Implementation of Smart Trash Bins based on IoT in Smart Cities – Case Study in Madurai City

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Abstract- If the volume of solid waste production growing day by day, it is likely that it must be handled. Solid waste management will continue with smaller trash bins. Nowadays Sustainable cities are the most critical factors, solid waste management is an essential task in any smart community. Yet the bitter reality is that only the smaller garbage bin is not being tracked. First of all, it is important to track the overfilled dustbins and to collect the waste accordingly. The volume of waste in the garbage can be tracked using an ultrasonic sensor. Mosquito repellent is used to control insect invasion, pests in the trash bin, therefore waste collectors are not affected by any disease. The motion sensor is connected to detect human motion and the thrash can be opened by using it. The sensors are attached to the Arduino Uno board and the correct encoding data are obtained. The optimal route is eventually configured using GIS.

Keywords – Arduino Board, ,Internet of Things, Motion Sensor.

I. INTRODUCTION

Waste control (or recycling) is the operation used to handle waste from its origin to its final recycling. This covers the procurement, storage, care and recycling of waste, as well as control and enforcement of the waste management process. Internet of Things (IoT) refers to the idea of expanding Internet access beyond standard computing networks, such as personal computers and handheld devices, and to any number of typically "dumb" or non-internet-enabled physical devices and ordinary objects. Embedded with circuitry, Wireless access and other types of hardware (such as sensors), these machines can communicate and engage with others over the Wireless, and can be centrally tracked and controlled.

The expectation of this project is to solve the problem of garbage not being collected and to make it easier to monitor the trash. It also becomes an easy-to-use trashbin that can be used for all kinds of people. Cleaner can collect garbage when you get information that the trashbin is full, so it will save them time to do the garbage collection without going to the trashbin and checking it out. It can also help cleaner do other work and not focus on collecting garbage at any time. When the garbage is collected in a very smart and faster way, it can prevent the spread of bacteria. This project can also ensure that the complete garbage can be collected as soon as possible without allowing it to overflow. When the trash is not removed, it will have an effect on our attitudes and will also have an effect on odor emissions. This initiative will solve the problem posed by cleaning administrators. Another expectation for this project is the use of a new application or system called GSM to monitor the complete garbage. This project will become one of the projects that can help people to their convenience.

II. OBJECTIVES

- To detect the amount of solid waste generated in the trash bins and alert if the limit exceeds 90%.
- To control invasion of pests and animals in bins.
- To prepare optimized route for Effective Solid Waste Collection.

III. METHODOLOGY

First of all, the regions of higher solid waste generation has to be identified. Then the sensors have to be attached to the trash can. Mosquito repellants and solar panel will be fixed. Creation of Arduino code and convert the sensor data into function using Arduino. After fixing, the reflector should be fixed for safety purpose against traffic. Finally collection routes have to be optimized. Routes are monitored using GIS. The longer distances have been converted

to shorter distances in order to consume time. Using the above mentioned methodology, we obtained the successful result.

IV. RESEARCH AREA

In the Southern region of Tamil Nadu, Madurai is a major city. It is located on the banks of Vaigai. Madurai is a temple city and ancient inhabited city. The total area of the city is 144,99 Km^2. As per 2011 data, it has the population of 1470755. The city is provided with High Court Bench of Chennai.

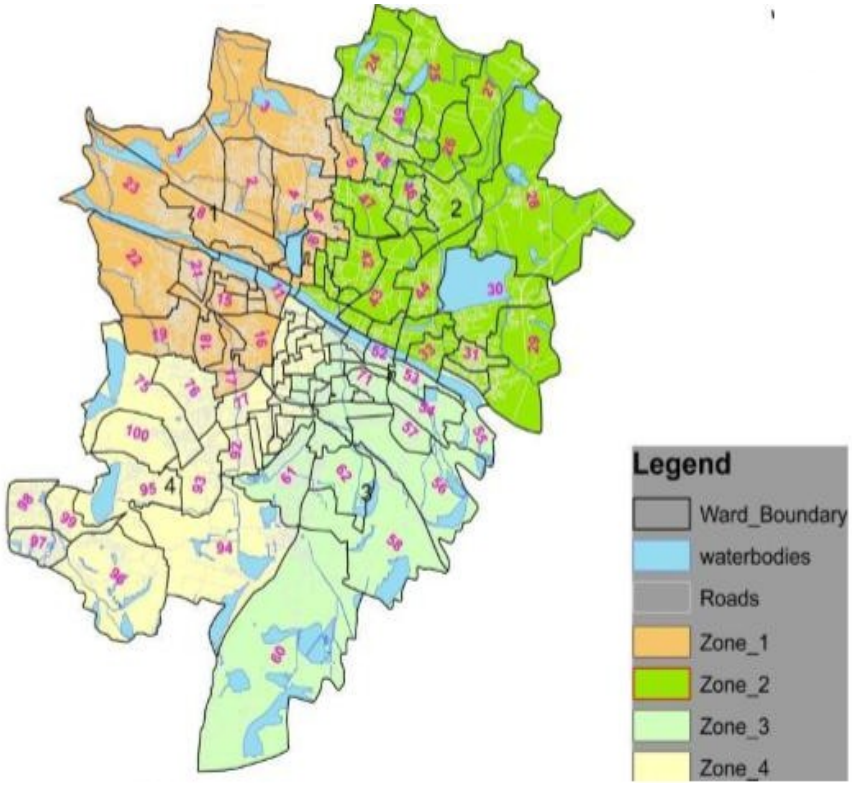

Figure 1. Study area

V. IoT BASED SOLID WASTE MANAGEMENT AND PROTOTYPE DEVELOPMENT

First, the ultrasonic sensor will measure the level of the garbage using sound waves. The sound waves are going to shoot from the Trigger part of the sensor. Instead the sound wave is mirrored back by the barrier and hits the Echo portion of the sensor. The period taken by the sound wave to pass from Trigger to Echo is estimated and analyzed as the gap. The Arduino is designed to translate the distance to a percentage. The garbage level will be shown in the LCD display connected to the Arduino. As the garbage amount exceeds 90%, the GSM module sends SMS to the Waste Collection Vehicle. When the waste is not collected within a short period, the GSM module can send an SMS warning to the Waste Monitoring Official that the waste has not yet been processed. Both links have been made utilizing jumper wires and three 9v batteries have been used for the power supply. The Pictorial representation is in below Figure.2

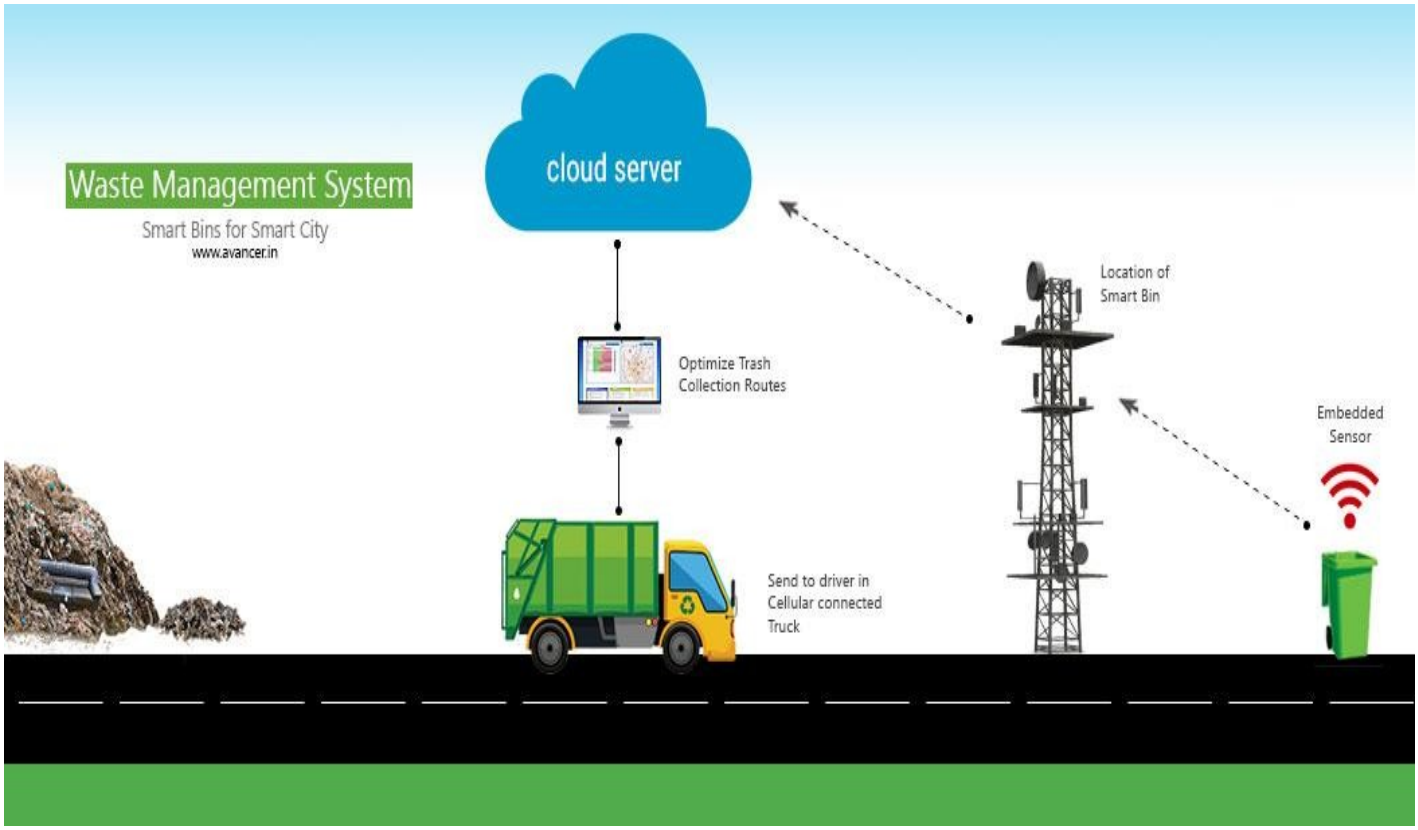

Figure 2. IoT based SVM procedure

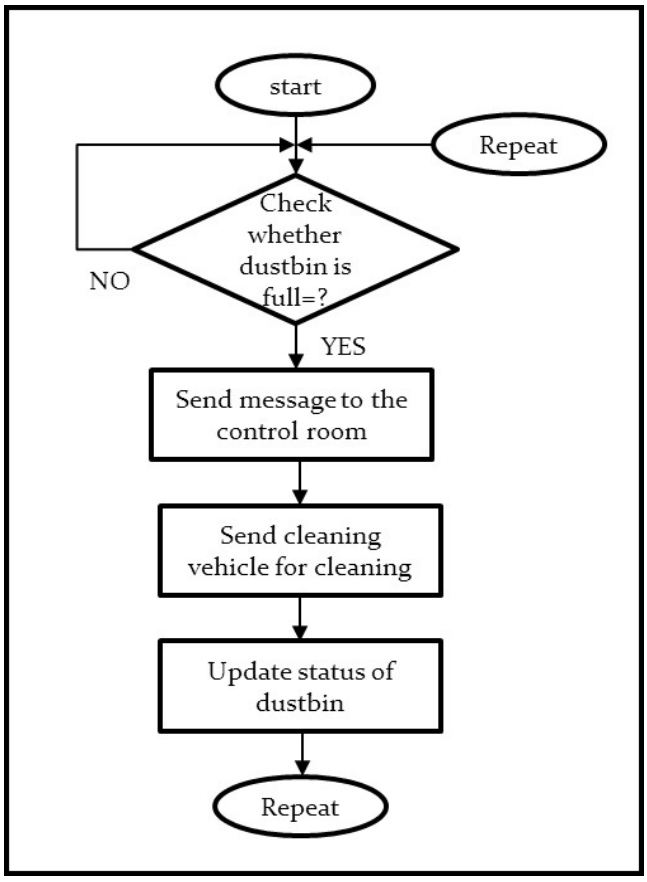

Figure 3. Flowchart of SVM

VI. SCOPE OF PROTOTYPE

Using the prototype developed, the monitoring of waste could be carried out in real time, tracking the amount of waste in-bin and preventing the excess of waste from the bins, thus preventing the pollution of the area. The bins, which need only be cleared completely. Unnecessary trips would be reduced, and fuel usage will be decreased.

VII. ROUTE OPTIMIZATION

The actual waste collection route from each ward was studied using TRUCKBOSS which is planned for the Madurai Vehicle Monitoring Program. The period required to extract waste from the current path and planned routes has been tabulated. The optimized route would help to minimize fuel usage by the shorter paths. Both wards would be quicker to navigate the new roads than the current path. If the vehicle name is pressed, it will highlight the route followed by the vehicle and display it in google maps.

VIII. RATIONALIZING THE EXISTING SYSTEM WITH ALTERNATIVES

The existing system has a number of limitations, such as going on long routes, collecting empty bins, unnecessary trips, etc., and the alternative measures to solve the existing SWMS problems are being considered. Consequently, many solutions have been attempted as examples. The established scenarios are presented below.

DO NOTHING SCENARIO

The actual program is analyzed in this case. Consideration is taken of the amount expended each day by utilizing established road. Measure the total distance to be reached from all wards to vellaikal dumping point and estimated number of journeys, too. The amount expended is measured according to those parameters.

Table -1 cost spend per day

Total distance covered for all wards	2179 Km
Bin Capacity to collect waste	1210 Kg
Average number of trips per day	438
Number of Trips per ward	4.5
Total no.of bins collected per day	876
Average waste collected per bin	790 Kg
Diesel charge per litre	Rs.71
Vehicle Mileage	4Km/litre
Total Cost spent per day for fuel	Rs1,54,270

. From the table above we can see that in the current situation the amount expended every day is about Rs.1.55lakhs which is Rs.5.54Crores every annum. The premium is just for the price of fuel itself. That is the latest network cost per unit per extracting solid waste and delivering it to waste disposal.

CHANGE IN ROUTE SCENARIO

In this case, the path would be modified from the current route to the planned route that we built using Google map and Truckboss for both wards. The gap between each ward and Solid Waste Disposal device was modified to a shorter path. Consequently, the fuel usage may be reduced to any degree.

The expense saved each month Rs.13,046/-, when the current path is transferred to the improved path. The reduced proportion of expenses relative to the current program is 8.45%, which is 4 lakhs per month.

Table -2 cost of change in route

Total distance covered for all wards	1989 Km
Number of Trips per ward per day	4
Total distance covered per day	7956 Km
Vehicle Mileage	4Km/litre
Total Diesel needed	1989 litre
Total Cost spent per day for fuel	Rs1,41,219
Cost saved	Rs.13,406

INTRODUCING IoT WITH EXISTING ROUTE SCENARIO

The system that was built in this scenario is applied to the bins. Hence, the container can only be carried to the Solid Waste Collection Plant when the bins are entirely loaded. Therefore, needless trips taken to track the bins would be stopped, contributing to a decrease in the amount of journeys. As the IoT-based module connects to the bins, the waste disposal fuel expenditures are saved about 11Lakhs a month. This is a 25 percent saving relative to the current device.

Table -3 cost of existing route

Total waste to be collected per day	700 tonnes
Bin Capacity to collect waste	1210 Kg
Number of bins to be collected per day	584
Number of Trips	292
Number of Trips per ward	3
Total distance to be travelled per day	6513 Km
Total diesel needed	1628 litre
Total cost per day per diesel	Rs.1,15,588
Cost saved by introducing IoT	Rs.38,677

INTRODUCING IoT AND CHANGE IN ROUTE SCENARIO

The IoT activated module is considered in this scenario and the waste collection is also carried out utilizing the optimized path. Therefore, only the fully loaded bins will be used and the path will also be altered which contributes to decreased fuel consumption.The expense saved every day is Rs.48,333/- which is about 15Lakhs a month and 1.7crores every annum when the current path is shifted to the improved path and IoT powered bins are used. The expense achieved in terms of productivity is 31.33 per cent. Thus, the best scenario is that IoT introduced bins with optimized route.

Table-4 cost spent on IoT and change in route

Total distance covered for all wards by new route	1989 Km
Number of Trips per day	3
Total distance to be travelled per day	5967 Km
Vehicle Mileage	4Km/litre
Number of Trips per ward	3
Total diesel needed	1492 litre
Total cost per day per diesel	Rs.1,05,932
Cost saved	Rs.48,333

COMPARISON OF DURATION AND DISTANCE DIFFERENCE BETWEEN EXISTING AND PROPOSED ROUTES

The current solid waste system in Madurai City is evaluated using the data gathered, the Truck boss device, and the solid waste collection plant through going through field visits. The distance between the Melamadai and Vellaikal was 12.6 km which has been shortened to 11 km in the proposed road. Graph 1 indicates the disparity in length relative to the current and planned routes for all 100 wards duration comparison between existing and proposed routes for solid waste collection.

The graph demonstrates in minutes the time gained when utilizing the new path as opposed to the current road. The overall time saved on Ward number:25 (Kannanendhal) was 7 minutes. And the least of these was around 2 minutes for Ward number:96 (Pambansamynagar).

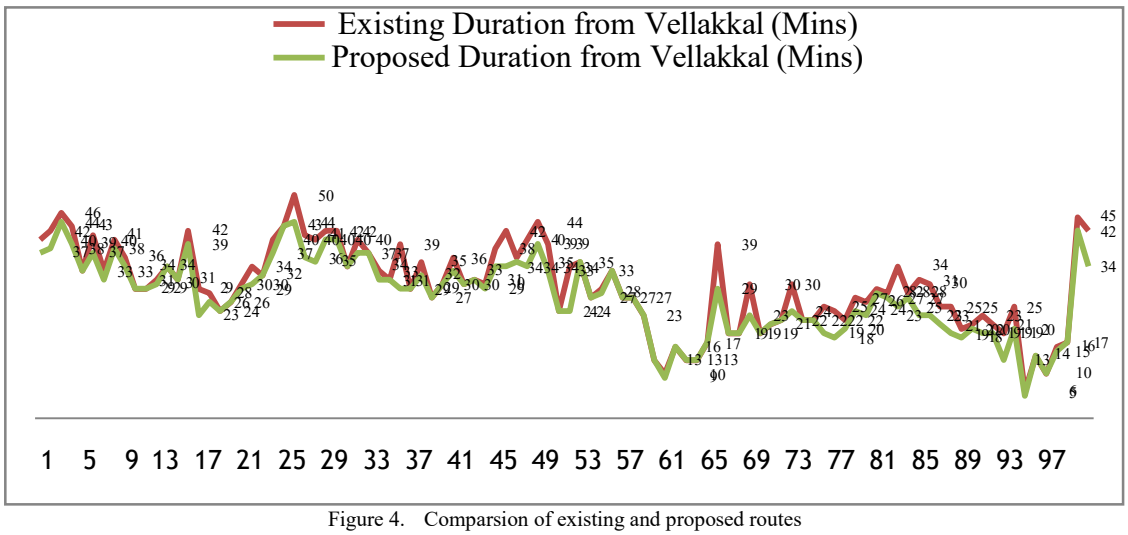

Figure 4. Comparsion of existing and proposed routes

IX .RESULTS AND DISCUSSIONS

This project focused exclusively on collecting and transporting solid waste management in the area of Madurai corporation. The data obtained focuses on solid waste disposal at ward point. The scheme can be expanded by estimating the operational costs and the solid waste collection network repair costs. In addition, shortest path and remote sensing dependent image analysis based on GIS and GPS can be used for collection monitoring of solid waste management. To this issue, cloud storage and web page design may be applied. Using the Truckboss software and Google maps, the current solid waste management collection network in Madurai Smart City has been customized based on route frequency. A working prototype has been built at Madurai Smart City as proof of concept for the IoT Enabled Solid Waste collection method.

REFERENCES

[1] Kellow Pardini , Joel J. P. C. Rodrigues , Sergei A. Kozlov , Neeraj Kumar and Vasco Furtado,"IoT-Based Solid Waste Management Solutions:A Survey", 1 January 2019, jsan8010005

[2] Nachalida Yukalang , Beverley Clarke and Kirstin Ross, "Solid Waste Management Solutions for a Rapidly Urbanizing Area in Thailand: Recommendations Based on Stakeholder Input", 21 June 2018, 1302

[3] Ahsan, M. Alamgir, M. M. El-Sergany, S. Shams,M. K. Rowshon, and N. N. Nik Daud, "Assessment of Municipal Solid Waste Management System in a Developing Country",27 March 2014, Volume 2014, Article ID 561935

[4] Rajkumar Joshi & Sirajuddin Ahmed, "Status and challenges of municipal solid waste management in India: A review", ISSN: 2331-1843, 19 Feb 2016.

[5] Norfadzlia Mohd Yusof, Mohd Faizal Zulkifli, Nor Yusma Amira Mohd Yusof, Azziana Afififie Azman, "Smart Waste Bin with Real-Time Monitoring System",ISSN725-729

[6] Ms. Rupa, Ms. Rajni Kumari, Ms. Nisha Bhagchandani,Mr. Ashish Mathur, "Smart Garbage Management System Using Internet of Things (IOT) For Urban Areas",Vol. 08, Issue 5 (May. 2018), ISSN (e): 2250-3021, ISSN (p): 2278-8719

[7] Dhaval Patel, Aditya Kulkarni, Hrushikesh Udar, Sachin Sharma, "Dustbins for Smart Cities", ISSN: 2456 – 6470, Volume: 3,Issue: 3,Mar-Apr 2019

[8] Shilan Abdullah Hassan Noor Ghazi M. Jameel,Boran Şekeroğlu, "Smart Solid Waste Monitoring and Collection System", Volume 6, Issue 10, October 2016 ISSN: 2277 128X

[9] Nimisha Singh, Prajakta Wagh, Neha Sameer Shahare, "A Review Paper on Garbage Level Monitoring System for Smart Cities" ,Vol. 6, Issue 10, October 2017 ,ISSN 2319 5940

[10] Norfadzlia Mohd Yusof1,*, Aiman Zakwan Jidin1 , and Muhammad Izzat Rahim,"Smart Garbage Monitoring System for Waste Management",ISSN 01098

[11] S.S. Navghane, M.S. Killedar, Dr.V.M. Rohokale, "IoT Based Garbage and Waste Collection Bin", May2016.

[12] Ghose,M.K.,Dikshit,A.K.,Sharma,S.K. "AGIS based transportation model for solid waste disposal– A case study on A sansol municipality .Journal of Waste Management".Oct 2017

[13] Guerrero, L.A., Maas, G., Hogland, W.: "Solid waste management challenges for cities in developing countries,Journal of Waste Management."Jan 2016

[14] Alexey Medvedev, Petr Fedchenkov, ArkadyZaslavsky, Theodoros, AnagnostopoulosSergeyKhoruzhnikov, "Waste Management as an IoT- Enabled Service in Smart Cities".

[15] KasliwalManasi H., SuryawanshiSmitkumar B, " A Novel Approach to Garbage Management Using Internet of Things for Smart Cities" .Mar 2015

[16] Monika K A, Nikitha Rao, Prapulla S B, Shobha G, "Smart Dustbin-AnEfficient Garbage Monitoring System". May 2018

[17] Africa, J. Aguilar, C. Lim Jr, P. Pacheco, and S.Rodrin "Automated Aquaculture System that Regulates Ph, Temperature and Ammonia." 9th International Conference on Humanoid, Nanotechnology, InformationTechnology, Communication and Control, Environment,and Management (HNICEM). 2017.

[18] R.C. Gustilo, and E. Dadios, "Machine vision support system for monitoring water quality in a small scale tiger prawn aquaculture." Journal of Advanced Computational Intelligence and Intelligent Informatics. Vol. 20, No. 1, pp. 111-116, 2016.

[19] R.C. Gustilo, and E. Dadios, "Behavioural response analysis using vision engineering (BRAVENet)."Journal of Advanced Computational Intelligence and Intelligent Informatics. Vol. 21, No. 2, pp. 211-220, 2017.

[20] D. Ahamad, M. Akhtar, and S. Hameed, "A Review and Analysis of Big Data and MapReduce." International Journal of Advanced Trends in Computer Science and Engineering (IJATCSE). Vol. 8, No. 1,pp. 1-3, 2019