Hackathon Project Report: Smart Dustbin IoT System

Track: Internet of Things (IoT) & Hardware

Team ID: [Your Team ID]

Team Members:

- [Your Name]
- [Team Member 2 (if any)]

Repository Link: [Your GitHub Repository]

Demo Link: [Video/Live Demo Link]

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1. Project Abstract

The Smart Dustbin is an IoT-enabled waste management system that automatically monitors garbage fill levels using an ultrasonic sensor and provides real-time notifications via the Blynk IoT platform. The system includes a servo motor for touchless lid operation via IR sensor detection, allowing hygienic and automated waste disposal. Data is displayed on a mobile app showing dustbin fill percentage and status (Empty/Half Filled/Full), enabling efficient waste collection management and reducing manual monitoring efforts.

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2. Problem Statement

Traditional waste management systems lack real-time monitoring capabilities, leading to:

- Overflowing dustbins causing hygiene and environmental issues
- Inefficient collection schedules with manual inspections
- Lack of touchless operation contributing to hygiene concerns
- No data on waste accumulation patterns for optimized collection routes

The Smart Dustbin addresses these challenges by providing automated fill-level monitoring, remote notifications, and touchless operation for modern smart city waste management.

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3. Solution Overview

The Smart Dustbin system comprises:

Physical Device:

- ESP32 microcontroller as the central processing unit
- HC-SR04 ultrasonic sensor for accurate distance/fill-level measurement
- IR sensor for hand detection and touchless lid opening
- SG90 servo motor for automated lid operation
- Real-time WiFi connectivity to Blynk Cloud

Cloud Integration:

- Blynk IoT platform for cloud connectivity and mobile dashboard
- Virtual pins (V0, V1, V2) for data streaming
- Event-based notification system for full bin alerts
- Web and mobile app access for remote monitoring

User Interaction:

- Real-time fill-level percentage on mobile app (0-100%)
- Status display (Empty, Half Filled, Full)
- Push notifications when bin reaches full capacity
- IP address display for network diagnostics
- Automatic servo lid operation triggered by IR sensor

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4. Hardware & Technical Stack

4.1 Components List

Microcontroller:

- ESP32 Dev Module (240MHz, dual-core, built-in WiFi)

Sensors:

- HC-SR04 Ultrasonic Sensor (distance measurement, range: 2-400 cm)

- IR Motion Sensor (touchless hand detection)

Actuators:

- SG90 Servo Motor (180° rotation for lid control)

Other Components:

- Breadboard and jumper wires
- USB cable for programming and power (5V/3A recommended)
- Optional: External power supply for servo and sensors

4.2 Communication Protocols

- **WiFi (802.11 b/g/n):** ESP32 to Blynk Cloud connectivity
- **UART (9600 baud):** Serial communication for debugging via USB
- **PWM (Pulse Width Modulation):** Servo motor control via GPIO 23
- **Digital I/O:** IR sensor input and ultrasonic trigger/echo pins

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5. Circuit/Architecture Diagram

Pin Configuration:

Component	ESP32 Pin	Function
Ultrasonic Trigger	GPIO 5	Ultrasonic pulse trigger
Ultrasonic Echo	GPIO 19	Echo signal capture
IR Sensor	GPIO 21	Hand detection input
Servo Motor Signal	GPIO 23	PWM control signal
Power (VCC)	5V	Common power rail
Ground (GND)	GND	Common ground rail

Architecture Flow:

- Ultrasonic sensor continuously measures distance → ESP32 calculates fill percentage
- IR sensor detects hand → Servo opens lid (90°)
- No hand detection → Servo closes lid (0°)
- Fill level sent to Blynk via Virtual Pin V0 (percentage)
- Status text sent to Blynk via Virtual Pin V1 (Empty/Half/Full)
- When fill > 70%, notification sent to user smartphone

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6. Prototype & Implementation

Physical Build

The prototype is constructed on a breadboard setup with the following layout:

- **Breadboard Assembly:** All components mounted on a solderless breadboard with common VCC and GND power rails
- **Sensor Placement:**
  - Ultrasonic sensor positioned at dustbin lid for accurate distance measurement
  - IR sensor mounted near lid opening for hand detection
- **Servo Mounting:** SG90 servo attached with mechanical linkage to dustbin lid for smooth operation
- **Wiring:** Organized with color-coded jumper wires (red for VCC, black for GND, others for signal lines)

Software Implementation

Arduino IDE Setup:

- Board: ESP32 Dev Module
- Baud Rate: 921600 (upload), 9600 (serial monitor)
- Libraries: BlynkSimpleEsp32.h, ESP32Servo.h, WiFi.h

Key Code Functions:

- `setup()` : Initialize pins, WiFi/Blynk connection, servo, and timer
- `loop()` : Run Blynk client, timer, and IR-based servo control
- `sendSensor()` : Measure ultrasonic distance, calculate fill %, determine status, send to Blynk

- Notification logic: `Blynk.logEvent("dustbin_full", "...")` when fill level ≤ 30%

Blynk IoT Dashboard:

- Gauge Widget (V0): Display dustbin fill percentage (0-100%)
- Label Widget (V1): Show bin status text (Empty/Half Filled/Full)
- Label Widget (V2): Display ESP32 IP address

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7. Challenges & Solutions

Challenge	Solution
Sensor Inaccuracy	Calibrated maxDistance (30 cm) and minDistance (5 cm) based on actual dustbin dimensions; added error handling for zero readings
Repeated Notifications	Implemented `notifiedFull` flag to send notification only once when bin reaches full state
WiFi Connectivity Issues	Added WiFi connection wait loop with timeout; Serial debugging for troubleshooting
Servo Jitter	Used PWM stable pins (GPIO 23) and debouncing in IR sensor reading logic
Pin Definition Compatibility	Replaced NodeMCU-style (D5, D19) with direct GPIO numbers for ESP32 compatibility
Blynk Event Setup	Initially Events tab not found; resolved by accessing web dashboard (blynk.cloud) instead of mobile app

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8. Scalability & Commercial Viability

Cost Analysis

Per Unit Cost Estimate:

- ESP32 Dev Module: ₹400-500
- HC-SR04 Ultrasonic Sensor: ₹100-150
- IR Motion Sensor: ₹50-80
- SG90 Servo Motor: ₹150-200
- Breadboard, Jumper Wires, USB Cable: ₹100-150
- **Total: ₹800-1,080 (~$10-13 USD)**

Manufacturing Feasibility

Scalability Advantages:

- Low component cost makes mass production viable
- Standard off-the-shelf components available globally
- Modular design allows customization for different bin sizes
- Blynk IoT platform supports unlimited device scaling on cloud

Commercial Implementation:

- Integration with municipal waste management systems for city-wide monitoring
- Data analytics for optimized collection routes and schedules
- Integration with smart city platforms for waste segregation tracking
- Expansion to multiple bin types (regular, recyclable, organic)
- Potential revenue through IoT subscription for real-time monitoring features

Market Potential:

- Growing smart city initiatives worldwide
- Increasing focus on hygiene and touchless technology post-COVID
- Cost-effective solution for waste management optimization
- Estimated addressable market: Smart city waste management (projected $5.2B by 2030)

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9. Conclusion

The Smart Dustbin IoT system successfully demonstrates an efficient, cost-effective, and scalable solution for automated waste management. By integrating affordable sensors, cloud connectivity, and mobile app interface, the project provides real-time monitoring, touchless operation, and remote notifications—addressing key challenges in modern waste management. With minimal per-unit cost and high commercial viability, this solution is well-positioned for deployment in smart cities

and municipal waste collection systems.

10. Future Enhancements

- GPS integration for route optimization of collection vehicles
- Machine learning for predictive collection scheduling
- Multiple bin monitoring with centralized dashboard
- Odor sensor for environmental quality monitoring
- Integration with payment systems for waste segregation incentives
- Battery-powered operation with solar charging for wireless deployment