Theoretical modelling and fabrication of smart waste management system for clean environment using WSN and IOT

S. Murugesan [a,*], S. Ramalingam [b], P. Kanimozhi [c]

[a] K. Ramakrishnan College of Technology, Trichy, Tamil Nadu, India
[b] Alagappa Chettiar Government College of Engineering and Technology, Karaikudi, Tamilnadu, India
[c] Moogambigai College of Engineering, Keeranur, Tamil Nadu, India

ARTICLE INFO

ABSTRACT

In present day situation, we frequently see that the garbage can is positioned in open locations in city communities that are flooded due to amplify in waste each and every day. It creates an unsanitary condition for individuals and creates a horrible smell round environmental elements that lead to the advent of some hazardous and human ailments, to continue to be away from the environment we diagram for "IoT-based waste management for smart cities". In the proposed system, there is a lot of waste available in the city or on campus. These boxes get a minimal gadget that helps keep tune of the nice of the garbage cans and a new ID will be placed on each bin. From the town with the aim that it is far from difficult to understand which dust bin is full. The moment the degree arrives faster, the device will transfer the level alongside with a unique ID. The specialists can get this better result from their area with the help of the Internet and rapidly clean the rubbish cans. One of the essential troubles with our circumstance used to be robust waste management which impacts the well-being and stipulations of our public. Recognition, verification and costly retirement are one of the most important matters for the present day period. The common approach of bodily verification of leaks in waste containers is a hard procedure to manipulate and uses with extend in human effort, time and charges which can be averted without much effort with our current technology. This is our answer, an approach the place undesirable managers are computerized. This is our framework for IoT Garbage Monitoring, an extraordinary way to assist maintain city areas as clever cities.

© 2020 Elsevier Ltd. All rights reserved.
Selection and peer-review under responsibility of the scientific committee of the International Conference on Advances in Materials Research – 2019.

1. Introduction

With increment in populace, the situation of tidiness as for trash the executives is corrupting colossally. The flood of trash in open zones makes the unhygienic circumstance in the shut with the aid of encompassing. It may incite a few real illnesses among the close with the aid of individuals. It likewise debases the valuation of the zone. To maintain a key distance from this and to upgrade the cleaning, 'brilliant trash the board system' is proposed in this paper. In the proposed system, the diploma of junk in the dustbins is identified with the help of Sensor frameworks, and imparted to the accredited manage room by way of GSM framework. Microcontroller gave to connect the sensor framework with GSM framework. Arduino IDE apparatus is similarly developed to screen the best data recognized with the undesirable for various areas. This will aid with dealing with the trash assortment adequately.

Due to fast populace growth, disorganization of regional authorities, an absence of open care and constrained financing for applications squander the board is became into a world problem. The Central Public Health and Environmental Engineering Organization (CPHEEO) has evaluated that squander age in India is as tons as 1.3 lb per person per day. Municipal Corporation of Greater Mumbai (MCGM) labored a great armada of 983 Vehicles for assortment of waste introduction 1396 number of excursions each and every day. Solid Waste Management (SWM) use cost in the 12 months 2007–08 is Rs.10479.3 million. But still there is flood of undesirable in several regions in Mumbai. To maintain away from this wise trash the board machine is created in this

---

* Corresponding author.

Please cite this article as: S. Murugesan, S. Ramalingam and P. Kanimozhi, Theoretical modelling and fabrication of smart waste management system for clean environment using WSN and IOT, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.09.190

paper. A big challenge in urban cities is solid waste management. The project gives us one of the most efficient.

The Internet of Things (IoT) shall be able to contain transparently and in a similar fashion a giant number of exceptional frameworks, while giving data for tens of millions of human beings to use and capitalize. Creating a universal architecture for the IoT is very complicated task. It is mainly due to the fact of the extraordinarily greater range of devices, link layer technologies, and services concerned in such a system. Seepage condition ought to be screen so as to keep up is legitimate capacity. Indeed, not all zones have seepage checking group it releases unpredictable observing of the waste condition .Wireless Sensor Network (WSN) is a checking approaches to keep our garbage level condition.

Due to the characteristics and merits of the IoT technology sectors, waste management has become a major issue in academia, manufacturing, and government. Lack of adequate waste treatment, inadequate waste management policies contributed to severe environmental problems. Various researches has been done into waste management to address these issues. The Garbage Collection Vehicle (GCV) nowadays collects the waste two or three times a week. The problem, then, is the flow of wastage on the roads. Therefore, a scheme on smart waste management using Wireless Sensor Networks (WSN) and IoT (Internet of Things) is proposed in this paper to address the limitation.

The garbage bins are deployed with sensors and interconnected via WSN. The sensors that are installed in the garbage bins collect the data at any given interval. It creates a request to the GCA (Garbage Collector Agent), until the threshold is reached. This agent gathers all the filled vehicle requests and communicates using IoT system.

High construction costs and low performance are the big downside of current works. Using GSM and Zigbee communication, the communication between garbage and the receiver side has analyzed. Monitors and intimates the designated person to collection agent. This is time-consuming and coordination challenge missing.

To solve this problem, we need to design and implement the theoretical modelling and garbage collection using the Internet of Things and the wireless sensor network. BLYNK server has created a specialised IoT android application to control garbage level. The proposed work has low cost and effective Garbage level monitoring in smart city. The collection agent tracks the entire city's garbage level via Android app blynk and simple way to collect and clean the garbage.

2. Literature review

The novel thought, for the execution of keen dust container. This is our arrangement for structuring savvy trash container with an Ultrasonic and infrared Sensors and Ethernet module for moving the information. We surveyed the published papers which manage these savvy canister ideas. The audit comprises of various techniques are proposed for squander removal and the executives.

In the paper [1] examines the various strategies utilized to oversee Internet of things and portrays the point by point usefulness of IoT, and gives a general thought of getting ready application identified with data the board over web. An outline of the idea for joining client application with IOT [2] and manages point by point portrayal about versatile investigation and Sensor data the board. They laid out late progressions by world first trailblazers in creating IoT Standards, large information the executives and versatile investigation, just as norms and as sources for creating IoT applications. To understand the Internet of Things vision we should address various IoT achievements we have laid out in this paper. Tending to this critical difficulties both global joint effort and high effect executioner applications are required. Every single

significant achievement in IoT research. Another method was presented in this paper and actualize for shrewd city squander the board associated with an IoT [4], dynamic planning idea required for dustbin cleaning occasionally and the Top-l inquiry leads to need based dustbins cleaning.

In [5] Smart Garbage Management using IoT in Smart Cities suggested a system as follows. The garbage level in the dustbins is measured using the system of ultrasonic sensors and transmitted via the GSM system to the approved control room. Using Arduino microcontroller, the sensor device is interfaced with GSM. Also an Interface is built to track the desired garbage related information for various selected locations. This will assist in the effective management of garbage collection. Level detector consists of IR sensors that are used to measure the level of the dustbin garbage. Level detector output is given to microcontroller. Four IR sensors are used to show the varying amounts of the volume of garbage collected in the dustbin that is located in public room. When the dustbin is filled to the highest level the fourth IR receiver output becomes active low. This output is provided to the microcontroller to transmit the message via GSM module to the Control Room. Control room is located at the receiver where all of the operations are handled.

In [6], on a mobile web browser with Wi-Fi html tab, a dustbin is interfaced with a microcontroller-based system with IR wireless systems along with a central device displaying current garbage status. Hence the status on the html page will be changed. Thereby human capital and energies along with reinforcing a vision of a smart city is reduced.

In [7], The paper proposed an Innovative Decision Support System (DSS) for effective Smart Cities waste collection. To perform waste collection and dynamic route optimization, the framework implements a model for data sharing between truck drivers on real time. The device manages inaccessible areas within the Smart City where waste is ineffectively collected. Surveillance cameras are installed in to record disturbed areas and provide evidence to authorities. The waste collection system aims to provide the people of a Smart City with high quality of service.

In [8], Organizing the garbage collection system of residential or commercial areas, Kalsiwal Mansai proposed model of garbage management using Internet of Things for Smart Cities. The level of waste material in the garbage bin has been detected in the proposed system with the aid of an ultrasonic sensor and it will communicate continuously with the approved control room via GSM module. Micro-controller is used to connect GSM device sensor system.

In [9], once the garbage reaches the threshold level ultrasonic sensor will activate the GSM modem which will alert the appropriate authority continuously until the garbage is squashed in the dustbin. If the dustbin is squashed, the dustbin can be used again by people. Dustbin will be squashed at periodic intervals. The GSM 900A modem is used to send the messages using this form. It consists of a GSM / GPRS modem with standard communication interfaces such as RS-232 (Serial Port), USB, to allow easy connectivity to the other devices. The ultrasonic sensor is used to locate garbage height filled at varying time intervals.

In [10], there are several dustbins located throughout the city or campus, these dustbins are fitted with low-cost embedded devices that help monitor the level of the garbage bins and a unique ID is given for each dustbin in the city to make it easy to identify the garbage bins are full. The project module is divided into two sections segment Transmitter and Receiver. Here we use 8051 microcontrollers, RF Transmitter and sensors in the transmitter section which are attached to the dustbin. Where sensor is used in the dustbin to detect the level of whether the dustbin is full or empty. The sensor senses the dustbin's content and sends out the signal or the data to the 8051 microcontroller.

S. Murugesan, S. Ramalingam and P. Kanimozhi

The ZigBee, GSM (Global Mobile Communication System), and ARM7 are used in [11] to form the Integrated Framework for remote control of the waste bins. The sensors are mounted on public places in the local garbage bins.

When the garbage hits the sensor level, the ARM 7 Controller will then receive the signal. The controller will give the garbage collection truck driver an indication as to which garbage bin is fully filled and urgently needs attention.

By sending an SMS using GSM technology, ARM 7 will give the indication.

In [12] it explains the application of our "Smart Bin" model to the management of an entire city's waste collection system. The sensor network allowed smart bins linked through the cellular network produce large amounts of data, which is further analysed and visualised in real time to gain insights into the state of waste across the city. The aim of this paper is also to promote more research into waste management issues.

Prajakta et al.[13] suggested the storage of garbage structures modified with data collection structure subject to photo arrangement and GSM module arrangements. To achieve this confinement point, the system uses a camera that is placed at each location where garbage is accumulated near a stack cell sensor arranged at the base of the waste holder (Fig. 1).

3. Proposed system

We propose a keen waste assortment framework based on level of squanders present in the waste canisters. The information from the sensors is transmitted through the Internet to a worker for capacity and preparing frameworks. It is utilizing for observing the day by day choice of unwanted canisters, in the view of which the courses to pick a few of the waste containers from different areas are chosen. Frequently the laborers receive the refreshed streamlined systems in their navigational device gadgets. The noteworthy element of this network system is that it is committed to refresh the experience from the past and choose on the day to day wastage level status as well as the anticipate future state concerning factors like gridlock in a zone where the unwanted canisters are put, cost-proficiency balance, and different elements that is hard for people to watch and investigate. In light of this chronicled information, the rate at which waste canisters gets filled is handily broke down. Accordingly, it very well may be anticipated before the flood of squanders happens in the waste containers that are set in a appropriate area. Contingent upon

monetary prerequisites indicated at beginning phases, the upgraded choice of waste containers to be gathered is normal (Fig. 2).

Sensor hub is introduced in each Smart-container with a force flexibly parts (It comprises of a bridge Rectifier, step down transformer, a channel of circuit and device of Voltage Regulator). The Receptacle completion, reports of Sensor statuses and readings by utilizing Ethernet modem of arduino UNO is detecting by the sensor hub. It has a capacity to locks the receptacle entryway in addition when it is filled and furthermore at blustery duration. The accompanying material parts are connected with container. Ultrasonic sensor is utilized to find the degree of residue receptacle. It can be similarly refresh the statuses of the container and sends the data to its closest control room. The status in the workplace get from HTML based site page. It works based on sending a sound signal, and it is gotten once again from opposite end.

To computing the time of movement of sound signal can make sense of separation by the distance equals to multiplication of speed and time. Where Time consumed by the sound signal to receive at the canister and return to Speed movement has Velocity of Sound. Which is equivalent to 350 m/s? By this way, distance = [required separation * 2]. Furthermore, it may be refresh the statuses of canister to partnership room by utilizing through html pages based on SPI Ethernet shield. (The SPI Interface is utilized based on information yield connector for Arduino. The board which has joined by Ethernet module and it is utilized to associate with various PCs/workers. It gives fundamental LAN dependent web association.) This gives the current progressed IOT strategies to recognizing container by its signal. Downpour Sensor is associated with distinguishes precipitation, to abstain from entering the downpour water to the canister. Canister is a collection of water Sensors pinned with a AND door. In this way, it identifies downpour by setting 3 sensors nearby the receptacle. Infra Red Sensor has utilized to recognize the close by objects are set nearer to canister (K = 0 or 1). In the event that any item is put nearer to canister, the ringer shall be gone ON to provide a caution to client and Continuously update the statuses in IOT. Motors and transfers are utilized to shutdown the entryway consequently it gets receptacle full signal of downpour and ultrasonic Sensor (Fig. 3).

We can decide the waste level by estimating the good ways from the head of the refuse container to the loss by sonar. The sonar that can be utilized in this model to furnish estimation from 2 cm to 400 cm with 3 mm exactness, which gives satisfactory for ordinary trash canisters, e.g., (URM) Ultrasonic Ranging Module (HC-SR04). It is basic to advance the battery utilization for accom-
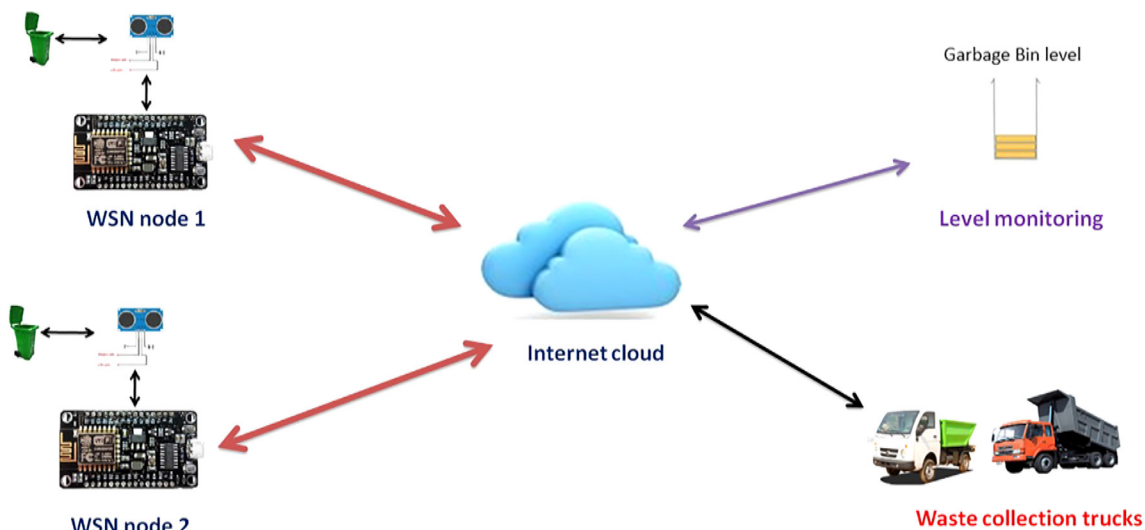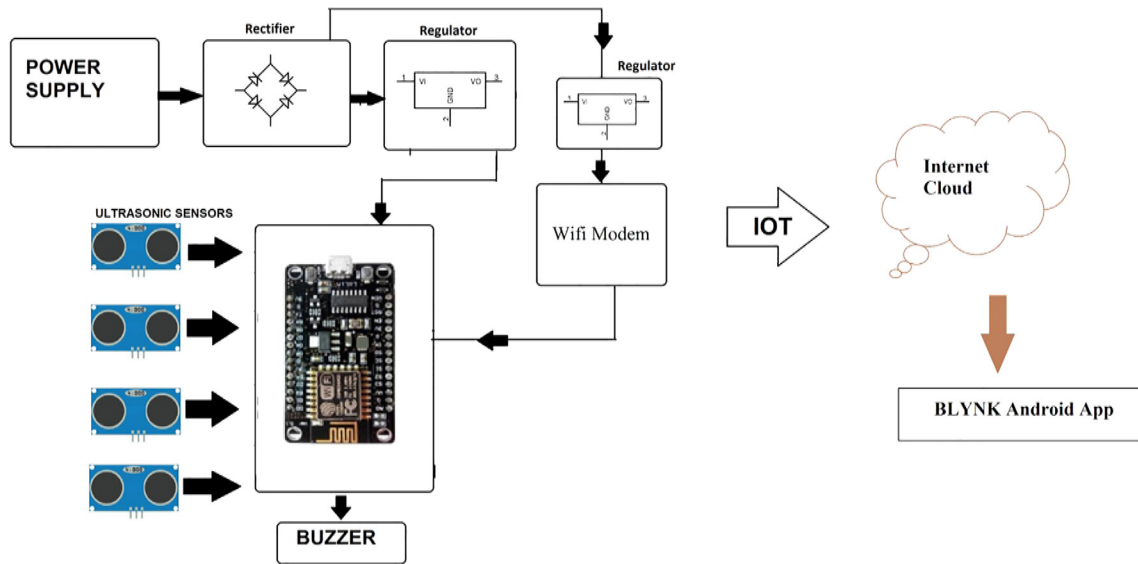

Fig. 1. Garbage collection using IoT and WSN.

S. Murugesan, S. Ramalingam and P. Kanimozhi

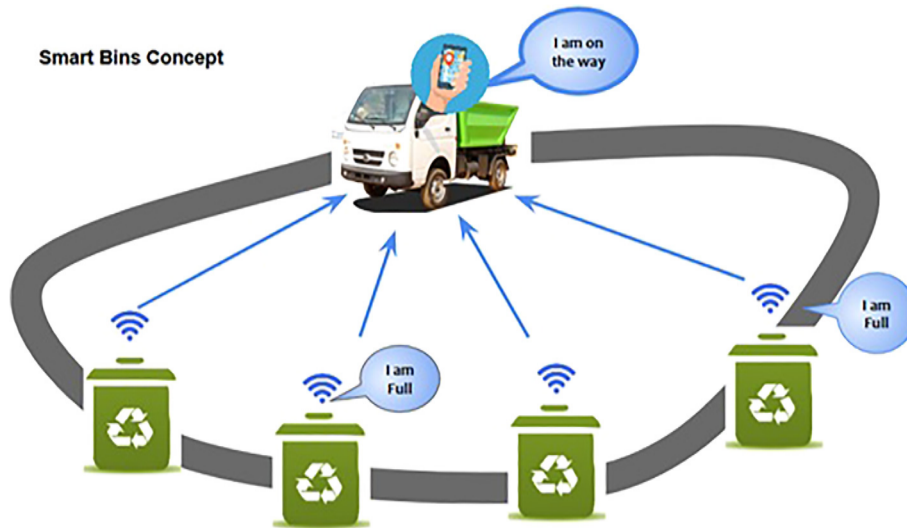**Fig. 2.** Circuit layout of proposed system.

Fig. 3. Proposed architecture.

plishing greater life expectancy of the gadgets. Detecting and information sending rates, and remote innovation utilized affect vitality utilization. Assortment and sending of information should be possible on more than one occasion in per day. The information gathered is sent to a far off worker by means of a remote connection.

For our innovation work, Wi-Fi is considered as a system. MySql is used for capacity of all information gathered by the sensors and the trucks. Data adjustment and sending: The goal way should be sent to the gatherers in justifiable organization. The ESP8266 Wi-Fi Module is an impartial SOC which coordinates TCP/IP convention stack that can provide any microcontroller access to your Wi-Fi arrangements. The ESP8266 is organized to do both facilitating an utility in all Wi-Fi organizing capacities from some other application processor. Each ESP8266 module has pre-modified with an AT order set firmware. The ESP8266 module is an excitingly financially savvy board with a colossal and ever growing network.

This module has an interesting adequate prepared to getting ready and potential of ability that lets in it to be integrated with the sensors and different utility express gadgets via its GPIOs with enhancement in increase and avoid stacking at some stage in run-time. Its serious extent of on-chip combine takes into account insignificant backyard hardware, inclusive of the front-end module, is intended to involve in negligible PCB territory. The ESP8266 bolsters APSD for VoIP purposes and Bluetooth concurrence interfaces, it incorporates a self-aligned RF permit to work under each and every single working condition, and no outer RF parts required.

4. Implementation and methodology

This efficient container system is exceptionally helpful in forestalling flood of dustbins and gathering of solid wastages near the dustbin. This models screen the containers and it gives insights regarding degree of the trash gathered from trash receptacles through sensors and live network. This system has used in esp8266 device gadgets with force gracefully. Ultrasonic sensors are set on the canisters layer to recognize trash outside the container. Infrared sensors are utilized to detect close to trash assuming any (Fig. 4).
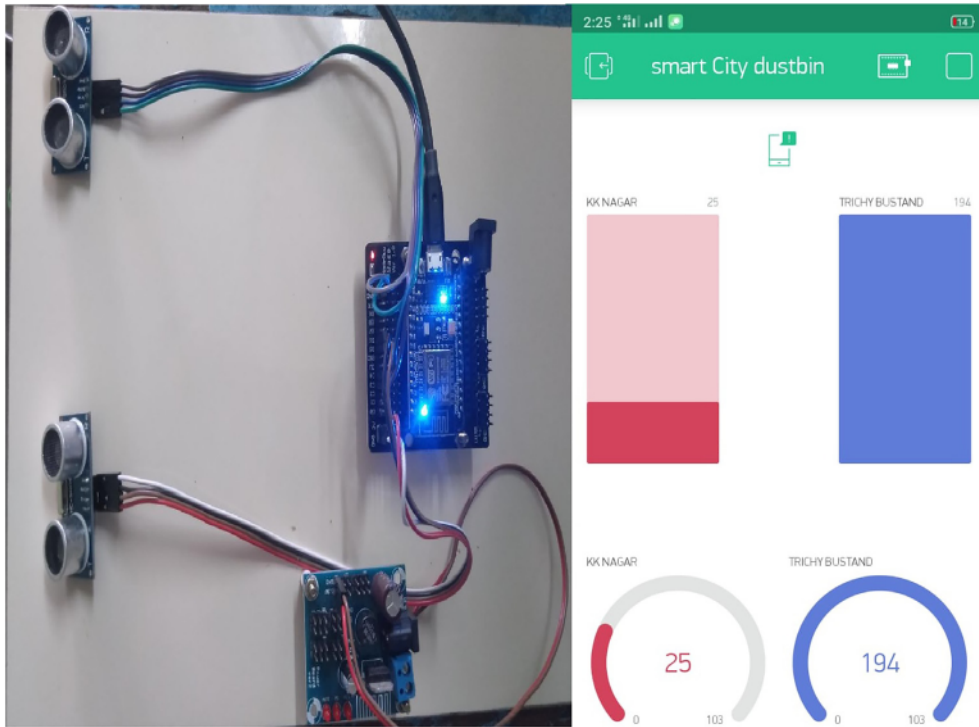
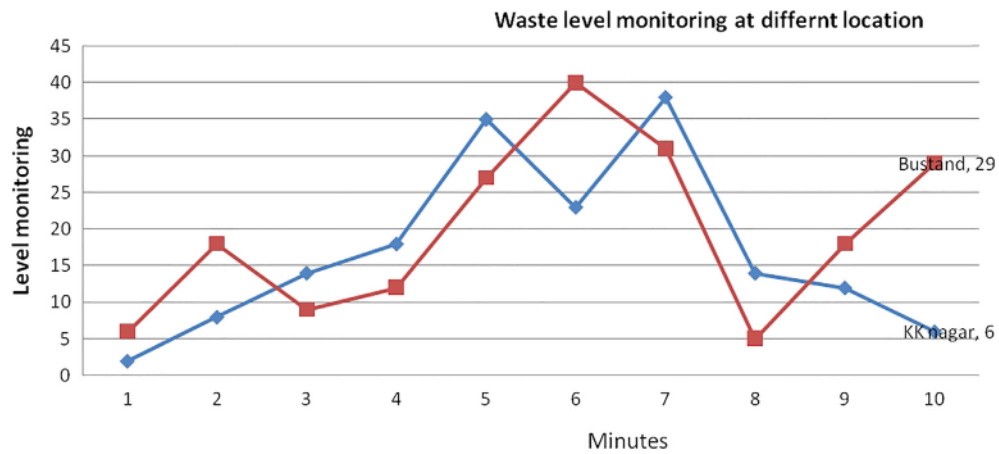**Fig. 4.** Prototype model and IoT BYNK Android Application Results.

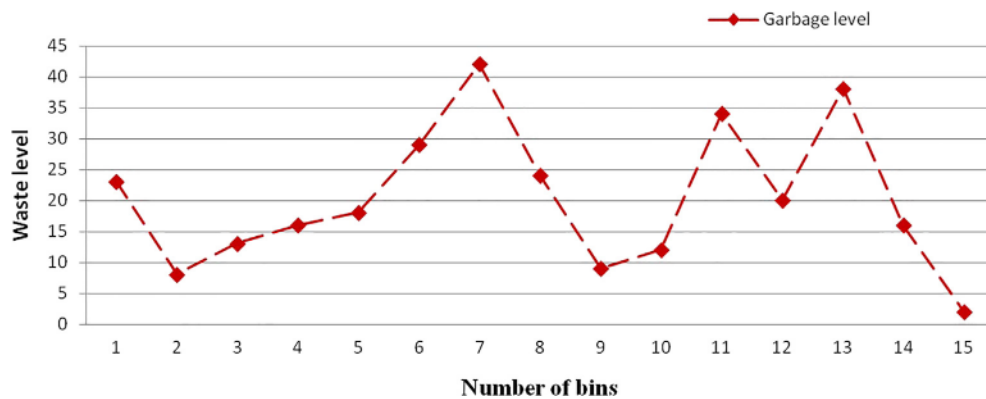**Fig. 5.** Different location garbage level monitoring using ultrasonic sensor.

Fig. 6. Simulation of result of garbage level monitoring at number of bins-15.

Fig. 5 shows the result of waste level monitoring system using internet of things and wireless sensor network. In this work two WSN nodes are designed and garbage level of different location is monitored using blynk android application. The variation of ultrasonic level is monitored in visualized graph. It indicate waste level of particular dustbin. Fig. 6 shows the result of garbage level monitoring with number of sensor is 15. The waste level is monitored by measuring of distance in dustbins.

5. Conclusion

A brilliant waste container is implemented in which waste variety is kept far away from observation and control. The waste container was manufactured using open source phase microcontrollers. The IoT stage used is blynk IoT android, and information is transmitted using IoT module. We provided an overview of the proposed architectures and simulation of our ongoing work towards intelligent solid waste management using a modelling methodology for wireless sensor networks. Real time and continuous monitoring of the bins waste level status ensures the citizen's safe and green environment and well being in a community. Using WSN Technology ensures MSW operations efficiency, despite having technical challenges such as internet connectivity, component security, power supply, and sensor error readings to be overcome before actual implementation. Further work would consider complete development of the WSN for the monitoring and collection of waste in real time. Real Geographic Information System (GIS) map of the area of case study will be used to identify nodes for the smart bins located. A truck will calculate cost per trip by calculating the distance from one node to the next. As the garbage level in the bins crossed the threshold, the corresponding authority will be told if it was found to be overlooked then the data will be forwarded to the higher authority to take the appropriate steps. So you can have a safe and hygienic atmosphere. This survey helps to recognise all possible methods of smart garbage management which can be introduced to clean up the area. Testing waste canisters for executive angle range is still growing and this undertaking's development will focus on streamlining asset allocation and knowledge analysis for emotionally positive network customer selection.

CRediT authorship contribution statement

S. Murugesan: Conceptualization, Methodology, Writing - review & editing. **S. Ramalingam:** Software, Writing - review & editing. **P. Kanimozhi:** Data curation, Writing - original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] P. Suresh, J. Vijay Daniel, R.H. Aswathy, Dr. V. Parthasarathy, A state of the art reviews on The Internet of Things (IOT International Conference on Science, Engineering and Management Research (ICSEMR 2014).

[2] Arkady Zaslavsky, Dimitrios Georgakopoulos, Internet of Things: Challenges and State-of-the-art Solutions in Internet-scale Sensor Information Management and Mobile Analytics 16th IEEE International Conference on Mobile Data Management, 2015.

[3] S. Murugesan, M.V. Suganyadevi, Hybrid renewable energy parameter monitoring and control of smart street light using IoT, Int. J. Sci. Technol. Res. (IJSTR) 8 (10) (2019) 645–651, ISSN: 2277-8616.

[4] S.S. Navghane, M.S. Killedar, Dr. V.M. Rohokale, IoT Based Garbage and Waste Collection Bin, May 2016.

[5] L.A. Guerrero, G. Maas, W. Hogland, Solid waste management challenges for cities in developing countries, J. Waste Manage, 2013.

[6] K. Monika, Rao Nikitha, S.B. Prapulla, G. Shobha, Smart dustbin-an efficient garbage monitoring system, 2016.

[7] Amr El-Mougy, Mohamed Ibnkahla, Lobna Hegazy, Software-defined wireless network architectures for the internet-of-things, in: 40th Annual IEEE Conference on Local Computer Networks, 2015, pp. 804–811.

[8] Javier G. Monroy, Javier Gonzalez, Carlos Sanchez, Monitoring household garbage odors in urban areas through distribution maps, Sens. IEEE (2014).

[9] Dr. Debmalya Bhattacharya, Miss Waikhom Reshmi, Miss Kiruthika Priya, Miss. Banu Priya, Analysis and design of an embedded environment informer for waste disposal cleaning, in: International Conference on Green Computing, Communication and Conservation of Energy, 2013.

[10] Vikrant Bhor, Pankaj Morajkar, Maheshwar Gurav, Dishant Pandya, Smart garbage management system, Int. J. Eng. Res. Technol. (IJERT) 4(03) (March 2015) ISSN:2278-0181 IJERTV4IS031175.

[11] Insung Hong, Sunghoi Park, Beomseok Lee, Jaekeun Lee, DaebeomJeong, Sehyun Park, IoT-based smart garbagebsystem for efficient food waste management. Sci. World J. 2014 (2014), Article ID 646953.

[12] Chaitanya More, Darshan Mestry, Parag Kedia, Reshma, Efficient garbage collection using Wsn, Int. J. Res. Eng. Technol. eISSN: 2319 -1163- pISSN: 2321-7308., Volume: 05 Issue: 01- Jan-2016.

Further Reading

[1] Theodoros, Anagno stopoulos, Arkady. Zaslavsky, Alexey Medvedev, Sergei Khoruzhnicov, "Top–k query based dynamic scheduling for IOT enabled Smart City Waste Collection" by. 16th IEEE International Conference on Mobile Data Management, 2015.

[2] Akshay Bandal, Pranay Nate, Rohan Manakar, Rahul Powar, Smart Wi-Fi dustbin system, Int. J. Adv. Res., Ideas Innov. Technol., 2016.

[3] Michael Batty, Kay Axhausen et al., Smart cities of the future, ISSN 1467-1298, Paper 188 - Oct 12.

[4] Narayan Sharma, Smart bin implemented for smart city, Int. J. Sci. Eng. Res. (sep-2015).

[5] Alexey Medvedev, Petr Fedchenkov, Arkady Zaslavsky, Theodoros, Anagnostopoulos Sergey Khoruzhnikov, Waste Management as an IoT-Enabled Service in Smart Cities.

[6] H. Kasliwal Manasi, B. Suryawanshi Smitkumar, A novel approach to garbage management using internet of things for smart cities.

[7] S. Thakker, R. Narayanamoorthi, Smart and wireless waste management, Innovations in Information, Embedded and Communication Systems (ICIIECS), 2015 International Conference on, Coimbatore, 2015.

[8] Parkash, Prabu V, IoT based waste management for smart city, Int. J. Innov. Res. Comput. Commun. Eng. 4 (Feb 2016) 1267–1273.

[9] B.K. Priya, T. Lavanya, V. Samyukta Reddy, Yarlagadda Pravallika, Bin That Think's, Int. J. Sci. Technol. 3 (June 2015) 218-223.

[10] Sean W. Pritchard, Gerhard P. Hancke, A.M. Abu-Mahfouz, Security in software-defined wireless sensor networks: threats, challenges and potential solutions, in: IEEE 15th International Conference of Industrial Informatics, 24-26 July, Emden, Germany, pp. 168–173, 2017.

[11] H.I. Kobo, A.M. Abu-Mahfouz, G.P. Hancke, Fragmentation-based distributed control system for software defined wireless sensor networks, IEEE Trans. Ind. Inform. Press (2018), https://doi.org/10.1109/TII.2018.2821129.

[12] Emmanuel U. Ogbodo, David Dorrell, A.M. Abu-Mahfouz, Cognitive radio based sensor network in smart grid: architectures, applications and communication technologies, IEEE Access 5 (9) (2017) 19084–19098, https://doi.org/10.1109/ACCESS.2017.2749415.

[13] S.V. Kumar, T. Senthilkumaran, A. Krishna Kumar, Mahantesh Mathapati, Smart garbage monitoring and clearance system using Internet of Things, in: IEEE International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), 2017.

[14] M.A.B. Abdullah, N. MohdYusof, A.Z., Jidin, M.L., Rahim, S.Z., Abd Rahim, M.E., Muhammad Suandi, M.N., Mat Saad, M.F. Ghazali, Smart garbage monitoring system for waste management, MATEC Web of Conferences, 2017, 97.

[15] Gaikwad Prajakta , Jadhav Kalyani, Machale Snehal, Smart garbage collection system in residential area, IJRET: Int. J. Res. Eng. Technol. 2015, 4(3).