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Smart Solid Waste Monitoring and Collection System

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Abstract— Nowadays due to the industrial revolution and technology development, consumption patterns of the people all over the globe have changed. This lead to huge quantities of different types of solid waste are producing every day, which creates an alarming problem of their disposal. Therefore, an effective way is required for solid waste collection and utilization rather than concentrating on disposal alone. In this paper, a smart solid waste monitoring and collection system is designed and developed. The system consists of smart containers or smart bins, each bin or container installed with Arduino Uno, ultrasonic sensor and Radio Frequency (RF) transmitter on the top of the container. When the container is full of waste, it sends signal to the control center which will have the level of waste in the containers and through GSM/GPRS , a message (SMS) will send to the mobile phone of the truck driver of which waste bin is full and need to be empty.

Keywords— smart city services, smart waste management, smart monitoring and controlling, Arduino, Radio Frequency transmitter and Receiver, ultrasonic sensor, GSM/GPRS.

I. INTRODUCTION

Currently the Municipal Solid Waste (MSW) is one of the main urban lifestyle materials. The annual solid waste is about 1.3 billion tons and it seems it will raise to 4.3 billion tons by the year of 2025, which will cover 50% of the general population worldwide [1]. In addition, managing the waste collection process is one of the most complicated tasks in the rural habitat because the amount of solid waste generated by residential and commercial-industrial sites are huge. Furthermore, the budget spent on the management of solid waste, which is equivalent to 50-70% is used for waste collection. Due to the high amount spent on collection, only a low amount is left for amelioration of the collection operation [2]. The waste management cycle includes the generation of the waste from industries, houses, markets etc. from which the waste is thrown in the garbage bins. This waste is further picked up by the municipal corporations to finally dump it in dumping areas and landfills. But due to lack of resources, ineffective groundwork, some waste is not collected which poses serious health hazard to the surrounding environment. Proper cleaning intervals may provide a solution to this problem. But keeping a track of the status of the bin manually is a very difficult job [3]. A smart waste monitoring and collection system is designed and developed to reduce the cost and the time of waste collection as well as to protect both public environment and public health and provide safe life. Waste collection and monitoring by using new technologies such as Radio Frequency (RF), ultrasonic sensors, GSM/GPRS as well as Arduino, offer a new way to optimize the waste management systems. The Related Works, Proposed System, Results, Conclusions and Future Work have been discussed in the next sections to give detailed information on the work done in this field.

II. RELATED WORKS

Recently, with expanding size of cities, the need for smart services arise such as smart and intelligent traffic, smart health care system, smart waste collection, smart education, smart living, smart energy and etc. Many studies were carried out on the field of solid waste management, collection as well as monitoring. Because the importance of this field impacts the environment and pollutant the air as well as creates health issues. Many researchers had given special guidance on different types of economical, technological and managerial challenges for the solid waste collection and management in developing countries. An application based on distributed sensor technology and geographic information system to be used in the monitoring of municipal solid waste has been proposed in paper [4]. A case study based in Pudong area is presented in this paper. The most important outcome of this paper is calculation of waste weight and volume to be further used for optimizing routes of garbage collection vehicles and material density evaluation. Another framework based on the integration of RFID and communication technologies such as GSM, GPRS, and GIS has been proposed in paper [5]. Theoretical framework and algorithm have been developed in this paper for successful hardware implementation. The information retrieved is stored for monitoring and management activities and a Graphical User Interface is presented for user interaction. The researchers in [6] proposed a new architecture with the aim to improve the on-site handling and transfer optimization in the waste management process. The system architecture is based on sensor nodes and makes use of Data Transfer Nodes (DTN) in order to provide a remote server the retrieved data measurements from the garbage bins. A remote monitoring solution has been implemented, providing a user the possibility to interact with the system by using a web browser. Several activities with the aim to provide a Decision Support System (DSS)

able to find solutions for resources organization problems linked to solid waste management. In paper [7], a system was designed to monitor the solid waste bin condition on real time. The system architecture is designed using wireless sensor networks. A set of carefully chosen sensors were used to measure the status of the bins, ZigBee and GPRS were used as communication technologies. The physical architecture of the system contains three levels such as smart bins for the measurement and transmission of bin status, gateways for storing and forwarding bin data to server and control station for storing and analyzing the data. After the framework design, a simulation is performed using Castalia to ensure the feasibility and accuracy of the system. In paper [8] the researchers developed the process of solid urban waste as a method to monitor and plan urban solid waste management. The Smart-M3 platform was used to provide solutions to the problems in different aspects such as decoupling and scalability. The smart waste collection system contains different components: light pole, control center, trucks and mobile device. The researchers in [9] proposed a smart bin application based on self-contained information in tags associated to each waste item. The waste is tracked by smart bins using a RFID-based system without requiring the support of an external information system. Two crucial features of the selective sorting process can be improved using this approach. First, the user is helped in the application of selective sorting. Second, the smart bin knows its content and can report back to the rest of the recycling chain. A smart waste management system was proposed in [3] which focused on the waste collection process. The status of the bin is continuously monitored at the control station and was presented in a Graphical User Interface to provide a user interaction with the system. The values stored in the database helps a user to have the updated data of the bin as well as the previous values of the parameters of the bin. Paper [10] dealt with development work for continuously monitoring and management of solid waste. The proposed system, was able to monitor the solid waste collection, manage the transportation system and it was comprised of four activities: waste generation, collection, transportation and disposal. The proposed system was an integration of ARM7, with various wireless communication technologies such as GSM, GPS, and GIS.

III. SYSTEM ARCHITECTURE

The system is designed to decrease the improper use of valued human resources like human effort, time and cost and the need for smart waste collection and monitoring system. This study has been carried out in two parts. The first part was integrating the real system and developing smart services for smart waste collection and monitoring, and the second part was implementing the system for specific city to prove it. Fig (1) illustrates the general block diagram of the system.

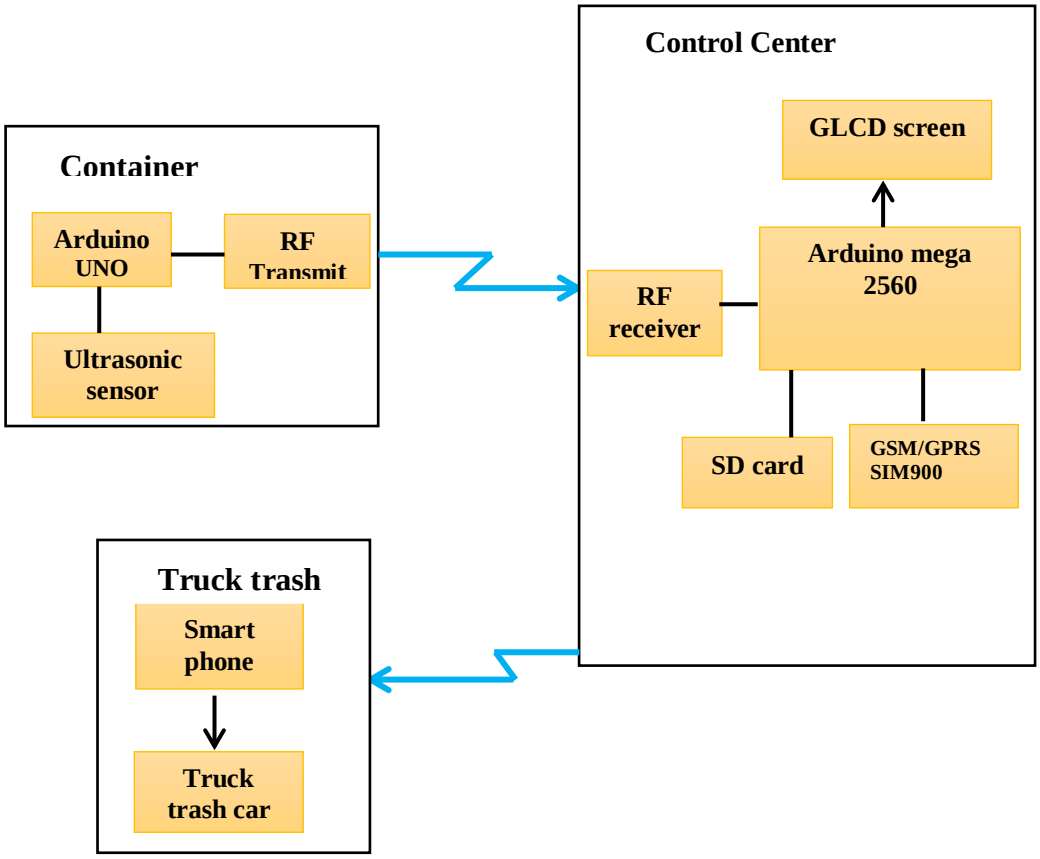

Fig. 1 block diagram of the smart waste monitoring and collection system

IV. SYSTEM COMPONENTS

The system consists of three subsystems, Smart Bin, Control and Monitoring system, and Waste Vehicle. Fig (2) shows the general architecture of the smart waste monitoring and collection system and fig (3) illustrates the detailed architecture of the system and key items included in the design and the connection among them.

Fig. 2 the general architecture of the smart waste monitoring and collection system

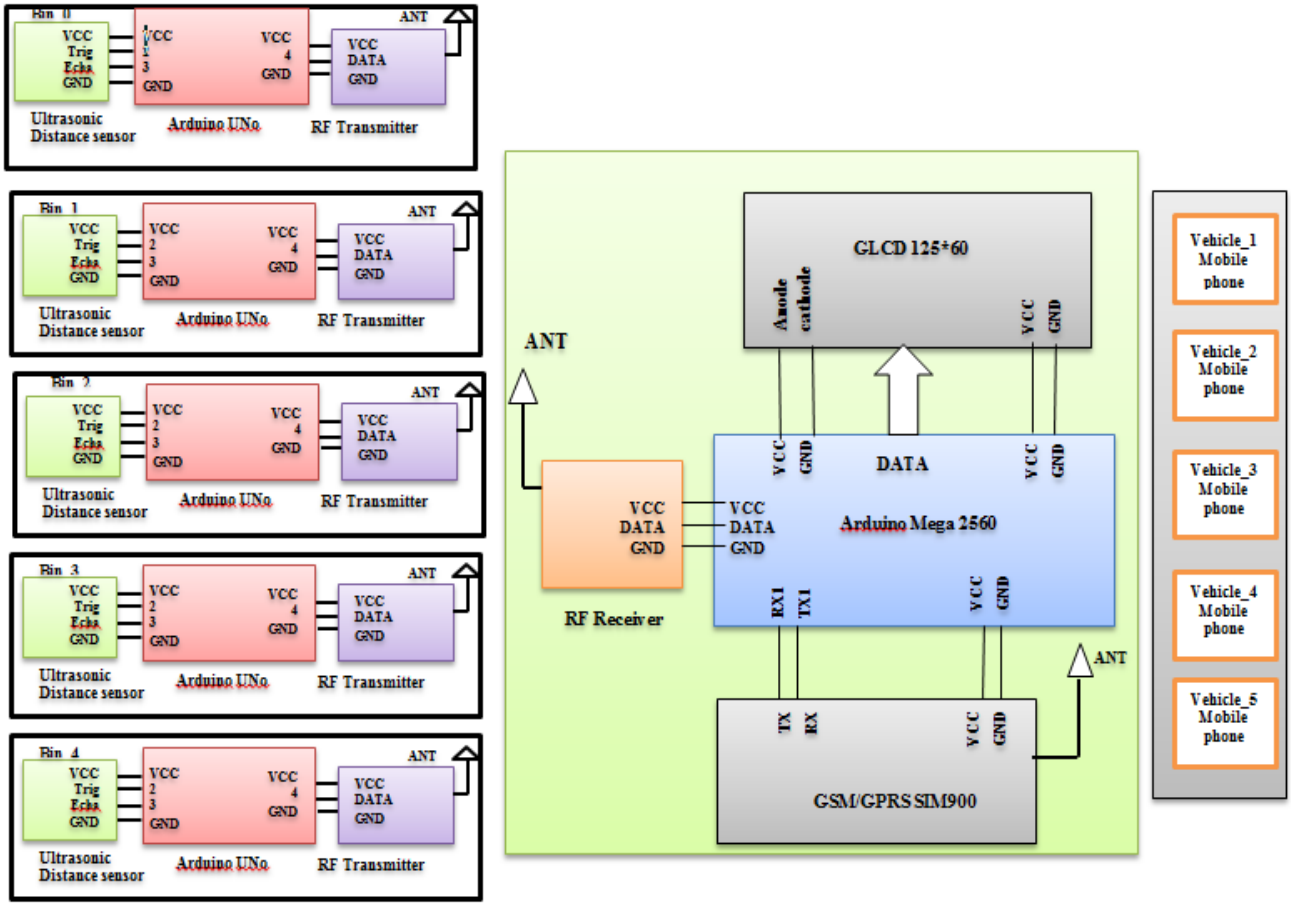

Fig. 3 the detailed architecture of the system

A. Smart Bin

In this work, we used five bins. Each bin or container consists of a Radio Frequency (RF) transmitter, Ultrasonic sensor with Arduino UNO. The Ultrasonic sensor which is placed near the top of the bin, and used to sense the waste fill level in the bin. The Radio Frequency signal is transferred only when the sensor is in a high state whenever the Smart Bin

is filled to specific load or level, the sensor generated a signal and transferred via the RF transmitter fitted in the Smart Bin. The Signal which is transferred via the RF transmitter is received via the RF receiver which is placed at the Central Station. The Smart garbage bin with its components is shown in fig (4).

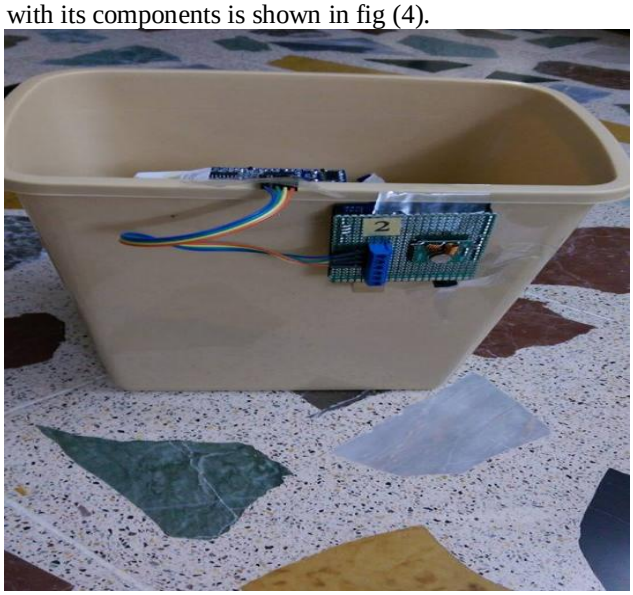

Fig. 4 the Smart Bin

B. Smart Control and Monitoring System

The smart control and monitoring system is the heart of the whole structure of this system. It is located in the Control center which consists of Arduino mega2560, GSM/GPRS, SIM900, GLCD screen and Radio Frequency (RF) receiver which gets the state of the bins by RF communication. The time, date and the waste level of the bins are stored in SD card and shown in the GLCD screen on the center. If there is a filled bin, the system will send SMS to the waste vehicle through GSM/GPRS. The smart waste monitoring and control system is developed using C and C++ programming language with Arduino software and the output is shown on the GLCD screen with the total number of smart garbage bins and whether they are filled or unfilled. Fig 5 shows the hardware components of the smart control and monitoring system.

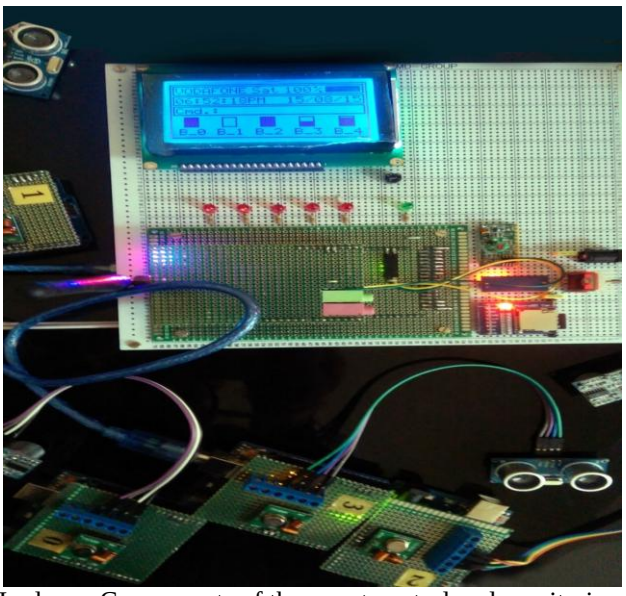

Fig 5 Hardware Components of the smart control and monitoring system

C. Waste Vehicle

Trucks or vehicles with mobile phone, when bins are filled of trash the central system will send SMS to the vehicles to go to the place where the bins are located to empty them. If the vehicle doesn't go to empty the bin, after one hour the system will send SMS to another vehicle.

V. RESULTS

In this section, the data which is collected from the sensors is discussed. The data collected from the sensors (the level of waste in the bin with the date and time are stored in the SD card which is attached to the Arduino mega2560 and shown in the GLCD screen on the center with the total number of smart garbage bins and whether they are filled or unfilled. We have measured three distinct waste levels: empty, half full and full.

- If the waste level in the bin is full or more than the half full level, a message will send to the vehicle to collect the waste from that bin.
- If the waste level in the bin is empty, half full or less than the half full level. A message is not send to the vehicle.

Fig (6) shows the output of the system on the GLCD screen. And figure (7) shows the SMS message which is sent to the vehicle to collect the waste from the filled bin.

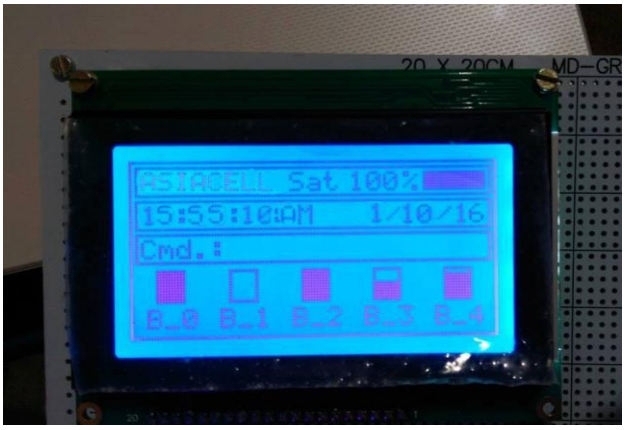

Fig 6 GLCD Output

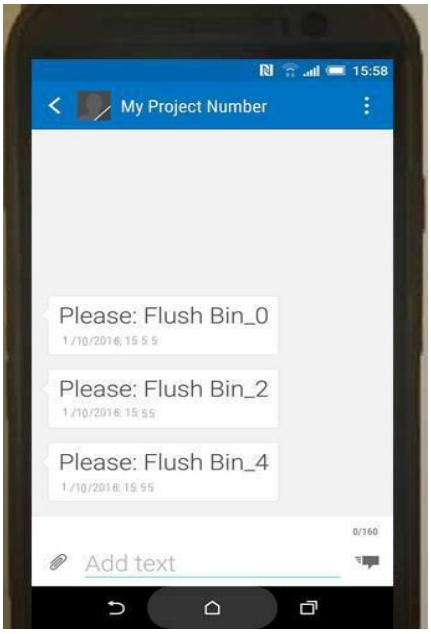

Fig 7 SMS sent to the mobile phone of the driver

VI. CONCLUSIONS AND FUTURE WORKS

A smart city is an efficient and sustainable place with intelligent public services. There will be an urban environment that is always connecting with the residents and capable of managing public services in real time to increase the quality of life through waste collection, traffic management, irrigation systems, alerting the local authority when an event occurs and allowing the government to stay in touch with people. So, the designed smart waste monitoring and collection system is a step to make the manual collection and detection of waste smart in nature. The system is used to decrease the human effort and cost. The system has many advantages than the other systems done before because the hardware used and developing the system with Arduino which is open foundation can be easily get the semantics and programming and advance it with free libraries, the system offers a high quality service to citizens, it can be use everywhere when the place has network and signal of mobile phone and it is economical design.

The System can improved by developing a mobile application and using GPS to show the route and send message to the nearest waste vehicle to the filled bin.

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