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RESEARCH ARTICLE OPEN ACCESS

Smart Bin Waste Management Network using LoRa and Internet of Things

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ABSTRACT
Even the economies of the developing nations are improving at a good rate, but the health standards have a long way to go. Often areas with developing economies experience exhausted waste collection services and effective waste management in these countries is an ongoing challenge. This work is mainly focused on improving the quality of waste disposal and reducing the cost and time involved in waste management. This paper presents the real time monitoring of the container using an embedded system, followed by collecting and transmitting the data to a central gateway and publishing the result along with the location of the containers in the Internet to determine the optimized disposal of the waste that are filled over the set threshold.
Keywords: Ultrasonic sensor, Waste Management Network, IoT, GPS module, LoRa, Smart bin.

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I. INTRODUCTION

Waste management and accumulation of waste has become a serious problem in many populated cities. These wastes should be cleared on a regular basis to avoid health issues and to prevent diseases from spreading. Waste disposal is an activity which requires complete monitoring from its inception to its final disposal. The health standard of Indian Environment needs to improve as India stands only at 177th position at the Global Environmental Performance Index according to 2018

Health contributes to 40% of EPI. Any plastic material which is left unattended at the overflowing garbage also prevents the penetration of water into the ground. When the garbage is left unattended for a long time, it emits harmful gases like Carbon-di-oxide, methane and nitrous oxide which can cause Respiratory diseases. The Smart Bin Waste Management System that has been proposed here ensures proper monitoring of the waste within a given period. On reaching the maximum capacity, it informs the authority that the trash can in this particular location is full. In this manner, a local authority can keep track of the status of all the bins in that area by just logging into the account at ThingSpeak. Sensor placement is crucial and it is done so as to get the best result with minimal error. The code is customized to give the result after the waste has settled down in the container and not abruptly when the waste is being dumped.

The data is collected on a daily basis and the status of the bin is monitored at regular intervals. The time taken by a particular container to reach 80-85% of its capacity is also stored with a timestamp value. This data is transmitted from multiple nodes to a single gateway node using LoRa technology. It involves Spread Spectrum Modulation Techniques derived from Chirp Spread Spectrum technology. Using LoRa technology with WiFi reduces the cost of deployment of Internet of Things [3]. A single receiver can be synchronized with multiple transmitters and hence it can handle multiple nodes from a locality unlike a WiFi based system, which needs to have many access points to increase coverage. Moreover providing a WiFi connectivity at every node would be practically impossible. So following the proposed architecture will reduce the resources involved.

The main focus of this work is to design a low cost and effective waste management system that can be deployed in any locality. This design functions even in rural areas where the line of sight obstruction for LoRa communication is minimum as the number of tall buildings obstructing the signal flow is minimal.

II. LITERATURE SURVEY

Many studies were carried out extensively in the fields of waste management, collection and monitoring. It is vital to the Global Environmental Performance Index of a nation to deal with health issues. Research has been undergone on different types of economical, technical and managerial challenges for waste collection and management in developing countries. In [1] a working methodology using wireless sensors and Internet of things technologies were used to monitor the waste containers. This ideology was taken as the base concept. The idea is backed up by accurate placement of the sensor nodes for minimum error and maximum efficiency and its performance is tested in a rugged environment. The code flow for the working of the sensor is different to the available one in [7]. A network of these nodes is created using Lora technology with a similar architecture model discussed in [3]. The range of LoRa along with its associated payload are tested and compared to the values described in [4] under different conditions. The existing system is also improved by connecting the bins with a GPS Receiver to add the location of the bins to the data which is to be published. The MQTT protocol for publishing the data to the Internet is done through a gateway node to the IoT platform ThingSpeak as implemented in [2]. The Future scope as discussed in [1] looks promising with an optimization process which can create the most efficient garbage collection routes by analysing the pattern of filling of the containers in a particular locality. This paper is mainly focused on the efficiency and economic feasibility of the system through low power transmission.

III. METHODOLOGY

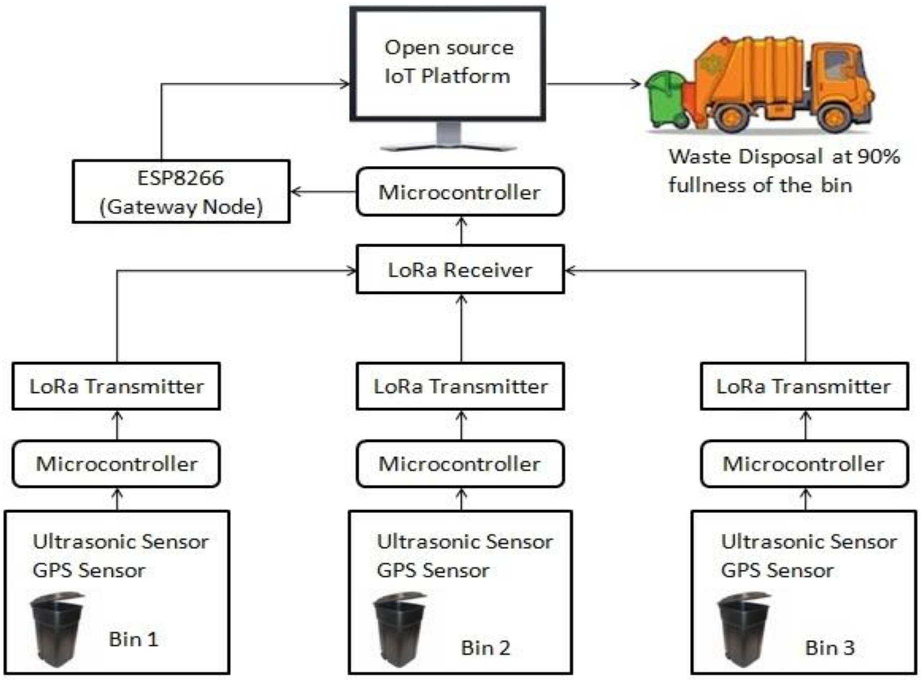

Fig. 1. Block Diagram

A. ULTRASONIC SENSOR

Ultrasonic sensors measure the distance using sound waves. The sensor emits the wave which travels and reflected back after hitting the object. By measuring the time between the emission and reception of the wave, ultrasonic sensors calculate the distance between them. Ultrasonic sensors have 4 pins such as Vcc, trigger, echo and ground. The trigger pin is an input pin and echo is an output pin. In order to generate the Ultrasonic waves, the Trigger pin is kept in the HIGH state for a minimum of 10 microseconds. As a result, an ultrasonic burst is produced, which generates eight cycles of 40 KHz frequency. Initially calibration of the sensor is carried out to test its accuracy and error deviation. The Ultrasonic sensors are calibrated to the depth of the Garbage containers and when the wastes are dumped into the containers, the length of the pulse generated by the Echo pin varies, thus enabling us to calculate the distance between the lid and the waste with the help of Distance formula. Distance can be calculated using the formula

L = 1/2 * T * C * 100

where L – distance (cm)

T – Time between transmission and reception (sec)

C – Speed of Sound waves (m/s)

B. LORA COMMUNICATION

With the number of devices getting connected to the Internet increasing day by day, this is the golden age for IoT. IoT requires a Wireless technology to connect these devices to the Internet. LoRa Communication is one of the wireless technologies which can help reach IoT a brand new level. LoRa operates in several frequency bands like 433 MHz, 868 MHz, 915 MHz and 923 MHz, each band corresponds to a particular continent. LoRa devices are capable of providing ultra-long range spread spectrum communication with high interference immunity whilst minimizing current consumption. LoRa chipset features include long range, low power consumption, high transmission power, small size and secure data transmission. LoRa (Long Range) uses spread spectrum modulation technique which is based on chirp spread spectrum (CSS). LoRa uses the chirp signals as carrier signals upon which the message is encoded. A chirp is a tone in which the frequency increases or decreases with time. It is robust to channel noise as the entire allocated bandwidth is used to transmit a signal. Since each spreading is orthogonal, multiple transmitted signals can occupy the same wireless channel without interfering. A single receiver in the LoRa network is able to handle multiple nodes at different locations in that area, unlike the Wi-Fi based systems, which requires many access points to increase the coverage area. The LoRa module which is used in this project is RA-02 module which is based on SX1278 developed by Semtech. Several transmitters are deployed at different nodes and they are synchronized to a common receiver which is connected to the gateway node.

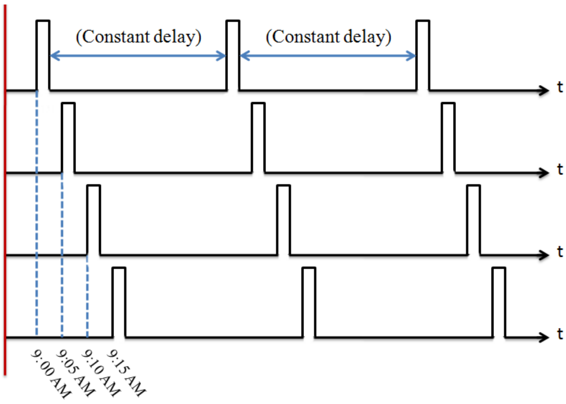

Fig. 2. Synchronization Timing Diagram

C. GPS RECEIVER

GPS stands for Global Positioning System which works on the method of Trilateration. The GPS Navigation Satellites are spread out uniformly in 6 orbits. For Accurate positioning details, it requires 24 Satellites in the Constellation. At present the number of operational GPS Navigation Satellites in the orbit is above 30. GPS satellites are placed in such a way that a system uses four satellites at a time from almost anywhere on the surface of earth and its accurate position is received in three dimension. A GPS signal information is split into 3 fields which are

- Pseudorandom code is an I.D. code that is used to identify which satellite is transmitting information.
- Ephemeris data is needed to determine a satellite's position and gives crucial information about the health of a satellite, current date and time.
- Almanac data specifies the GPS receiver where each GPS satellite will be at any time throughout the day ideally and shows the orbital information for that satellite and every other satellite in the system.

This project also involves monitoring the different locations of several trash bins using GPS Receiver module. The data is sent to the Gateway with a time stamp, so that the time at which a particular bin has been filled and emptied is determined. The heart of the sensor module is a NEO-6M GPS chip from u-blox which can track up to 22 satellites from 50 channels. The LED on the Neo-6M module serves its purpose by indicating whether the position is fixed or not. When there is no blinking, it means that it is searching for satellites and if it blinks for every 1 second, it means that the location has been fixed.

D. IOT PLATFORM

Internet of things play a vital role in making our cities smarter and the lives of people a lot easier. These smart devices communicate with one another and share information that they gather. A Network of such smart devices is called Internet of Things. System integrators, network operators and people try to collaborate with government and come up with new and beneficial solution for the development of the cities. But, providing scalable solutions are quite the task.

For efficient waste management, we use Internet of things and sensors to make it way easier. This helps us to read, collect and transmit huge volume of data and store it in the internet. Sensors are mainly used to calculate the amount of wastes filled in the dustbin. This known data obtained from the sensors is transmitted over the wireless networks and then published to a server through the gateway node for storage and processing mechanisms. As a result, the fullness of these bins is predicted before it gets overflowed in a specific location. It allows to create a route for garbage trucks in order to collect these filled and almost filled bins in a most efficient manner. Based on the results published in the IoT platform every day, workers receive the updated status of every bin in that channel. Depending on economic requirements specified at early stages, the optimized selection of dustbins to be collected is expected to improve collection efficiency.

The data gets collected at the Gateway node and it gets transferred to the online UI through a data transfer protocol called MQTT (Message Queuing Telemetry Transport). MQTT is a publish-subscribe based messaging protocol. In this project, only publishing of the data is done on to the server for monitoring purposes. This gives the municipality officials a clear idea of when to dispatch the garbage truck by monitoring the live status of the garbage bins in that locality. Publishing data to the server involves the following steps,

- Connect the client to the internet.
- Connect the client to the server.
- Publish data to the server.

IV. DESIGN FLOW

A. ALGORITHM

1. Start
2. Calibrate the sensors.
3. Generate the Trigger Pulse at Regular intervals to create the Ultrasonic burst.
4. Calculate the distance using distance formula
5. If the distance is lesser than the threshold, goto step 6 else goto step 7.
6. Define the packet as critical with a message “Needs to be Cleared” and skip to step 8.
7. Update the packet with normal status value of the bin.
8. Start LoRa communication and synchronise the transmitter at an end node to the common receiver.
9. Carry over the data from the receiver to the Gateway Node for publishing it to the Internet.
10. Setup connection and connect client to the Internet.
11. Connect the client to the server.
12. Publish the data to the server with unique key details corresponding to a particular container.
13. Dispatch the Garbage truck at the right instance using the collected data.
14. Stop

B. FLOWCHART

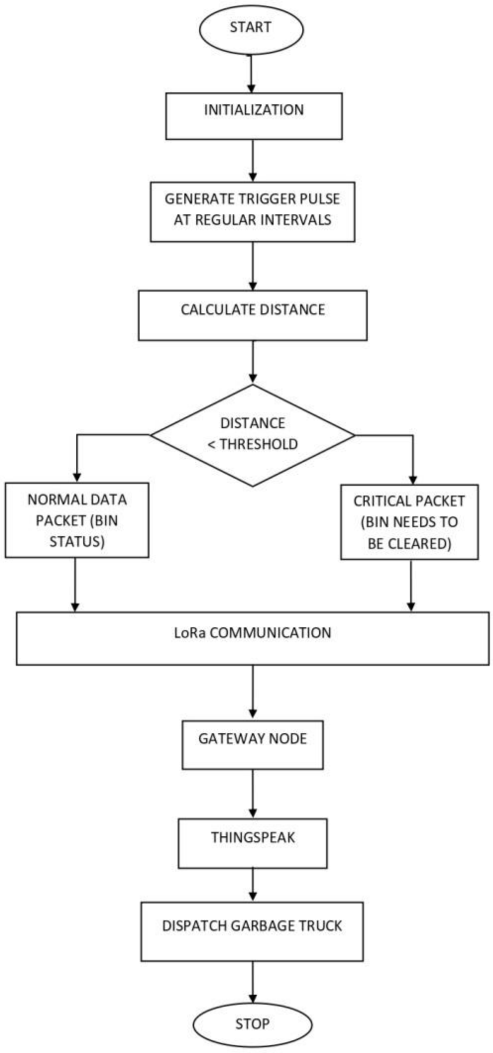

Fig. 3. Flowchart

V. IMPLEMENTATION AND RESULTS

This project enabled to build a waste management network using multiple sensor nodes at different dustbins and also using multiple channels at the ThingSpeak Network. The different channels at the network enabled to visualize the bins separately and keep a track of real time monitored value with critical record fields as well.

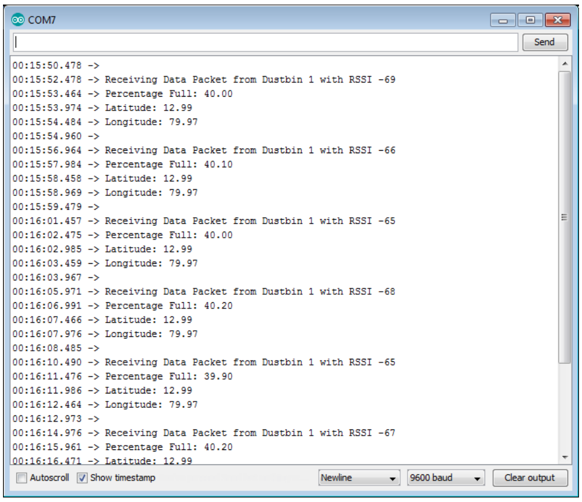

Fig. 4. Serial Monitor Results

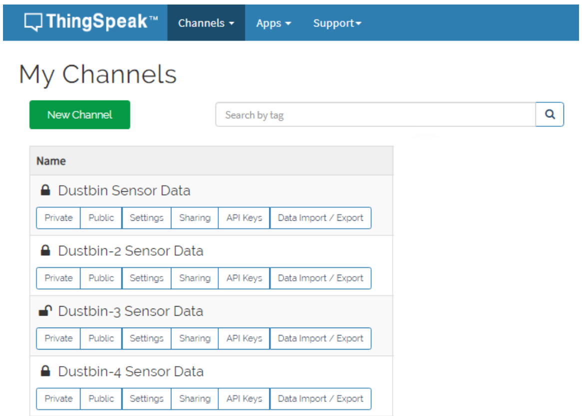

Fig. 5. Multiple Channels at ThingSpeak

Each Channel created in the ThingSpeak Network was created with 4 fields. The first field denotes the percentage fullness of the respective dustbin. The next two fields are used to display the latitude and longitude of the corresponding bin. These two fields are used to find the location of the bins. Accurate Visualization can be obtained by entering the Latitude and Longitude value in https://www.google.com/maps by entering it in the format – Latitude, Longitude. The fourth field is created as an indicator to monitor the threshold level for critical limit of the waste containers. It will give a Red Light alert when the percentage value crosses the set threshold of 80% By changing the Channel Settings to Public, any other person with an account can view the data published to Thinspeak.

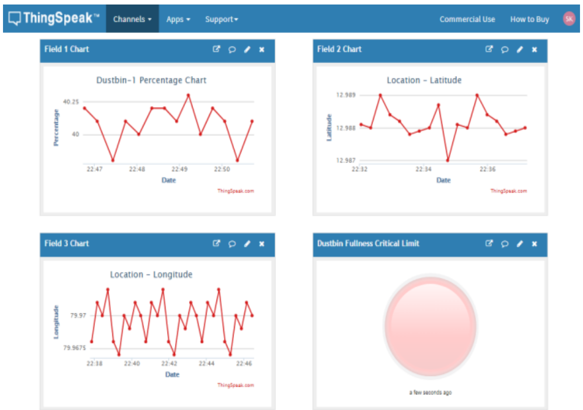

Fig. 6. Real Time Monitoring Values

VI. CONCLUSION

In this paper, we have proposed a model which ensures that the waste management is done in an effective manner. The effectiveness lies in the fact that the real time monitoring of solid waste management helps in timely removal of garbage and prevention of any harmful waste from harming the environment. By using a protective casing, the electronic components are protected from damage that may occur due to the different types of waste dumped in the container. From the findings in the project, the range of transmission increases if there are less obstacles nearby obstructing the path of Radio wave propagation. The Network is formed based on the range of the central node and its capacity to connect with all the nearby sub nodes. The problem of low range can be tackled by using the concept of Relays as LoRa is a transceiver module capable of behaving as a transmitter as well as a receiver. After the network is created, the multiple transmitters are to be perfectly synchronized at different time intervals with the receiver. If the time instances overlap or synchronisation is lost, one of the original data gets lost in the communication. So synchronization of the nodes is essential in this method according to the study.

VII. FUTURE SCOPE

The waste management system is an advanced system that can be integrated onto Smart City concept to maintain the cleanliness of the environment and to reduce the time and cost involved in the cleaning process. This existing system can be improved by using the tracking system in waste transport vehicles to determine the best and shortest path to be followed in collecting the garbage waste from multiple points in the vicinity. One can utilize the stored data by analysing it with Big Data and Prediction Algorithms to predict the hike of waste during a particular time of the year so that the authorities can anticipate and handle it better. The efficiency of the model has plenty of potential for research. The design of the waste management model has been carried out to cater to the current waste situation and optimised to meet the objectives of providing an affordable waste solution with the underlying objectives to achieve a zero waste place. Research on the efficiency attribute can be carried out further to enhance the overall operation.

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