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SMART INTERACTIVE DUSTBIN NETWORK

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Abstract:
In the era of industrialization, scientific and technological progress has led to greater convenience and a larger global population, but it has also resulted in increased waste production. The government has allocated significant resources to tackle this waste reduction problem as public bins are filling up quickly and overflowing before trash collection, causing unhygienic and messy streets that negatively impact health and the environment. To avoid such negative consequences, modernizing dustbins and garbage management through the use of the Internet of Things can be a potential solution. The Smart Interactive Dustbin Network is a solution designed to help communities manage their waste collection efficiently, keeping their surroundings clean and hygienic. This network uses LoRa technology to wirelessly transmit data from multiple dustbins to a gateway, which can then notify authorized personnel when a bin is full. The ultrasonic sensor connected to the LoRa node measures the level of garbage in the dustbin, allowing for efficient and hygienic waste collection management. This system has the potential to be implemented in various locations, helping to eliminate littering in cities and reduce the need for human involvement in waste disposal.
Keywords: NodeMCU(ESP8266),LoRa(LongRange),LiPo(Lithium-ion Polymer),WiFi,ThingSpeak.

1 Introduction

The United Nations Department of Economic and Social Affairs (UNDESA) predicts that by 2050, 68% of the world's population will be living in urban areas, leading to a significant increase in the amount of urban garbage. The current waste management system is not efficient as garbage bins are emptied at a fixed schedule, regardless of how full they are, leading to hygiene risks and operational inefficiencies. Many municipalities have attempted to address this problem by changing collection routes or adding more bins, but these solutions are only temporary. Instead, a dynamic system that uses IoT technology to monitor bin fill levels in real-time is proposed. This model aims to prevent overflow of garbage and extend the lifetime of the node to avoid frequent battery recharging through rechargeable batteries. When the dustbin is about to overflow, it alerts the respective municipal authority.

1.1 Literature Survey:

The Smart Bin for clean cities paper discusses the use of ultrasonic sensors in smart bins to measure the level of garbage. The sensors send data to the cloud via WiFi module when the garbage exceeds a certain level. The paper also suggests waste compression in the bin to avoid unnecessary space occupation by light-weighted particles. To optimize battery utilization, the project uses the ESP8266's deep sleep mode and RTC memory to push previous values that were not pushed due to Wi-Fi unavailability. The paper also explores the integration of ESP8266 with LoRa for the project, highlighting the advantages of LoRa over other communication techniques. Other proposed solutions use different wireless transmission technologies such as ZigBee, RFID, and GSM, but these have drawbacks such as short communication range, power consumption, and high running costs. The emergence of Low Wide Power Area Network (LPWAN) technologies provides an energy-efficient, low-cost solution for wireless data collection in large areas without the need for cellular transmission technology.

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1.2 Objectives:

Considering the management of proper waste disposal due to increase in population, a network with the subsequentcharacteristics is designed:

- LoRa is used to transmit data through long range with low power consumption.
- In built WiFi in microcontroller is used for data transmission.
- Rechargeable battery is used to minimize the power usage during the process.
- Alert notification is sent through the triggering of event using IFTTT applets.

2 Hardware Description

The hardware used in building this network are given below:

NodeMCU: It is an open-supply firmware and improvement package primarily based totally at the ESP8266 WiFi chip. It allows users to easily create IoT devices with Wi-Fi capabilities, as it includes built-in support for Wi-Fi networking.TheNodeMCU board features a microcontroller unit, flash memory, and various input/output pins, making it versatile for a wide range of projects. Additionally, it can be programmed using the Arduino IDE and is compatible with many libraries and shields. As NodeMCU is a convenient and flexible tool for prototyping and building Internet of Things applications this microcontroller is choosen to implement this project.

Ultrasonic Sensor (HC-SR04): It is used to calculate the trash levels at every node . The trash level is calculated through the utilization of high-frequency sound waves that bounce back after hitting an object to measure the distance to that object. This sensor is composed of both a transmitter and a receiver, with the transmitter emitting ultrasonic waves that travel through the air until they reach an object. Once the waves make contact with an object, they reflect back to the receiver. The sensor then determines the time it takes for the waves to travel to the object and back, which allows it to calculate the distance to the object. This distance measurement gives the level of trash at different nodes.

LoRa: TheLoRa Communication Module (RFM96W) that uses LoRa technology to provide long-distance wireless communication by utilizing low power. This module is used to form a network that includes transmitter nodes with the centralized receiver. LoRaWAN is a communication protocol which is used for wireless data transmission and packet forwarding in the LoRa network.

LiPo Battery: One of the rechargeable batteries , lithium-ion polymer(LiPo) which is equipped with polymer electrolyte is used in this project. This technology results in a battery with higher specific energy than other lithium battery types. The electrolyte is formed by high conductivity semisolid polymers, such as gels. In this project Lithium polymer batteries are used to avoid the replacement of batteries at the transmitter nodes.

3Software Description

ArduinoIDE: TheArduino IDE is open-source software that allows users to easily write and upload code to an Arduino board. It is user-friendly and available for various operating systems without the need for special hardware components or licenses. The software supports various Arduino modules, including Arduino Mega, Uno, and Leonardo, and primarily uses C/C++ functions for coding. The IDE includes a text editor, message area, textual content console, toolbar, and menus, which connect to the Arduino and Genuino hardware for programming and communication. The software is used in this project to interface all hardware components for the vehicle's operation.

ThingSpeak: ThingSpeak is an open-source tool that allows you to store and retrieve data from Internet-connected devices or through a local network. It enables you to create applications for logging sensor data, tracking locations, and creating a social network of things with status updates. Additionally,ThingSpeak provides numeric data processing capabilities such as averaging, summing, rounding, and more. Each channel supports up to 8 data fields, location data, and status. You can integrate the feeds into your applications with JSON, XML, and CSV formats. ThingSpeak enables real-time visualization of the data, and it allows you to execute MATLAB code for online analysis

and processing of the data. It also has the ability to configure devices easily and supports popular IoT protocols. You can aggregate data from third-party sources and use MATLAB to analyze and make sense of IoT data. ThingSpeak also lets you run IoT analytics automatically based on schedules or events, and you can build IoT systems without setting up servers or developing web software. Finally, it enables you to act on your data automatically and communicate using third-party services.

IFTTT:IFTTT platform connects different applications to trigger events that refers to automations involving those applications using applets. IFTTT is used to automate web application tasks, track mentions of companies in RSS feeds, and automate home automation tasks. The platform uses the concepts of services, triggers, actions, applets, and ingredients to accomplish its tasks. Each service has a specific set of triggers and actions, and applets are created by combining triggers and actions to perform specific tasks.

4 Block Diagram and Working

4.1 Block Diagram

This block diagrams depicts he structure of the project. The LoRa network consists of multiple transmitters with the centralized receiver.

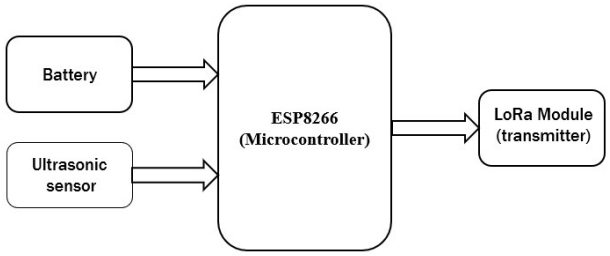

Fig 4.1 Block Diagram of Transmitter

The components of transmitter includes rechargeable battery, ultrasonic sensor and LoRa module interfaced with microcontroller ESP8266. In the receiver microcontroller ESP8266 is interfaced with various components other than that of transmitter. Receiver consists of external WiFi, battery, LoRa module. Microcontroller is also programmed in such a way to establish connection with the cloud used for data analysis.

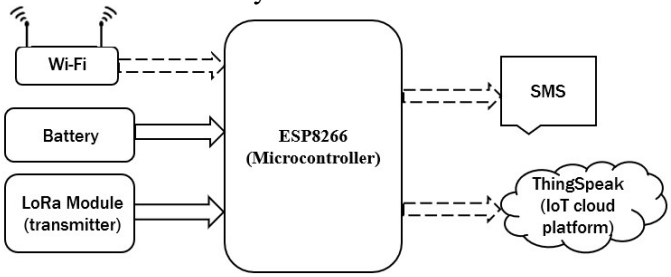

Fig 4.2 Block Diagram of Receiver

4.2 Working

The smart interactive dustbin network is designed to improve the condition of overflowing dustbins in the cities. If the dustbin is full, the ultrasonic sensor will detect it and send an alert to the collection center that the dustbin is full. The Ultrasonic sensor is placed at the top of the dustbin which measures the trash level that is the height at which the garbage is from the top of the dustbin. A threshold value is set according to the size of the trash can. In Transmitter Ultrasonic Sensor data will be collected using the microcontroller, then the processed data is sent wirelessly using LoRa module after LoRa initialization. The data through the different transmitters is sent in a similar way to the centralized receiver.

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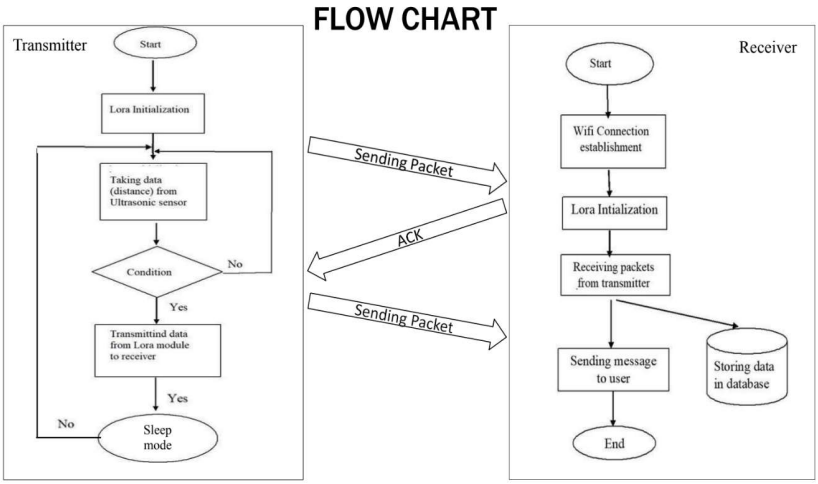

Fig 4.3 Flow chart of the proposed system

Now when the transmitter sends data, acknowledgement is received from the receiver. After receiving the acknowledgement microcontroller goes into the sleep mode to minimize the power utilization. The sleep mode is set in microcontroller to ensure that the trash level detection is proper only during the required conditions. The continuous trash level detection can result in receiving the similar data if there is no change in trash level of dustbin .This can increase the wastage of power used. To avoid this condition microcontroller is programmed in such a way to activate the sleep mode after every successful data transmission. If acknowledgement is not received the data is sent again by the transmitter to receiver.

At Receiver WiFi connection is established and Lora is initiated. Then the transmitted data is collected by LoRa module and by using gateway this data is stored in the Thinkspeak cloud as well as alert notification is sent to authorized person as SMS through the IFTTT applets.

5Results and Discussions

In this section, the simulation results of the proposed smart waste management system are discussed. The level of the dustbin is measured in centimeters, and the values are communicated to the ThingSpeak channel using a Wi-Fi module. Data is uploaded to the cloud only when there is a significant change in the level, and this occurs every half an hour. The distance in cm inside the bin indicates the amount of empty space remaining in it. Few values were collected since the dustbin was not frequently used. The data collected can be downloaded in a CSV format for further analysis.

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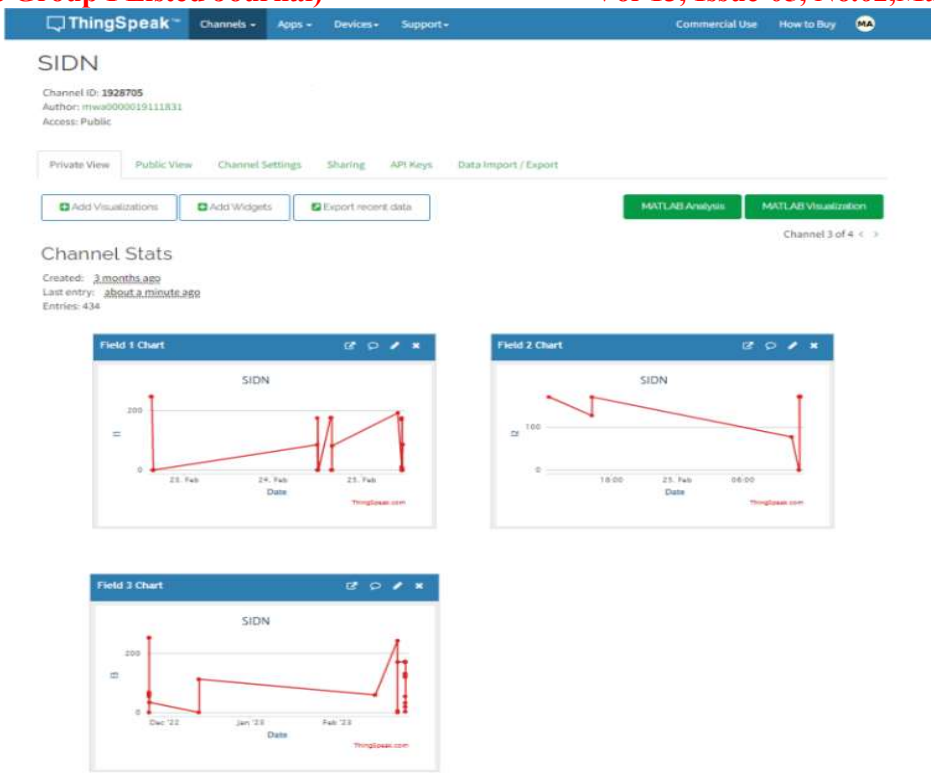
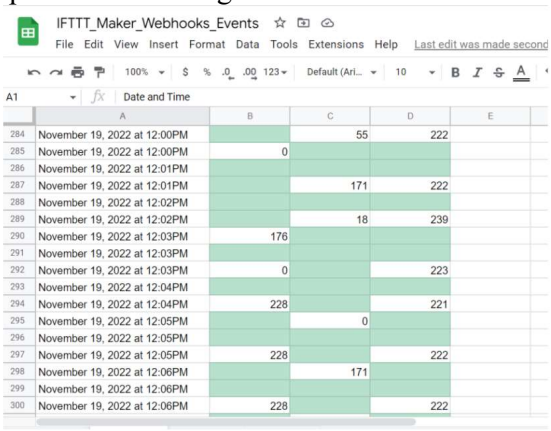


Fig 5.1 Data Analysis in ThingSpeak

The data from different transmitters is sent to the ThingSpeak cloud for data analysis and also data is recorded in the spread sheets along with the time of data sensed.



	A	B	C	D
284	November 19, 2022 at 12:00PM		55	222
285	November 19, 2022 at 12:00PM	0		
286	November 19, 2022 at 12:01PM			
287	November 19, 2022 at 12:01PM		171	222
288	November 19, 2022 at 12:02PM			
289	November 19, 2022 at 12:02PM		18	239
290	November 19, 2022 at 12:03PM	176		
291	November 19, 2022 at 12:03PM			
292	November 19, 2022 at 12:03PM	0		223
293	November 19, 2022 at 12:04PM			
294	November 19, 2022 at 12:04PM	228		221
295	November 19, 2022 at 12:05PM		0	
296	November 19, 2022 at 12:05PM			
297	November 19, 2022 at 12:05PM	228		222
298	November 19, 2022 at 12:06PM		171	
299	November 19, 2022 at 12:06PM			
300	November 19, 2022 at 12:06PM	228		222

Fig 5.2 Transmitter data entry in spread sheets

When the dustbin overflows, the user is notified through an SMS alert. The registered community receives the message via an IFTTT applet triggered by the SMS event using the API key written in the receiver node's code. The user can take necessary action after receiving the alert.

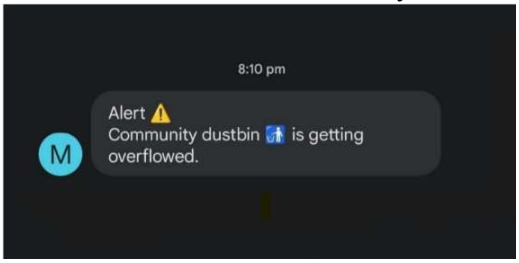


Fig 5.3 SMS alert

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Conclusion:

The rapid growth of populations and urbanization in both cities and rural areas has led to a significant increase in the amount of waste produced. On average, each person generates between 0.56 to 0.74 kg of waste, which conventional waste management plans are struggling to handle. To address this issue, the implementation of smart garbage technology offers a solution to improve the unsanitary conditions in cities.The aim of this project is to provide an effective waste collection solution for municipal authorities, resulting in cleaner urban areas. This is achieved through the use of real-time waste management systems, which utilize smart dustbins to monitor the level of waste periodically. Information about each smart bin and its level can be accessed from anywhere at any time, enabling concerned individuals to make informed decisions based on alert notifications.In many major cities, garbage collection vehicles visit the area only once or twice a week, which can lead to overflowing bins and illegal dumping of waste. This smart waste management system informs the authorities about the status of each dustbin so that immediate action can be taken. This system benefits both households and the Municipal council by improving waste collection efficiency and cleanliness.

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