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SMART WASTE MANAGEMRNT SYSTEM USING IOT TECHNOLOGY

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Abstract: **This research paper presents the successful implementation of a Smart Waste Management System utilizing IoT technology, specifically incorporating Arduino Uno, ultrasonic sensors, GSM 900A, and GPS Neo-6M modules. The system aims to address the inefficiencies in traditional garbage collection methods by integrating these hardware components seamlessly. Ultrasonic sensors, strategically positioned within the dustbin, detect garbage levels at different heights. Upon the joint detection of garbage by both sensors after a 10-second delay, a signal is transmitted to the GSM 900A module, triggering the generation of an SMS. This SMS includes the unique ID of the dustbin and a GPS location link, generated using the GPS Neo-6M module. The SWMS, developed using the Arduino IDE, demonstrates promising results in streamlining waste collection processes, minimizing unnecessary trips, reducing traffic congestion, and optimizing fuel consumption, thereby exemplifying a successful integration of IoT technology into waste management practices.**

Keywords— **ultrasonic sensors, GSM 900A, GPS Neo-6M.**

I. INTRODUCTION

Proper waste management is a critical aspect of urban living, yet traditional methods often prove inefficient and costly. With the advent of Internet of Things (IoT) technologies, opportunities arise to revolutionize waste management practices. This research paper delves into the development and implementation of a Smart Waste Management System utilizing IoT principles to streamline garbage collection processes and address associated challenges.

The developed system centers around a smart dustbin equipped with ultrasonic sensors strategically placed at two different levels within the bin. These sensors continuously monitor the level of garbage within the bin. Upon detecting garbage at both sensor levels with a brief delay of 10 seconds to ensure accuracy, the sensors trigger a signal to a GSM module integrated into the system.

Utilizing the GSM module in conjunction with GPS locating technology and various other components, the system generates an SMS containing vital information. This includes the GPS location link pinpointing the exact coordinates of the dustbin and an identification code unique to each bin. The SMS is automatically dispatched to designated truck drivers responsible for garbage collection within the vicinity. Upon receiving the SMS, the truck drivers can utilize the GPS location link to navigate directly to the designated dustbin location using popular mapping applications such as Google Maps. This real-time information empowers them to optimize their routes, reducing unnecessary trips and minimizing fuel consumption.

In addition to alleviating traffic congestion caused by inefficient garbage collection practices, this Smart Waste Management System enhances the convenience and efficiency of garbage collection for municipal authorities and waste management personnel. By leveraging IoT technologies, this system exemplifies a sustainable solution to modern urban challenges while promoting environmental stewardship and resource optimization.

Choice of the topic with reasoning:

The pressing need to address environmental challenges arising from inefficient garbage collection practices in rapidly advancing technological landscapes has spurred the development of the Smart Waste Management system. This system aims to mitigate pollution caused by frequent and inconsistent garbage truck trips through localities, which contribute to air pollution, traffic congestion, and unnecessary human efforts. The proposed solution involves intelligent bins equipped with advanced sensors to monitor garbage levels. When full, these bins trigger the transmission of an SMS to the municipal cooperation, providing the unique bin identifier and GPS coordinates. This data-driven approach optimizes waste collection processes, reducing

unnecessary trips and improving overall efficiency.
The Smart Waste Management system integrates cutting-edge Internet of Things (IoT) technologies, including GSM modules and GPS sensors, to facilitate seamless communication and precise location tracking. The GSM module enables real-time updates on garbage levels, while the GPS sensor ensures efficient routing, minimizing unnecessary journeys. Overall, this innovative system represents a forward-thinking approach to promote sustainable waste management practices, reduce pollution, and alleviate traffic congestion caused by avoidable garbage collection trips.

II. LITERATURE REVIEW

Amidst the rapid evolution of waste management technology, the persistent challenges linked to unnecessary pollution from frequent garbage truck trips have spurred efforts towards innovative solutions. This dilemma not only results in air pollution but also amplifies traffic congestion and involves unwarranted human efforts. The inefficiency becomes apparent when garbage trucks traverse certain localities without waste to collect, leading to a wasteful utilization of resources. Additionally, sporadic garbage pickups occasionally result in overflowing bins, exacerbating the complexities of waste management. To address these issues, the development of a Smart Waste Management system is imperative.
Researchers and innovators have directed their focus towards solutions, and the incorporation of advanced technologies has played a pivotal role in the evolution of waste management systems. A notable concentration in this domain is the implementation of intelligent bins equipped with IoT-based technology, such as GSM modules and GPS sensors. These smart bins aim to revolutionize waste collection by autonomously sensing garbage levels and triggering notifications upon reaching capacity.
H. P. Khandagale et al [1] , worked on an system which enables users to initiate automation operations by sending coded SMS messages to a base station controller, which executes the required actions and confirms successful execution. This research paper discusses the development and implementation of this SMS-based street light control system, emphasizing its efficiency and practicality.
Tejashree Kaduset al [2] , Smart NetBin integrates hardware and software, employing Wi-Fi-connected bins to incentivize cleanliness. Users receive free internet access as a reward for maintaining a clean environment. The system measures dumped trash, monitors waste movement, and signals Wi-Fi connectivity. Operating on a client-server model, it promotes a clean, healthy, and pollution-free society.
Shyamala S.C et al [3] , The Smart Waste Management System utilizes smart sensors to provide real-time data on fill levels, garbage presence, and odors. This information is transmitted to Waste Management Centers via GSM/GPRS modules, with authorized phone numbers collecting data from containers citywide. The Atmega328P 8-bit microcontroller oversees the operation, enabling systematic route planning for efficient garbage collection. Additionally, the report proposes a potential design for an IoT gateway, streamlining waste management processes.
Kellow Pardini et al [4] , Worked on IoT-based solution for waste management, encompassing hardware, software, and communication technologies. By continuously monitoring waste levels in smart bins and utilizing IoT middleware, the system optimizes collection routes and provides valuable statistical insights. Citizens can access bin information via web or mobile applications. Through prototype development and real-scale experimentation, the efficacy of the proposed system in revolutionizing waste management and resource optimization is demonstrated.
Ankit Kumar et al [5] , Ensuring environmental hygiene is vital, particularly in urban areas where overflowing waste containers pose significant risks to public health and the environment, leading to pollution and related health hazards. In response, real-time monitoring and management of waste containers have become imperative, prompting the adoption of IoT technologies. This study focuses on leveraging IoT devices and ultrasonic sensors for continuous monitoring of waste container fill levels. Notifications are triggered when bins reach 85% capacity with a 15% margin, complemented by visual indicators signaling delays in the emptying process. Keywords: Ultrasonic sensor, IoT, LCD display, I2C Converter, Node MCU.Top of Form
Beauty L. Komane et al [6] , worked on smart waste management system for Johannesburg to address these challenges. Although the city provides basic waste services, traditional collection methods are insufficient to cope with the increasing waste volume. The proposed system integrates sensors, user applications, and real-time monitoring to enhance waste management efficiency. Experimental methodology is employed to validate the system's effectiveness.
Edoardo Longo et al [7], Worked on solution focusing on smart waste management, aimed at enhancing recycling rates and streamlining waste cycle management within campus premises. Central to this solution is a prototype smart waste bin equipped with a hybrid sensor/image classification algorithm, facilitating accurate trash classification and automated segregation of waste materials. The paper details the system's design, encompassing requirements analysis, implementation specifics, and performance evaluation across various scenarios. Additionally, it explores advanced application functionalities centered on the smart waste bin, including optimized maintenance scheduling.

Soumyabrata Sahaa et al [8] , Worked on waste management, including illegal waste disposal and inadequate policies, exacerbating health and environmental concerns.

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Through an integrative review, the proposed technique explores the potential of smart cities to address these challenges. Focused on urban areas, particularly COVID-19 affected households in India, the study proposes an IoT-based smart waste management system to enhance waste handling efficiency and accommodate pandemic-related requirements. The framework facilitates regular environmental sanitation and provides convenience amidst COVID-19 situations. By emphasizing interaction between waste generators and service providers, the proposed system enables real-time monitoring of bin fill levels, dynamic waste collection scheduling, and route optimization to ensure quality of service.

Bindushree V et al[9], Worked on An IoT system is developed to monitor bin levels and segregate waste types, comprising sensors such as IR sensors to detect waste presence and soil moisture sensors to differentiate between wet and dry waste. Ultrasonic sensors are deployed to measure bin capacity, facilitating timely emptying. Data on bin levels are visualized using ThingSpeak, while notifications are managed through the IFTTT platform. These IoT solutions streamline waste monitoring, reducing the need for frequent manual inspections.

Atul Kumar et al [10] , The IoT's rise and internet infrastructure improvements have seamlessly integrated IoT technologies into daily life. Anticipated advancements like 5G technology promise to revolutionize IoT device communication, broadening community access to these innovations. This trend has accelerated the development of "Smart Waste Management Systems," utilizing embedded systems with sensors, microcontrollers, and communication devices for real-time waste bin monitoring, aiming to cut collection costs and fuel consumption. This paper explores IoT device implementation and societal perspectives on waste management challenges and opportunities in India, providing insights for companies and waste management authorities regarding Smart Waste Management Systems' commercialization.

Pulkit Bindal et al [11] , Worked on IoT technology to manage waste information in smart cities. By measuring the depth of waste using sensors, the system can alert local authorities to garbage accumulation in different city sectors. Each bin is connected to a central system via a microcontroller ATSAM3X8E Board and an ultrasonic sensor, providing real-time data on trash levels. A graphical user interface (GUI) module is integral to the project's success. This research highlights the potential of IoT-enabled solutions for efficient waste management in urban environments.

III. SYSTEM ARCHITECTURE

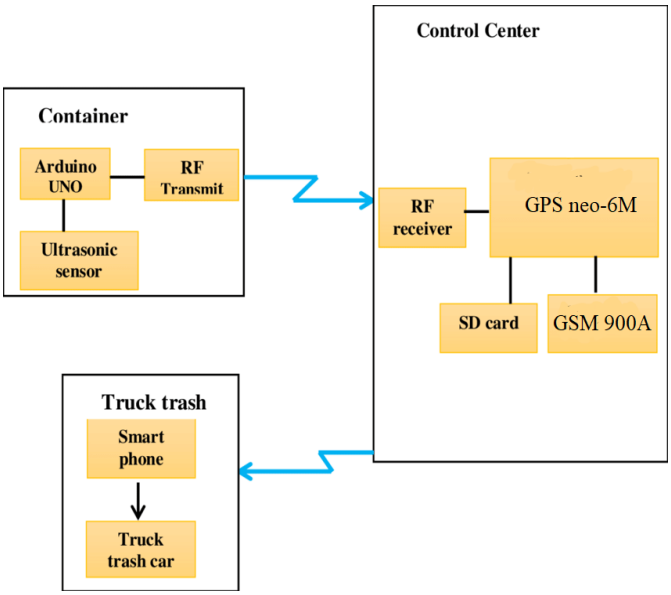

Fig1. System Architecture

The system architecture operates in three phases

1. Garbage bins equipped with ultrasonic sensors detect garbage levels.
2. Signals are transmitted to the control system, which comprises a GSM module.
3. The GSM module generates an SMS containing thelocation and ID of the bin, which is sent to the mobile phones of designated truck drivers.

Methods of data analysis

Our Smart Waste Management system is structured into three key modules to enhance its functionality:

1. Garbage bin status monitoring:
- The system operates using the energy stored in the storage unit, which is derived from solar power.
- The switching on and off of the smart bin is efficiently managed by an automated structure programmed using Arduino in conjunction with an IR sensor.

2. Sensor module:
- The sensor module is a crucial component integrated with two Ultrasonic sensor HC SR04.
- These sensors play a pivotal role in monitoring and analyzing the garbage level within the smart bin.

3. GSM Module:
- The GSM module serves as the central hub for managing the Smart Waste Management system.
- Its primary role is to gather and record information, which is then directly transmitted through the system to the SMS driver.

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- Integrated with an Arduino Uno and GPS NEO-6M, this module facilitates the direct transmission of essential data related to the smart bin's status to designated recipients, such as truck drivers.

IV. IMPLEMENTATION

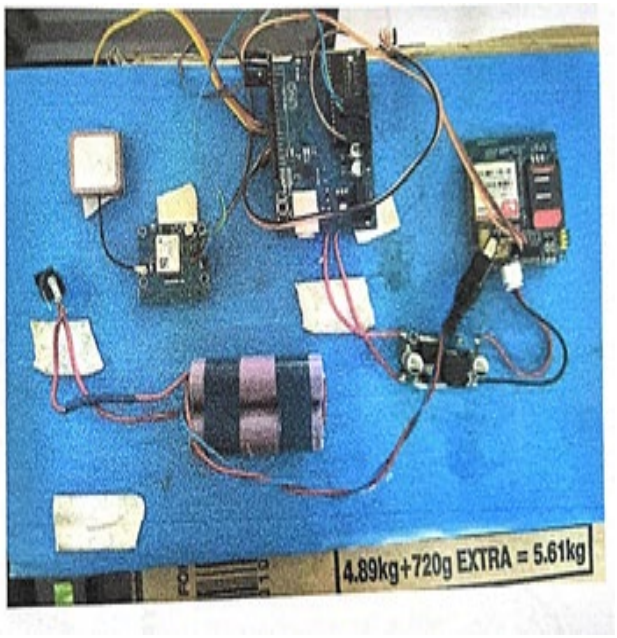

Fig.2 Circuit Connection.

Components involved

- Ultrasonic sensors (two): Detect garbage levels within bins.
- Arduino Uno: Central control unit for data processing and communication.
- GSM 900A module: Facilitates SMS alert generation and transmission.
- GPS NEO-6M module: Provides precise location data for inclusion in SMS alerts.

The components are connected as follows

1. The GSM 900A module is directly connected to the Arduino Uno board using connecting wires.
2. The GPS NEO-6M module is also connected to the Arduino Uno board via connecting wires.
3. The ultrasonic sensors are connected to the Arduino Uno board using connecting wires.
4. All components are securely connected to the Arduino Uno board, which serves as the central control unit for the system, facilitating communication and data processing between the components.

V. RESULT & ANALYSIS

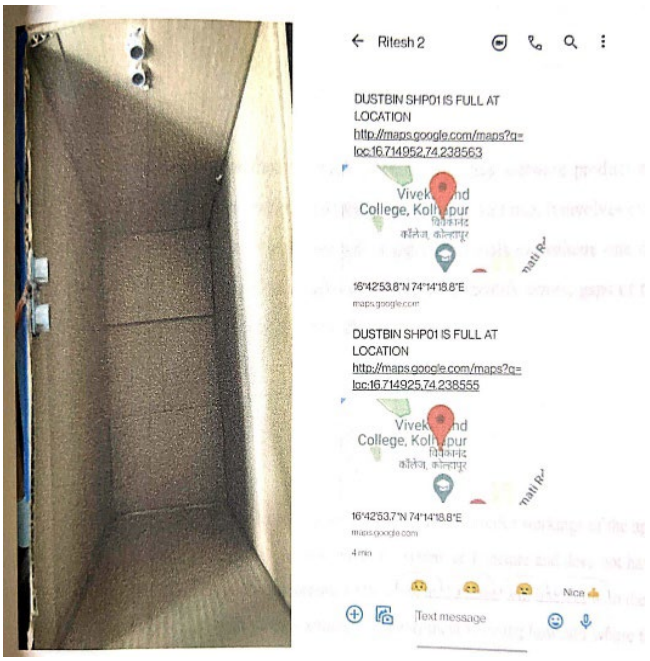

Fig.3Smart waste management system result.

Asshown in Fig .3 , we can see the connection of the sensors to the dustbin , and the image of screenshot which is the SMS notification received by the truck driver / intended reciver. The SMS contains crucial details, including the unique identification (ID) of the dustbin as per its area code and a GPS link providing the precise location of the bin. This information equips the truck driver with the necessary data to navigate efficiently to the designated bin.The Smart Waste Management System operates through a streamlined process, beginning with the ultrasonic sensors detecting garbage levels within the bins. This data is then swiftly processed by the Arduino Uno board, which serves as the central control unit for the system. The Arduino Uno coordinates the interaction between various components, such as the GSM 900A module and the GPS NEO-6M module.

The GSM 900A module plays a crucial role in generating and transmitting SMS alerts, containing essential information such as bin ID and GPS coordinates. Simultaneously, the Arduino Uno communicates with the GPS NEO-6M module to obtain precise location data, ensuring accurate information for the SMS alerts. Once generated, the SMS alerts are sent to designated recipients, such as truck drivers, who receive real-time notifications regarding the garbage levels in the bins. Armed with this information, truck drivers can efficiently navigate to the specified bin locations for prompt garbage collection, contributing to a more effective waste management system.

VI. CONCLUSION

From this project, we conclude that there is a critical need for the implementation of this system, especially in our country, as the waste management process lacks proper coordination. This project is not just a conceptual idea; instead, we have successfully implemented and executed it. The advancements made in this project pave the way for future improvements and innovations in the field of Smart Waste Management.

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