International Journal on Recent and Innovation Trends in Computing and Communication ISSN 2321 – 8169

Volume: 1 Issue: 7 604 – 609

Concept, Design and Implementation of Automatic Waste Management System

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Abstract--- **One of the main concerns with our environment has been solid waste management which in addition to disturbing the balance of the environment also has adverse effects on the health of the society. The detection, monitoring and management of wastes is one of the primary problems of the present era. The traditional way of manually monitoring the wastes in waste bins is a complex, cumbersome process and utilizes more human effort, time and cost which is not compatible with the present day technologies in any way. This paper proposes an advanced method in which waste management is automated. Radio frequency identification (RFID) is one of the most promising and anticipated technologies in recent years. The system makes use of radio frequency (RF) tags and web support. This work presented here certainly provides a novel approach in handling and disposing off the day to day solid wastes in an efficient and easy way. The system consists of four main subsystems namely Smart Trash System (STS), Local Base Station (LBS), Smart Vehicle System (SVS) and Smart Monitoring and Controlling Hut (SMCH). The proposed system would be able to automate the solid waste monitoring process and management of the overall collection process. The technologies that would be used in the proposed system are good enough to ensure the practical and perfect for solid waste collection process monitoring and management for green environment.**

Keywords: Smart Trash Bin, Local Base Station Smart Vehicle System, Smart Monitoring and controlling Hut, Control Panel, Data Control, Unique Trash Bin Code.

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1. Introduction

The trend of making the manually controlled things automatic has become a common practice these days. The process of making the things automatic is being exploited in almost all the major fields of life. Making things automatic reduces burden on the humans. The cost and effort used in manually controlled products is much higher than the automated systems. Considering the fact, that the problem of efficient waste management is one of the major problems of the modern times, there is an utmost need to address this problem. The proper waste management system is must for the hygienic society in general and for world as a whole. Solid waste which is one of the sources and causes of environmental pollution has been defined under Resource Conservation and Recovery Act as any solid, semi-solid liquid or contained gaseous materials discarded from industrial, commercial, mining or agricultural operations and from community activities [2]. Solid waste also includes garbage, construction debris, commercial refuse, and sludge from water or waste treatment plants or air pollution, control facilities and other discarded materials [3]. In order to protect human health and the environment from the potential hazards of delayed waste disposal and environmental pollution a systematically supervised and controlled handling of these wastes is must. The type of wastes which constitute environmental pollution and which this work emphasizes on is domestic refuse consisting of degradable food wastes, leaves, dead animals and non-degradable ones such as plastics, bottles, nylon, medical and hospital wastes, generated in households, hospitals, industries and commercial centers [4]. The complexity of issues involved in municipal solid waste management necessitates development and application of new tools capable of processing data inputs of varying formats, numerical models and expert opinions in multi objective decision making scenario. Decision Support Systems (DSS) are among the most promising approaches to confront such situations. The DSS models should ideally be integrated with geographical information system (GIS) to optimize collection,

transportation, processing and disposal processes. An attempt to present an overview of DSS in the area of solid waste management with specific reference to their development and applications in India. [1].

Waste management is a continually growing problem at global and local levels. Solid wastes arise from human and animal activities that are normally discarded as useless or unwanted. In other words, solid wastes may 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 [5]. The domestic waste products are collected through waste bin at a common place at a particular spot for an area/street. A major difficult task is that checking process of waste bins for the collection of wastes. The usual method by which, a person has to wander through the different spots and check the places for waste collection. This is somewhat complex and time consuming process. The present day waste management system is not as efficient as it should have been taking into consideration the advancements in the technologies that arose in the recent years. There is no surety about the management/ clearing of wastes at all the places. To overcome this problem a new approach, *Automatic waste management system* is proposed. It is a step forward towards making the waste collection process automatic and efficient in nature. Whenever the waste bin gets filled this is acknowledged by placing a RF transmitter at the waste bin, which transmits it to the receiver at the desired place in the area or spot. The received signal indicates the waste bin status at the monitoring and controlling system.

2. Automatic Waste Management System

We designed a method for managing the wastes in an efficient way in order to reduce the improper utilization of valuable resources like human effort, time and cost. Fig. 1 shows the architecture of our design. In our approach, we divided the overall system of waste detection into four subsystems viz Smart Trash System, Smart Vehicle System, Local Base Station and Smart Monitoring and controlling Hut. All these sub-systems work intelligently and in coordination to automate the waste management in the Smart Trash Bin(s) so as to dispose-off the waste as and when required without keeping a continuous eye on the waste bins manually.

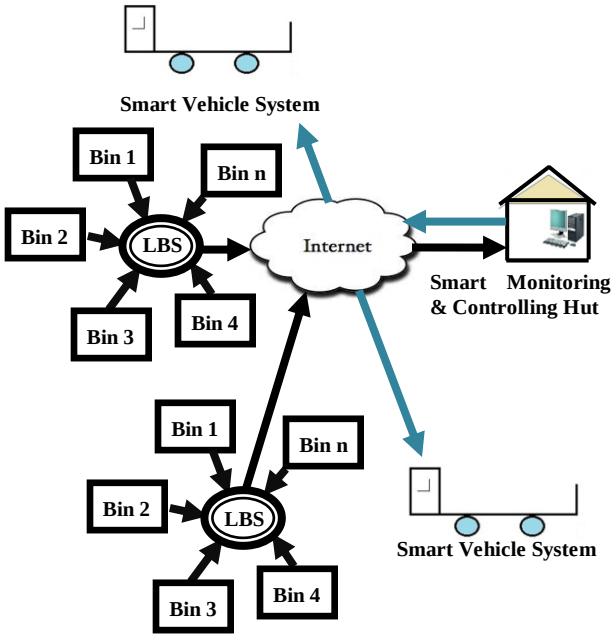


Fig 1: Architecture of the AWMS

2.1 Smart Trash System

Smart Trash System embodies an electronic device known as Smart Trash Bin, which consists of Sensors and a Radio Frequency (RF) transmitter. The sensors sense the waste status being collected by the Smart Trash Bin. Two types of sensors are used in the Smart Trash Bin. The first one is a Load sensor which is used to sense the load of the waste in the smart trash bin and the second one is an IR proximity sensor whose function is to detect the level of the waste in the smart trash bin. There are two IR sensors, one placed at the middle of the Smart Trash Bin and the second is placed near the top of the Smart Trash Bin. The use of two IR proximity sensors makes the decisions more reliable and exact. As shown in the diagram below, the RF signal is transmitted only when all the sensors are in a high state. Whenever the Smart Trash Bin is filled up to the specified load and level, the sensors get activated and it generates a signal that is transmitted by the RF transmitter fitted in the Smart Trash Bin. The signal transmitted by the RF transmitter is received by the RF receiver which is present at the local base station. After receiving the signal, the local base station decodes the trash bin location and accordingly sends a signal to the smart monitoring and controlling hut which sends signal to Smart vehicular system about the location of the trash bin. The monitoring and controlling hut in addition to the site of bin also sends the dumping site to the smart vehicular system.

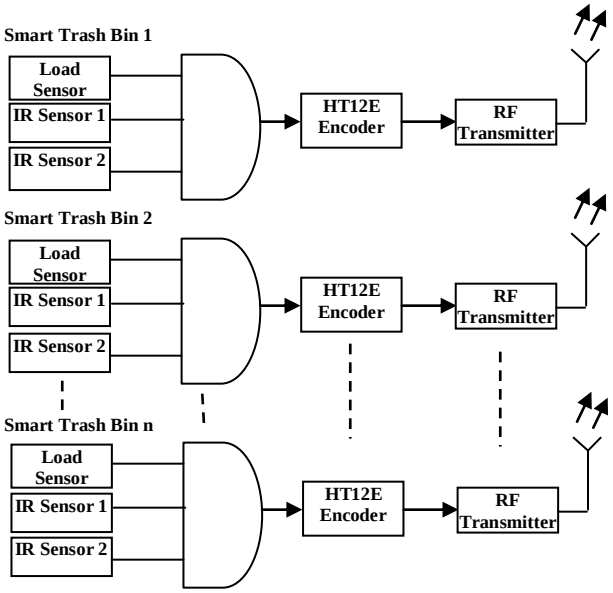


Fig 2: Smart Trash System

2.2 Local base station

The Local base station is the RF receiver site that is not far distant from the smart trash bins and gets the status of the bins via RF communication. This base station receives the status of the nearby trash bins on regular basis and the base station keeps this status information intact with the monitoring and controlling hut. The local base stations keep track with the monitoring cum controlling hut over the internet. The use of internet in this automation makes this system efficient and reliable with long distance coverage.

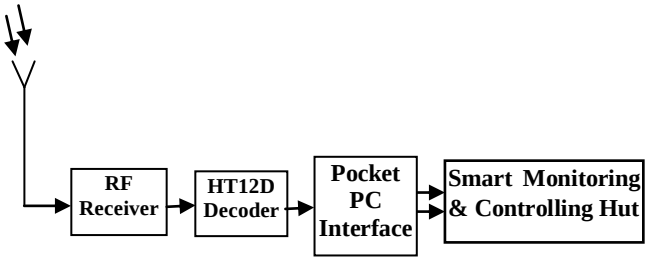


Fig 3: Local Base Station

2.3 Smart Monitoring and controlling Hut

The Smart Monitoring and controlling Hut is a centrally controlling hub for all the smart functioning of this management system. This is the heart of the entire system and always takes signals as input from the local base stations spread over an area. It is the signal from the local base stations that invokes the controlling hut to make a decision about the management of waste of some particular trash bin. The local base stations and the monitoring cum controlling hut communicate over the internet by the use of the pocket PC at local base station and desktop/laptop at the SMCH. The details of the filled Smart Trash Bin are displayed accordingly on the interface, developed using VB.Net at the SMCH. The total number of Smart Trash Bin(s) and their details like City, Ward, Locality, Street, whether filled or unfilled is also displayed on the interface.

2.4 Smart Vehicle System

The Smart Vehicle System is web interlaced vehicle that continuously keeps track with the monitoring and controlling hut about the status of the previous jobs that have been assigned to it and constantly waits for the new task. The Smart vehicular system consists of a task profile display. The new task of disposing a trash bin and all the relevant details about it are displayed on the Pocket Pc present in the smart vehicle. The Smart Vehicle System after receiving all the details of the bin site and the dumping site goes to the bin site and uses a robotic arm for disposing specific trash bin. The robotic arm in the vehicle has a jaw shaped flanges that pick the bin and pops out the waste in the vehicle's waste holding container which has a large capacity. After the completion of the task, the smart vehicle acknowledges the monitoring and controlling hut. The vehicle then moves on to perform next task in the queue assigned to it by the monitoring and controlling hut.

2.5 Smart Monitoring and controlling Hut Interface

The interface at the smart Monitoring and controlling Hut has been developed using VB.Net which is an object-oriented programming language that can be viewed as an evolution of the classic Visual Basic (VB), and is implemented on the .NET Framework. The software is to be installed on the Computer System in Smart Monitoring and controlling Hut, which receives the information from the local base stations through internet. The Smart Trash Bin through RF transmitter sends signal to LBSs which then forwards it to SMCH via internet. At the SMCH, the details about the filled trash bin(s) are displayed on the interface like the location of the trash bin, unique trash bin code, etc. Accordingly, the AWMS software obtains further information of the trash bin which has sent the signal like the city, locality, area to which this trash bin belongs and then makes a decision about the

vehicle to be selected to dispose off the waste. The smart monitoring cum controlling hut smartly selects the vehicle keeping in view the distance, cost and others factors and these factors reduce the implementation cost of the overall system. After the assigned job has been accomplished successfully by the smart vehicle, an acknowledgement is sent to SMCH. This makes the overall system efficient and reliable. The interface provides an initial Login page to authenticate the user. After valid authentication, the user is directed to the Control Panel page which displays the status of the Smart Trash Bin(s). Whenever the Smart Trash Bin gets filled an alarm signal is produced and the details of the filled Smart Trash Bin are displayed on the interface. The total number of Smart Trash Bins and their details like City, Ward, Locality, Street, whether filled or unfilled is also displayed on the interface. The interface consists of the Login Form, Data Control and Control Panel pages.

Login Window: Only authorized users (employees and administration of city Municipality) can access the system. The restricted access is to employ the security in the Smart Monitoring and controlling Hut.

Data Control: The Data Control has a database connected to it where the information of the Smart Trash Bin(s) is stored. It is also used to maintain the information about the Smart Trash Bin(s) installed in the various locations of the city. This includes the insertion, deletion and updating of information. The information is then accessed by the Control Panel to verify the availability of the Smart Trash Bin. This module has been authorized only to the administrator of the system.

Control Panel: The Control Panel module works on receiving the information via internet and then performs logical operations through programming methodology to display the status of the Smart Trash Bin(s) and also produces an alarming signal, if the Smart Trash Bin(s) is filled. The screen shots of the three components of the Interfacing module i.e. Login Page, Control Panel and Data control are given below in Fig 4, Fig 5 and Fig 6.

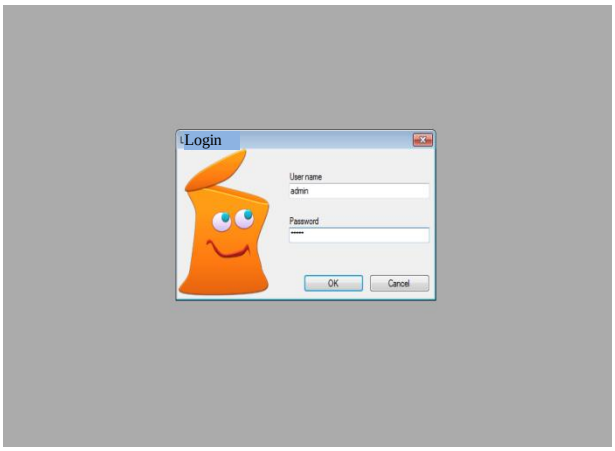


Fig 4: Login Page

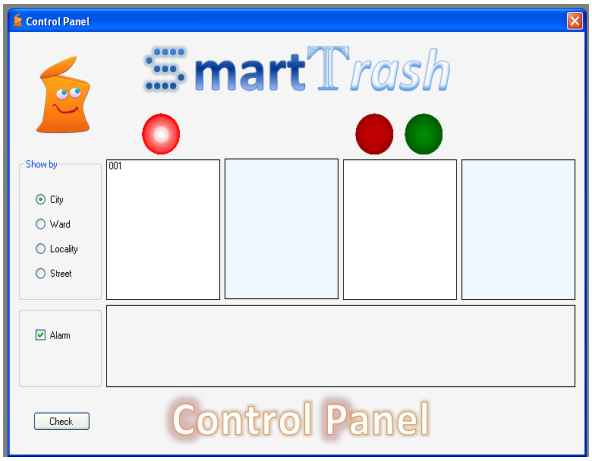


Fig 5: Control Panel

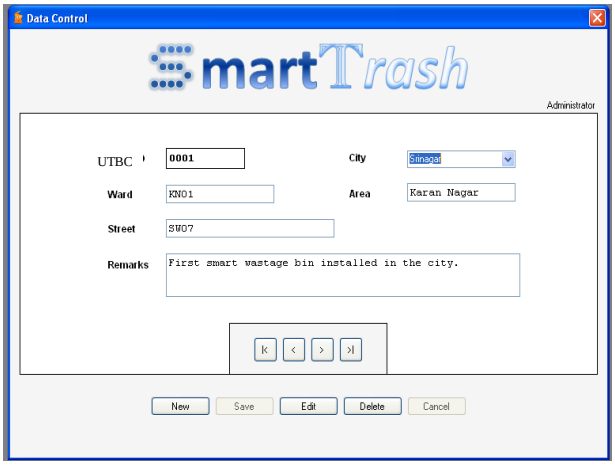


Fig 6: Data Control

3. Operation

Since the AWMS consists of four sub-systems and the main system on which the others work is the Smart Trash System which has the functional unit called as Smart Trash Bin. It consists of sensors, encoder and the RF transmitter. Sensors are used to detect the load as well as the level of the waste in the Smart Trash Bin. Whenever the Smart Trash Bin gets filled, the sensors get activated and generate a high signal which is encoded by the encoder. This encoded signal is transmitted by the RF transmitter mounted on top of the Smart Trash Bin. This transmitted signal is received by the RF receiver tag which is placed in the local base station. The RF receiver in local base station receives the signal and then the decoded signal is sent to monitoring cum controlling hut over the internet with the help of a pocket PC. At this monitoring cum controlling hut site, the information and status of the Smart Trash Bin is displayed. The details like Trash Bin ID, location, etc of the filled Smart Trash Bin are displayed on the Smart Monitoring and controlling Hut Interface. The Smart Monitoring and controlling Hut then sends the information signal to the Smart Vehicle System. Once the job detail is received by the vehicle, it moves to the spot and disposes off the waste from that Trash bin that has send "Trash Bin full" status to the Monitoring and controlling hut. On the task completion a task done signal is send by the vehicle to the monitoring and controlling hut.

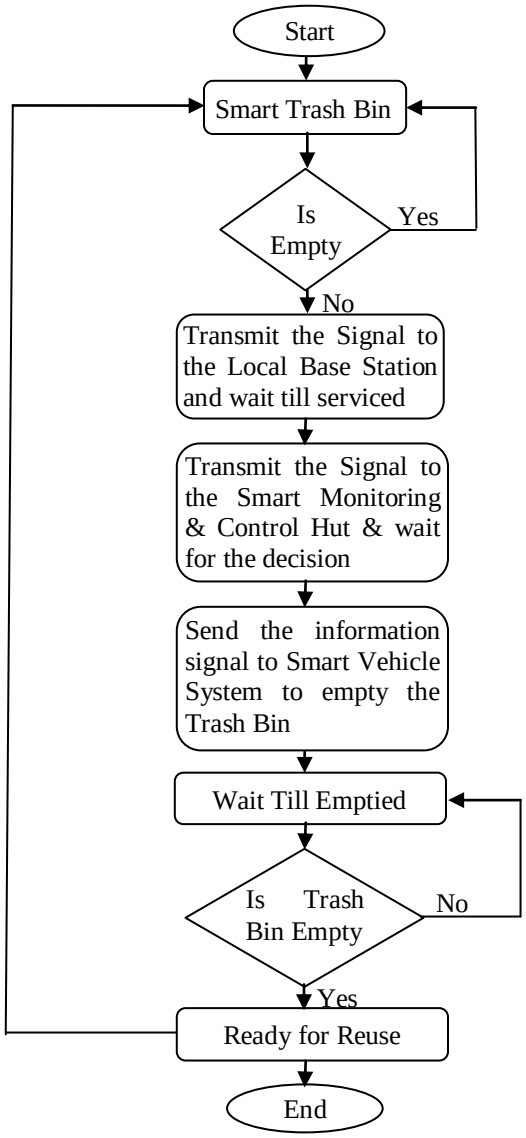
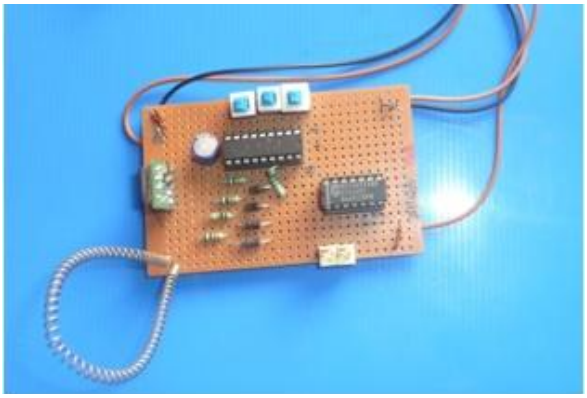


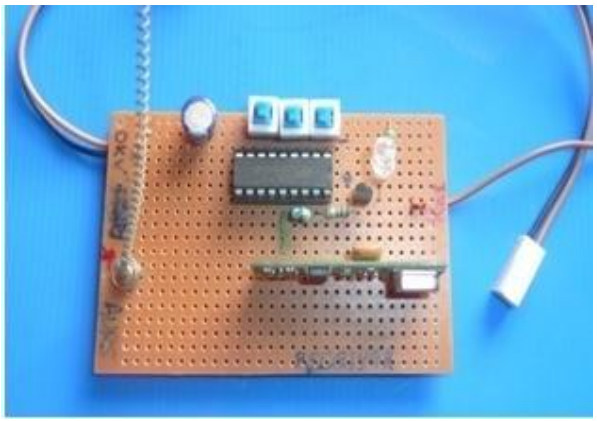
Fig 7: Flowchart of the AWMS

4. Conclusion

The Automatic waste management system is a step forward to make the manual collection and detection of wastes automated in nature. The developed system integrated by using four sub systems the Smart Trash System (STS), Local Base Station (LBS), the smart Vehicle System (SVS) and the Smart Monitoring and controlling Hut (SMCH) including RFID and internet, in which it would pioneer work for solid waste collection, monitoring and management processes. This proposal for the management of wastes is efficient and time saving process than the currently employing method in which concerned municipal employee has to look for the filled waste bins manually across different spots in an area/street for checking regularly whether



Layout of RF Transmitter Module



Layout of RF Receiver Module

the waste bin is filled or not, which is complex and time consuming process. This automation of waste also reduces the human effort and consequently the cost of the whole process. This system can be implemented at any place with ease and within reasonable amount of time. The implementation costs for the automation is also affordable. The overall method for the detection and management of waste becomes efficient and intelligent. We have shown the application and implementation of the above system. This proposed system would not only function for collecting and updating data automatically and timely, but also it could analyze and use data intelligently. The proposed system would solve a lot of problem related to solid waste collection, monitoring, minimizing cost and accelerate the management.

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