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DESIGN A SMART WASTE MANAGEMENT SYSTEM USING IOT

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ABSTRACT
Through the waste management system, waste collection plays an essential part. This waste management is an important problem, particularly for developing countries. Due to its exceptional population growth and expansion, waste management is a difficulty in developing countries like India. Studies related to waste management indicate that managing the growing amount of waste produced in urban areas is challenging. The incorrect collection and disposal of waste materials is the cause of the problems with handling waste. The lack of a proper waste management strategy leads to issues like waste overflow, which seriously damages the environment. An epidemic of different diseases is caused by a polluted surroundings. The Internet of Things (IoT) is a new technology that has the potential to improving the modernize processes. In this work, a smart waste Management system using Internet of Things (IoT) is presented. In this approach, two levels of dustbin checking is performed. If the dust bin reaches 76% then it will send the message to municipality then municipality may keep the dustbin the queue to collect. If the dustbin reaches 95% it will send an emergency message to collect the dustbin waste immediately and the municipality sends their vehicle prior to that particular location.

Keywords: Waste Management, Garbage, Waste Collection and Internet of Things (IoT).

I. INTRODUCTION
India is one of the most populated country in which one sixth population of the world resides. As the population is high, a large amount of waste are produced from houses and industries. Sometimes waste is decomposed and produce unhygienic gases which pollute the environment[1]. A huge amount of waste is produced from smart cities.Mumbai produce a huge waste amongst 46 other cities. It generates 11,000 tons of waste per day.

To manage this waste, dustbins are placed in different areas of a city but mainly they overflows and remains unattended. The municipal corporation doesn't get real time information about overflow of dustbins [2].

Mostly, a city collects data through Smart devices and sensors and the communication for transmitting this data can be wired or wireless. There are several problems in a smart city which are needed to be addressed. IoT finds a smart way to deal with these problems. Cleanliness is a major issue to be handled in a city. The amount of daily waste is increasing day by day due to increase in Global population [3]. This waste dumped in any dumping areas by municipal people. But sometimes when waste is not dumped properly then it creates some bad impact on health and the surrounding environment. The improper way of dumping waste creates environmental pollution and all living things get affected. Environment pollution creates a lot of diseases. An overflow of dustbin looks very ugly and it creates a bad smell in the environment and air pollution occurs. The existing dustbins are not smart as a result of which their status can't be estimated. So, most of the times dust overflow occurs and the area surrounded gets unhygienic [4].

Pollution prevention is a process that involves the reduction of acquired or disposed toxic and hazardous materials. Through enforcing sustainable practices for pollution prevention and recycling, it is then possible to reduce or eliminate the use and acquisition of topic materials. Diverting waste materials after collection is a very costly process. In addition, source separation at sorting facilities and tracking substance diversion involve complex processes [5]. This prompted many waste management companies to perform source separation on site in an attempt to reduce costs associated with sorting substances after disposal.

The environment is rapidly changing due to waste accumulation, and carbon emissions are increasing. Waste paper, fabrics, kitchen cabinet waste, broken glass and ceramics, waste vehicles, waste plastic products, waste

electrical appliances, and waste coal ash are the most prevalent types of urban domestic waste. The output of household waste has grown quickly along with the development of living standards and the rapid increase of life's pace, but the percentage of inorganic materials like slag and coal ash in the waste has been gradually decreasing. The percentage of recyclables, organic materials, and the amount of combustibles in the waste is continually expanding [6].

Any country has to take Solid waste management (SWM) into consideration. Waste produced by urban living is known as municipal solid waste, due to the rapid population increase, this waste has expanded significantly in quantity. The Solid waste collection (SWC) has emerged as one of the most difficult SWM operational procedures. Waste is collected and transported as part of SWC. Waste money and operational costs are increased by inefficient solid waste collection and transportation. Solid waste management is one of major aspect which has to be considered in terms of making urban area environment healthier. The common dustbins placed by the municipal corporation are leading no. of health, environmental and social issues. Various causes are there like improper dustbin placement in city, improper system of collecting waste by City Corporation, and more specifically people are not aware enough to use dustbins in proper way[7].

In many developing countries, the focus of municipal SWM has also been on clearing out waste from households and commercial buildings, with little consideration was done with the waste after it was removed. Garbage collected from houses is disposed of landfills or dumpsites in most developing countries; most of these sites are expected to fill up in a decade [8]. The organic waste from vegetables and fruits market is biodegradable quickly and releases bad odor. Rats, flies and other pests are attracted due to discharge of organic waste. These cause diseases such as typhoid and cholera, and can also cause diarrhea, eye problems, skin diseases etc. Due to improper disposal of waste in the environment many diseases are attracted due to the presence of many insects like flies, mosquitoes. Better SWM (Solid Waste Management) with improved waste collection improves the health of all citizens. The solid waste management is very difficult in developing countries as there is no proper management system for collection of waste and recycling[9].

Municipal Solid Waste (MSW) is composed differently based on the local economy and the consumption patterns of the inhabitants. The use of plastic packaging and modernization in the rural IHR (International Health Regulation) region may have increased the load of SWM. Selecting the appropriate approach for waste management techniques is significantly impacted by the methodical manner in which MSW is collected and separated [10].

Although waste is always being produced, waste management is a constant challenge in developing countries. Developing countries are experiencing a collapse and improper handling of the waste management system, particularly with regard to solid waste management. Insufficient disposal of waste not only affects the local economy and budget, but it also has an impact on human health and the environment [11]. Internet of things(IoT) is the expansion of web availability into physical gadgets and everyday items are inserted with gadgets, net availability and diverse sorts of equipment,(for example, sensors).These contraptions will convey and connect with others over the web and that they can be remotely observed and controlled .It is a registering thought that depicts the idea of regular physical items being associated with the web and being able to spot themselves to elective gadgets. Usage of a system of sensors and different gadgets through the methods for electronic and other programming so as to get information about that physical gadget[12].

The Internet of Things, or IoT, uses a wireless network to connect real objects like vehicles, refrigerators, thermostats, and connecting additional appliances to the Internet allows them to collaborate and share data. The IoT has several uses, including in the transportation, manufacturing, home automation, healthcare, and power grid. The global economy is expanding and living standards are increasing in large part because to the Internet of Things [13]. The physical world is becoming an information and knowledge system as a result of advances in Information and communication technology (ICT), which are producing an increasing number of devices having sensors integrated into them and the ability to communicate with other objects [14].

This has been found that the latest study on smart city applications still lacks effective waste management. The current models are not very effective in identifying the particular position of the bins as well as the exact state of the bins when they are filled [15]. Consequently, the goal of the SWM System application is to address the problems associated with waste collection in smart cities. The SWM reduces the overall cost of the garbage collection procedure while maintaining timely waste collection.

This paper presents a smart waste management system that makes use of the Internet of Things. This work has been arranged as follows: In section II, the literature survey is presented. The section III presents a smart waste management system using Internet of Things (IoT) is presented. A review of the result analysis is provided in section IV. In the end, section V contains the conclusion.

II. LITERATURE SURVEY

Li Haolin, Hu Yi, Quan Hao, Lyu Junyan, Xu Xiang, and Li Chenxi et. al., [16] explains that the Two-Echelon Waste Collection Network reduces transportation risk associated with waste disposal in the healthcare system. This study examines a vehicle routing issue that increase throughout the healthcare system's waste collection process, with a focus on transportation risk. This research examines three categories of facilities that have been removed from the health system: minor facilities, facilities both with and without collecting points. A method related to mixed-integer linear programming that considers vehicle capacities and time durations. To solve complex problems, they utilize the Particle swarm optimization (PSO) algorithm. The suggested algorithm's ability is demonstrated through numerical experiments. Sensitivity analysis is used to look into the facilities that have collection sites and routes affect points. Still, there are certain restrictions on the study. The only deterministic circumstance examined by the authors is one in which the transportation risk is predetermined and the waste quantity is known ahead of time. For the network to function better, a stochastic optimization with randomly distributed waste amounts might be more beneficial.

Yun Arifatul Fatimah, Andi Widianto, Muhtar Hanafi et. al., [17] discusses the use of cyber-physical systems to manage waste sustainably. 4.0: An Intelligent Waste Management System for Semi-Urban Indonesian Communities. The aim of this research is to create an intelligent waste collecting system that combines physical sectors to process, manage, and exchange data on all waste-related elements, such as facilities, technology, information, sensors, actuators, and networking. A smart waste collecting system that uses a sensing platform and is appropriate for semi-urban cities in developing countries are presented by in-depth research on the management of nonorganic waste banks. It also includes a task sharing platform. The model represents a linked and integrated component of garbage collection management.

Lei C., Jiang Z. and Ouyang Y. et. al., [18] discusses the use of a hybrid discrete-continuous approach to frequently scheduled waste garbage vehicles in combination with recycling activities. To address the issue of waste collection in urban areas, a linear program model with mixed integers was developed, taking into consideration the sorting facility's recycling operation. The challenge is solved by using a hybrid solution method that combines discrete and continuous optimization components. The continuous component is combined into the discrete optimization component using an iterative stochastic approximation technique, extending on the literature on continuous approximation's asymptotic routing cost products. The hybrid solution approach and proposed model perform significantly better than the most advanced benchmarks found in the literature, according to the results of a series of numerical experiments.

Ahmad S., F. Jamil, N. Imran, F. Iqbal, and Kim D. et. al., [19] demonstrates the ability to use predictive model optimization to create the most effective procedures for managing municipal waste. The approach attempts to both guarantee a specific degree of sanitation in the region and recommend the quantity of resources that result in the lowest possible cost. The solid waste dataset from 2017 to 2019 which was produced by several home grids is the topic of the research. Together with prediction algorithms, the analysis enables policymakers to create a waste profile specific to a home grids. Depending on the amount and frequency of waste produced inside the grid, the optimization algorithm then recommends the smallest number of resources needed to meet the area's hygienic

standards. The results are displayed across multiple domains, and the lowest possible cost is recommended. This helps policymakers to ensure a clean and green environment while also allocating resources effectively.

D. Anghinolfi, M. Paolucci and M. Robba et. al., [20] offers Door-to-Door Multiple Material Separated Waste Collection's Optimal Planning. In order to reduce operational expenses and potential inefficiencies of the recycling logistic system that could have a negative impact on the environment, a multiobjective optimization model is presented. The model is applied to an actual case study, and the answer is found using a mixed integer programming heuristic technique. Conclusions are reached after a discussion of the acquired results. The analysis highlights the necessity of moving to a management system based on a free calendar policy, where collection days are unknown in advance and can change from street to street.

Saeed M., Saeed M. H., Ahsan M., Mehmood A. and El-Morsy S. et. al., [21] explains that to evaluate solid waste management strategies using an effective complex fuzzy hypersoft set algorithm that takes similarity and entropy measures into consideration. The structure that is being presented is the best choice for investigating SWM issues because it supports a larger range of membership values and allows P-terms to be used to represent the content's periodic nature, developing the Fuzzy HyperSoft Set (FHSS) and extending the content to a unit circle in a dynamic reference frame. Second, to make the features of CFHSS (Complex Fuzzy Hypersoft Set) easier to understand, they might be further separated into attribute values. Additionally, the research investigates colloquial meaning and demonstrates that entropy (ENT) and CFHSS Similarity measures (SM) appear to be related. These techniques can be applied to select the most effective plan of action from a range of options with a wide range of optimization-related applications. Through comparing the obtained results to those of many previous studies, the reliability and efficiency of the suggested methodology is evaluated. The robustness of the proposed approach is validated through an assessment conducted with different values of the parameters.

Abdulla Al Mamun M., Hannan M. A., Hussain A. and Basri H. et. al., [22] In regard to Automating Solid Waste Bin State Management through Integrated Sensing Systems and Algorithms. The integrated sensing system and solid waste bin algorithm that are implemented and run in this analysis automate the solid waste management process. In order to detect bin conditions and measure their parameters, a number of sensing techniques have been combined and integrated. To evaluate the prototype system's performance, several test runs have been carried out. The results demonstrated the efficiency and intelligence of the sensor system with the algorithm, easily it can be utilized to automate any solid waste bin management procedure.

D. Rutqvist, D. Kleyko and F. Blomstedt et. al., [23] discusses A Smart Waste Management System's Automated Machine Learning Approach. The existing manually-engineered model, traditional machine learning algorithms and automated ML are investigated in this analysis. A Random Forest classifier is used in this approach to analyze a set of features depending on the filling level at various time durations. In conclusion, the optimal solution outperforms the baseline manually-engineered model in terms of predicting recycling container emptying times.

Qurban Ali, Asim Zeb, Khalid Mahmood Awan, Muhammad Qaiser Saleem, Ali Saeed Alowayr, Saleem Iqbal, Jamal Uddin, and Bashir Faisal et. al., [24] describes a recommended Internet of Things-enabled smart garbage bin management system that benefits from efficient route selection. This article describes the architecture for smart cities' smart trash management as well as an effective routing method that takes the design's lowest possible latency into consideration. One of the Quality of key Services (QoS) parameters in wireless sensor networks for minimizing data transfer delays is end-to-end delay. In this paper, they examine end-to-end delay reduction in intelligent waste management applications. The whole time a single packet takes to get to its target node is referred to as the "end-to-end delay". The suggested plan takes into consideration the degree of interference, the routing path's length, and the number of hops along the way. The suggested design performs better than the current schemes, according to the simulation results.

Naveen Reddy D., Pavan Kumar Reddy M., Sudarsan Reddy I. V., Hemanth Kumar Reddy E., Shanky Saxwna et. al., [25] explains the Smart Dustbin for the Waste Management System. They utilize an ultrasonic sensor to detect objects and distance, along with another sensor, to enable smart dustbin working. The garbage can top is opened

and closed by a servomotor, the level of the dustbin is determined by a PIR (Passive Infra-Red) sensor, and any dangerous gases inside the dustbin are located by a gas sensor. A buzzer is used to sound an alert when the dustbin is filled.

III. A SMART WASTE MANAGEMENT SYSTEM

In this section, a smart waste management system using Internet of Things (IoT) is presented. The block diagram of presented model is shown in Figure 1. The main components include in this system are IR (Infra-Red) sensors, LCD (Liquid Crystal Display), Global positioning system (GPS), Arduino Uno, Global system for mobile communication (GSM), and RS232 (Recommended Standard). The power supply unit, the initial subsystem, in charge of transforming the AC (Analog Current) voltage into a low-level DC (Direct Current) voltage and giving all of the electronic system's DC-powered devices a steady DC-level voltage. A voltage regulator, passive parts, and a bridge rectifier make up the power supply circuit. The Power supply will provide electrical power for the microcontroller. A light-emitting electrical devices called an Infrared (IR) sensor was uses light to detect objects in its environment. A device known as an IR sensor makes use of infrared technology to identify objects or environmental changes. Many different physical characteristics, including closeness, motion, and temperature, can be detected by IR sensors. Here, the device uses an infrared sensor to determine the bin's level.

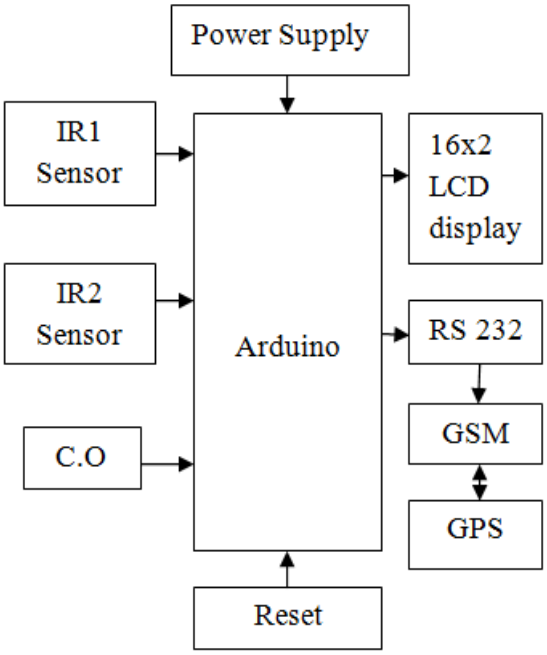

Figure 1: Block Diagram of smart waste Management

Arduino**:** It is an attempt, a client group, a computer tool that generates microcontroller parcels for programmable devices are the construction of smart objects, then a programming group. Its primary function is to allow communication between a PC and a wide range of sensors and microcontrollers. Whenever Reset button is pressed the program counter will be 0x00 and all of the RAM (Random Access Memory) data will be erased. The Arduino UNO will restart executing the program from first line of code such as void loop () or any code of line. Simply, if want to start your program from first line, then press the Reset Button. The data on the bins is used to identify which waste bins require early emptying and which ones can wait until the following waste collection cycle. The Global System for Mobile Communications is referred to as GSM. A device that modulates and demodulates GSM signals is called a GSM modem. Use of the SIMCOM Sim300 modem is performed. The local waste management department or municipality receives a notification from the infrared sensor for level when it detects that the dust bin is full and that garbage has to be collected. The Figure 2 shows the workflow diagram.

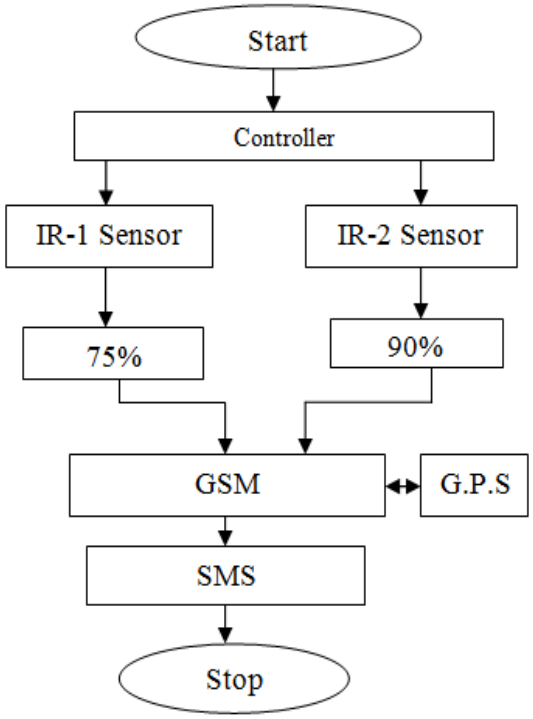

Figure 2: Workflow Diagram

GPS Module: It's a routing device that connects to the Arduino UNO and locates the bin using the Global Positioning System (GPS). The GSM module built inside the device is used to transmit the location that has been recorded to the authorities. The interface that uses serial binary data exchange to connect data terminal equipment and data communications tool is known as RS232 (Recommended Standard). The modem is referred to as Data communication equipment (DCE), while the computer is referred to as Data terminal equipment (DTE). The RS232 protocol allows the controller to give commands to the devices through a voltage signal. LCD display is used to display the level of the dustbin.

Using IR sensors built into each bin, the waste level in each bin is monitored. The IR-1 sensor is used to detect the first level of dustbin i.e. 75%. The IR-sensor-2 is used to detect the level 2 of Dustbin i.e. 90%. The output of the IR sensor is represented by the declared variable ir. The dustbin is full when this variable is found to be high, which also triggers the GSM to send a message to the municipal groups. The relevant authorities are subsequently contacted to empty the dustbin. Less human interaction is required to segregate the waste and if the waste level at is low, then no action is taken. If the bin level is 75%, the information is sent to the municipality for alert generation to add that dustbin in queue, which allows the client to empty the bin. If the bin level is 90% it will sends an alert message to collect the dustbin immediately. Therefore, this system has effectively collects the bin before it gets overflowed. Hence this approach, overcomes the overflow of bin.

IV. RESULT ANALYSIS

In this section, a smart waste management system using Internet of Things (IoT) is presented. The result analysis of presented approach is evaluated in this section.

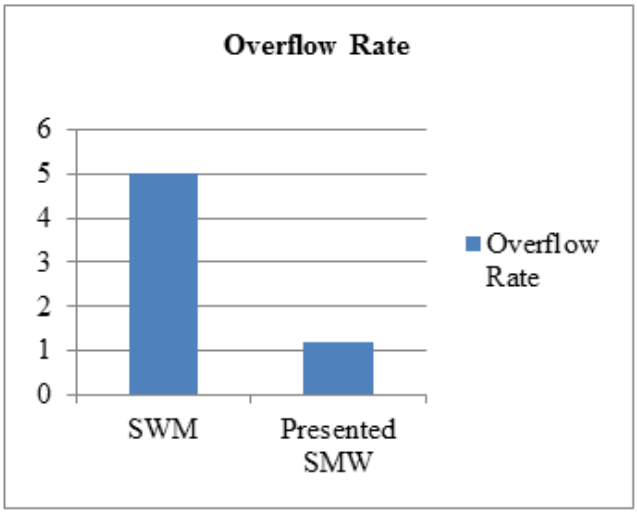

Figure 3: Dustbin Overflow Rate Comparison

The Figure 3 shows the comparison between Solid Waste Management (SWM) and presented model in terms of dustbin overflow rate. In Figure 3, the x-axis indicates different waste management models and y-axis indicates the number of bins. Compared to SWM Approach, presented smart dustbin model has very less dustbin overflow rate. Figure 3 shows the delay in dustbin collection.

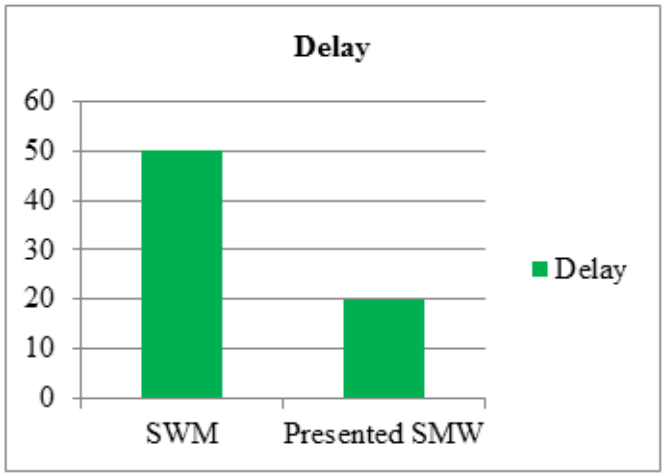

Figure 4: Delay for Dustbin Collection

In Figure 4, the x-axis indicates different waste management models and y-axis indicates time in terms of minutes. SWM has more delay in dustbin collection and presented model has very less delay in dustbin collection. Every bin has ultrasonic sensors that are used to track the level of waste within it. This whole setup makes automated waste collection and as a result it reduces the human intervention required in segregating the waste provides successful collection of the garbage from the bin at the appropriate time.

V. CONCLUSION

The management and collection of waste is an integral aspect of village and city life. Public health is seriously affected by insufficient garbage collection systems, which also increase costs. Therefore, a smart waste management system that uses the Internet of Things (IoT) is provided in this analysis to address these problems. The main components include in this system are IR (Infra-Red) sensors, LCD (Liquid Crystal Display), RS232 (Recommended Standard), Global position system (GPS), Arduino Uno, and Global system for mobile

communication (GSM). The dustbin level is detected by the IR sensors 1 and 2. The Arduino Uno controls all the operations. If the dustbin reaches the level 1 then the Arduino alerts the municipality through GSM and GPS to add that particular dustbin to the queue to collect that particular bin. When the dustbin reaches 90% it will send a alert message to collect the bin as soon as possible. Through this model, waste is collected on time. As a result, dustbin overflow is reduced. Hence this approach will be used in real time for effective waste collection and dustbin management.

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