

APPLICATION OF INTERNET OF THINGS (IoT) TO SOLID WASTE COLLECTION AND MONITORING IN LADOKE AKINTOLA UNIVERSITY OF TECHNOLOGY (LAUTECH) OGBOMOSO NIGERIA

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ABSTRACT

Waste management is one of the environmental problems faced in our world today. As technology advances, there is need for devising means to use technology in collecting and managing waste. The major issue in solid waste management is its collection and monitoring. With this major issue, poor collection poses hazards to community health. It's important to provide a smart way of collecting and monitoring waste using the Internet of Things (IoT) technology. This project aims to design and develop a smart intelligent alert system for proper solid waste management by giving an alert signal to the waste management team of the school for instant cleaning of dustbin with proper verification based on the level of waste filling. This process is aided by the ultrasonic sensor which is interfaced with Arduino UNO mounted on the lid of the dustbin to check the level of waste fillings in the dustbin and sends the alert message to the waste management team of the school once the dustbin is filled. The designed system will show the real depth status of all the dustbins located inside the school and it will be checked accordingly, the mounted device will help in measuring the level of the waste fillings and it will generate the alert signal and message once it reaches the specified depth. When the level of the waste reaches the maximum limit, the signal will be sent to the concerned authorities with the help of the internet of things (IoT) and cleaning of dustbin will be done effectively.

1. INTRODUCTION

Wireless sensor networks (WSNs) are highly promising outfits in the field of remote monitoring. Several monitoring systems have been implemented by using WSN such as Solar Powered Aquatic environment monitoring (Adedeji and Salami, 2011; Alipp et al., 2011, Nuhu et al, 2014). On-board monitoring of Railway Freight Wagons (Schiavo, 2016), Cattle health monitoring (Wang et al., 2016); monitoring an ozone sterilizer (Luqueta et al., 2016); monitoring radioactive materials (Ding et al., 2009); smart medication system (Chang et al., 2011; Arulogun et al., 2012; Ramson and Moni, 2016);); urban areas security surveillance (Arulogun and Adigun, 2014; Rashid and Rehmani, 2016) and so on. Solid waste management is one of the important applications of WSN. Solid waste management is the process of collecting, shipping, treating and disposing of waste material. Improper handling of solid waste leads to unsanitary conditions and this can create environmental pollution and diseases. The responsibilities of handling solid waste present complex technical encounters. The critical issues in handling solid wastes are, if solid wastes are scheduled to collect in daily basis, in case if the bins are unfilled, then it is wastage of time, fuel and manpower, and if the solid wastes are scheduled to collect in weekly basis, in case if the bins overflow, it spreads around the area, producing illness to the people and pollutes the environment. Remote monitoring systems using wireless sensor networks resolve the above said critical issues and provide a clean environment.

Waste management is one of the environmental problems faced in our world today. As the world population increases, the waste generated increases and this makes our environment eco-unfriendly. During the last few years, the school population has been greatly increased and this has led to more waste generation on the university campus. However, these wastes are not properly managed. Wastes are left unattended and unnoticed for a longer period. These wastes include papers, nylon, plastic bottles etc. and with the constant increase in the population of the students, the school generate a lot of waste disposal problems and can lead to the poor management of this waste disposed which cannot cope with the amount of waste that is generated and sometimes it over flow in some waste bin and indiscriminate dumping of waste.

This makes the cleaning of waste disposed of very difficult and tedious. As technology advances, the need for devising means to use technology in monitoring, collecting and managing waste becomes very essential. In the modern era of technology-driven society, there is a need to implement a system to automate the process of collecting and managing waste. To further proceed with the process of automation, waste bins were designed to help with the technology. These smart dustbins can be implemented on a large scale and the traditional dustbins may be removed so that it can avoid dumped wastes in the classes, halls and along with various offices in the school. The system implements the smart technology with the help of ultrasonic sensors placed over the dustbins to continuously detect the wastes that are being put inside the bins and the level of the waste in the bin. This project aims to provide a smart and proper way of collecting and monitoring waste using the Internet of Things (IoT) technology.

2. RELATED WORKS

The various proposals were put forward and some of them already implemented but some cannot be considered as effective smart garbage management in cities using IoT.

Medvedev *et.al*, (2015) reported IoT components such as RFIDs, sensors, cameras and actuators for efficient waste collection by the proposed Decision Support System (DSS) for efficient waste collection in Smart Cities. The system handles ineffective waste collection by incorporating a model for data staring between truck drivers in real-time and dynamic route optimization.

Smart Garbage System (SGS) was proposed by Hong *et. al*. (2016) to reduce the amount of food waste. The system exchange information with each other using wireless mesh networks, and a router. The server collects and analyses the information for service provisioning and operated as a pilot project in Gangnam district

Prakash and Prabu (2016) designed IoT Base Waste Management for Smart City for solving the trash over flow which creates unhygienic condition and bad smell around the surrounding. This project has two parts. These are transmitter section and receiver. The 8051microcontroller, RF Transmitter and sensors in the transmitter section were attached to the dustbin. The receiver section consists of RF Receiver, Intel Galileo, and Web Browser. This system can detect waste levels in the dustbin and avoid the overflow of the dustbin.

Mahajan *et. al*, (2014) proposed a waste bin monitoring system using IoT. In the proposal, Zigbee and the global system for mobile communication are one of the better ways to be used. The sensors are placed in the garbage bins at the public places and the threshold level indication is indicated to the ARM7 controller. The controller indicates the driver of a garbage collection truck as to which garbage bin is completely filled and needs urgent attention. ARM7 gives indication of sending messages using GSM technology.

Issac and Akshai (2013), proposed a system called SVASTHA (a Sanskrit word, meaning —be healthy and hygienic), to effectively control the municipal solid waste. This system is based on RFID and GPS in which data is gathered using the RFID reader via Bluetooth and this data is stored on the central server.

Susila *et. al*. (2018) proposed a waste bin system implemented with the Arduino based Garbage bins. When the garbage reaches the threshold level, notification is sent to the Authority, where they are tracked to the path to clean the same. For a few decades, the wastes in the city are overflowing creating an unhygienic environment. The previous work involved manual intervention to clean up the full bins. The plastics and other intoxicants when dropped inside the dustbins most of the time land up being dropped outside or the filled garbage bin overflows the excess outside the bin causing untidiness all over. Thus, this kind of technology provides a great opportunity to maintain a clean environment and saving millions of lives from danger due to illness. In this system, the ultrasonic sensor was used.

Yusof *et. al*, (2017) presented an Arduino micro controller based smart garbage monitoring system to ascertain the level of waste in the garbage bin in real-time and before there is overflow in garbage bin the system sense out and alert through SMS municipality for the bin to be emptied and garbage to be collected immediately. The ultrasonic sensor is used to estimate the level of waste while the GSM module is used for sending SMS and Arduino UNO is used to control the system operation.

3. METHODOLOGY

In the existing waste management system, the waste is collected on the campus on a daily basis, although this system was very inefficient. An area in the school may have easy accessibility and thereby populated whereas another area may not. In these scenarios, it's quite apparent that the waste bins located in the easily accessible area will get filled easily than the latter. The IoT will enable the smart waste management system to focus on cleaning the waste from the dustbins in the selected area then and there so that cleanliness and hygiene will be preserved. The system deployed the Arduino processor, GSM module and ultrasonic sensor to collect information regarding the wastes dumped. If the bin level is less than the required depth, the bin will not send a signal for it to be emptied. This system also helped in avoiding the dustbins left unattended for more than 3 days. This project focused on sending messages at three states namely the status of filled bins, unattended bins, and empty bins. This solution involved less time and will manage energy as regarding the cleaners which will enable them to visit only the selected dustbins. The sensors installed on the dustbins provided real time information on the fill level. This information will help determine when and where to prioritize collection.

The level of waste in the dustbins is detected with the help of an ultrasonic sensors system and communicated to the smart waste management team through a GSM system. Arduino microcontroller is used to interface the sensor system with a GSM system. A GUI (Graphical user interface) is also developed to monitor the desired information related to the garbage for different selected locations. This helped to manage the garbage collection efficiently. The output of the level detector is given to the microcontroller. When the dustbin is filled up to the highest level, the output of the ultrasonic sensor receiver becomes active low. This output is given to the microcontroller to send the message to the waste management team via the GSM module. Figure 1 portrays the WSN framework proposed in this article.

The system assured the cleaning of dustbins as soon as the waste level reaches its maximum. If the dustbin is not cleaned at the specified time, then the record will be sent to the higher authority who can take appropriate action against the concerned team. It helped to monitor and additionally to observe the collection record which cannot be denied. This reduced the total number of trips of the cleaners and hence the overall cost associated with the waste collection. It ultimately helped to keep the society clean. Therefore, the smart waste management system makes waste collection more efficient. Figure 2 shows the flow chart for the bin monitoring algorithm, waste collection, and optimization.

4. 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 systems. 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 a specific area in LAUTECH to prove it. Figure 3 illustrates the general block diagram of the system. The system consists of three subsystems, Smart Bin, Control and Monitoring System, and Waste collector. Figure 4 shows the circuit diagram as each component connects each other.

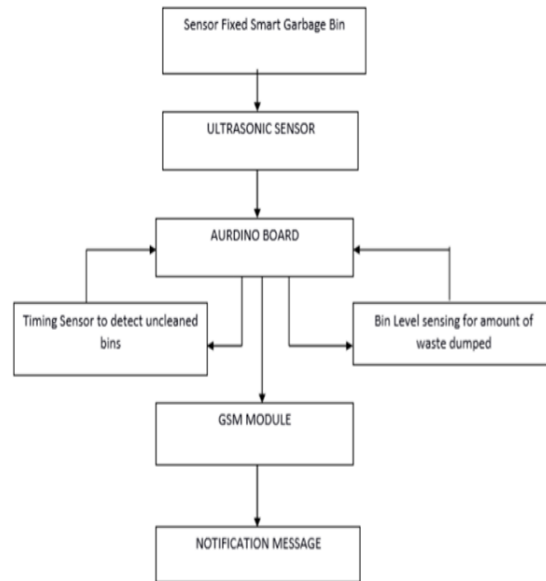


Figure 1: the WSN framework proposed in this work

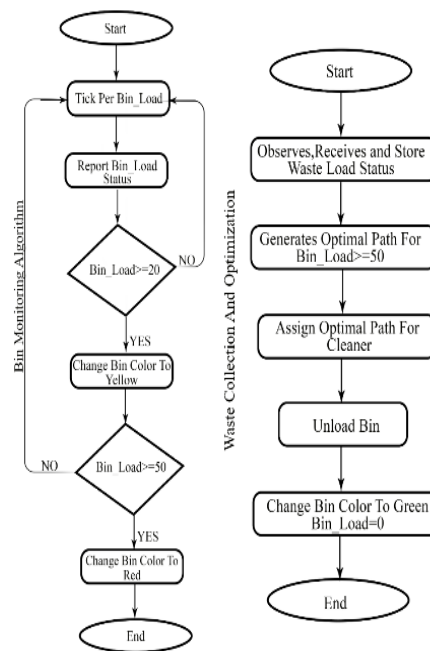


Figure 2: Flow chart for bin monitoring algorithm, waste collection and optimization

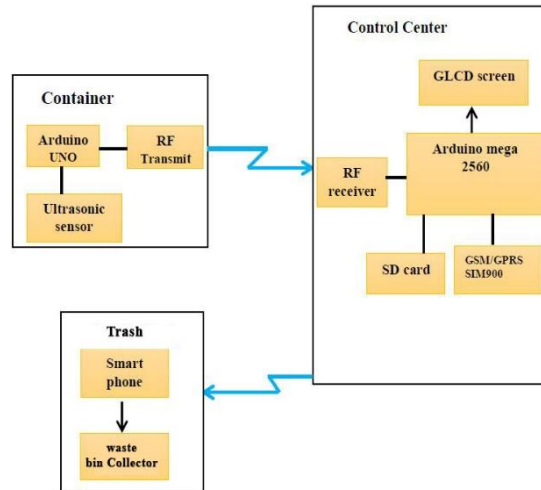


Figure 3: block diagram of the smart waste monitoring and collection system

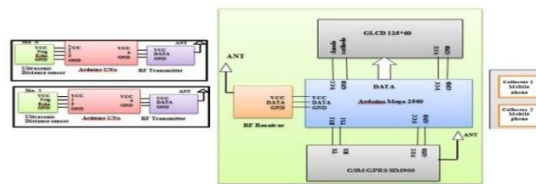


Figure 4: the circuit diagram as each component connect each other

A. Smart Bin

In the present project, two bins were used. Each bin or container consists of a Radio Frequency (RF) transmitter, Ultrasonic sensor with Arduino UNO. The Ultrasonic sensor was placed near the top of the bin and used to sense the waste fill level in the bin. The Radio Frequency (RF) signal is transferred only when the sensor is in a high state whenever the Smart Bin is filled to a 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 in the Central Area. The Smart garbage bin with its components is shown in Figure 5.



Figure 5: 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 and Radio Frequency (RF) receiver which gets the state of the bins by RF communication. The time, date and waste level of the bins are stored in the SD card. If there is a filled bin, the system will send SMS to the waste collector through GSM/GPRS. The smart waste monitoring and control system was developed using C and C++ programming language with Arduino software and the output is sent through SMS with the total number of smart waste bins and whether they are filled or unfilled. Figure 6 shows the hardware components of the smart control and monitoring system.

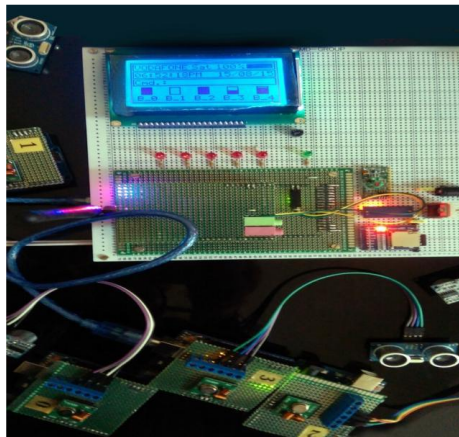


Figure 6: Hardware Components of the smart control and monitoring system

C. Waste collector

Waste collector with mobile phone: when bins are filled with trash the central system will send SMS to the collector to go to the place where the bins are located to empty them. If the collector doesn't go to empty the bin, after one hour the system will send SMS to waste administrator for necessary action against the collector.

5. RESULTS / DISCUSSION

In this section, data collected from the sensors were 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 mega 2560 and with the total number of smart garbage bins and whether they are filled or unfilled. Three distinct waste levels were measured: empty, half full and full

I. If the waste level in the bin is full or more than half full level, a message will be sent to the waste collector to collect the waste from that bin.

II. If the waste level in the bin is empty, half full or less than the half full level. A message is not sent to the waste collector. Figure 7 shows the SMS message which is sent to the collector to collect the waste from the filled bin.

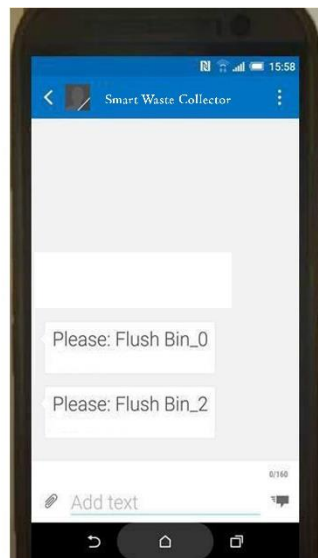


Figure 7: SMS sent to the mobile phone of the waste collector

6. CONCLUSION

The main aim of this project is to maintain the hygienic and dirt-free environment on campus which in turn creates an environment for better living. By implementing this project on a real-time basis, it assured the improved database for waste collection time and waste management amount at each location. If the respective bins are not emptied in the allotted time then all the record is sent directly to the higher authority that will take appropriate actions accordingly. This, in turn, reduces the entire journeys of the collector which ultimately maximizes the energy and time. Also, it helps to keep cleanliness within the school. It can be used everywhere when the place has a network and signal of a mobile phone, and it is economical. This present system can be improved by developing a mobile application and using GPS to show the route and send a message to the nearest waste collector to the filled bin. Therefore, the smart waste management system makes waste sorting and recycling more economical.

7. REFERENCES

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