Municipal Waste Collection and Management in Smart Cities : A Survey

Vijaya Guru Kamakshi. K[1], Shwetha. C. N. T[1], Swathi. G[1], Madhumathi. R[2]

[1]Student, Department of Computer Science and Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India

[2]Assistant Professor, Department of Computer Science and Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India

ABSTRACT

In recent years, due to the increase in population, there are various challenges that are arising in this entire world. Waste management is one among those problems which has to be addressed immediately for a healthy and sustainable environment. It is not only an issue faced by the government but also by every individual since improper management of waste causes environmental pollution and health problems. It is necessary for the development of a smart and reliable solution to overcome this situation. The Internet of Things(IoT) along with Cloud computing could pave a way for developing a Smart Waste Management model. An analysis of existing waste management solutions is done in this paper. The aim of this paper is to discuss various factors involved in smart waste management and to describe an IoT based smart bin model along with route optimization . Finally, the advantages in implementing the proposed method and few ideas of how to improve the system in future is discussed.

Keywords: Smart City, Smart Dustbin, Route Optimization

I. INTRODUCTION

Environmental issues are one of the major problems that every nation is facing. One of such environmental issues is waste management. The world waste bank states that the waste generated by cities over the world is about 2.01 billion tonnes in 2016 and warns that it would increase to 3.06 billion tonnes in 2050 if this activity is not given importance. So the current issue is to provide a smart and ideal solution for waste management. This is one of the major concerns, when it comes to a smart city development model.

Smart city is a scheme in which cities integrate information and communication technologies with IoT to use the available resources and services effectively[13][16]. The aim   of a smart city mission is to provide a clean, sustainable environment by the application of 'smart' solutions such as IoT, sensors, cameras, wireless devices, fast networks like 5G, cloud computing and big data analytics[3][15]. Smart city comprises smart traffic, smart lighting, smart cars, smart home, smart road, smart disaster management, smart waste management, smart governance etc.. The

city has malls, hospitals, houses, commercial areas, marketplaces, and institutions which are some of the sources of waste. Smart waste Management is a process of collection, segregation, and managing the enormous waste generated on a daily basis by using emerging technologies.

Social awareness is being created among people which helps them know how important waste management is, how it would help the nation to overcome this environmental issue on waste and also to cooperate with the technology implemented[2][18]. Along with the awareness created a smart waste management could reduce the cost, and provide an efficient collection and segregation mechanism. With this technology a proper maintenance and intimation can be done. Managing the waste is a great challenge (especially during the COVID-19 pandemic situation) mainly for city administration and waste management organizations [4][8]. There are various methodologies for possibly solving this problem which will be discussed in this paper.

In Section 2 (**Need for Waste Management**), a brief description about the importance and need for waste management is given. In Section 3 (**Related Works**) literature review is done on smart waste management. In section 4 (**Factors of Waste Management**), economic aspects and people's responsibilities are considered and discussed. In section 5 (**Proposed Model)**, a reliable model is proposed and it's advantages are discussed. Finally, in Section 6 (**Conclusion**) conclusion and future scopes are put forth.

II. NEED FOR WASTE MANAGEMENT

Waste has increased in a rapid manner in recent years, so a proper framework for managing the waste generated from various fields has to be maintained and managed in an appropriate way to provide a healthy society. In order to provide a better environment a smart city paves a way and one of the smart city concepts is smart waste management. So in the fourth coming era, smart waste management would be needed to provide a safe and sustainable environment. Due to improper waste collection systems and lack of collection schedule information, the bin collection and transport practices are negatively influenced[10]. So it is also important to consider a method which provides a best way for collecting the waste which would save other resources like fuel and time. During a pandemic situation like Covid-19 waste management is important which helps in maintaining a clean environment and would reduce the spread of disease[4][8].

III. RELATED WORKS

A smart city is to incorporate every activity over the city by emerging technologies, Iot, and machine learning. Each bin around the cities would have a RFID tagging system which identifies it uniquely[3][17]. The level in the bin is measured by using an ultrasonic sensor and the entire system is powered by using a solar[3][7][16]. There would be a threshold value set for the level in the bin, when the threshold reached it is informed to the server[7][12][16].Then the data received from various bins in the server is analysed through the machine learning method like KNN which matches the nearest bins and gives an optimal path[1][14][16]. At the municipality level the non-biodegradable waste can be segregated by placing the waste in a conveyor belt and by using inductive proximity sensor to separate metal,a capacitive proximity sensor to separate wood and plastic and the remaining cannot be segregated, once this waste reaches threshold level of a particular type, then municipal corporation is sent an alert and biodegradable waste is sent to a compost pit and other types of waste are treated appropriately as shown in figure 1. The bins can also be designed in such a way that there is no foul smell made by the organic waste

by making it properly aerated and it being a rotary drum so that it mixes the organic waste properly[6][9].

CloudSWAM is a Cloud-Based Smart Waste Management methodology in which real-time tracking of waste is enabled. Here the characteristics of the waste like type and quantity , location of bins are uploaded in the cloud automatically and route optimization algorithm is available for the bin collectors[10][12].
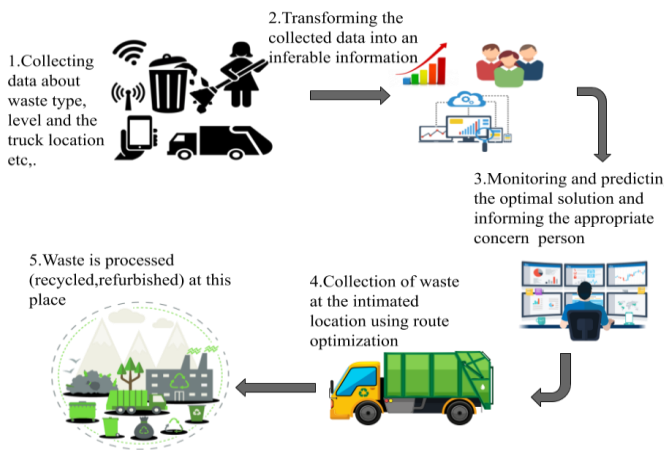
Fig. 1. The concept of waste management using IoT and Cloud

E-waste is one of the types of waste which should be treated separately. E-waste is the end of electronic equipment which are generally the hardware parts of those equipment. Most e-waste items are not properly separated from other waste, not treated properly and dumped into the land which leads to many human diseases and also affects aquatic life near the land. Recycling the e-waste is an environmentally friendly approach which also paves the way for sustainability. The lifecycle of Electrical and Electronic Equipments(EEE) is categorized into 3 levels in India, such as Production of EEE , UEEE(Used EEE) generation and WEEE re-processing. Virtualization, energy saving gadgets, 3 R's ,testing and using the parts, etc could be done in order to reduce the production of E-waste[5][7][9].

For sustainability, it is necessary for the CPS (Cyber Physical System) in which multi-disciplinary components or approaches are interfaced ,to be integrated with ICT(Information Communication Technology) and IoT[19].

IV. FACTORS OF WASTE MANAGEMENT

A. Economical aspects in concern to waste management

Urbanisation and the ability of people to buy things to make them update to the new technologies which are changing rapidly in recent years, leads to an increase in generation of waste. So we need to manage the waste generated. Countries which are financially high and technologically developed, turn their garbage into money. Circular economy increases economic, social and environmental values by extension of the life-cycle of products by using a production and consumption model based on reusing, refurbishing, remanufacturing, recycling and sharing of materials[3][11]. Waste management has become a booming industry in developing countries. They turn the waste generated into useful materials and earn profit and also contribute to the nation's economy. Suez Environment is one of the largest waste management companies in the world. The company generated 20.17 billion U.S. dollars in 2019. More and more companies are making wealth from waste and saving the environment from devastation.

B. Role of People, Data and Technology in Smart Cities

In order to use the resources wisely and make it available for the future generations , it is necessary to take relevant steps and make use of the technology[20]. Smart cities aim to achieve this objective and also to develop a standard living. In this section, the role of three main components: data, people and technology in a smart city is discussed[3]. For providing smart solutions, collection appropriate

data is necessary. When smart cities are considered, traffic data, pollution data, waste production data, weather data and so on are to be collected. When specifically concerned with the smart waste management system, data which includes the type of waste(like organic, plastic, paper, metal,e-waste or glass), amount of waste produced in a specific area, location of the waste bin ,location of waste bank, recycling spot ,etc., are to be collected and uploaded in the cloud[10]. Data can be grouped into two types, 1) data generated by the citizens and 2) data collected using sensing technologies. People who are the users of smart city applications, also provide citizen-generated data which is also included in the database using mobile devices and smartphones. Regarding smart cities, data related to people like the citizen's behavior, tracing social relations, residents behavior and so on are taken into consideration[3].

Reduce ,Reuse and Recycle (3R) should be followed by every individual which is one of the best waste management practices.This also suits for e-waste management[5][18]. While coming to the technology, which is the major component, Iot including sensors, cloud computing, data analytics,RFID,GPS, user interface are all involved in the model[3][7].

V. PROPOSED MODEL

A. Smart Bin

A smart dustbin design that shall be proposed contains an ultrasonic sensor to measure the level, a compression mechanism to compress the waste after being thrown inside and so the space is completely utilized, a communication device like zigbee or a wifi module is used to transmit information and solar by which the complete system is powered is protected from environmental damage by a polycarbonate shield.

B. Route Optimization

For route optimization by which the bin collectors will easily identify the shortest path is done using a combination of A* algorithm and KNN using the parameters like traffic and the dustbins filled. Using this method, usage of fuel and time will be reduced.

C. Cloud Information

An user interface is created for real-time tracking of waste information through the data on the cloud easily. This could be useful for the stakeholders and the municipal corporation in knowing the waste generation trends in particular areas, spatial distribution of waste, increasing the generation of energy from waste and so on. In figure 2 , the architecture of the proposed model is shown.
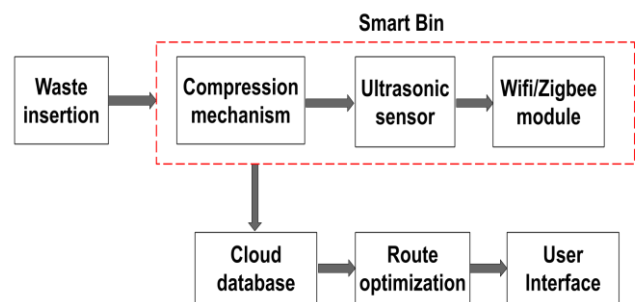

Fig. 2. Block diagram

D. Advantages of Smart Waste Management

Smart waste management reduces pollution and helps for the improvement of a green and clean environment. Route optimization saves time, fuel and maintenance costs upto 30% and paves the way for sustainable development. The frequent waste collection can be eliminated that reduces the cost for it. Since the data is stored in the cloud, it can be easily accessed by concerned persons whenever needed.

VI. CONCLUSION

The study was done on Smart waste management systems which have been focused on the system of smart dustbin and, 3R's practice, raising awareness among people,waste classification, and modern practices with modern technology. As a future scope , the bins should act like a waste bank, on inserting a smart card or by using a QR code, the bin opens and the user can throw the trash. The weight of the trash is taken into the user account and a certain amount for the trash is deposited into their bank account. This would be motivating for the public to dispose of the waste in a proper way and cooperate with the Municipal cooperation. The municipality could generate money with the waste collected by recycling the waste like paper,plastic ,refurbishing the electric waste, glass, and making manure or gas out of organic waste.

VII. REFERENCES

[1]. Abhimanyu Singh, Pankhuri Aggarwal, Rahul Arora (2016)."IoT based Waste Collection System using Infrared Sensors",IEEE 5th International Conference on Reliability, Infocom Technologies and Optimization.

[2]. Anurima Mukherjee Basu, Shruti Punjabi (2020)."Participation in solid waste management: Lessons from the Advanced Locality Management (ALM) programme of Mumbai",Journal of Urban Management Volume 9, Issue 1, March 2020

[3]. Behzad Esmaeillian, Kemper Lewis, Ben Wang, Fabio Duarte, Carlo Ratti, Sara Behdad(2018)."The future of waste management in smart and sustainable cities:A review and concept paper",Waste Management Volume 81, November 2018, Pages 177-195.Elsevier.

[4]. Bhargavi N. Kulkar, Anantharama.V (2020)."Repercussions of COVID-19 pandemic on municipal solid waste management: Challenges and opportunities",Science of The Total Environment Volume 743.

[5]. Biswajit Debnath, Reshma Roychoudhuri, Sadhan K Ghosh(2016)."E-Waste Management – A Potential Route to Green Computing", Procedia Environmental Sciences Volume 35, 2016

[6]. Collins O. Ugwu, Chigbogu G. Ozoegwu, Paul A.Ozor(2020)."Solid waste qualification and characterization in university of Nigeria ,Nsukka Campus and recommendations for sustainable management",Heliyon, Volume 6 Issue 6

[7]. Gopal Krishna Shyam, Sunilkumar S. Manvi, Priyanka Bharti(2017)."Smart Waste Management using Internet -of-Things (IoT)", IEEE

[8]. HariBhaktaSharma,KumarRajaVanapalli,Shankar CheelaVR,VedPrakashRanjan,AmitKumarJaglan, Brajesh Dubey,SudhaGoel,JayantaBhattacharya(2020)."C hallenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic",Resources, Conservation and Recycling, Volume 162.

[9]. Jouhara.H, Czajczynska.D, Ghazal.H, Krzyzynska.R, Anguilano.L,Reynolds.A.J,Spencer.N(2017)."Mu nicipal waste management systems for domestic use",Energy , Volume 139, 15 November 2017, Pages 485-506.

[10]. Mohammad Aazam, Marc St-Hilaire, Chung-Horng Lung, Ioannis Lambadaris(2016)."Cloud-based Smart Waste Management for Smart Cities",IEEE 21st International Workshop on Computer Aided Modelling and Design of Communication Links and Networks.

[11]. Mirela Ionela Acelean , Andreea Claudia Serban, Marta Christina Suci, Teodora Ioana Bitoi(2019)."The Management of Municipal Waste through Circular Economy in the Context of Smart Cities Development",IEEE Access, vol. 7.

[12]. Muhammad Zar Mohd Zaid Harith, Mohammad Asif Hossain, Ismail Ahmedy,Rafidah Md Noor, Mohd Yamani Idna Idris, and Tey Kok Soon(2020)."Prototype Development of Iot based

smart waste management system for smart city",Sustainable & Integrated Engineering International Conference.

[13].Popescu .D.E, Bungau .C, Prada .M, Domuta.C,Bungau.S,Tit.D.M(2020)."Waste management strategy at a public university in smart city context",Journal of environmental protection and ecology.

[14].Shabir Ahmad, Imran, Faisal Jamil,Naeem Iqbal, and Dohyeun Kim(2020)."Optimal Route Recommendation for Waste Carrier Vehicles for Efficient Waste Collection:A Step Forward Towards Sustainable Cities",IEEE vol. 8.

[15].Shanzhi Chen, Hui Xu, Dake Liu, Bo Hu, and Hucheng Wang(2014)."A Vision of IoT: Applications, Challenges,and Opportunities With China Perspective",IEEE Internet of Things Journal, vol. 1 2014

[16].Sonali Dubey, Pushpa Singh, Piyush Yadav, Krishna Kant Singh(2020)."Household Waste Management System using IoT and Machine Learning",Procedia Computer Science,Volume 167, 2020, Pages 1950-1959

[17].Taha darwassh hanway hussein,kamal hassan jihad,ehab hashim shaker(2019)."New Smart waste management system using RF technology",International Journal of Civil Engineering and Technology.

[18].Vipina Valsan, Govid Sreekumar, Vignesh Chekkichalil, Abhimanyu Sunil Kumar(2020)."Effects of Service-Learning Education Among Engineering Undergraduates:A Scientific Perspective On Sustainable Waste Management",Procedia Computer Science Volume 172, Pages 770-776

[19].Yun Arifatul Fatimah , Andi Widianto , Muhtar Hanafi(2020)."Cyber-physical System Enabled in Sustainable Waste Management 4.0: A Smart Waste Collection System for Indonesian Semi-Urban Cities",Procedia Manufacturing 43:535-542

[20].Zhihu Yang and Dan Li (2020)."WasNet: A Neural Network-Based Garbage Collection Management System",IEEE Access, vol. 8, pp. 103984-103993.

Cite this article as :