A Review- On IOT Based Garbage Monitoring and Collection System

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Abstract: Many times, in our city we see that the garbage bins or dustbins placed at public places are overloaded. It creates unhygienic conditions for people as well as ugliness to that place leaving bad smell. To avoid all such situations we are going to implement a project called IoT Based Smart Garbage and Waste Collection bins. As the population is increasing day by day, the environment should be clean and hygienic. In most of the cities the overflowed garbage bins are creating an unhygienic environment. This will further lead to the arise of different types of diseases. This will degrade the standard of living. To overcome these situations an efficient smart waste collection system has to be developed. As the scope of IoT is developing day by day effective methods can be found out easily. Various designs were proposed and have advantages as well as disadvantages. This paper is a survey based on Smart Waste Collection System based on IoT.

Key Words: Internet of Things, IR Sensors, Wireless Network, Smart Garbage, controlling system, Communication system, Smart City, Microcontroller, RFID.

1. Introduction

The garbage collection issue on megalopolis became a real problem across many cities around the world. One of the great areas of study within Smart City and Internet of Things (IOT), involves the proposal of solutions to common problems of the cities, one of these problems is precisely the Garbage Collection. Indicators show that Brazil has a low performance when it comes to the collection and disposal of urban waste [1]. Solid waste management is still poorly explored segment with great potential for growth. The optimization of collection resources, in

addition to costs reduction, which are significant for municipalities, enables a better service provided to the population. Among the effects resulting from the practice of inadequate disposal, we have, besides visual pollution and bad odor, risks to people's health, floods, silting, among others [2]. The questions related to garbage collection and that need to be solved are several, in this work the issue that will be addressed is the one that deals with the collection itself, that is, the generation of the routes for the trucks in order to allow reduction in the fuel consumption, CO2 emissions and city traffic reduction. Considering that the routes will be optimized in order to avoid a truck moving to an empty trash for example or to send a truck to a route in which the sum of the occupations of the dumps do not extrapolate the capacity of the truck, which will allow optimization of the number of trucks used in a given area. The municipal waste collection has already been optimized through programming and mathematical methods [3], however the results were not satisfactory, due to the large amount of variables that resulted in a great computational time which may make the use of remote sensors not easy and viable. According to [4] as the Internet and other technologies continued to develop and evolve in the first decade of the twenty-first century, several solutions emerged from giants markets that made Internet of Things a viable option for a good number of cities.

Management of waste is a big challenging problem in urban areas for most of the countries throughout the world and is seen in most of the developing countries than in the developed countries. An efficient management of waste is a requirement for maintaining a clean and green environment as there is increase in all kinds of wastes thrown by many places like industrial, agricultural, home waste, etc. Waste collection and recycling is done through various technologies. Collection of information is big and cumbersome. The current growth in nation with large residential area and a demand for modernization in the city creates a challenging task for waste management people [5].

India particularly generates approximately 1, 33,760 tons of Municipal solid waste (MSW) management per day, of which approximately 91,152 tones are collected, and a huge sum of money is spent on collection [6]. World waste production is expected to be approximately 27 billion tons per year by 2050, one-third of which will come from Asia, with major contributions

from China and India [7]. Waste generation in urban areas of India will be 0.7 kg per person per day in 2025, approximately four to six times higher than in 1999 [8]. The Table 1 and Figure.1

[9] shows Urban India generated 31 million tons of waste in 2001 and is currently generating 46 million tons. By 2041, waste generation is predicted to be 161 million tons, a fivefold increase in four decades [10].

Year	Population $x10^6$	Per capita generation(kg/day)	Total waste generation ($x10^3$ tones / year)
2001	195	0.44	31
2017	263	0.5	46.9
2021	341	0.57	70
2031	451	0.65	106.8
2036	517	0.7	132
2041	594	0.739	159

Table 1. Population growth and its impact on waste generation in India

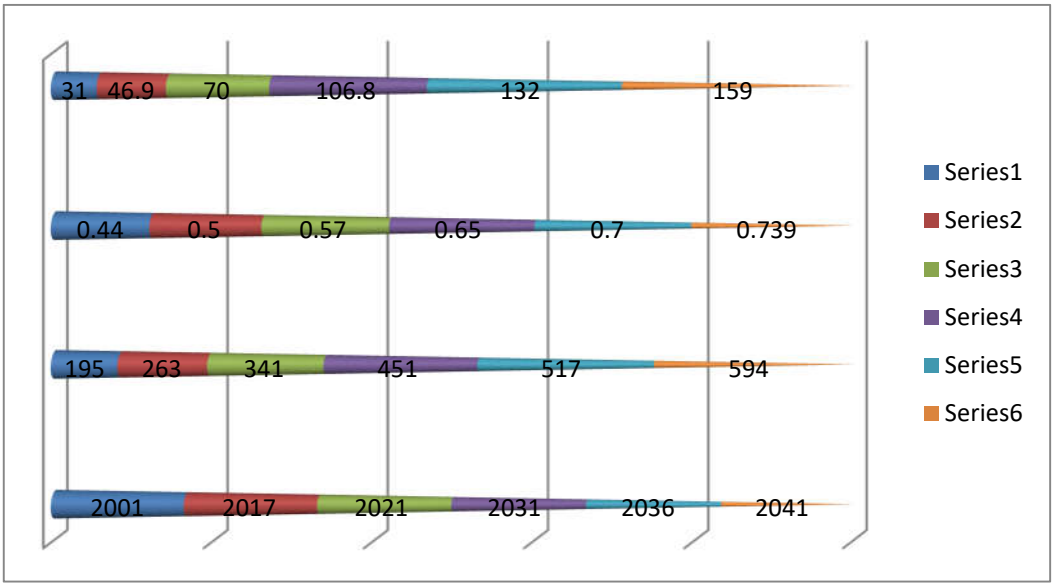

Figure1. Graphical representation for Population growth and its impact on waste generation in India.

Internet of Things will help the cities to be improved by making the people use modern technologies for different kind of activities. With new hardware and software technologies all common “things” and infrastructures will be integrated. The sensors will be placed in the road and all streets to measure the temperature, noise, traffic etc., actually it means all things.

Collected data from all the sensors will be transferred to other “sensors” and process them. To provide better services to people for monitoring the environment and react to the natural disasters quickly [5].Internet of Things (IoT) is the new emerging technology which has vast applications. In internet of things all the devices are made to talk to each other. Any data shared using the real world application can be viewed from any place at any time. This helps the user to make the decision in a suitable way [11] [12].

The survey conducted by FICCI reveals MSW realization at dumpsite varies from 16 to 100%, like in Kozhikode it is 16% and in Greater Mumbai it is 100%. Greater Mumbai (Maharashtra) and Ludhiana (Punjab) have 100% waste disposal, in Delhi and Surat (Gujarat) around 95% of MSW reached its landfill sites, and in the rest of the cities/town less than 90% waste reached dumpsites (CPCB, 2013; FICCI, 2009). The variation in collection efficiency (i.e. 100% waste collected/waste generated) of selected Indian States in the year 2011 is shown in Figure.2 and Table.2 [13].

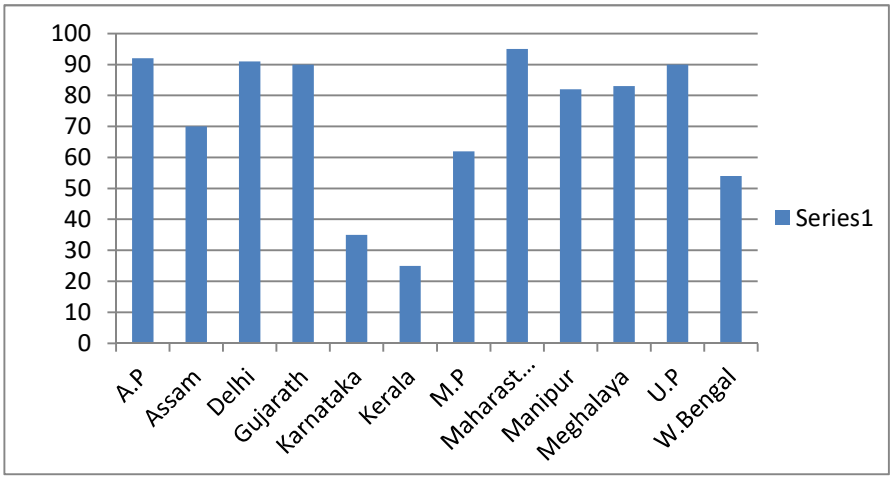

Figure2. Graphical representation for Garbage collection Efficiency in indian States.

State	Collection Efficiency
A.P	92
Assam	70
Delhi	91
Gujarath	90
Karnataka	35
Kerala	25
M.P	62
Maharastra	95
Manipur	82
Meghalaya	83
U.P	90
W.Bengal	54

Table2: Garbage collection Efficiency in indian States.

2. Motivation

A healthy environment is necessary if we want to stay healthy. However, in today's fast paced life individuals scarcely have time to stop and configure things manually and hence the idea of automation is by and large broadly embraced. Either because of our fast paced life or because of our casual approach often small though critical things like cleanliness gets ignored. In big institutions or a city under a municipal corporation where there are extensive quantities of garbage bins deployed and workers are kept specifically for this task, the antiquated technique for physically hunting down filled garbage bins is wasteful and does not run well with the technological era we are in. Routine checks for cleaning the garbage bins which depend on time crevices are wasteful in light of the fact that a dustbin may get filled early or may get tampered and might require prompt consideration or there might not be any need of a routine check for a drawn out stretch of time. Likewise, to save fuel and time and make the entire process more effective and convenient, the workers going on routine check should know the shortest route comprising of all the filled garbage bins [14].

3. About Internet of Things

The Internet of Things is a novel paradigm shift in IT arena. The phrase "Internet of Things" which is also shortly well-known as IoT is coined from the two words i.e. the first word is "Internet" and the second word is "Things". The Internet is a global system of interconnected

computer networks that use the standard Internet protocol suite (TCP/IP) to serve billions of users worldwide. It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies [15]. Today more than 100 countries are linked into exchanges of data, news and opinions through Internet.

Internet of Things is maturing and continues to be the latest, most hyped concept in the IT world. Over the last decade the term Internet of Things (IoT) has attracted attention by projecting the vision of a global infrastructure of networked physical objects, enabling anytime, anyplace connectivity for anything and not only for any one [16]. The Internet of Things can also be considered as a global network which allows the communication between human-to-human, human-to-things and things-to-things, which is anything in the world by providing unique identity to each and every object [17]. IoT describes a world where just about anything can be connected and communicates in an intelligent fashion that ever before. Most of us think about "being connected" in terms of electronic devices such as servers, computers, tablets, telephones and smart phones.

3.1 Applications

Consumer applications: A growing portion of IoT devices are created for consumer use, including connected vehicles, home automation/smart home, wearable technology, connected health, and appliances with remote monitoring capabilities[18].

Smart home: IoT devices are a part of the larger concept of home automation, which can include lighting, heating and air conditioning, media and security systems.[19][20] Long term benefits could include energy savings by automatically ensuring lights and electronics are turned off.

Elder care: One key application of smart home is to provide assistance for disabled and elderly individuals. These home systems utilize assistive technology to accommodate an owner's specific disabilities.[21] Voice control can assist users with sight and mobility limitations while alert systems can be connected directly to Cochlear implants worn by hearing impaired

users.[22] They can also be equipped with additional safety features. These features can include sensors that monitor for medical emergencies such as falls or seizures[23].

Medical and healthcare: The futurologist's vision seems to be that soon you will share your exercise levels, heart rate, activity, and other essential data accumulated by your mobile device with your doctor. "More and more care will be delivered outside hospitals and clinics", "This means mobile devices – from smart phones to monitoring devices – will become increasingly important as the number of patients cared for at home or in sheltered accommodation or other community centers increases."[24] IoT devices can be used to enable remote health monitoring and emergency notification systems.

4. Literature Survey

The garbage management in cities has to be effectively and efficiently implemented. The various proposals were put forward and some of them already implemented. But it cannot be considered as an effective one. So a survey was done among different proposals and this survey paper includes survey among different methods for Waste Collection System based on IoT.

The paper [25] proposed waste collection system is based on waste level data from trashcans in a metropolitan area. The data collected by sensors is sent over the Internet to a server where it is stored and processed. The author collected data is then used for monitoring and optimizing the daily selection of trashcans to be collected, calculating the routes accordingly. Every day, the workers receive the newly calculated routes in their navigation devices. The key feature of this system is that it is designed to learn from experience and to make decisions not only on the daily waste level status but also on future state forecast, traffic congestion, balanced cost-efficiency functions, and other affecting factors that a priori humans cannot foresee.

Another method [26], there are multiple dustbins located throughout the city or the Campus, these dustbins are provided with low cost embedded device which helps in tracking the level of the garbage bins and a unique ID will be provided for every dustbin in the city so that it is easy to identify which garbage bin is full. The project module is divided into two parts Transmitter section and receiver section. Here in the transmitter section we are using 8051 microcontrollers, RF Transmitter and sensors these are attached to the dustbin. Where sensor is used to detect the level in the dustbin whether the dustbin is full or empty.

Another method [27] is that, once the garbage reaches the threshold level ultrasonic sensor will trigger the GSM modem which will continuously alert the required authority until the garbage in the dustbin is squashed. Once the dustbin is squashed, people can reuse the dustbin. At regular intervals dustbin will be squashed. In this method, GSM 900A modem is used to send the messages.

Another method for garbage management is introduced [28] as follows. A dustbin is interfaced with microcontroller based system having IR wireless systems along with central system showing current status of garbage, on mobile web browser with html page by Wi-Fi. Hence the status will be updated on to the html page.

In paper [29] Infrared sensor (IR sensor) is used which is a multipurpose sensor, which can detect the level of garbage. IR sensor emits the light, which is invisible to naked eye but the electronic components can detect it.

In Paper [30] System monitors the garbage bins and informs about the level of garbage collected in the garbage bins via a web page. For this the system uses ultrasonic sensors placed over the bins to detect the garbage level and compare it with the garbage bins depth. The system makes use of AVR family microcontroller, LCD screen, Wi-Fi modem for sending data and a buzzer.

In paper [31] assures the cleaning of dustbins soon when the garbage level reaches its maximum. In his management system IOT as the working in the field for networked radio-frequency identification (RFID), tracking the collection vehicle, Dustbin monitoring and other emerging sensing technologies.

Authors in [32] consider dynamic scheduling over a set of previously defined collection trips. The main objective of the approach is to minimize the total operational and fixed truck costs. A mathematical formulation methodology is proposed in [33] developing a plan of service areas, defining routing, and designing scheduling taking into consideration possible new alternative solutions in managing the system as a whole. In [34] authors evaluate dynamic planning methods applied for waste collection of underground bins. Model reduces the amounts of carbon dioxide released in the environment from trucks by making dynamic routing more effective.

In Smart Recycle Bin by authors Mohd Helmy Abd Wahab, Aeslina Abdul Kadir, Mohd Razali Tomari, Mohamad Hairol Jabbar have proposed a system that rewards the users by calculating points on the basis of weight and the type of wastes inserted in them using a waste type detection system. This system eliminates the problem of waste sorting as user's points are deducted if the type of waste inserted does not match with the type of dustbin, but detecting the type of the waste is not yet figured and remains conceptual. Also, nothing is done to eliminate the problem of the collection of waste [35].In Smart bin: Smart Waste Management System, the proposed system is very well presented, and the methodology is quite well, but if they use clusters in their system efficiency would have been maximized. Moreover, no attention is made on the toxicity as it can still cause harm to their environments even if they are not full [36].

In Top–k Query based Dynamic Scheduling for IoT enabled Smart City Waste Collection by authors Theodoros Anagnostopoulos, Arkady Zaslavsky, Alexey Medvedev, Sergei Khoruzhnicov have discussed about global positioning system (GPS), Geographic Information Systems (GIS), and ultrasonic sensors based bin monitoring system for optimized routing using top-k query based algorithm in integration with Google API's. In this system, the truck that can collect waste from top-k bins ranked according to the fullness of the bins [37]. These trucks are then provided with shortest route this system has trucks equipped with GPS sensors adding to its costs of implementation .Smart Garbage Management System by Vikrant Bhor, Pankaj Morajkar, Maheshwar Gurav, Dishant Pandya. It provided us with additional details and designs needed for flow and management of garbage while collection [38].

In A Smart Waste Management with Self-Describing objects by authors Yann Glouche, Paul Couderc have proposed an idea by using RFID tags on wastes, which has ID's categorized based on the type of waste. This enables bins to sense the type of the waste added, but equipping wastes with RFID is not feasible in any manner [39].

ShubhamThakker, R.Narayanamoorthi, in this paper [40], using the Near Infrared Reflectance (NIR) spectroscopy we can identify the type of plastic. The alienated dissipate equipment from MSW (municipal solid waste) can be place in a needy area. By Using a dissenter materials which can be mix into a uniform material. The entire process is repeated every hour. The fermentation mechanism took place in a sealed atmosphere, where bacteria converted into undividable enzymes which results in biogas [41] Andrei Borozdukhin, Olga Dolinina and Vitaly Pechenkin,

[42] this proposed system consists of two parts: software and special signaling equipment. The equipment is placed on the side walls of the bin which consists of two parts: one is the receiver-transmitter and sensor. Sensor is used to indicate the level of the bin which is connected to the transmitter that transmits a signal of fullness of the bin to the receiver at the server host. A manager is appointed at the server side whose job is to find the shortest route and intimate it to the truck driver to collect it in a short interval of time [40].

In this paper they described the system architecture to find time-optimal dynamic route for garbage trucks within "Smart Clean City" project. They proposed a formal mathematical model of the task of dynamic optimal route and formal the optimization criterion for time-optimal garbage collection of all waste from landfills [42].

BelalChowdhury, Morshed U Chowdhury [43] explained, here they used RFID to provide a specific identity to the bins. Each house bins have been assigned with a unique RFID, using which the administrator of the municipal area can detect the amount of waste generated from the particular house. The RFID (Radio Frequency Identification) along with cell sensor technology is mitigated waste management costs and facilitated smart waste management systems. Waste management administrators can assign an RFID waste tag to take away from bin and this is totally password protected which ensure data security. The administrator is able to search for a particular client or house number or write the addhar card number to the waste tag using the "Write to Waste Tag" button.

In USA UG (Under Ground) LIFT waste compactor space saving and system in which environment poses the challenges to the owner. There is only a tiny bin in the underground. It consists of two unit's i.e., container with a steel frame and compactor. The system is suited to Dry & Wet and is an efficient solution for recycling. This system can be graphed to match the location with standard compactor sizes are $10m^3$, $16m^3$ and $20m^3$ [44] [45].

System in Australia An automated vacuum waste collection procedure, also called pneumatic refuse collection (or) automated vacuum collection (AVAC), transports the waste at maximum velocity through underground pneumatic tubes to the collection station & it is compacted and sealed in containers or bins. When the container is full, it is transported away and emptied (by using trucks) [46] [47]

Title	Proposed	Analysis
"Smart Waste Collection System Based on Location Intelligence" [25].	The key feature of this system is that it is designed to learn from experience and to make decisions not only on the daily waste level status but also on future state forecast, traffic congestion, balanced cost-efficiency functions, and other affecting factors that a priori humans cannot foresee.	Here the forecasting plays the major role.
"IoT Based Waste Management for Smart City" [26].	Embedded device which helps in tracking the level of the garbage bins and a unique ID will be provided for every dustbin in the city so that it is easy to identify which garbage bin is full.	Helps the monitoring in any devices which connected with internet.
"Smart Dustbin-An Efficient Garbage Monitoring System" [27].	When the garbage reaches maximum level the system send the message to the related person.	Messaging system plays the major role.
"IoT Based Garbage and Waste Collection Bin" [28].	The system will display the bin level in the web page.	Helps the monitoring in any devices which connected with internet.
"IOT Based Intelligent Bin for Smart Cities" [29].	The system will displays the wastage level in the bin.	Helps the monitoring in any devices which connected with internet.
"Smart Garbage Collection Bin Overflows Indicator using Internet of Things" [31].	To track the vehicle which collects the garbage?	Helps the monitoring in any devices which connected with internet.
"Truck Scheduling for Solid Waste Collection in the City of Porto Alegre, Brazil" [32].	The main objective of the approach is to minimize the total operational and fixed truck costs.	They concentrated on the scheduling for the garbage vehicle.
"Dynamic Waste Collection: Assessing the	Authors evaluate dynamic planning methods applied for waste collection of	They concentrated on the dynamic

Usage of Dynamic Routing Methodologies" [34].	underground bins.	scheduling for the waste collection.
"Top–k Query based Dynamic Scheduling for IoT enabled Smart City Waste Collection"[37].	the truck that can collect waste from top-k bins ranked according to the fullness of the bins	Helps the monitoring in any devices which connected with internet.
"A Smart Waste Management with Self Describing objects"[39].	The authors have proposed an idea by using RFID tags on wastes, which has ID's categorized based on the type of waste.	RFID plays major role.
"Solid Waste Management Architecture using Wireless Sensor Network technology" [41].	In this paper a new architecture is proposed with the aim to improve the on-site handling and transfer optimization in the waste management process. In detail, each garbage bin is supported by sensor nodes which provide the filling monitoring and are able to send the retrieved data to the supervisor system, through the data transfer nodes.	Wireless sensor network plays major role.
"Approach to the Garbage Collection in the Smart Clean City Project" [42].	They proposed a formal mathematical model of the task of dynamic optimal route and formal the optimization criterion for time-optimal garbage collection of all waste from landfills	They concentrated on the dynamic scheduling for the waste collection.
"RFID based Real-time Smart Waste Management System" [43].	Here they used RFID to provide a specific identity to the bins.	RFID plays major role.

Table3: Review on Garbage collection .

The above Table 3 which provides the brief information about the waste management system, the table emphasizes that all authors provided different solution for the waste management system using different sensors, RFID technology and different radio modules but no one can not talking about the system performance means which can operate at the low power, this is the main drawback which we want to overcome in our solutions.

5. Uses of IOT Based Smart Garbage

IOT Based Smart Garbage monitoring system is helpful for monitoring the garbage in garbage bins. This can be implemented in present days, as solid waste management is big issue throughout the world. The concept helps in reduction of solid waste management problems so that helpful in increasing public health safety precautions by Government. This is a small attempt to fulfill the challenges of Swatch Bharath Abhiyan (or) Clean India Mission [48].

6. Disadvantages of the existing system

I. Time consuming and less effective: trucks go and empty containers whether they are full or not.
II. High costs.
III. Unhygienic Environment and look of the city.
IV. Bad smell spreads and may cause illness to human beings.
V. More traffic and Noise.

7. IOT Based Smart Garbage Architecture

One of the main problems with the IOT based Smart Garbage system is that it is so vast and such a broad concept that there is no proposed, uniform architecture. In order for the idea of IOT based Smart Garbage system to work, it must consist of an assortment of sensor, network, communications and computing technologies, amongst others [49].

8. Conclusion

This overview has been performed for gathering the points of interest of Smart Waste Collection System in light of IoT and to discover compelling techniques which are helpful for giving cleanliness condition in urban communities. As the level of garbage in the bins crossed the verge, the information has been sent to the related authority, if it was found unnoticed then the detailed information should be forwarded to the superior departmental officers to take necessary actions. Thus a hygiene and clean environment can be provided. This survey helps in identifying all possible smart waste collection methods that can be implemented to make city clean.

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