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Bin2Win: Incentive-Based Intelligent Dustbin System

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Abstract: Improper waste disposal and lack of public motivation remain major challenges in maintaining urban cleanliness. This paper presents an IoT-based Smart Dustbin with a Reward System that encourages people to dispose of waste properly by giving digital reward points. The system uses sensors and an ESP32 to detect waste, monitor bin level, and send real-time data to the cloud. It also prevents misuse and helps authorities track waste collection efficiently. The system demonstrates scalability, low cost, and suitability for smart city applications. This system combines IoT and automation to improve waste management and encourage people to keep surroundings clean. The system helps improve cleanliness and supports smart waste management in public areas.

Keywords: RFID, IoT, Reward System, Smart City, Arduino, ESP32, Sensors, Cloud Monitoring, Sustainable Waste Management.

I. INTRODUCTION

Improper waste disposal and lack of public participation are major challenges faced by modern cities. Rapid urbanization and increasing population have resulted in a significant rise in daily waste generation. Traditional waste management systems rely heavily on manual monitoring and scheduled collection, which often leads to overflowing bins, unhygienic surroundings, and inefficient resource utilization. Therefore, there is a growing need for smart and automated waste management solutions that can improve efficiency and encourage people to dispose of waste properly

In recent years, the Internet of Things (IoT) has emerged as a powerful technology for developing smart city solutions. IoT helps in monitoring, automation, and easy system control. Smart bins equipped with sensors and cloud connectivity can provide live information about bin status, reduce manual effort, and optimize waste collection routes. However, most existing smart bin systems focus only on monitoring and do not address the key issue of public motivation to dispose of waste properly.

To solve this problem, this paper proposes an IoT-based Smart Dustbin with a Reward System that encourages users to disposal of waste responsibly by providing digital reward points. The system uses sensors and an ESP32 controller to detect waste usage, monitor bin level, and send real-time data to the cloud. RFID authentication sensors users, preventing misuse. This approach combines automation, cloud monitoring, and incentive-based engagement to promote cleanliness and sustainable waste management.

The proposed system in low-cost, scalable, and suitable for smart city applications such as public places, campuses, malls, and railway stations. By integrating technology with human motivation, the system aims to create a cleaner, healthier, and more sustainable environment.

The objectives of this project are:

1. To study existing smart waste management and IOT-based monitoring systems.
2. To analyze the limitations of current system lacking user motivation.
3. To design an automated smart dustbin using sensors and ESP32.
4. To implement RFID-based authentication for user identification.
5. To develop a reward mechanism to encourage proper waste disposal.
6. To enable real-time cloud monitoring for smart city applications

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II. RELATED WORK

Previous research on Smart Bin Monitoring Systems used ultrasonic sensors and GSM modules to notify authorities when bins are full. These systems successfully reduced manual inspection and improved collection efficiency. However, they mainly focused on monitoring and lacked user interaction or engagement [1].

Some researchers proposed Waste Segregation Systems that use moisture sensors, metal detectors, and image processing techniques to automatically classify waste into wet, dry, and metal categories. These systems improved recycling efficiency and reduced manual sorting. However, most of these solutions were limited to segregation and did not include real-time cloud monitoring or user participation [2].

Other studies introduced RFID-based waste tracking systems that record user activity and monitor waste generation patterns. These systems helped in data collection and analysis but did not provide incentives to motivate people for proper waste disposal [3].

A few recent works explore smart city waste management platforms integration of IoT and cloud technologies for real time monitoring and analytics. While these systems improved operational efficiency, they still lacked a reward-based approach to encourage public involvement [4].

The proposed system helps overcome these limitations by combing IoT monitoring, waste detection, RFID authentication, and a reward mechanism in a single integrated solution. This helps improve waste disposal and encourage public participation in cleanliness [5].

III. PROPOSED SYSTEM

A. OVERVIEW OF SYSTEM

The proposed system is an Iot-based Smart Dustbin with Reward Mechanism designed to promote proper waste disposal and improper waste management efficiency. The system integrates sensors, RFID authentication, and cloud connectivity to create an automated and smart and easy waste disposal system.
After the waste is dropped, multiple sensors analyze the type and quantity of waste. A moisture sensor distinguishes between wet and dry waste, an inductive proximity sensor detects metal waste, and a load cell with HX711 module measures the weight of the disposed garbage. A stepper motor then rotates the internal compartment to direct the waste into the correct section. A buzzer provides feedback to indicate successful disposal and system operation.

The ESP32 microcontroller processes all sensor data and sends it to the cloud for real-time monitoring and data storage. Based on the weight and frequency of waste disposal, reward points are automatically credited to the user. This system uses automation and IoT technology to improve waste management.

Unlike traditional smart bins that only focus on monitoring, the proposed system introduces a reward-based approach to encourage public participation. Users receive reward points for proper waste disposal, making the process more engaging and motivating.

B. SYSTEM ARCHITECTURE

System Architecture The system architecture of the Smart Reward-Based Waste Segregation System is divided into four main layers: Input Layers, Processing Layer, Segregation Layer, and Cloud & Reward Layer. These layers work together to automate waste identification, segregation, and reward generation.

The overall architecture of the system includes following components:

- Upper Lid Servo
- Lower Lid Servo
- IR Sensor
- Ultrasonic Sensor
- Proximity Sensor
- Water Sensor
- I2C LCD Display
- Arduino Nano
- ESP32
- RFID Reader

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- Stepper Motor Driver
- 5V 5A SMPAS SYSTEM2

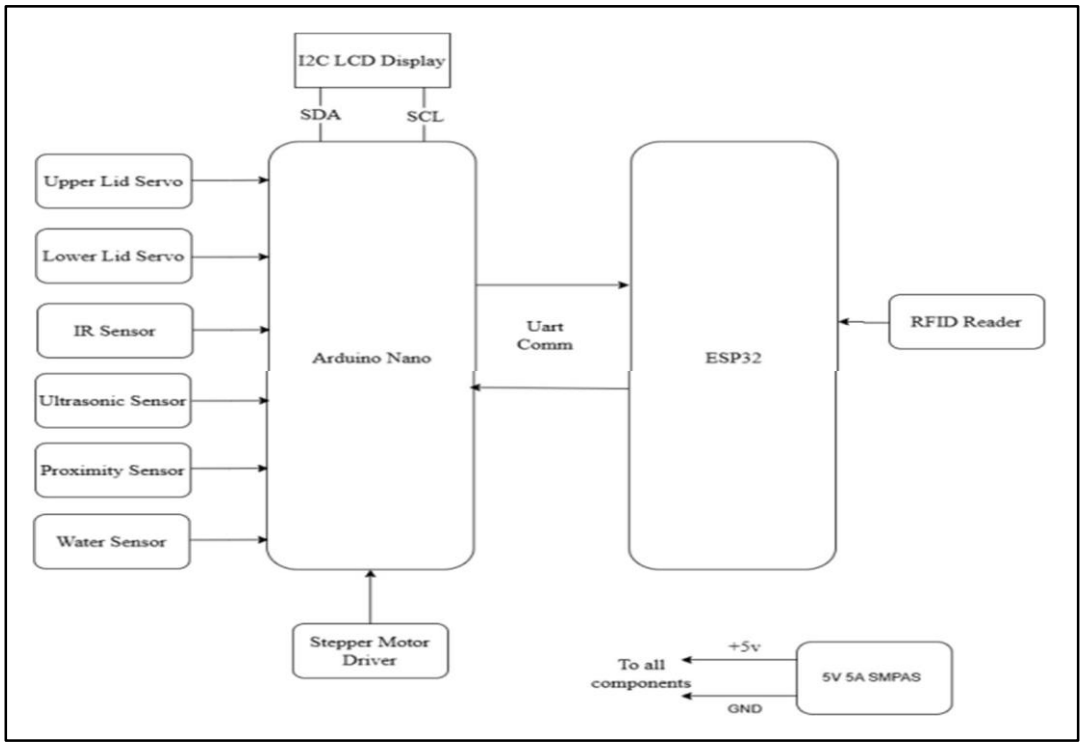

Fig.1 Block Diagram of Proposed Model

C. WORKING PRINCIPLE

The proposed system operates through a dual-controller architecture using an ESP32 and Arduino Nano to enable user authentication, waste classification, reward allocation, and real-time cloud monitoring. Initially, the user is authenticated using an RFID reader connected to the ESP32. Upon successful verification, the ESP32 transmits the user ID to the Arduino Nano via UART communication. The upper lid of the smart bin opens for a fixed duration, allowing the user to dispose of waste.

After disposal, multiple sensors including IR, moisture, and inductive proximity sensors analyze the waste to determine whether it belongs to dry, wet, or metal categories. Based on the detected waste type, a stepper-motor-driven rotating mechanism aligns the appropriate compartment. The lower lid then opens to transfer the waste into the corresponding bin, ensuring automatic segregation.

Users receive rewards points after proper waste disposal. Waste levels and user points are displayed locally and transmitted to the ESP32, which uploads the data to the Blynk IoT cloud for real-time monitoring through a mobile application. When any bin reaches full capacity, the system announces the user with the highest points and resets for the next cycle after manual emptying.

Overall, the proposed system successfully integrates IoT, automation, and reward-based motivation to promote responsible waste disposal. By combining user authentication, automatic waste segregation, real-time monitoring, and a points-based reward mechanism, the system not only improves waste management efficiency but also encourages active public participation. The project is simple, affordable, and suitable for smart city use.

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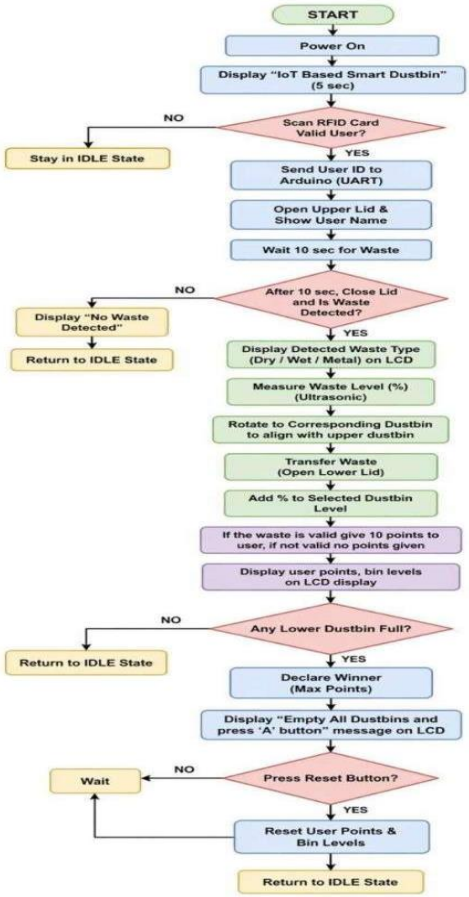

Fig.2 Flow Chart

IV. HARDWARE SETUP

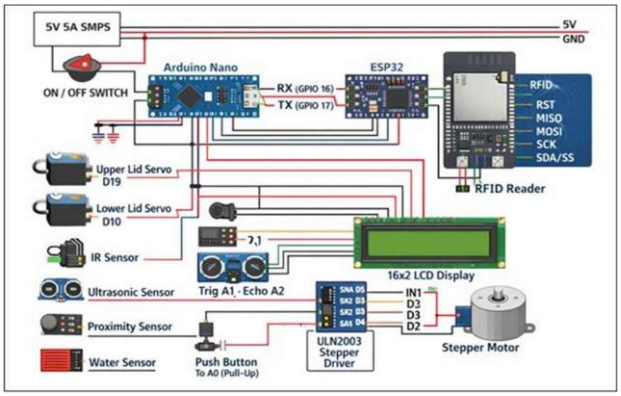

Fig. 3 Circuit Diagram

3.1 IR Sensor

The IR sensor is used to detect a person or waste item near the dustbin. When an object is detected, the lid opens automatically, making the dustbin easy to use without touching it.

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3.2 Proximity Sensor

The proximity sensor is used to identify metal waste. When a metal object is detected, the system automatically separates it and directs it to the metal waste compartment.

3.3 Water detection Sensor

The moisture sensor is used to detect wet waste by measuring the amount of moisture present in the material. Based on the moisture level, the system identifies whether the waste is wet or not.

3.4 Ultrasonic sensor

The ultrasonic sensor is used to monitor the garbage level inside the dustbin. It measures the distance between the waste and the sensor to determine whether the bin is full or has available space.

3.5 Servo Motor

Servo motors are used to automatically open and close the upper and lower lids of the dustbin. They provide precise movement, ensuring smooth and efficient operation of the system.

3.6 Stepper Motor with ULN2003 Driver

The stepper motor rotates the internal mechanism to direct the waste into the appropriate compartment. The ULN2003 driver is used to control the motor and ensure its proper operation.

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3.7 Arduino Nano

The Arduino Nano acts as the main controller of the system. It processes data from the sensors, controls the motors, and manages the overall operation of the smart dustbin.

3.8 ESP32

The ESP32 plays an important role in providing RFID and IoT functionality to the system. It sends the collected data to the cloud, making it possible to monitor the dustbin and its status remotely.

3.9 Tactile Push Button

The push button is provided for manual operation and system testing. It allows the user to control specific functions of the dustbin whenever required.

3.10 16×2 LCD with I2C Module

The LCD display provides information such as user details, the type of waste detected, and the reward points earned. The I2C module is used to connect the display efficiently, helping to minimize the number of wires needed in the system

V. SOFTWARE SETUP

1. Arduino IDE

- The program for the smart dustbin system was developed using the Arduino IDE environment.
- Embedded C/C++ was used to write and upload the code to the controller.
- The required ESP32 board packages and supporting libraries were installed in the Arduino IDE before programming.

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- Libraries for the RFID module, ultrasonic sensor, servo motors, and LCD display were included to ensure proper system operation.
- The Serial Monitor was used during implementation to observe sensor readings, verify communication between components, and monitor the overall system performance.

2. Dashboard Setup

- The Blynk IoT platform was used to enable remote monitoring of the smart dustbin system.
- The ESP32 was connected to the Blynk cloud through Wi-Fi communication.
- The Wi-Fi credentials and authentication token were configured to establish a secure connection with the dashboard.
- The dashboard displayed real-time information, including the dustbin level, sensor status, and user reward points.
- The mobile dashboard allowed users to monitor the system conveniently and access its status from any location.

VI. RESULT AND ANALYSIS

5.1 Implementation result

Initial condition of the smart dustbin showing zero waste level on the LCD display and Blynk IoT platform, indicating that the bin is empty and ready for use.

Fig 5.1 Initial Condition on LCD

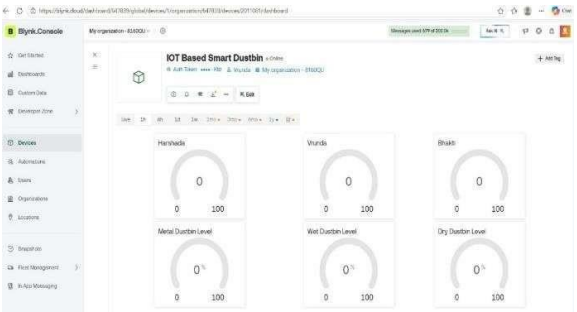

Fig. 5.1.1 Initial Condition on Dashboard

5.2 RFID-Based User Authentication

The LCD display shows user identification after successful RFID authentication. The user “Bhakti” is recognized, and access is granted to operate the smart dustbin.

Fig 5.2 User Access the Bin

5.3 Metal Waste Detection and Classification

The LCD display shows the initial detection and classification of metal waste disposed by the user. It indicates that the system has identified the waste type correctly.

Fig 5.3: Waste Type Detection

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5.4 Metal Waste Level Monitoring

The LCD display shows the current percentage level of metal waste present in the dustbin before disposal by the user. It indicates how much metal waste has already been collected in the system.

Fig 5.5: Waste Level Monitoring

5.5 Reward Point Display

The LCD display shows the reward points earned by the user after successfully disposing of metal waste. It reflects the points added to the user's account for proper waste disposal.

Fig 5.5: Reward Point Display

5.6 IoT Monitoring Dashboard

The Blynk IoT dashboard displays the metal waste level as 5% along with the reward points earned (10 points) by the user "Bhakti" after successful waste disposal.

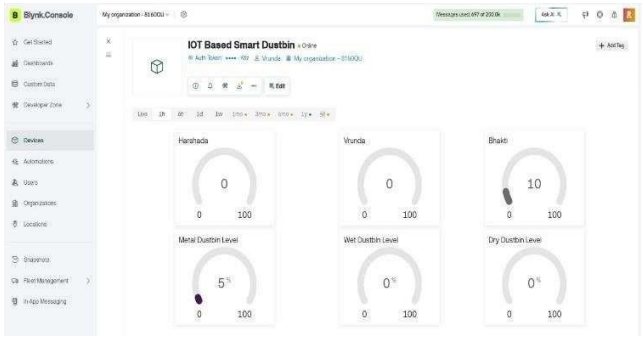

Fig 5.6: Final Dashboard

VII. ADVANTAGES OF THE SYSTEM

Helps maintain cleanliness and encourages proper waste disposal by users.
RFID authentication ensures that only authorized users can access the system.
Automatic lid operation improves hygiene by minimizing direct contact with the dustbin.
Reduces the time and efforts required for manual waste segregation.
Promotes responsible waste disposable through the reward-based system.
Provides a contactless waste disposal process, helping to maintain better hygiene.

VIII. CONCLUSION

The proposed RFID-enabled IoT Smart Dustbin system offers a simple and effective solution for waste management. It uses automatic lid operation, RFID authentication, and IoT monitoring to improve the waste disposal process and reduce manual effort.

The reward system motivates users to dispose of waste properly, while the Blynk IoT platform enables real-time monitoring of the dustbin status. The developed system is simple, cost-effective, and suitable for implementation in colleges, offices, and public places.

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