SMART MONITORING WASTE MANAGEMENT THROUGH IOT - ENABLE MOBILE APPLICATION

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Abstract - *The rapid growth of urban populations worldwide has led to an escalating challenge in managing municipal waste effectively, posing environmental, health, and economic concerns. In response to this issue, the integration of Internet of Things (IoT) technology has emerged as a promising solution. This paper presents an IoT-based waste management system designed to enhance the efficiency, sustainability, and overall effectiveness of waste collection and disposal processes in urban areas. The proposed system leverages a network of smart waste bins equipped with various sensors, including ultrasonic sensors for waste level detection, GPS modules for accurate bin location tracking, and monitoring. These sensors enable real-time data acquisition, which is then transmitted to a central cloud-based platform. The platform employs data analytics and machine learning algorithms to optimize waste collection routes, predict fill levels, and schedule collection activities dynamically. Furthermore, the system integrates a user-friendly mobile application to access real-time information about nearby waste bins' fill levels and collection schedules. This encourages active citizen participation by promoting responsible waste disposal practices and reducing overflow instances. Municipal authorities benefit from reduced operational costs through optimized collection routes, minimized fuel consumption, and improved resource allocation. The IoT-based waste management system showcased in this paper represents a significant step toward creating smarter and more sustainable cities. By harnessing the power of IoT, data analytics, and user engagement, the system offers a comprehensive solution to the pressing challenges of urban waste management. As cities strive for enhanced sustainability and improved quality of life for their residents, the implementation of such innovative technologies becomes imperative.*

***Key Words*: IoT, Smart Bins, Firebase, Waste Management, Mobile Application, Sustainability, Urban Environment, Sensor Technology.**

1.INTRODUCTION

India's rapid urbanization has resulted in a significant increase in municipal waste generation, straining existing waste management systems. Traditional waste collection methods often struggle to cope with the escalating volume of waste, leading to environmental degradation and health concerns. To tackle these issues, the integration of Internet of Things (IoT) technology holds great promise. This overview explores how an IoT-based waste management system can be tailored to the Indian context to optimize waste collection, promote sustainability, and contribute to cleaner and smarter Indian cities Smart waste systems are mandatory to reduce the impacts of garbage on general well-being. Smart Waste Bins: At the core of the system are smart waste bins equipped with sensors.

1.1 Motivation

The motivation behind our project to create an IoT-based waste management system is to make our cities cleaner, healthier, and more sustainable. As more people live in cities, the amount of garbage produced is increasing, causing pollution and health problems. This saves money, reduces pollution, and makes sure bins do not overflow. Ultimately, our project aims to improve the quality of life in our cities while also protecting the environment for future generations.

1.2 Problem Definition

India's cities are struggling with increasing garbage, leading to pollution and costs. We aim to use smart bins and tech to handle waste smarter, save money, and educate people about proper disposal. The goal is to make Indian cities cleaner, greener, and more effective.

2. Literature survey

The Internet of Things (IoT) is intricately linked to innovation, presenting a clever extension of the Internet wherein various objects in our surroundings connect to exchange and organize data. However, there is a limited emphasis on citizen engagement in this context. With the escalating global population, the issue of solid waste has become a worldwide concern in both urban and rural areas. Effective waste management strategies are essential, requiring appropriate decisions to address the mounting garbage generated from residential, commercial, and industrial sources. Yet, there is limited discussion on scalability and cost in the existing literature [1]. The concept of a smart city revolves around integrating Information and Communication Technology (ICT) and the Internet of Things (IoT) to efficiently manage a city's assets, including local in our daily lives. Developed countries employ various departments, information systems, libraries, schools, hospitals, and transportation systems. Unfortunately, there is minimal consideration given to the environmental impact of implementing such smart city initiatives [2]. The current state of the environment is threatened by the increasing accumulation of global waste, posing catastrophic consequences for human life and surroundings. Projections from the World Bank indicate a potential 70% growth in global waste by 2050 unless immediate measures for monitoring and control are implemented [3]. Additionally, the rising global population and urbanization are anticipated to result in a global waste volume of 3.4 billion tons within the next three decades. Despite these alarming statistics, there is a lack of focus on the environmental aspects in the existing literature. The surge in waste production from industries and households, fueled by the widespread use of packaged items, textiles, paper, food, plastics, metals, and glass, underscores the critical importance of waste management efficient techniques for waste management, but the literature predominantly emphasizes technology, neglecting social aspects of waste management.

3. System Architecture

The system is developed for smart and urban cities. The IoT structure of the waste collection system based on the cloud, including the cloud service provider to store the information. The central server deals with the volume of the accumulation information such as the number of waste loads. This information is accessible through secure network portals. This smart system consists of various components including the central server for the information regarding the waste location, the Arduino connected to sensors which consist of a precise control device for garbage collection system implementation, and the Android application. Description of the design Components: The main components of the design can be divided into three units. The use of IoT is seen where ESP32 is connected to the ultrasonic sensor to collect data from the waste bin and to send data back to the cloud.

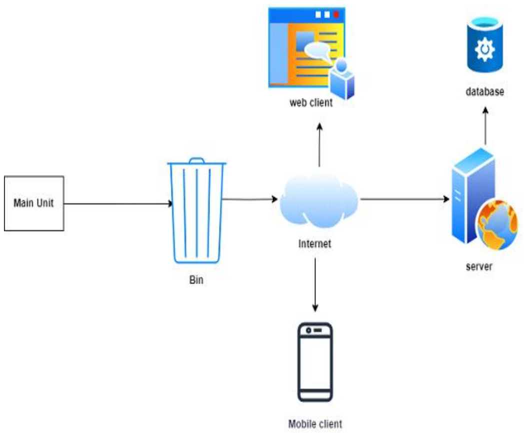

Fig -1: System Architecture for WMS

3.1 Proposed System

The connection between the hardware components of the proposed system. The ESP32 is connected to the ultrasonic sensor and sends a 40 kHz ultrasonic wave. The period it takes to hit the body and return to the sensor is important for the distance's measurement in ESP32. The EPS32 sends the received data to the Internet database and is received through the mobile application. The hardware connection of the other bins is demonstrated. The ESP32 is used to achieve the processing process, the Ultrasonic Sensor to determine the remaining distance of the device volume, and ESP32 to transmit data. The GND is connected by ESP32, and two VCC and GND are connected to 5V. Each Arduino pin will be connected by an Echo and a trigonometric. The function AS of each pin is responsible for receiving and sending the signals. The RX and TX functions are connected to the Arduino through the EPS32 and operate only at 3.3V for each of the eight pins. For Wi-Fi enabled, the CH-PD and VCC are connected at the same voltage as ESP32.

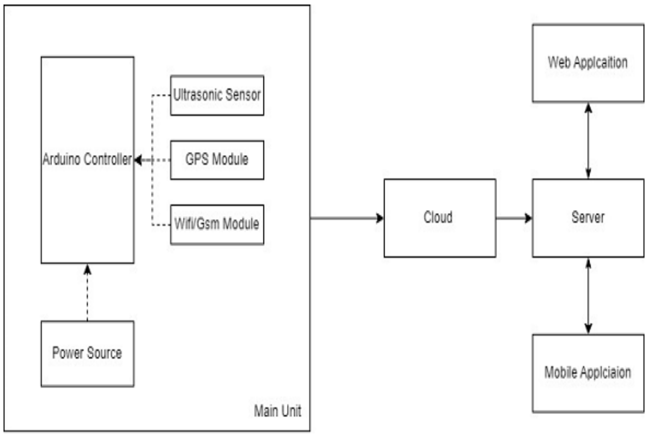

Fig -2: Proposed System for WMS

3.2 System Flow

The Process Starts with Following Steps:

Step 1: - Data Collection by IoT Device: The IoT device installed in waste bins measures the fill level using an ultrasonic sensor and retrieves the GPS coordinates using a GPS module. It sends this data along with the bin ID to the server via a SIM module.

Step 2: - Data Transmission to Firebase Server: The IoT device establishes a connection to the internet and sends the collected data to the Firebase server.

Step 3: - Data Storage in Firebase Database: The Firebase server receives the data and stores it in the database, associating each entry with the corresponding bin ID.

Step 4: - waste picker Interaction via Mobile App: waste picker accesses the mobile app where they can log in, register, or view their profile. They can also view the map screen displaying the locations of waste bins and their fill levels.

Step 5: - Displaying Bin Status on Mobile App: The mobile app retrieves bin data from the Firebase database and displays it on the map interface. waste picker can see which bins are full and need attention.

Step 6: - Routing Calculation for Waste Pickers: When waste pickers access the mobile app, they can view the bins' status and request the shortest route. The app calculates the optimal route based on the location and fill level of bins using a google map (API) routing algorithm.

Step 7: - Alerts for Waste Pickers: Waste pickers receive alerts or notifications through the mobile app about bins that are almost full or require immediate attention.

Step 8: - Waste Collection: Waste pickers follow the route provided by the app, collecting waste from bins efficiently.

Step 9: - Update Data in Firebase Server: After waste collection, the IoT devices may update the fill level of bins in real-time, reflecting the changes in the Firebase database.

Step 10: - Continuous Monitoring and Maintenance: The system is continuously monitored for any issues or anomalies. Regular maintenance and updates are performed to ensure the system operates smoothly and efficiently.

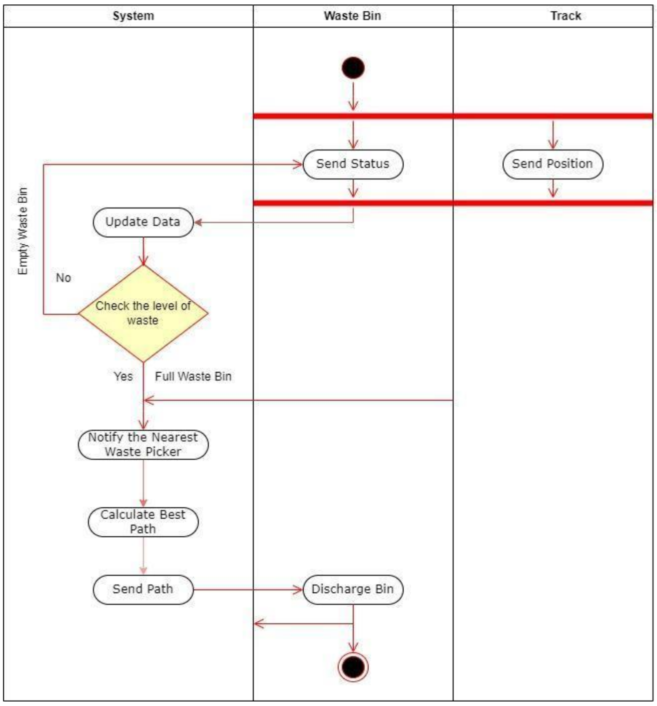

Fig -3: Activity Diagram for WMS

4. Results

The prototype has been created by connecting all the components i.e. the ESP32, Ultrasonic Sensor, GPS together. The ESP32 microcontroller efficiently manages the communication between the ultrasonic sensor and GPS module. The ultrasonic sensor accurately measured the waste levels in the Dustbin, providing valuable data for waste management. The GPS module contributed to location tracking, allowing for a comprehensive waste management system that can monitor waste levels at specific geographical locations.

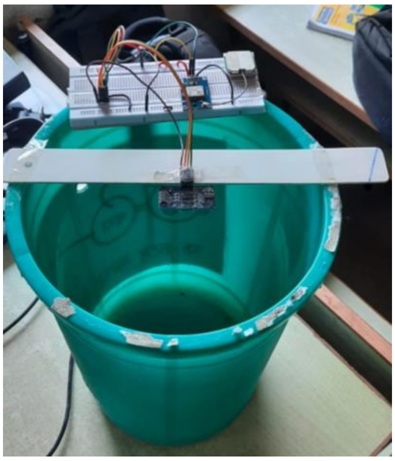

Fig -4: Hardware Prototype for WMS

The Sign-up Screen serves as the initial interface that users encounter when they open the waste management application. Elements describe the design elements incorporated, such as the sign-up Screen is used login in existing user to the application by validating the credentials.

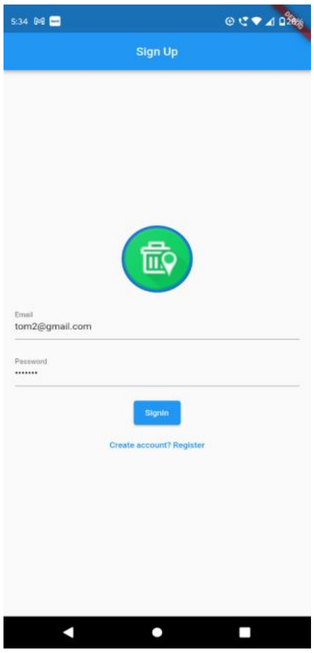

Fig -5: Sign-Up Screen for WMS

The Registration Screen enables new users to create an account for accessing the waste management system. The design elements present, such as registration fields (e.g., name, email, password), validation checks, and submission controls. The about page display user I'd and name in the text filed with a sign out button at the bottom for signing out the user.

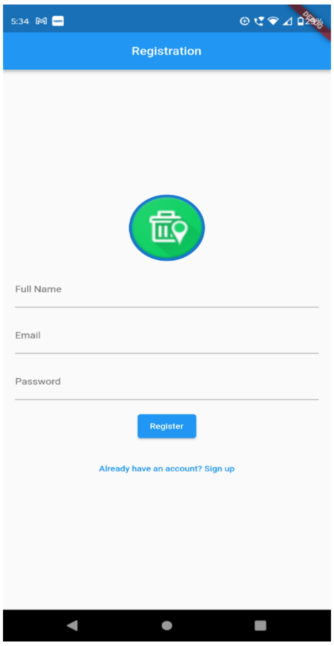

Fig -6: Registration Screen for WMS

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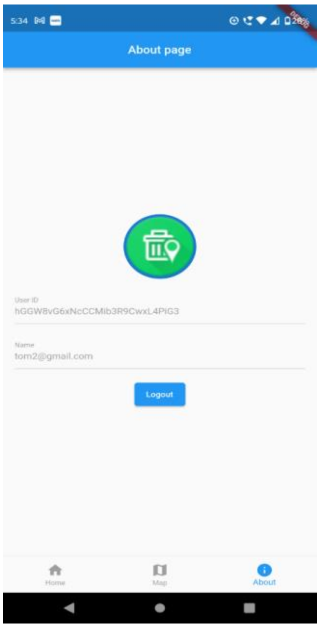

Fig -7: About Screen for WMS

The home page contains list bin bin card title each repenting a bin with unique I'd according to different bin placed in the locality.

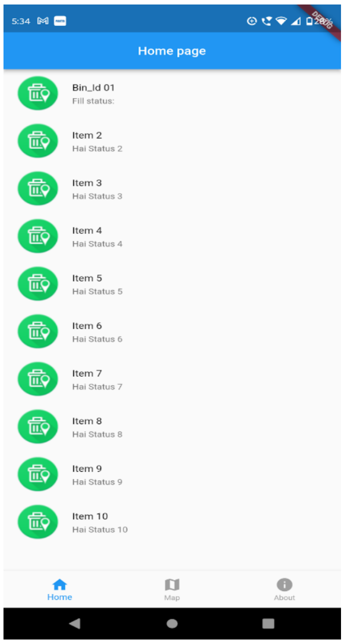

Fig -8: Home Screen for WMS

The single bin page detail view of list tile with bin I'd 101 with display battery status and fill level of the bin to the user real time and a map button to navigate to the map screen.

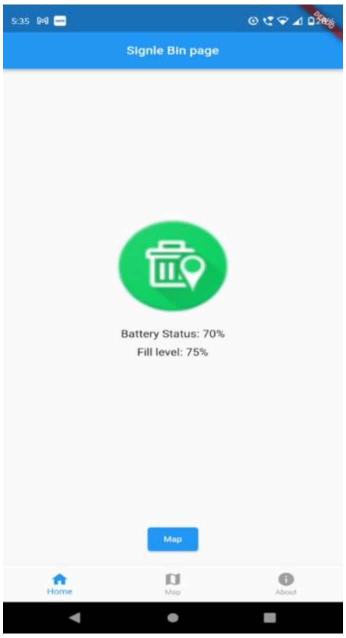

Fig -9: Single Bin Screen for WMS

The map screen contains the overall location of the bin marked with a marker to identify the location where the bin in installed and a direction navigation buttons at the bottom right side.

After clicking the navigation buttons the user in redirect to the map application which help the user to find the shorted path /route form the current user location till the bin by showing life traffic status to the driver.

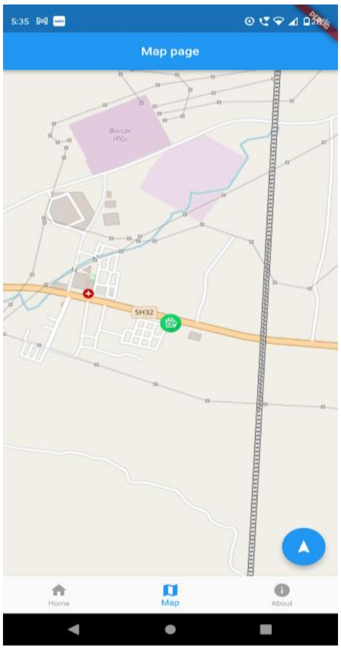

Fig -10: Map Screen for WMS

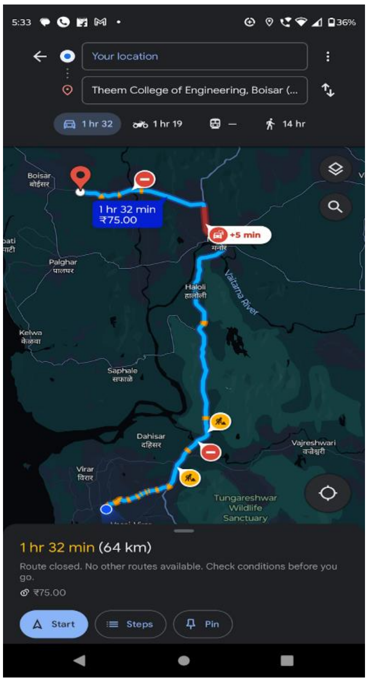

Fig -11: Navigation Screen for WMS

RTDB Server: It is used for sorting the data received via the bin module installed in a dustbin in Realtime via cloud functionality. Overall, the RTDB server serves as the backbone of our smart waste management system, enabling data-driven decision-making, optimizing operational workflows, and enhancing the overall efficiency of waste collection processes.

Authentication Server DB: It the auth service provided by firebase to save n authenticated every user sign in or register to the application help in managing user credentials.

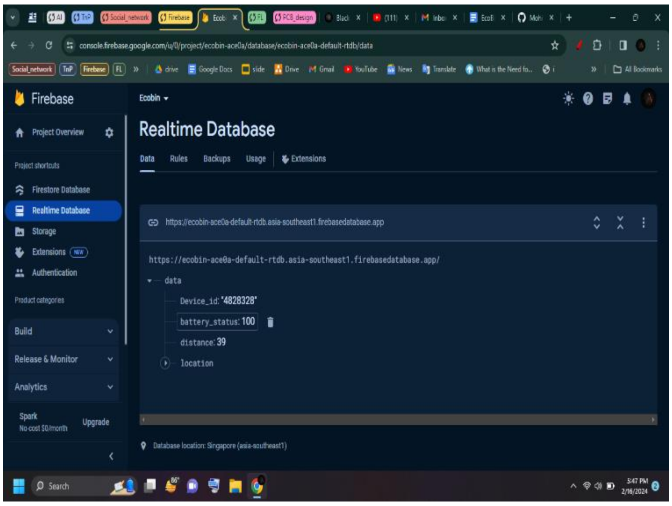

Fig -12: RTDB for WMS

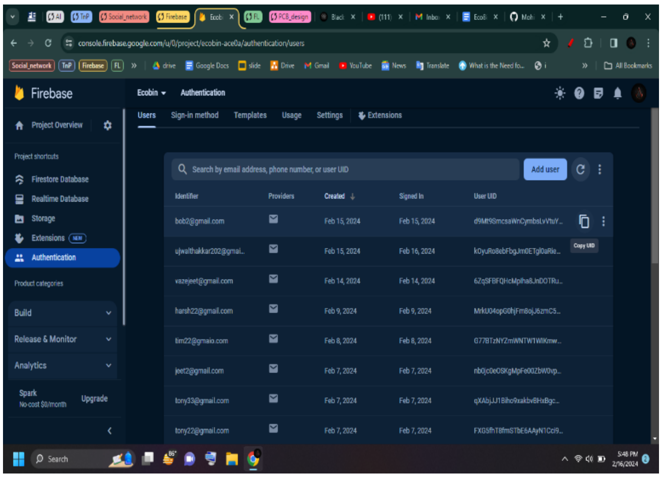

Fig -13: Authentication for WMS

5. CONCLUSIONS

We presented an intelligent waste Management system. The IoT-based smart bin system specifically tailored for waste collectors, seamlessly integrated with a mobile application. By harnessing ESP32 hardware, ultrasonic sensors, GPS modules, and Firebase integration, the system has demonstrated exceptional efficacy in waste collection optimization, real-time monitoring, and cost-effectiveness. This review underscores the critical role of IoT solutions in addressing the mounting challenges accompanying urbanization and increased waste generation. This research significantly advances waste management practices by amalgamating IoT technology, Firebase communication, and mobile application integration. Notably, the proposed system is meticulously designed to cater exclusively to waste collectors, streamlining their operations and enhancing efficiency. By focusing solely on waste collector needs, the system offers tailored functionalities to optimize routes, improve resource allocation, and minimize operational costs.

Our specialized approach underscores the paper's contribution to advancing waste management practices while emphasizing the importance of customized solutions in addressing industry-specific requirements

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