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Smart Waste Management System Using IoT

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Abstract : Municipal solid waste collection is one of the most pressing challenges in urban environments. Traditional waste collection methods are inefficient, often resulting in overflowing bins and increased environmental hazards. This paper presents a Smart Waste Management System using IoT, where ultrasonic sensors detect waste levels and communicate with a cloud-based dashboard using NodeMCU and the ThingSpeak platform. Real-time data transmission helps municipalities plan optimized waste collection routes. The system reduces operational costs, minimizes overflow risks, and contributes to cleaner and more sustainable urban spaces. We also review similar systems in recent literature, highlighting advancements and differentiating features.

I. INTRODUCTION

Waste management involves the collection, transportation, processing, recycling, or disposal of waste materials. With the rapid growth of urban populations, managing waste efficiently is becoming increasingly difficult. Overflowing garbage bins cause hygiene problems, attract pests, and emit unpleasant odors. There is a strong need for a system that can automate waste monitoring and inform authorities in real-time.This paper proposes a smart waste management system leveraging IoT technologies, including ultrasonic sensors and Wi-Fi-enabled microcontrollers, to provide real-time bin status to a centralized dashboard. Authorities can monitor multiple bins remotely and dispatch collection vehicles efficiently.

2. Literature Review

Several research efforts have proposed IoT-based smart waste management solutions. Below is a summary of seven notable studies, comparing their key features:

Author(s)	Year	Title	Method Used	Key Outcomes
Kodwo Miezah et al.	2017	Municipal Solid Waste Characterization in Ghana	Survey and report-based analysis	84% biodegradable sorting efficiency
Sehyun Park & Sunghoi Park	2015	IoT-Based Smart Waste Management for Food	Smart bins + web service	Increased collection efficiency by 39%
P. Rajkumar Joshi	2017	Challenges of Municipal Waste Management	Policy and technical review	Emphasis on biodegradable materials
C. Jeya Bharathi	2018	IoT System for Solid Waste Management in Indian Cities	Load cell + ultrasonic sensors	Automated smart bin system for cities
Medevdev.J	2017	Waste Collection System	Load cell & ultrasonic monitoring	Enhanced municipal coordination
Navaghane M & Mahesh K	2017	Waste Collection Using IR Sensors	IR sensors + web-based monitoring	Cost and trip reduction
Vaishali P & Manoj T	2017	Smart Waste Collection Using Raspberry Pi	Raspberry Pi + web notifications	Improved bin monitoring and reduced collection cost

These works demonstrate the effectiveness of combining sensors, wireless communication, and cloud platforms to modernize waste collection systems. Our proposed method is distinguished by its simplicity, cost-effectiveness, and real-time cloud analytics via ThingSpeak.

3. Methodology

Smart bins may be affordable given the needs of today's technology, but considering the need for bins in India, expensive bins will not be the first test, so we decided to use sensors to reduce cost while increasing efficiency. in all applications. Different types of waste are generated in our homes every day.People will skip it in the trash. The trash can is sometimes full, sometimes not.Every day garbage collectors come and throw away this garbage. Since all the bins are full, the waste material will be used in the future, and not full will mean a waste of fuel, time and manpower, it is best to do it right after the bins are finished. Use them all after a day or a few days. So, to know if the container is full, we create a smart container where the container will have a sensor and the sensor will report if the container is full

3.1 System Architecture

The proposed system comprises:

- **Ultrasonic Sensor (HC-SR04)**: Measures distance from the bin lid to the waste surface.
- **NodeMCU (ESP8266)**: Microcontroller with built-in Wi-Fi that processes sensor data and uploads it to the ThingSpeak cloud.
- **ThingSpeak Platform**: Cloud IoT analytics platform for real-time monitoring and graphical display.

3.2 Working Flow

1. The ultrasonic sensor continuously checks the bin level.
2. If the bin reaches a defined threshold, NodeMCU transmits the data to ThingSpeak.
3. Municipal authorities monitor fill levels on the cloud dashboard and dispatch garbage trucks accordingly.

4. Sample Circuit Diagram

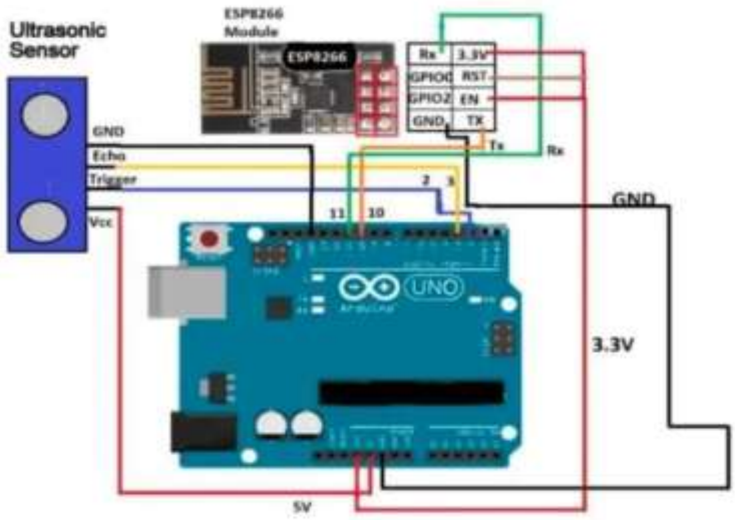
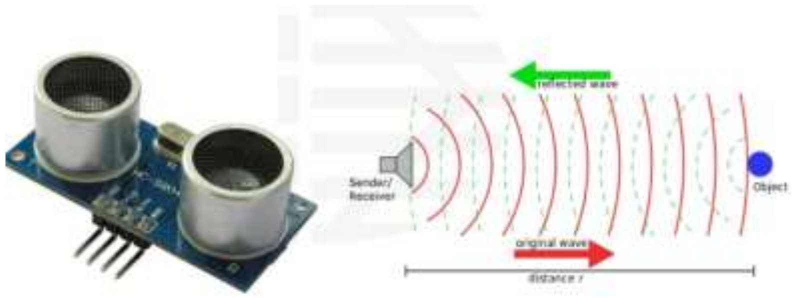


Fig 1 : Circuit Diagram



5. Sample Code

cpp

CopyEdit

```cpp
#include <ESP8266WiFi.h>
#include "ThingSpeak.h"

char ssid[] = "Your_SSID";      // WiFi SSID
char pass[] = "Your_PASSWORD";  // WiFi Password
WiFiClient client;

unsigned long myChannelNumber = 1234567;
const char * myWriteAPIKey = "XYZ123ABC";

const int trigger = D0;
const int echo = D1;
long duration;
float distance;

void setup() {
  Serial.begin(115200);
  pinMode(trigger, OUTPUT);
  pinMode(echo, INPUT);
  WiFi.begin(ssid, pass);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.print(".");
  }
  ThingSpeak.begin(client);
}

void loop() {
  digitalWrite(trigger, LOW);
  delayMicroseconds(2);
  digitalWrite(trigger, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigger, LOW);

  duration = pulseIn(echo, HIGH);
  distance = (duration * 0.034) / 2;

  Serial.print("Distance: ");
  Serial.println(distance);
```

```
  ThingSpeak.writeField(myChannelNumber, 1, distance, myWriteAPIKey);
  delay(15000); // update every 15 seconds
}
```

6. Sample Pictures

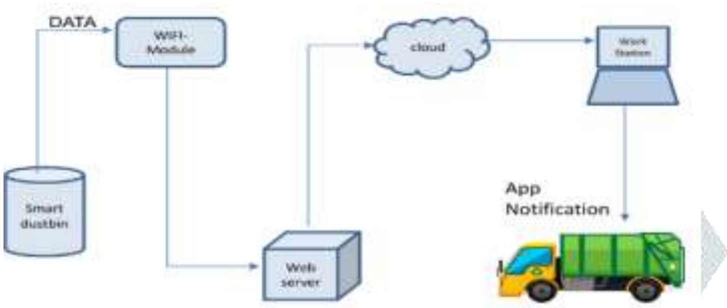


Fig 1 : Architecture Of Proposed Method

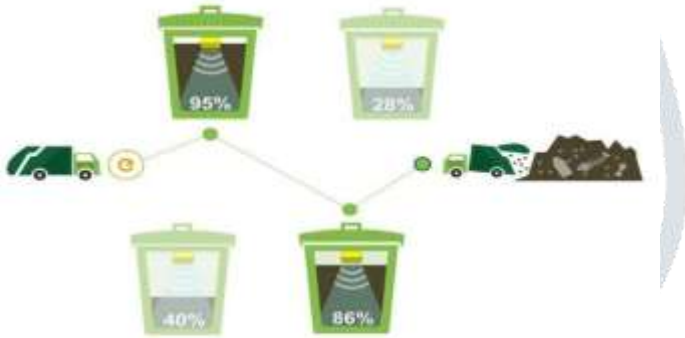


Fig 2 : Proposed method block diagram

7. Advantages & Disadvantages

Advantages

• A reduction in the number ofwastecollections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion.

• Cost reduction , Our smart waste logistics solution reduces waste collection frequency dramatically, which enables you to save on fuel, labor, and fleet maintenance costs.

• Improved cleanliness , In densely populated areas, a rapid waste generation often leads to over-flowing waste bins and unsightly streets. Our solution enables waste collection staff to read filllevels in real time and receive notifications of waste overflows.

• CO_2 reduction , Collecting garbage is a very pollutant heavy proposition. Our solution offers you the means to have less trucks on the road for less time, which means less greenhouse gas emissions, less noise pollution, and less road wear.

Disadvantages

• System requires more number of waste bins for separate waste.collections per population in the city. This results into high initial

cost due to expensive smart dustbins compare to other methods.

• Sensor nodes used in the dustbins have limited memory size.

• The training has to be provided to the people involved in the smart waste

management system.

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