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Waste Disposal Management System for Smart Cities Using LoRa

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***Abstract* - As the population of major urban cities keeps on increasing, the amount of waste generated is also seeing an exponential growth. In order to combat this, the existing waste management system is not enough, we can already see it becoming overwhelmed by the traffic. We need a new smart system that is able to handle this increasing growth and also provide features that allow us to decrease the pollution that is being caused by the existing system. Apart from the disposal of waste we also need to focus on segregation of waste while it is being collected based on their moisture, as there are better and safer ways of disposing wet and dry waste separately in a way that is beneficial to the environment.**

Keywords - IoT(Internet of Things), LoRa, Waste Management, Smart Cities, Ultrasonic Sensor, Microcontroller, Moisture Sensor

I. INTRODUCTION

The Internet of Things (IoT) is ceaselessly investing an energy in overhauling and offering interesting yet effective answers for individuals' everyday issues. The Smart City is a usage that plans to improve individuals' ways of life using keen urban communities, shrewd foundation and brilliant innovation.

Taking the waste administration emergency in Bengaluru, India for instance, the whole framework design and convention stack was created to give an IoT-based arrangement that improves framework unwavering quality and productivity. Perhaps the greatest obstruction for most urban areas is strong waste administration, and powerful waste administration has become an indispensable piece of savvy urban communities. This paper intends to give an IoT-based building answer for the issues looked at by current waste administration frameworks. By giving a total IoT-based framework, all parts of strong waste assortment and the executives can be robotized and checked continuously.

The data is collected from the containers by means of sensors and sent to a gateway using LoRa technology, which is then sent back to the gateways for processing.

The main problems in waste management are waste separation and waste collection, and proper waste collection must be respected. The garbage truck can only be directed to the bins that need to be cleared, and can also use mobile apps to find efficient ways to ensure that the truck does not waste time visiting unfilled bins. Data mining and analysis can be carried out on the basis of the data collected during the process in order to understand the amount of waste collected and its relationship to the site and establish an appropriate management system. In order to collect data from all containers, data such as the number of containers and the size of the container are included in the collection process.

By integrating IoT into the system, precise statistical models can be created to ensure the proper management of solid waste. Integrated IoT systems enable waste management systems such as waste collection and separation systems to efficiently monitor the flow of waste from the site to the landfill and the disposal of waste in the local environment.

II. RELATED WORK

Previously the systems which have been suggested by many journals had been focused on creating a network of smart bins that used technologies like GRPS, SMS, Zigbee, GSM or Wi-Fi to communicate with each other and with the central server. Even though these methods proved to be effective they come at the cost of power and need to be maintained at a periodic time period.

This defeats the purpose of creating a system that requires very less maintenance. Hence the cost of

operation increases drastically for such a system. If we want a system to scale to the size of a modern city then we need to take the cost of operation into consideration as well. For that purpose we introduce the LoRa network module into our system. The LoRa module is a wide area network that operates at very low power consumption, requires very low maintenance and can run on a single cell for weeks. These attributes make it perfect for our implementation.

Many existing systems focus on creating a smart bin module but do not pay any attention to the segregation of waste at this level. If we are able to segregate waste while the waste is dumped we don't have to have waste segregation plants that use manual labour to do the segregation. Thus we are proposing a separate module that focuses solely on waste segregation.

III. MODULES

A. Smart Bin Module

The smart bin module consists of the LoRa module setup along with ultrasonic sensor and the moisture sensor. It is responsible for collecting data about the contents of the dust bin and transmitting the data to a centralized server.

LoRa was chosen for this purpose due to its ability to transfer data in a long range with very less power consumption. Therefore this module need not be maintained as often and can work without hindrance for a long time.

This is the most important part of the whole waste management system. It consists of a contraption that lives in the dust bin at a given location. It is responsible for locating data about the contents of the dust bin and periodically reports to the waste centre with this data.

An intelligent sensor embedded in the intelligent container detects the level of the container and sends the data to a cloud-based monitoring and data analysis platform. The platform supports location monitoring of intelligent waste bins to optimize collection routes and plans based on real-time data. When the waste bins reach a specified level, a solar-powered waste compactor activates and compresses the waste, allowing the bins to absorb eight times more waste and reduce the collection frequency by up to 80%.

This increases operational efficiency by reducing emissions from collection vehicles, thus ensuring full visibility of all types of containers and planning collection routes accordingly.

The module consists of an ultrasonic sensor that detects and measures the level of the container filled with waste. The module itself consists of sensor modules to precisely record the data and perform corresponding actions.

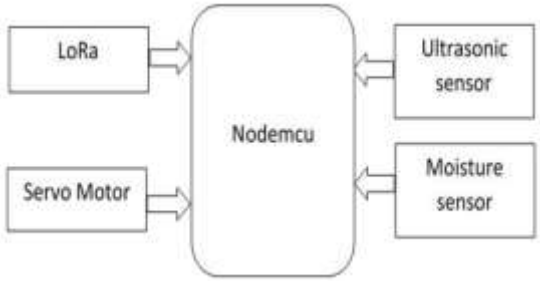

Fig 1. Smart Bin Architecture

Waste segregation basically means keeping wet and dry wastes separately, so that dry can be recycled and wet waste can be composted. So that it reduces waste that reaches landfills and reduces pollution to air and water. So that different processes- composting, recycling, incineration can be applied to different kinds of waste.

This module is also responsible for waste segregation. When a waste is dropped into the bin the moisture sensor quickly calculates the moisture of the waste and comes to the conclusion if it can be classified as wet or dry waste. It then signals the servo motor to move the waste to the corresponding bin.

B. Centralized Server

All the data from the various smart bins needs to be collected in a single place so that it can be used in a meaningful manner. The centralized server uses a single LoRa receiver that gets data from all the smart bins in the area.

The centralized server is responsible for collecting and processing the data including prediction and insight generation about the garbage production.

Now that we have several smart dust bins that collect data about its content, now we need a server to which

all these smart dust bins can communicate to and transfer the data they have collected. This server should be centralized such that all the smart bins have a single point of contact. If we have multiple points of contact for these bins then it will be hard to get all the data and process together. To prevent this issue we need a centralized server to which all the smart bins can transfer their data to.

While a unified framework needs a brought together proprietor to associate with different clients and gadgets, the accessibility of the system relies upon that proprietor. Information can't be directed through a system without the proprietor's authorization, which implies that if a server falls flat, all PCs associated with that system won't have the option to deal with the client's solicitations.

This centralized server will have to do a lot of processing using all the data that it gets. Since a large amount of data will need to be handled here, this centralized server needs to have the ability to scale without anti throttling. In order to successfully do that we need to divide the server into multiple microservices that perform different tasks but also depend upon the other microservices.

Centralized processing networks have sufficient capacity to avoid bandwidth bottlenecks, while decentralized networks need to be optimized to combat latency. Distributed networks are also more secure because important components of the system are distributed over the network. There is not a single central server for hackers to target, so if someone wanted to attack a network, they would have to gain access to a large number of networked computers. The more control and power over the network is in the hands of the collective, the more trust users will place in this system.

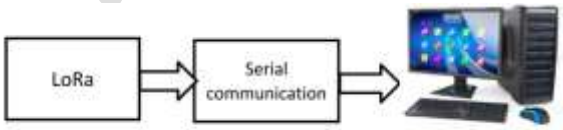

Fig 2. Centralized Server Architecture

The centralized server should be situated at a local waste management centre that is responsible for collecting waste from the areas where these waste bins are situated at. This allows the admin to understand the situation of the dust bins in their area and can take action as and when they need to. Apart from data collection, this server will also have the ability to process the data and provide useful insights that can prove to be beneficial to the admin.

C. Dashboard

The dashboard allows the admin to check and see the level and location of the trash bins in their location. The admin will be notified when a particular trash bin has reached the overflow level and needs to be collected.

Using the dashboard the admin will be able to determine the best route to take in order to collect all the trash from all the bins in the most efficient manner.

Fig 3. Dashboard UI

The dashboard is made up of two components, namely the frontend and the backend. The backend API is designed to receive the periodic updates from the smart bin module and store it in the database. We have used MongoDB for storing data about the bins, mongodb was chosen due to its ability to quickly parse time series data. The DB consists of the coordinates of each bin in the area along with the level that is filled at a particular time.

The backend writes and reads to and from the database based on the endpoint that is being hit. It is responsible for updating the level of each bin based on the data sent by the smart bin module.

The frontend is in the form of a dashboard that consists of two components, namely the map and high level bins notifier. The map consists of the locations of all the bins in the vicinity, clicking on each of the bins shows a tooltip that shows the level of bins to which

it is filled at the particular moment. This allows the garbage collectors to plan out their route to take in order to collect all the bins in the most efficient way possible. The high level bin notifier shows the bins that are almost full and notifying the garbage collectors that the bin needs to be collected soon.

IV. CONCLUSION

In order to keep up with the drastic increase in population and the amount of waste generated, we need a smart system to keep up with this demand. With the help of the proposed system we can manage disposal of waste in the most efficient way possible. Thanks to waste segregation and notifications we can ensure the environment pollution is kept to a minimum. The proposed system includes a developed node which can operate efficiently for more than a year, obtaining useful data like level and moisture due to the low battery consumption. And due to its low cost design it can be deployed in large quantities in any modern urban city that supports a smart city technology.

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