IoT- Enabled Intelligent Solid Waste Management System for Smart City: A Survey

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Abstract

With the rise in the urbanization of cities and growing population there has been a major concern for improving health, hygiene and quality of environment.One of the important challenge is solid waste management, from its inception to disposal. Accumulation of waste causes health hazards, environment pollution and in turn spoil the area.Various initiatives has been takenwith an objective of promoting sustainable environment using smart solutions. To mitigate and eliminate the solid garbage, IoT based technologies have been emerging as a beneficiary approach.This paper summarises a survey on various IoT enabled technologies adopted as a smart solution for solid waste management in order to develop a smart city.

Keywords: *GSM, GPS, IoT, Microcontroller, Solid Waste Management, Sensors.*

1. Introduction

The total generation of waste in India is about 150 million tones in a day [1]. On considering the solid waste, it mainly includes the solid materials that are unwanted and useless and can be classified on the basis of its origin, potential hazards and material type.These solid wastes are laid across the public places as a trashwhich causes the unhygienic area in the surroundings and in turn causes contagious diseases.

Prior to the steps taken for the waste management, trash monitoring and collection steps requires the trash collector and the sanitation engineer to visit the place continuously. This human labor and in turn transportation is a tedious process [2]. Therefore, some durable and cost effective means are required for efficient solid waste management.

Solid wastebecomes hazardous and contaminated when not treated in time. It causes an adverse impact on the human health and environment if not treated before it becomes toxic. To tackle the problems and for sustainable management of waste in India, Swacch Bharat Abhiyan mission has been organized as an initiative at the national level [3].

For developing a smart city, use various technologies such as RFID (Radio Frequency IDentification, WSN (Wireless Sensor Networks), IoT(Internet of Things) etc. has emerged as an effective smart solutions so as to preserve the assets, resources and environmental surroundings [4]. Of these, IoT enabled devices are widely been used for monitoring, collection, transportation and disposal of solid wastes.

2. Internet of Things (IoT)

The Internet of Things allows every object or things in the surrounding get connected with each other through wired or wireless devices and are able to exchange information to serve as the smart services. Things are objects with sensing capabilities that enables them to automatically transmit information to the base station. In other words, nearby objects are able to interact with each other on the internet and serve the citizens for one or more problems. It involves the binding of Information and Communication Technology along with sensors, devices, smartphones and software etc. that are present around the human as a variety of things to provide a solution.

To develop smart city management of garbage is one of the major challenging. A well-organized functioning system is required to provide a clean and hygienic environment for civilizationwithout any human interventions. With the concept of using IoT based devices the waste accumulated across the residential or industrial areas can be monitored collected and disposed easily. It mainly deals with sensing, processing, gathering and transporting the trash by using wired or wireless devices connected to the internet in either physical or virtual manner.Mainly sensors and programmable hardware devices are deployed across the region that gathers the information and transmit it to the end user with the help of equipments and mobile devices.

For waste management systems using IoT a number of smart trash cans that are placed in different locations throughout the area or campus are connected to the Internet.It collects real-time information and transfers its status to the monitoring units. These information includes detection of level of trash in the cans, inspection of overflows, transmission of information to the transport systems, etc.

3. Various Approaches

For management of solid waste management various techniques have been proposed and implemented. A brief overview on the different methods adopted on the basis of IoT are:

Garbage management system based on IoT [5] monitors the level of waste in the dustbin using the ultrasonic sensors installed in it. The sensed information is transmittedthrough RF signals to the PIC controllerwhich 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. No idea about waste collection methods and route optimization is identified.

Automatic dustbin monitoring system [6] is designed for waste management for smart city. Ultrasonic sensors are deployed at the top point in the dustbin to measure its level i.e. empty or full. To measure the weight of the garbage weight sensor is deployed inside the dustbin at its base and load cells are used to send the sensed electrical signal from both sensors to the PIC microcontroller. The Arduino kit is used as information receiver unit which displays the real time data on the webpage using an Ethernet. A measurement algorithm is used to determine the level at which the waste is to be collected from the dustbin. Based on the data displayed on the webpage monitoring unit tracks the location for garbage collection. GSM system is used for communicating the data through SMS

services to the collecting unit. Power consumption measures are not taken into consideration.

A Smart Garbage System [7] is designed for public surroundings. Wireless communication system are installed in a manner such that all dustbins located at the near places can exchange information and enable a smart management of food waste.The service users dump the waste in these dustbins and the IR sensors senses data from the smart dustbins and identifies whether it is filled up to the limit and finally transmit it to the contractor. The data is communicated to higher authorities if the actions are not taken by the contractor. Hence allows hierarchical data monitoring system. With this the public users get aware of the unwanted wastage of food and the disposed garbage can be recycled and reused for other effective means.

Force sensorsare used to monitor the measure the weight of garbage in the smart dustbin[8]. A threshold value is set in the sensors and the colour of the LEDs are used to monitor the overflow of the dustbin beyond the marked level. The GPS (Global Positioning system) system is used to identify the location of these smartbins. This location information are 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.

IoT based sensor system is applied to detect the volume of trash[9]. Graph Theory classification and regression techniques are applied to find the location of all the garbage bins and data is transmitted over the Internet. The bins places across the city are considered to be in a cluster and the regression algorithm is used to find the overflow of trash in the dustbins. The bin which has the highest level of trash is considered first for waste collection. Thus the weight factor becomes the priority factor for route selection of dump trucks.

The testbed is deployed for solid waste management system [10] which included 2 gateways and 11 smart bins. The maximum distances between smart bins and gateways are calculated as 240m. In every 5min the sensors installed in the smart bins senses it and informs the gateway about the fullness. On the basis of duty cycle power consumption of the sensing devices is minimized. The gateway transmit the gathered data to the cleaning contractors. GPS systems are installed in the dustbins so as to identify the location of dustbins. The wireless mesh network is deployed for the overall communication system. Data compression technique is used to transmit the information from the sensor node so that energy consumption of the system may get minimized.

Another waste collection method [11] led emphasis on sticking to the RFID on the plastic bins and tracking of the trucks for garbage collection.IR sensors are used for sensing which sends the data and forwards to the Raspberry Pi servers. ARM microcontroller performs processing and level detecting of the smart bins and forwards the report to the Municipal authority. The mailing and messaging system is used for informing the garbage collector vehicle about the route information and thus reduces the cost of expenditure.

Test for waste collection solutions [12] by using 5000 dustbins in 11 different locations across the cityis carried out that identifies the spatial and temporal context of the sensed data collected from the dustbins. The server manages database management, information forwarding and shortest path route optimization algorithms for waste collection. Use of Artificial Intelligence is proposed to predict the volume of waste on the particular daybased on previously recorded data.

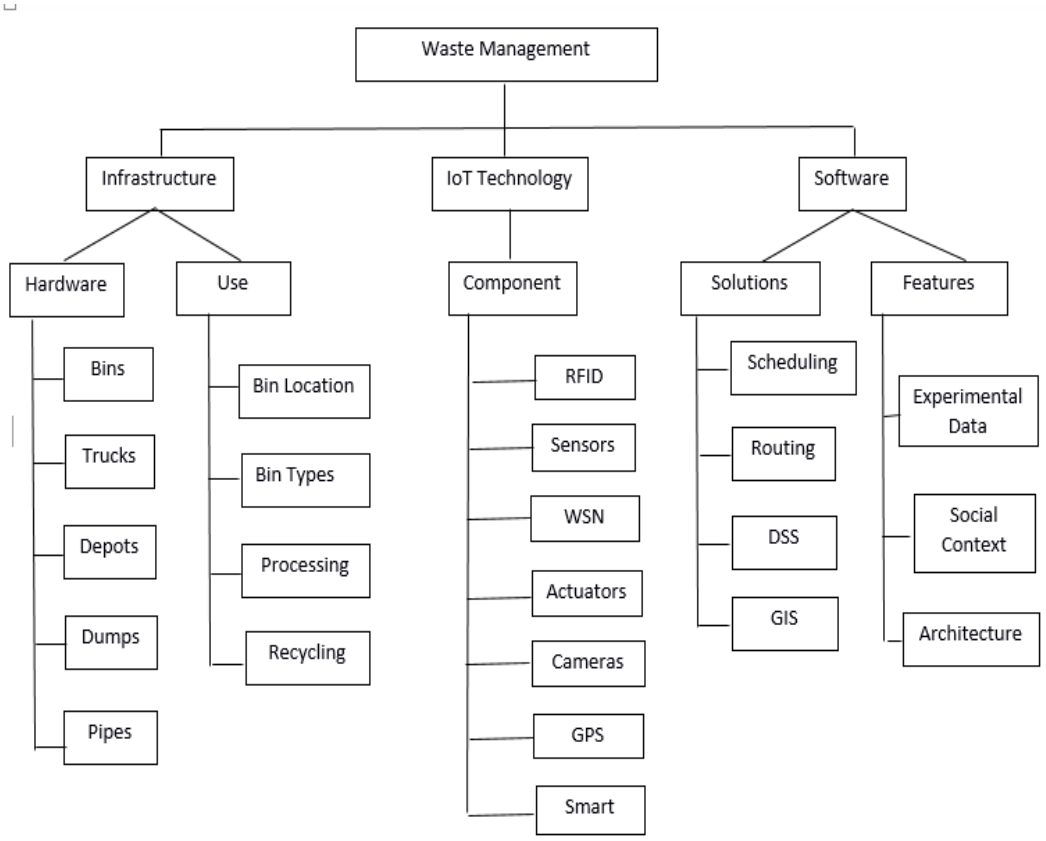

Figure 1. Taxonomy for Waste Management using IoT

4. Conclusion

From the survey it is found that IoTis being adopted as an effective approach for the management of waste in public areas. The experimental research done till now is found to be useful and progressive. Although the waste management include monitoring, collection, disposal, segregation measures, the experiments are found to be more focused on monitoring and collection steps only. Thus this survey concludes with identifying the initial steps and what other measures need to be considered. In this regard, more experiments should be done by using advancedtechnologiesto avail the smart waste management system so as to develop a smart city.

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