International Journal of Computer Sciences and Engineering Open Access
Review Paper Vol.8, Issue.9, September 2020 E-ISSN: 2347-2693

Smart Waste Management: A Conceptual Design and Analysis of GIS Based Real Time Waste Management using Mobile Application

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DOI: https://doi.org/10.26438/ijcse/v8i9.6469 | Available online at: www.ijcseonline.org

Received: 02/Sept/2020, Accepted: 12/Sept/2020, Published: 30/Sept/2020

***Abstract*—** One of the major pollutants of environment is waste, if it is not managed and controlled, it will cause health hazards and increase environmental pollution. Nowadays we observe much improvement in technology, most of the developed countries manage the waste using smart systems and automated machines. Some countries still use the traditional waste management system. Due to rapidly increasing of population, huge amount of waste is generated daily. Traditional waste management system has some drawbacks and problems, for instance, producer maintains the waste as mixed and collector also collects as mixed. There is no monitoring system on producer and collector, some producers throw the garbage around the trash bins, some collectors even do not collect the waste, so neither producer and nor collector do their job properly. To overcome the problems and manage wastes efficiently, this paper has proposed online (Geographic Information System) GIS based mobile application system. The producers and collectors of waste are monitored through online platform and requests the producers to maintain biodegradable and non-biodegradable wastes separately. Using mobile application, producer requests the system for collection of waste, meanwhile the system assigns the task to collector which is near to producer's location. The collector reaches to the location through the best path and collects the wastes as separate. Additional features and functionalities of the system also discussed in this paper.

***Keywords*—** Smart Waste Management System, Geographic Information System, Biodegradable and Non-Biodegradable waste, Mobile Application

I. INTRODUCTION

Health is one of the important things in human life, there is a popular quote "Health is wealth". Environment directly effects on health, if it is clean and has fresh atmosphere, so it has good effects on health otherwise if there is lots of pollutions, it will cause different diseases and endangers human life. Population is increasing day-by-day and environmental pollution is also increasing, if it is not controlled and reduced, we will face with lots of challenges. There are lots of environment pollutants, one of them is waste.

Waste is referred to the things that is not needed. Commonly we can say, waste is anything which is not useful or unwanted [1], [2]. There are many types of wastes, generally classified as Biodegradable waste (Figure 1) that includes wet waste (such as vegetable waste, fruit waste, food waste, etc.) and non-biodegradable waste (Figure 2) that includes dry and solid wastes (such as metals, glasses, plastics, etc.) [1], [3]. Waste is one of the noticeable challenges that creates environmental pollution. If it is not managed and controlled, it will cause various health hazards and affects the environment [4]. Managing the waste in a better way will help us to keep the environment clean and to reduce the pollution.

Smart waste management is the process of monitoring, collecting, transporting, disposal and managing the waste by using technology like, internet of things (IoT), smart devices and sensors that makes the process of management easy and effective [5].

There may be lots of ways to control and manage the wastes. This article introduces a smart waste management system as a better and effective solution. In this system the process of delivering waste by producer, collection of waste by collector and monitoring is done by using mobile application. Section 4, discusses the way the system should work.

Figure 1: Biodegradable Waste.
Source: https://www.gettyimages.ae

Figure 2: Non-Biodegradable Waste.
Source: https://www.gettyimages.in

II. LITERATURE REVIEW

There was a web-based system designed for waste management that enables people to locate the waste area through the website, a request will be sent to the management team and the collector comes in the area to collect the waste [8].

The concept of smart trash bins with multiple cells to store different types of wastes was proposed. People can access the trash bins using specific ID cards and put the separated waste in it, the final separation and storing is done by the system and monitors every producer using their ID cards [9].

A smart system for waste collection was proposed, in the system two trash bins are maintained, whenever the first one is filled, it is automatically closed and the second trash bin is automatically be opened simultaneously, meanwhile a filled-up notification is sent to the collector [10].

An IoT based waste collection system with embedded sensor was proposed, the sensor checks the level of waste in the trash bin and send the information to the server. Management team can check the status of all trash bins, if collection was needed, sends notification to the collectors [11].

The concept of trash bins with two types of sensors, one at the top of the bin to check the waste level and other at the bottom of the bin to measure the weight of the waste, and a website for monitoring the bins was designed for waste management. Sensors transmit information about the status of bins to the server, the bins are monitored using web-based application. A mobile application is also designed for monitoring the bins. When bins are filled, a notification will be sent to the collector for collection [12].

The idea of maintaining 4 different colored dust bins in every house, one for sanitary waste, second for wet waste, third for glass and plastic waste and the forth one for dry waste for the purpose of waste management was discussed [13].

A waste separation and management system was proposed. In the system the concept of smart trash bins having multiple sensors to separate each type of waste was discussed. The trash bin has several segments to store the different types of waste. Sensors detects the wastes and separate them and stores at the related segments. The trash bins also equipped with methane gas to annihilate the microbes. Sensors inform the collectors in case of trash bin filled up [14].

The mentioned literatures indicate that there are many smart systems proposed for waste management, each of them has their own advantages and disadvantages. This paper proposes an efficient costless and new approach system for waste management.

Table 1. Summary of Literature Review

Authors	Topic	Findings	Limitations
S. Labib	Volunteer GIS (VGIS) Based Waste Management	Locating the exact waste area by citizens leads to easy collection of waste from uncertain areas.	This research includes only a small part of waste management.
H. Esmaeili, P. C. Woods and A. A. Omar	Automated Network for Knowledge Transfer between Resource Management Agencies.	The complete separation at the source and monitoring the waste producers with the help of their ID cards.	The cost of implementation is too high.
G. Rohit, M. Chandra, S. Saha and D. Das	Smart Dual Dustbin Model for Waste Management in Smart Cities	By maintaining two smart trash bins, redundancy is considered that avoids overfill.	Separation of wastes are not considered in this approach.
Saha et al.	Waste Management using Internet of Things (IoT)	Transmitting the fill level of trash bin to the server avoids overfill of waste.	Separation of wastes are not considered.
A. S. Wijaya, Z. Zainuddin and M. Niswar	Design a Smart Waste Bin for Smart Waste Management	Tracking the waste bins and locating the approximately filled one helps easy collection and avoids overfill of waste bins.	Separation of wastes are not considered.
Atada, A. S, Sankhya and Sharma	Creating smartness in people towards waste management	By maintaining 4 different dust bins in every house, separation of waste at the source can be well managed.	For collection of each category of waste an individual collector is considered. This approach is not resource efficient and also cause inconvenience of people(producer).
Kumar et al.	Eco-Friendly IOT Based Waste Segregation and Management	Using smart trash bins, the wastes are separated at the source and filled up notification is sent to the authority.	The cost of implementation is too high.

III. EXISTING SYSTEM

Nowadays we observe that, most of the countries still use the old or traditional system for collecting wastes. The system works in such a way that there are trash bins in common places of the city and citizens throw the garbage there, and collectors based on their schedules come and collect the wastes. In urban areas usually, there are responsible collectors which collects the garbage from every single house. The following problems and cases are observable in such kind of systems [15], [16].

A. Problems

- Most of the time trash bins overfills and producers throw the waste around the trash bins [3], [9], [10], [11]. This situation remains for several days and lots of bacteria and microbes influence there and wind spreads them around. This situation increases environment pollution and brings lots of severe diseases.
- Society people are not aware of maintaining solid waste and wet waste separately, they put the wastes mixed.
- Collector collects the waste as it is. Since the wastes (biodegradable & non-biodegradable) are mixed, separating of them is an extra task that consumes time and resources.
- In some areas the trash bins are located hundreds of meters far from several houses, in this case, it will be difficult to carry the garbage until there. So, people of the area often throw the waste nearby their houses.

B. FEASIBILITY CASES

The following cases are observable due to lack of monitoring system:

- There are some employees (collectors) who do not do their duty completely, i.e. they do not collect the waste of few areas or even do not come to collect at all.
- Some of the society people do not perform their duty correctly, i.e. instead of putting the waste into the trash bin, they throw it around the trash bin.
- In case of some urban areas, when collector comes near to producer's house to collect the waste, producer may not be at home on that time, so the waste remains uncollected.

IV. PROPOSED SYSTEM

Nowadays we observe much improvements in technology, most of our procedural works are done by computer systems and almost everyone has smart phones and are connected to the network [17]. Our purpose is to have a networked system for waste management that covers whole city.

Collecting biodegradable waste and non-biodegradable waste separately, is our main observation. So, first of all, the awareness of maintaining separate trash bins for solid/dry waste and wet waste should be given to the citizens. Every producer must maintain separate trash bins for biodegradable and non-biodegradable wastes. The collector also must have separate trash bins for collecting the wastes. Next is collecting waste in the time, that is the most important thing to consider, synchronizing the time of collecting the waste is very difficult. This problem will be solved by using a mobile technology platform and particular mobile application that all citizens should have installed it.

A. SCENARIO

The scenario is, each producer of waste and collector of waste have the application installed in their mobiles and are connected to platform. Using GPS they can locate their locations, whenever the producers of waste request for collection of waste via application, the request transmitted to the server and the server locates the nearest collector node and assigns the task and also sends an acknowledgement notification to the producer node along with the estimated time of arriving of collector, meanwhile the collector receives the notification of assigned task and moves toward the producer's location when arrived to the exact location, an arrived notification will be sent to the producer and producer easily deliver the waste to the collector.

a. SCENARIO DIAGRAM

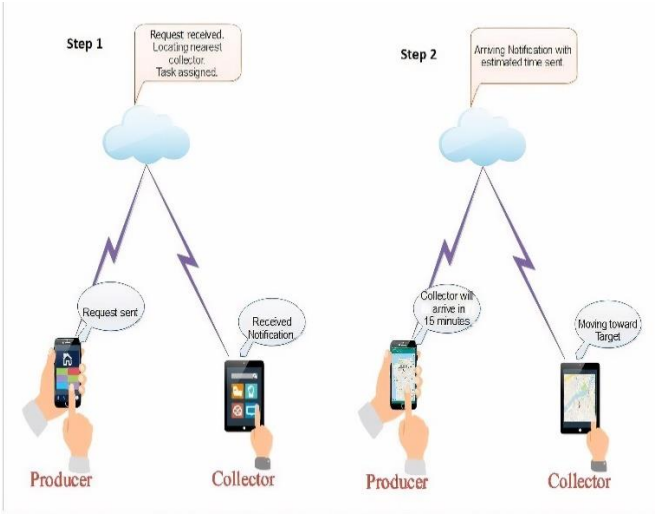

Figure 3: Step 1 indicates the process of request from producer and response from server. Step 2 indicates tracking process.

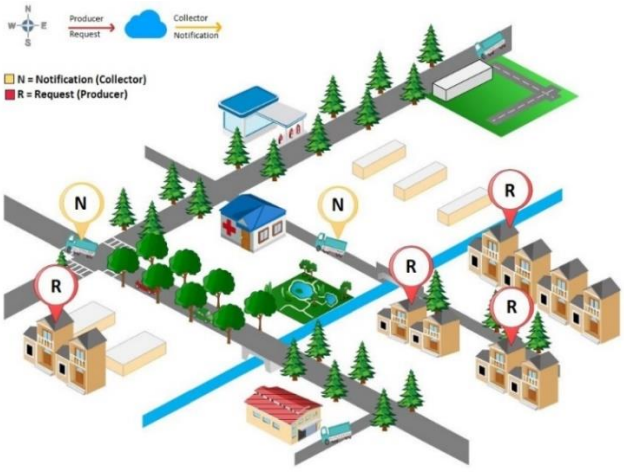

Figure 4: Directional map of the request and response process.

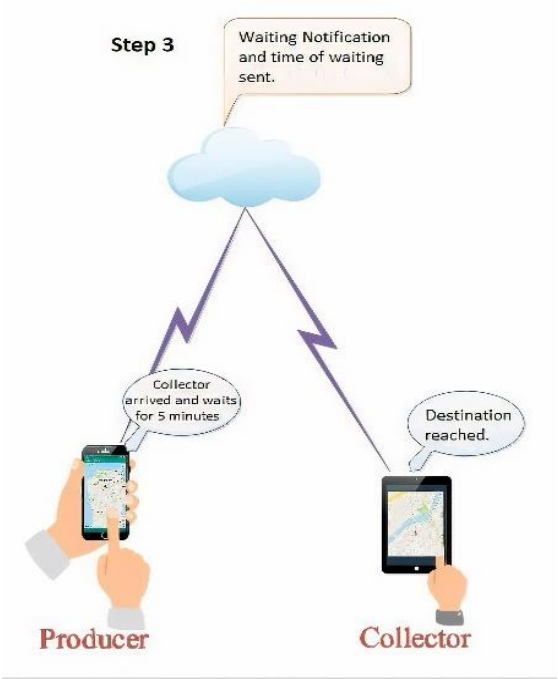

Figure 5: The figure indicates that the collector has arrived and waiting for certain amount of time for waste collection.

Figure 6: Directional map of arrival notification and waiting for collection.

B. FUNCTIONALITIES OF THE SYSTEM FOR PROBABLE CASES

In this system some rules and regulations are considered as a functionality to avoid probable cases. Some of them are described as follows:

a. PRODUCERS CASE

It is the fact that all of the producers will not do their responsibilities accordingly, there may exist some producers who will not cooperate in a good manner. Consider if a producer delivers the waste 5 to 10 minutes later and if we calculate such amount of time for 1000 producers, delayed time will be more than hundred hours, which is really huge amount of time.

i. RULES FOR THE PRODUCERS CASE

1. After arriving the collector, producer should deliver the waste within 5 minutes otherwise producer should be wording as penalty may be monitory or non-monitory like social responsibility calculation. The amount of penalty should be taken from the producer account automatically and a confirmation of payed penalty should be sent to the producer's mobile.
2. When the producer is out of the station or has no waste, he/she must inform the collector.
3. When the producer wants to shift the time of collection, he/she must update the time of collection in the system.
4. When the producer wants to change the location, he/she must update the location in the system.
5. When the producer has more wastes then as usual, he/she should inform the collector.

Figure 7: Producer Case Diagram 1

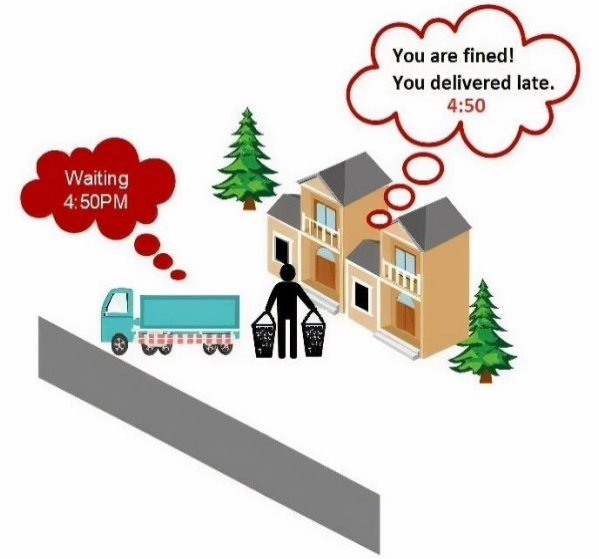

Figure 8: Producer Case Diagram 2

b. COLLECTORS CASE

Most of the employees (collectors) may work honestly but there are some employees who will not perform their task in a good way. If we do not have control on collectors, it will badly effect on system goals.

i. RULES FOR THE COLLECTORS CASE

The system has real time tracking feature and can track the collector's vehicle. When producer requests, the system locates the nearby collector and assigns the task(request) and alarms the collector.

1. If collector do not perform the task assigned or do late to arrive at the target without acceptable reason, the collector should be wording as penalty may be monitory or non-monitory like social responsibility calculation. The amount of penalty should be deducted from his salary and a confirmation of deducted amount should be sent to the collector.
2. If the collector regularly neglects the duty, he should be blacklisted through the system.

Regarding collectors' case, the following issues possibly may occur:

- In case of vehicle failure, system gives the ability for collector to notify the responsible department for fixing that issue.
- In case of accident, system gives the ability for collector to notify responsible department.
- If bin of vehicle is filled, system gives the option for collector to notify the system. In this case system will not assign any task between the calculated time period that will be taken by collector to empty the waste.

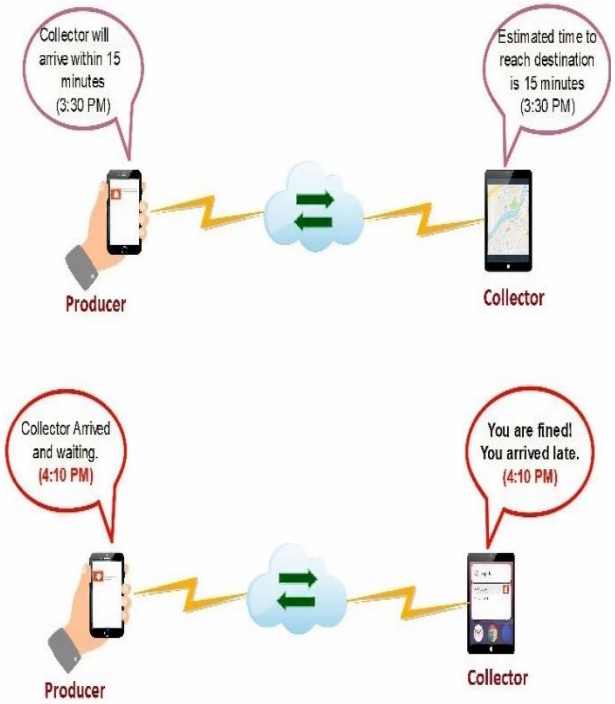

Figure 9: Collector Case Diagram

C. FLOW CHART FOR PROPOSED SYSTEM

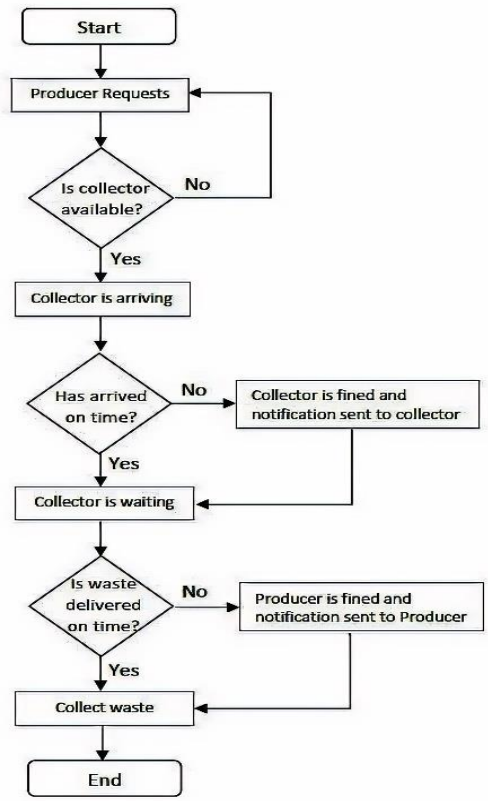

Figure 10: Flow chart for proposed system

D. GPS FUNCTIONALITY

Functionality of GPS [18] directly effects on performance of the system. In this system GPS selects shortest path to the destination and in case of traffic, selects best route. This results to time saving, less consumption of fuel (Gas, Petrol …) and fund saving. Whenever fuel consumption is less then air pollution decreases, this itself helps for controlling environmental pollution.

V. CONCLUSION

Waste is a major pollutant of environment which in case, if it is not managed well, it will increase environmental pollution and causes various diseases in the society. Most of the countries in the world utilize traditional system for waste management which has many drawbacks and deficiencies, for instance, the wastes (biodegradable & non-biodegradable) are not collected separately, wastes are not collected on time and there was no monitoring system to monitor the collector and producer job performance. In this paper we have proposed a smart waste management system based on mobile application to overcome all those drawbacks and deficiencies and facilitate the process of waste management. The proposed system forces the producer to maintain biodegradable and non-biodegradable wastes as separate. Producer request for collection of waste through the application, the location of the producer is located and collector comes and collects the wastes separately. The system forces the collector and producer to do their job correctly by

monitoring and tracking them. In case of any neglect in the duty, proper rule will be applied on collector or producer.

If this system implemented, in addition of solving the existing problems, brings facilities to producers, reduces the amount of budget being spent for management of waste and insures clean environment.

FUTURE WORK

Our future work includes the performance prediction of producer and collector of the wastes, analysis of social responsibilities for waste management and functionality of system as a real time system. We will use artificial intelligence and machine learning techniques to obtain a better prediction and analysis.

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