ISSN: 0976-3104
SPECIAL ISSUE (ASPM)

THE IIOAB JOURNAL

ARTICLE OPEN ACCESS

A COMPREHENSIVE EVALUATION OF WASTE MANAGEMENT SYSTEMS

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ABSTRACT

Managing the waste has become the integral part of our day to day life. It is very essential to dispose the day to day wastes in an efficient and easy manner. Lack of waste management can result in disturbance of the environmental balance and in turn lead to the degradation of the health and hygiene of society. The main problem that has arisen deals with the detection, monitoring and management of wastes. The existing method of monitoring the waste system is a complex and tiring process that requires a lot of human effort, cost and hence will not be compatible with the development in the technologies. Hence there is a need to automate the whole process of waste management. This paper proposes the same. ZigBee is one of the most anticipated and promising technology catching up pace in the recent years. This work presented here provides a new way of approaching the problem of waste management. The system consists of four main subsystems namely Smart Trash System (STS), Local Base Station (LBS), Vehicle System and Main Station. The proposed system will be able to automate the entire process of solid waste monitoring and manage the collection of the waste efficiently. The technologies that have been proposed for the automatic waste management are practical and can be used in order to promote the concept of Green Environment.

Received on: 25th-Dec-2015
Revised on: 29th-Feb-2016
Accepted on: 16th– Mar-2016
Published on: 15th –Apr-2016

KEY WORDS

Smart Bin; Local Base Station; Main Station; Vehicle System.

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INTRODUCTION

Due to the advancement in science and technology there is always a tendency to automate all the manually controlled things. As the tendency increases there is an increase in the risk of exploitation. Automating all the manually done things reduces the human effort. Manually controlled products involve a higher cost and effort when compared to automated systems. There is a need to address the problem of waste management and this has to be done immediately [1]. The purpose of addressing the problem of waste management is done by keeping in mind the health and hygiene of the society and the world as a whole. Solid waste which is the main cause of environmental pollution has been defined under Resource Conservation and Recovery Act as any solid, semi-solid, liquid or contained gaseous material from agricultural, commercial, mining or industrial operations and from community activities [2]. Be it locally or globally waste management is a continuously increasing problem. Solid wastes arise mainly from the activities of humans and animals. In general terminology, solid wastes can be defined as the organic and inorganic waste materials produced by various activities of the society and which have lost their value to the first user [3]. The day to day domestic waste is collected as a whole, by placing a dustbin at a particular place for a lane or street. The process of checking the status of the bin is the toughest part. In the existing method, the municipal worker has to look through all the different areas where the bins are placed in order to collect the waste. This is a tiring and a time consuming task. The existing method of the waste management system is considerably inefficient, when the current development in technology is taken into consideration [4]. There is no guarantee that the worker will arrive to the right place, at the right time to collect the waste. In order to overcome the problems faced due to the existing method, a new way of approaching the waste management system automatically is proposed. It is the leap taken in the direction of automating the waste management to make it more efficient [5]. A Recent advancement in the technology has led everything in this world to go and connect to the Internet [6]. Using internet, it is possible to build an intranet and coordinate all the bins there by having a centralized system.

LITERATURE SURVEY

For literature survey recent papers are considered. The summery of each of them is presented below

Overview for solid waste bin monitoring and collection system

This paper is based on finding solutions for solid waste management [7]. The technologies being used in this paper are Radio Frequency Identification (RFID), Global Position System (GPS), General Packet Radio Service (GPRS), Geographic Information System (GIS) and web camera. The collection trucks are embedded with RFID reader which helps in retrieving all the customer as well as bin information from the FRID tags placed in each bin. The location of the bins is given by GPS. Authentication by the use of driver id is needed to start the collection session. The waste disposal trucks with the help of RFID readers pick up the RFID tagged bins. The RFID tags are keys for retrieving the information stored in back end databases.

Automated waste clearance

This paper is based on the Automation concept which is under the domain of Public Cleanliness and Hygiene [8]. The entire trash bins will be embedded by specific sensors so as to notify the departments whether it is full or not. The bin status will be sent to the server. The server is directly connected to the worker's profile. In this manner the worker gets alerted about the bin being full. A certain mathematic calculation is implemented so as to determine the time gap between the sensors. Based on the results, the workers will be notified about the time left for the bin to be full before he arrives to the location. After the worker clears the waste, the server is updated automatically and the sensors are reset to their original state.

RFID and integrated technologies for solid waste bin monitoring system

This paper is based on a system which consists of a trash bin which is embedded by a RFID tag, a truck which is fitted with a RFID reader, a server based on GPRS/GSM, a map server based on GIS, a database server and a control server [9]. The RFID readers mounted in the trucks retrieve the bin location via GPS. This information is regularly transferred in real time through GPRS to a database which is centrally located. A web application is designed so that the users can view the current location of the trucks individually during collection. A map server stores a digital map which displays the positions of the trucks as well as trash bin information. The RFID tag notes the data of the bins. This data is transmitted to the RFID reader present in the truck. By using this technique, the system can come to know whether the truck has arrived to the bin location or not. The amount of waste can be determined by the intensity of grey image (0 to 255). The data collected is dependent upon the camera position. Thus the amount of waste can be calculated and the graphical user interface can be used to show the result.

Smart garbage collection system in residential area

This paper is based on a concept that includes a camera being mounted on each garbage collection marker as well as a load sensor fitted at the bottom of the trash bin. The camera is used to take regular snapshots of the trash bin. The camera and the load sensors are set with a threshold value so that they can be compared. A microcontroller is used to perform the comparison. An idea about the garbage level can be conceived by performing image analysis and the weight of garbage can be evaluated by using the load sensor. The threshold level of the trash bin is checked by the controller. The controller, with the help of GSM module, sends a message to the local central office of the garbage collection unit so that it can notify that the garbage needs to be collected [10]. Due to this, the authorities send the garbage collecting vehicle to dispose the wastes, which is performed by implementing a robot mechanism.

A smart waste management with self-describing objects

This paper is based on the concept of associating smart waste management with digital information. The digital information which is associated to a waste can be stored within a QR code or a RFID tag memory. If the QR codes are used, the objects are needed to be in the line of sight [11]. In the case of RFID technology, the information in the RFID tags can be retrieved without requiring the object to be in a particular position during the operation. Nowadays, the UHF tags are being used in the area of supply chain management since the data can be read easily within a distance of five meters from the antenna of the reader. This UHF tag based concept uses the memory of the tags to store the information in data banks memory. This tag memory is used to store the digital information of the associated waste. The smart waste system requires only RFID reader to read the data. The paper also proposes a classification system of the wastes. According to this proposal, a particular type of waste is

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allocated to an unique identification number. The classification is used to store the reference number which represents the waste type in the memory of each tag connected to each type of waste.

Real time bin status monitoring for solid waste collection route optimization

This paper is based on the reduction of solid waste management cost by optimization of the waste collection route, the location and number of bins used as well as their collection frequency [12]. The proposed system is implemented and started from throwing of waste inside the bin which results in updating the database in the control station for that trash bin. The trash bin is installed with a sensor which will be in sleep mode. The accelerometer sensor identifies the event when the bin cover is opened. The Hall Effect sensor measures the bin overload status by evaluating a time threshold. The data transmission from the bin is done by using ZigBee. The data is received at a remote monitoring point by with the help of GPRS coordinator. Due to this, the data sent by the GPRS coordinator is received by the Control Station and the data is stored for further processing. This technique is further optimized by using integer linear programming.

Smart recycle bin- a conceptual approach of smart waste management with integrated web based system

This paper is based on a concept of a Smart Recycle Bin [13]. This Smart Recycle Bin can be used for recycling glass, paper; aluminium can as well as plastic products. The bin automatically evaluates the value of the wastes and provides 3R card. The points collected on the 3R card can be used to rebate any item or can be cashed out in the bank account depending on the type or number of recycle waste. The aim of this system is collecting points according to the disposal activities done into specific bins. A calculator module is configured within an application algorithm which controls and coordinates the points system of the recycle bins. This concept increases the effectiveness of waste management of items which can be recycled.

An approach for monitoring and smart planning of urban solid waste management using smart-M3 platform

This paper is based on a waste management system which has a bin in which there are two types of sensors: a proximity sensor located on the upper part of the bin and a weight sensor located in the bottom of the bin [14]. The proximity sensor is used to measure the level of the wastes in the bin and the weight sensor is used to find the weight of the wastes present in the bin. Every bin has a ZigBee module installed which will be able to measure the physical quantities to the nearest light pole. The gateway of the system is implemented by a Raspberry PI which is used to collect process and transmit the data measured by the two sensors to the central control center. The control center uses the data retrieved by the sensors to implement efficient and effective optimization strategies as well as to find solutions for problems based on organization of resources on solid waste management. The control center is also responsible to inform any vehicle whether and when the bin is empty or full.

Waste bin monitoring system using integrated technologies

This paper is based on a system which implements waste management by using ARM 7 controller and ZigBee technology. The waste bins inserted with various sensors are placed at different localities. If the threshold values at the bins are exceeded, then the sensor will detect that and the data is transmitted to the ARM 7 controller using ZigBee technology. When a smart bin is detected as full by the ultrasonic sensor, the data is sent in the form of a command through ZigBee. The command is retrieved by a ZigBee receiver and the condition of the garbage bin is shown in a Liquid Crystal Display as well as on the computer. Simultaneously, the same message is sent to a driver's mobile through Short Message Service. The message consists of the entire bin information including the location of the garbage bin [15].

RFID-based real-time smart waste management system

This paper is based on a system which is proposed a RFID based waste management system [16]. This proposed system consists of a smart waste RFID tag, a RFID Reader as well as a Waste Management IT System (WMITS). A passive unique RFID tag is used in this system since passive tags do not require battery. These tags are powered by the RFID Reader and have a read range of about 10 meters. The antenna in the RFID Reader picks up the radio waves. The RFID Reader is attached to the Personal Digital Assistant (PDA) and the unique identification number of the bin is displayed. The PDA is installed in the garbage collecting vehicle. The waste collector truck consists of a robotic arm and the weighing system is present in the arm. The weight of the bin can be determined by the help of load sensors present in the weighing system. The Bin ID is used in the calculation of waste disposal charges of individual houses and the result is stored in a temporary storage in the PDA. At the end of the work shift, all the data is stored in a SQL back end server for storage and processing of information. This data transfer is implemented by using Wi-Fi connection and the internet.

The literature review summary **[Table-1]** as follows:

Table: 1. Summary of the literature review

References	Interface used	Sensors Used	Technology Used	Mode of Control	Result Analysis	Usage	Provision of new features
[1]	RFID reader	UHF tag, RF tag	RFID	Semi-Automatic	Available	Smart Bin Application based on tags	NO
[2]	Smart Space	Proximity Sensor, Load sensor	Smart M3-platform	Automatic	Available	Better management of resources	YES
[3]	ARDIUNO board	Simple transmitter and receiver	ARDIUNO SIM module	Semi-Automatic	Not Available	In time and proper disposal of waste	NO
[4]	RFID reader	RFID transmitter and receiver	RFID, GIS, GPRS	Semi-Automatic	Available	Improved database for waste collection	NO
[5]	Wireless sensor network	Accelerometer, load sensor, temperature sensor	GSM, GPRS	Automatic	Available	Reduces the operation cost	YES
[6]	RFID reader, camera	RFID transmitter and receiver	RFID, GPS, GPRS, GIS, Image processing	Semi-Automatic	Available	Monitoring and management of status of the bin	NO
[7]	Mobile Wi-Fi network	RFID tags, HBM SSC load cells	RFID and load self-sensor technology	Automatic	Available	Tracking customer identity, weight and missing, stolen bins	YES
[8]	Micro-controller	Web camera, load sensor	Robotic Mechanism	Automatic	Not Available	Avoid the overflowing of garbage from the container	NO
[9]	RFID reader	RFID tags	Wireless Internet	Semi-Automatic	Not Available	Improved collection of recyclable waste	NO
[10]	ARM Micro-controller	IR sensors	ZigBee and GSM technology	Semi-Automatic	Not Available	Monitor the solid waste collection	YES
Proposed	Serial Communication	Ultrasonic sensor, load sensor	ZigBee, Ad-hoc networks	Automatic	Available	Least expensive, reduced amount of human effort and efficient	YES

The Table shows that the proposed system is far better compared to the one already available.

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PROPOSED MEHTODOLOGY

The architecture of the proposed system is shown in the **Figure– 1.**

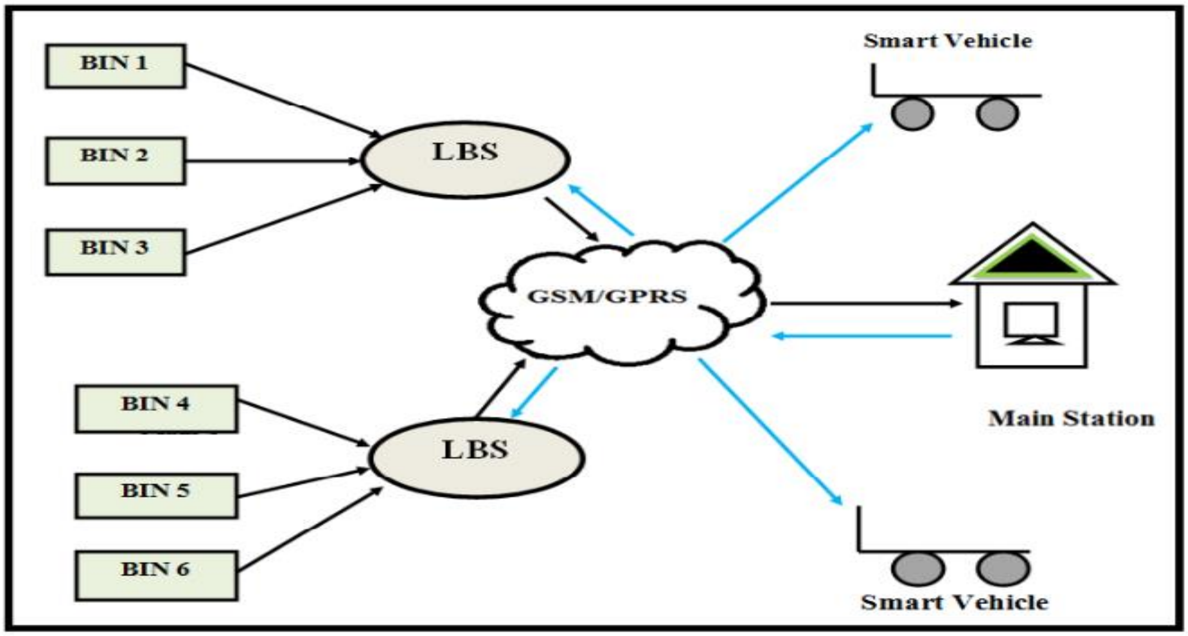

Fig: 1. Architecture of AWMS

Virtualization Smart Bin System consists of electronic device known as "Smart Trash Bin", which includes sensors and a ZigBee transmitter. Two types of sensors which are used in Smart Trash Bin are Ultrasonic Sensor and Load Sensors. The Ultrasonic sensor is used to detect the level of wastes in the Smart Trash Bin. The Load sensor is used to detect the weight of the waste present in the Smart Trash Bin. Whenever the threshold value any one of the sensors is reached, it gets activated and generates a high signal. This signal is transmitted by the ZigBee transmitter present in the bin and is received by the ZigBee receiver situated at the local base station. After receiving the signal, the local base station identifies the unique bin ID, decodes the trash bin location and then sends a signal to the main station about the location of the trash bin. The Main station will send the Bin information to the Smart Vehicle through GSM/GPRS. The Smart Vehicle consists of a Liquid Crystal Display (LCD) in which the bin location is displayed. Thus the workers approach to the location of the bin and collect the wastes.

RESULTS AND DISCUSSION

The **Figure– 2** depicts the webpage for managing the wastes in the Automatic Waste Management System. This portal is controlled by the Main Station. Using this webpage, the status of the Smart Trash Bins placed at many locations in the city can be efficiently and effectively monitored. The webpage consists of the areas of the Local Base Stations and the status of the Smart Trash Bins located within these areas.

The main problems of the existing solid waste collection process and management system are as follows:

- Lack of the information about the collecting time and area.
- Lack of the proper system for monitoring, tracking the trucks and trash bin that have been collected in real time.
- There is no estimation to the amount of solid waste inside the bin and the surrounding area due to the scattering of waste.
- There is no quick response to urgent cases like truck accident, breakdown, longtime idling.
- There is no quick way to response to client's complaints about uncollected waste.

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•Consumption of manpower to collect the trash.
•Time consuming

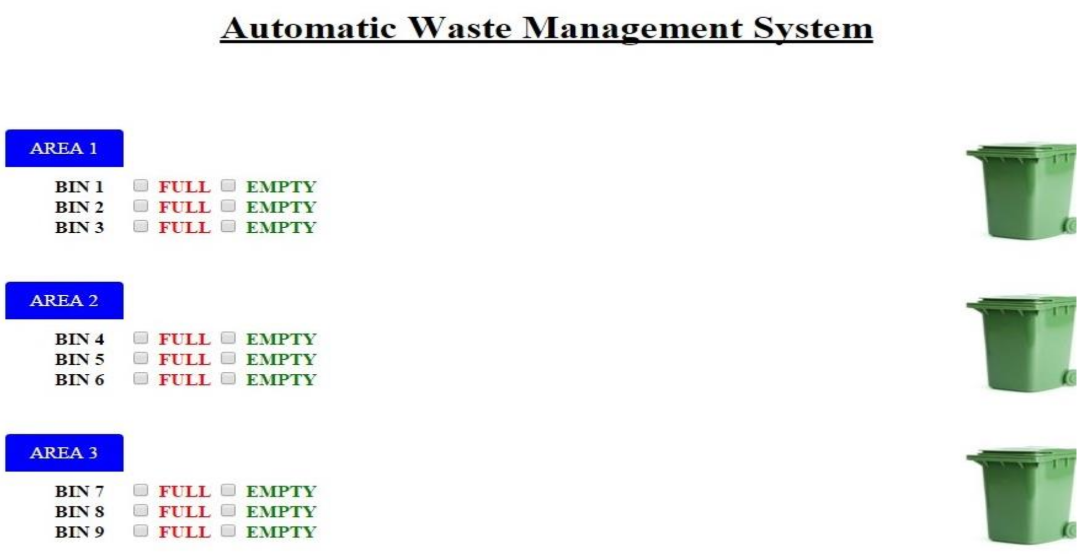

Fig: 2. Web portal for automatic waste management system

Compared to this, the proposed automated, efficient waste management system will do the following
•Saves time, human efforts.
•Makes the entire process traceable to see cleanliness is maintained in the city there by preventing spreading of diseases.

In the currently employed method concerned municipal employee has to look for the filled waste bins manually across different places in the different geographic area/street for checking regularly. He needs to analyze data manually. The proposed system is successfully employed in dust beans and found that it has solved a lot of problem related to solid waste collection, monitoring, minimizing cost and accelerate the handling management.

The outcome of the proposed system is found to be:

•Efficient handling of wastage.
•As soon as the Smart Trash Bin gets filled by the trashes or wastes, the signal is sent to the local base station.
•Once the base station receives signal from the smart trash bin signal, separate signal is sent to the Main Station.
•The Main Station sends signal to Smart Vehicle along with dumping yard details

CONCLUSION

The automatic waste management process is a step that is taken in order to reduce the hardship of manual collection and detection of wastes in an automatic manner. The developed system is a combination of four main subsystems. Those are Smart Trash System (STS), Local Base Station (LBS), Main Station (MS) and Smart Vehicle. The system makes use of the ZigBee technology which is a low cost, low power, wireless mesh network. The purpose of proposing the automatic management process is in terms of its efficiency and time saving nature when compared to the already existing one. In the currently employed method the concerned municipal worker has to locate the bins manually and check the status of the trash bin. This is a very complex and a time consuming process. Hence, there is an immediate need to automate the process of waste management to reduce the human effort and therefore reduces the cost of the whole process. This system can be implemented anywhere and is feasible. The reduced cost of the entire process makes it affordable. Hence the entire method used for the detection and management of waste makes the system efficient and intelligent. The system solves a considerable

THE IIOAB JOURNAL
ISSN: 0976-3104

amount of problems related to the waste collection, monitoring, reducing the cost and therefore accelerate the process of management.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

ACKNOWLEDGEMENT

None.

FINANCIAL DISCLOSURE

No financial support was received to carry out this project.

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ISSN: 0976-3104

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