

3. BLYNK

The integration of Blynk software within our waste management system introduces a pivotal dimension in location tracking and management of the smart bin. Blynk, a versatile and user-friendly IoT platform, serves as an instrumental tool in facilitating real-time tracking functionalities for the smart bins deployed in our system. Leveraging Blynk's intuitive interface and robust functionalities, we harness its GPS tracking features to precisely monitor the location of each smart bin. This integration enhances the system's efficiency by enabling remote monitoring

and management of the smart bins' movement patterns. Additionally, Blynk's customizable widgets and cloud-based infrastructure seamlessly complement our system's existing architecture, empowering users with comprehensive and accessible location data. By employing Blynk's capabilities, we ensure the effective utilization of location-based services, thereby contributing to streamlined waste collection logistics and optimizing the overall operational efficiency of the waste management system

Fig 4.3

V. BLOCK DIAGRAM

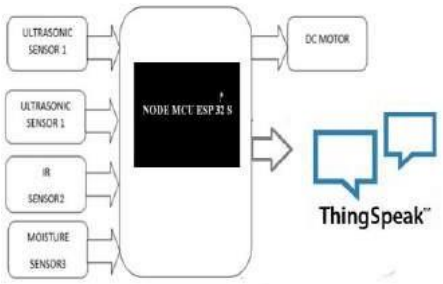

Fig 5.1 BLOCKDIAGRAM OF PHASE 1

Ultrasonic sensor Sensors measure distances by using ultrasonic waves. The sensor emits an ultrasonic wave and receives the reflected wave back from the target. Infrared (IR) sensors operate based on the detection of infrared radiation. These sensors can measure distances and detect objects by emitting infrared light and measuring the time it takes for the light to bounce back. A soil moisture sensor is a device that measures the moisture content in soil or other substances. These sensors are commonly used in agriculture, gardening, and various industrial applications to monitor and control soil moisture levels. The Node MCU ESP8266 is a popular open-source IoT (Internet of Things) development platform based on the ESP8266 Wi-Fi module. It combines a microcontroller unit (MCU) with built-in Wi-Fi connectivity, making it a versatile and cost-effective choice for developing IoT projects. A DC servo motor is an electric motor that uses direct current (DC) to drive mechanical systems and provide precise control over angular or linear position, velocity, and acceleration. These motors are commonly used in applications where accuracy and controllability are essential.

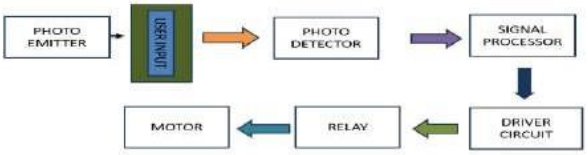

Fig 5.2 BLOCK DIAGRAM OF PHASE 2

VI. RESULT AND OUTPUT

PROTOTYPE OF WASTE MANAGEMENT SYSTEM

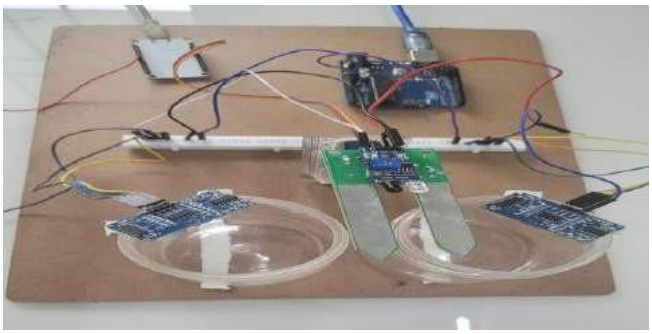

Fig 5.1 Design of Monitoring Unit

OUTPUT

Fig 5.2 Output for the Wet waste output

Fig 5.3 Output for the Dry waste output

VII. CONCLUSION

The culmination of the two-phase waste management system presented in this paper represents a monumental stride towards addressing the pressing challenges of contemporary waste disposal. Phase 1, focusing on waste segregation, showcased an innovative approach harnessing an amalgamation of sophisticated sensors and microcontroller technology. This phase's ability to autonomously identify and segregate solid and liquid waste, coupled with real-time monitoring capabilities, lays a robust foundation for responsible waste disposal practices.

Phase 2, building upon this foundation, introduced autonomous movement capabilities to the waste collection process. By envisioning a system where waste bins can autonomously navigate designated areas, coupled with user-friendly interfaces and cloud-based management, this phase offers a tangible solution to the logistical and environmental issues associated with manual waste collection methods. It sets the stage for a future where waste collection processes are streamlined, reducing traffic congestion and contributing to a cleaner environment. Collectively, the integrated system not only addresses the critical challenge of waste segregation but also signifies a paradigm shift in waste collection methodologies. The seamless integration of cutting-edge technologies, sensor networks, and cloud-based platforms presents a sustainable and efficient approach towards waste management.

This project's outcomes underscore its potential impact on environmental sustainability, resource optimization, and the promotion of responsible waste disposal practices. As we navigate an era defined by escalating environmental concerns, this waste management system stands as a beacon of innovation, offering a viable solution towards a cleaner and more sustainable future.

VIII. REFERENCES

H. Jouhara, D. Czajczyńska, H. Ghazal, R. Krzyżyńska, L. Anguilano, A.J. Reynolds, N. Spencer, "Municipal waste management systems for domestic use," Energy, Volume 139, 2017, pp. 485-506, ISSN 0360-5442.

F. Folianto, Y. S. Low, W. L. Yeow, "Smartbin: Smart waste management system," in 2015 IEEE Tenth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), Singapore, 2015, pp. 1-2, doi: 10.1109/ISSNIP.2015.7106974.

Amirhossein Salehi-Amiri, Navid Akbapour, Mostafa Hajiaghaei-Keshteli, Yuvraj Gajpal, Armin Jabbarzadeh, "Designing an effective two-stage, sustainable, and IoT-based waste management system," Renewable and Sustainable Energy Reviews, Volume 157, 2022, 112031, ISSN 1364-0321.

T. J. Sheng et al., "An Internet of Things Based Smart Waste Management System Using LoRa and Tensorflow Deep Learning Model," in IEEE Access, vol. 8, pp. 148793-148811, 2020, doi: 10.1109/ACCESS.2020.3016255.

Yadav, D., Pandey, A., Mishra, D. et al. IoT enabled smart dustbin with messaging alert system. Int. j. inf. tecnol. 14, 3601–3609 (2022)

N. S. Kumar, B. Vuayalakshmi, R. J. Prarthana and A. Shankar, "IOT based smart garbage alert system using Arduino UNO," 2016 IEEE Region 10 Conference (TENCON), Singapore, 2016, pp. 1028-1034, doi: 10.1109/TENCON.2016.7848162.

Chaudhari, Sangita S., and Varsha Y. Bhole. "Solid waste collection as a service using IoT-solution for smart cities." 2018 International Conference on Smart City and Emerging Technology (ICSCET). IEEE, 2018.

M. Pawaskar, S. Aneesh, D. Sharma, P. Sawale, R. Sharma and A. Sharma, "IoT enabled Smart Dustbin using Zigbee Network," 2021 International Conference on Advances in Computing, Communication, and Control (ICAC3), Mumbai, India, 2021, pp. 1-4, doi: 10.1109/ICAC353642.2021.9697275.