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A REVIEW OF IOT BASED INTELLIGENT BINS & SMART WASTE MANAGEMENT SYSTEMS

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Abstract: With the evolution of IoT, came the enrichments of human lifestyle. However, one issue that still needs improvement is the waste management and handling of garbage collection. The total generation of waste in India is about 150 million tons every day and hence waste management in India has become a very challenging task. This paper focuses on the IoT based system that can support the existing workforce to manage waste generated in the sectors of a smart city. In this paper, we have the critical analysis of existing literature which is relevant to intelligent dustbins and the mechanisms associated with IoT. Though, the literature consists of a lot many research contributions, but, here, we have analyzed around twenty research papers. We have analysed all the research works on common basis and represented them in tabular form so that comparison between the different methods can be easily done. The emphasis is on the platform used by the concerned authors, the software and programming language used and the various performance evaluation parameters like number of sensors, type of storage, and the other parameters like fire detection, waste prediction, waste classification, route scheduling, approx. cost, etc. Hence, the merits and demerits of each of the existing approach can be determined. Finally, the findings are summarized related to the studied and analyzed research papers.

Index Terms **– Smart waste monitoring and control, Internet of Things (IoT), Smart Cities, Intelligent Bins, Smart Bins**

I. INTRODUCTION

With the increase in the population of India one issue which comes as a repercussion is the generation of waste. This inherently has given rise to the demand of a smart waste collection and efficient management system. The current waste collection methods use static scheduling. The static scheduling system of waste collection has various demerits. The collection of waste is performed by considering all the bins and collecting them every morning on the same route. This collection does not consider whether the bins are filled or not, if it is not filled, it is still checked for collection. This kind of working not only increases the total distance traveled but directly affects the fuel costs and time taken to travel [1]. Hence the efficiency is reduced.

With the concept of digital India, came the idea of smart cities. As on date, there are 100+ identified cities which are on the way to become smart cities in India. With the tremendous growth in every sector, the advancement of smart waste collection is a must. Although, IoT based Smart bins are not entirely new as an idea but no particular and most efficient system developed yet. Hence scope of contribution still exists in this area of research. Also, to find the most efficient solution to the waste management problem and intelligent bins, we need to study the existing methods develops by different researchers. This motivates us for the literature review.

II. LITERATURE REVIEW

Although there are many research work on smart bins and intelligent waste management systems, here we have critically analyzed and summarized around twenty research works and projects addressing this issue. It is observed that most the the recent works uses Arduino Uno as their platform. Most of the works have the same working principle that their system based on IoT monitors the level of waste in the dustbin using the ultrasonic sensors installed in it. The sensed information is transmitted through RF signals to the PIC controller which in turn forwards the data to the central server. The data recorded can be checked on the webpage in the receiver's LCD that is connected to the server. For waste collection when the waste level in the dustbin gets beyond the limit buzzer alarm is used. With this the authority gets aware and the message is sent to the driver of the dump truck and the further actions are taken. The entire system is cost effective as less number of equipment and resources are required.

In other applications, IoT based sensor system is applied to detect the volume of trash. The GPS (Global Positioning system) system is used to identify the location of these smartbins. This location information is communicated to the waste management department through GSM (Global System for Mobile Communications) on smartphones. Using the Google Maps the location of the dustbin can be found.

Table 2.1 shows the comparative analysis of the related works. The emphasis is on the components used, their working software and programming languages used, number of sensors, type of storage, data prediction accuracy, other features as the fire detection rate and approximate cost in Rs.

Table 2.1: Comparative Analysis of the existing methods

Although the comparison between the above-mentioned methods doesn't yield any significant distinction between them, we need to have a more rigorous and exhaustive approach for analysis of the intelligent waste management systems. As a result, we furthermore compared other research work in depth and listed out their every aspect.

From the Table 2.2, we can see that the research works [8-16] are compared on the basis of Waste Recycling, Bins Location, GIS, Route Scheduling, Architecture, Experimental Data, Waste Prediction, Cloud Storage, Waste classification, Prototype, Algorithm. It is observed that although a method can address certain aspects, but it isn't the most efficient and workable on universal basis. Hence this motivates us to develop an approach that can work on universal basis and can handle all the issues.

Ref. No	Year	Hardware components	Software and prog. lang.	Number of sensors	Cloud Data Storage	Local Data Storage	Data Prediction Accuracy	Fire Detection Rate	Approx Cost in Rs.
[2]	2020	Sensors, Arduino Microcontroller, GSM/GPS/GPRS module, IoT devices, Wi-Fi	Lab view, Java and C++, and other relevant software	4	50%	50%	98%	100%	Rs. 10000
[3]	2018	Ultrasonic Sensor, Arduino, GSM Kit, etc.	Java, C++ and other relevant lab test software	2	100%	NA	NA	NA	Rs. 9000
[4]	2017	Ultrasonic Sensor, Arduino, GSM Kit,	Java, C++ and other relevant lab test software	2	NA	100%	92%	NA	Rs. 8000
[5]	2015	Sensors, Arduino Microcontroller, GSM/GPS/GPRS module, IoT devices, Wi-Fi	Java, C++ and other relevant lab test software	3	NA	100%	90%	NA	Rs. 9500
[6]	2016	Ultrasonic Sensor, Arduino, GSM Kit,	Java, C++ and other relevant lab test software	2	50%	50%	NA	NA	Rs. 8500
[7]	2018	Ultrasonic Sensor, Arduino, Wi-Fi GSM and GPRS Kit,	ThingSpeak platform, python or R, Google Map API	1	100%	0%	NA	NA	Rs. 9500

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Table 2.2: Comparative Analysis of the existing methods addressing the issue of smart waste management systems

Year	Ref. no.	Algorithm	Prototype	Waste classification	Cloud Storage	Waste Prediction	Experimental Data	Architecture	Route Scheduling	GIS	Bins Location	Waste Recycling
2014	[8]	No	Yes	No	Yes	No	No	Real Time	Yes	RFID	Yes	No
2017	[9]	No	No	Yes	No	Yes	No	Real Time	No	LoRa	Yes	Yes
2018	[10]	No	Yes	No	Yes	No	Yes	Real Time	No	LoRa	Yes	No
2020	[11]	Machine Learning	Yes	No	Yes	No	Yes	Real Time	Yes	LoRa	Yes	No
2019	[12]	AI	No	No	Yes	No	Yes	Real Time	Yes	GPS/ GSM	Yes	No
2018	[13]	Ai	Yes	Yes	Yes	No	Yes	Real Time	Yes	LoRa	Yes	No
2018	[14]	Heuristic	No	Yes	Yes	No	Yes	Real Time	Yes	N/A	No	No
2018	[15]	No	No	Partially	Yes	No	Yes	Real Time	Yes	GSM	Yes	No
2020	[16]	Predictive Analytic	yes	No	Yes	Yes	Yes	Real Time	Partially	GPS/ GSM	Yes	No

Based on the critical analysis of the above methods, we have developed a taxonomy for waste management using Iot as shown in Figure. 1. The waste management systems basically have the core features of IoT technology, Programming Software, and Infrastructure. The infrastructure includes the intelligent dustbins, pickup trucks, depots, dumps and pipes which are inherently useful for the processing and recycling of waste. The IoT technology includes the smart and communication components like microprocessors, RFID, Sensors, WSN, actuators, cameras, GPS/GPRS, etc. This acts as the brain and body of the system. The software or the programming languages are used to scheduling, routing, DGG, GIS and basically manages the experimental data, social context and overall architecture of the system.

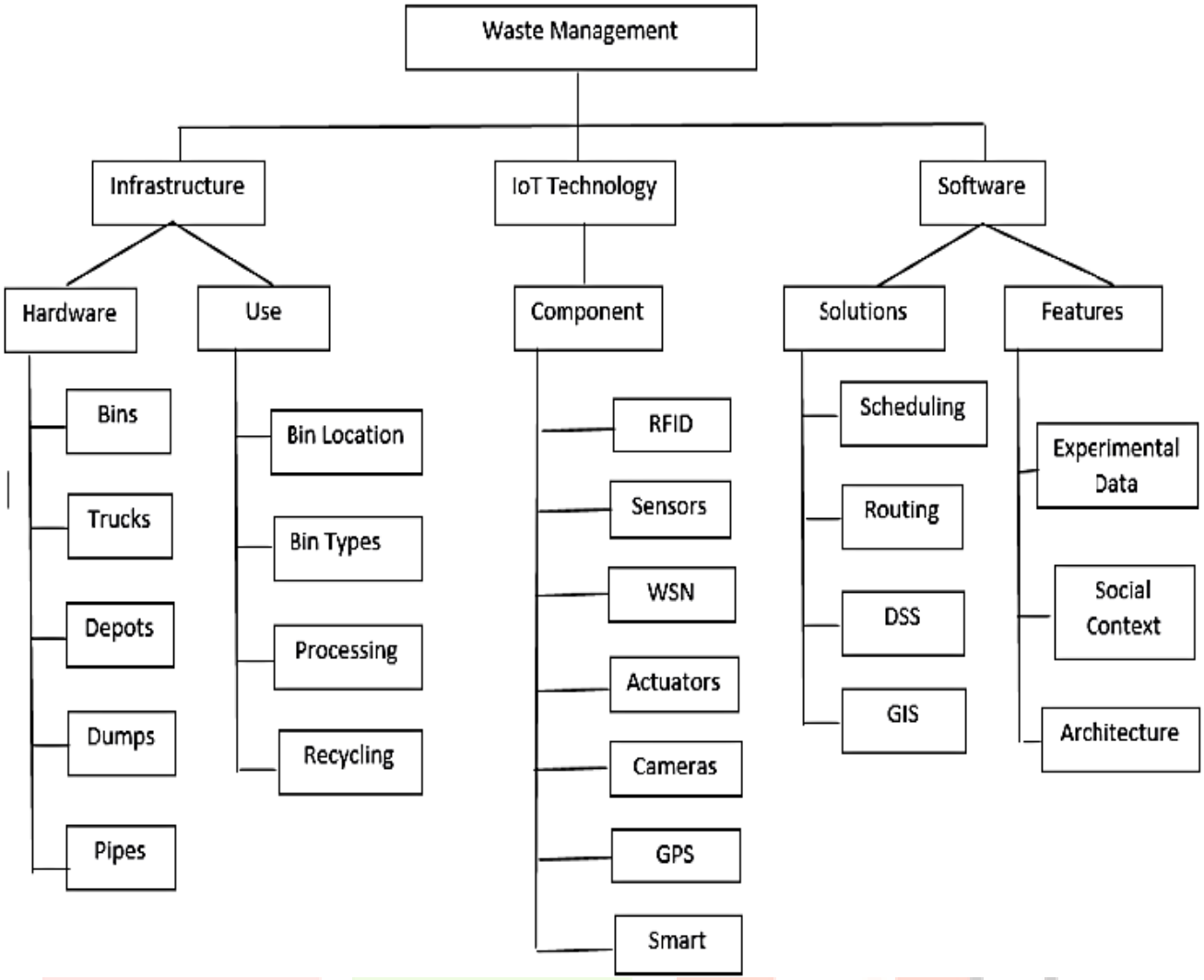

Figure 1. Taxonomy for intelligent waste management systems using IoT

III. Our Findings From Studied Literature

The findings from critically analyzed around sixty reviews and research papers are summarized below:

- Arduino Uno is the most recent and most efficient platform for Intelligent Bins
- In order to have the most effective system, we have to employ a number of sensors on the dustbins which will sense multiple parameters like weight, proximity, fire, etc
- We have to use GPS system for location of the dustbins.
- Segregation of waste is important parameter while designing of a waste management system
- Waste recycling should also be addressed
- Storage of data is important
- Communication plays a critical part
- Scheduling and routing of the dustbins are necessary
- Wet waste and dry waste can be separated
- Plastic waste can be segregated
- Real time system is necessary

IV. Discussion and Future Work

Although, IoT based Smart bins are not entirely new as an idea but no particular and most efficient system developed yet. Hence scope of contribution still exists in this area of research. More experiments should be done by using advanced technologies to avail the smart waste management system so as to develop a smart city. In future, we will implement the intelligent bins using tools from IoT and will move towards optimization of the waste management system.

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