DESIGN AND CONSTRUCTION OF AN INTERNET OF THINGS (IoTs) BASED INTELLIGENT SYSTEM FOR ENVIRONMENTAL SOLID WASTE MONITORING AND MANAGEMENT

BY

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Abstract

The traditional methods of managing waste products in the streets has not been very reliable as it is manual and involves much human efforts. This research work is focused on the design of Internet of Things (IoTs) based technology to enhance the management of wastes in our localities. The new system uses two ultrasonic sensors to monitor two different points at the refuse center. When the garbage level reaches threshold, the system reports to the agency in charge through IoT cloud platform (Blynk). The system also has a timer function which it uses to determine the time the next waste removal will be done by the agents. ESP8266 Nodemcu microcontroller was utilized which support WiFi network. Object Oriented Analysis and Design Methodology was adopted. Embedded C++ programming language was used to program the system. This goes a long way to improve on the current methods of waste management in our society at large. This system monitored and detected the level of solid waste disposed at the dump site at two different points remotely. This helped the department in charge of managing the disposal of the solid waste to check the activities of the agency contracted to evacuate the solid waste. Notification was sent to the appropriate authorities that are concerned with managing the evacuation of the solid waste dump site when the threshold was reached or exceeded.

Keywords: *Internet* of Things (IoTs), Waste Management, Pollution**,** Disposal*, Refuse, Environment, Dump*

I. INTRODUCTION

Most places where waste products are disposed in Abakaliki are obviously littered with wastes due to overfill and delay caused by the waste management agents. The different locations mapped out by the government for waste disposal are used by the masses. However, some of the users of these locations are not educated enough to empty these wastes appropriately. This leads to the littering of the location and the corresponding pollution and health hazard.

The existing system involves the users going to empty their waste at the designated junctions from time to time. At certain interval of time, the waste management agents use their vehicle and get rid of the waste. They keep going from one point to another to check for the level of waste in a particular location. This can be very stressful and costly.

Figure 2: Littered Dumpsite at Udemezue Street, Abakaliki.

One problem associated with the existing system as shown in figure 3 is that the waste management agents may not be able to cover all the places at a time. At times, they may even delay the refuse removal at a certain point and that can cause overfill and attract dangerous animals which affect human health.

Figure 3: Traditional Waste Disposal Method. Britannica, T. Editors of Encyclopaedia (2024, January 19). Encyclopedia Britannica. https://www.britannica.com/technology/waste-disposal-system

Some of the automated systems did not integrate IoT in monitoring and managing waste disposal. Most authors developed smart dustbins which are able to detect when the bin is full and blow an

alarm. Some of them which use IoTs were not able to monitor and report the activities of the waste management agents themselves. They only send IoT notification once the bins are full and the agents come to evacuate the waste.

This research work reviewed other related literatures to gain insight into the state-of-art in terms of waste disposal technologies in existence.

A model was proposed that renders an astute way to sort digestible and indigestible waste using a convolutional neural network (CNN), a popular deep learning paradigm. The scheme also introduces an architectural design of a smart trash bin that utilizes a microcontroller with multiple sensors. The proposed method employs IoT and Bluetooth connectivity for data monitoring. IoT enables control of real-time data from anywhere while Bluetooth aids short-range data monitoring through an android application (Rahman et al, 2022).

Karatagi et al (2022) designed remote operated robotic waste container named 'Smart Dustbin' with range ranging from minimum of 3 meters which can be extended up to 100 meters. This dustbin can be operated by the cleaning staff from a safe operation chamber and collect waste from confirmed contaminated persons reducing the risk of contamination for the workers of the Hospital. Moreover, this report contains details of changes in electrical parameters including potential difference observed during our survey to operate different components.

A smart waste system was designed which will help in keeping our environment clean and also eco-friendly. This smart waste management system is built on the microcontroller-based system having ultrasonic sensors on the waste tank. If waste tanks are not maintained then these can cause an unhealthy environment and can cause pollute that affect our health. The system was designed using ARDUINO UNO, along with ultrasonic sensor, servo motor, and battery jumper wire. After all hardware and software connection, now Smart waste program will be run. Waste bin lid will when someone comes near at some range than wait for user to put garbage and close it. It's properly running or not. For social it will help toward health and hygiene, for business for we try

to make it affordable to many as many possible. So that normal people to rich people can take benefit from it (Afolalu, 2021).

The idea of Smart waste bins is for the Smart buildings, Colleges, Hospitals and Bus stands. The Smart Dustbin thus thought is an improvement of normal dustbin by elevating it to be smart using sensors and logics. Smart dustbins is a new idea of implementation which makes a normal dustbin smart using ultrasonic sensors for garbage level detection and sending message to the user updating the status of the bin using GSM module. It is a common sight to witness garbage spilled out in and around the dustbins. The area around an improperly maintained dust bins can house disease spreading insects like mosquitoes, flies, bees and driver ants. The environment around a dustbin is also conducive for increasing the pollution level in air. Air pollution due to a dustbin can produce bacteria and virus which can produce life threatening diseases in human beings (Adithya, 2019).

The new system helps to avoid the overflow of dustbin because of breeding of mosquitoes and houseflies occur mainly in garbage which are a major causes for various diseases like malaria, dengue, chikungunya etc. This also causes headache and increase in the stress level. It will give the real time information about the level of the dustbin. It will send the message immediately when the dustbin is full. Deployment of dustbin based on actual needs. Cost of this system is minimum; the resources are available easily. Improves environment quality by reducing the smell and make the cities clean. It is open automatically without touch lid. It is kept to provide environment clean (Adithya et al, 2019).

Environmental pollution has inherently been associated with health issues including the spread of diseases, i.e., typhoid and cholera, some of which are largely seen as waterborne diseases (Zhao et al, 2015).

There are also non-communicable diseases (NCDs) that are brought about due to environmental pollution, such as cancer and asthma, or several defects evident at birth among infants.

The conventional methods of waste disposal are also stated by Jia et al (2022) as follows: dewatering, sedimentation, composting, incineration, disposal and root zone treatment.

The conventional methods of liquid waste disposal are very helpful. However, they all rely on human efforts to discover when the waste tanks are full. They are not automated and are not IoT enabled. They are not intelligent enough to detect and report the states of the dumb areas. Hence, if no humans are around, there will be cases of waste spill and its effects are very dangerous. They are not also able to monitor and ensure that the waste management agents do their works effectively and timely.

II. IOT BASED WASTE MANAGEMENT MECHANISM

Figure 4 shows the block diagram of the existing systems. Ultrasonic sensors are used to monitor the garbage level of the waste bin. Sensor signals are sent to ATMEGA328P microcontroller housed on the Arduino UNO. The controller does all the logics. The current levels are shown on the LCD Screen while the notification is done using alarm. The servo motor is to drive the bin cover open and close.

Figure 4: Diagram of the Existing System

The existing system has the following weaknesses: It is too stressful, costly and time consuming as the waste management agents will have to move round the whole city for waste removal, the existing system does not integrate IoT in monitoring and reporting the waste disposal remotely and it is not able to monitor and report the activities of the agents in charge of the waste removal as well.

Figure 5 shows how the proposed system is divided in three parts: the Detection unit, the processing or logic unit and the Feedback or output unit.

1. The detection unit is made up of two ultrasonic sensors which are mounted at two different points at the disposal area for determining the waste levels. The sensor readings are sent to the microcontroller for processing.
2. The processing unit is made up of the ESP8266 Nodemcu which is the microcontroller board programmed to do all logic work. It also integrated a wifi technology to enable the system to monitor and report the activities of the agents remotely through the Blynk cloud platform. After processing sensor data, the processing unit triggers the feedback unit. The processing unit also integrates a timer function which enables the system to determine the actual time interval required for the agents to dispose of the wastes. This helps the system to ensure that the agents do their jobs timely or disciplined.
3. The feedback unit involves how the system gives the waste management agents information about the current situation at the various refuse disposal points. The system uses the wifi technology and blynk cloud android application which is installed on the agent's android phone to monitor and report remotely.

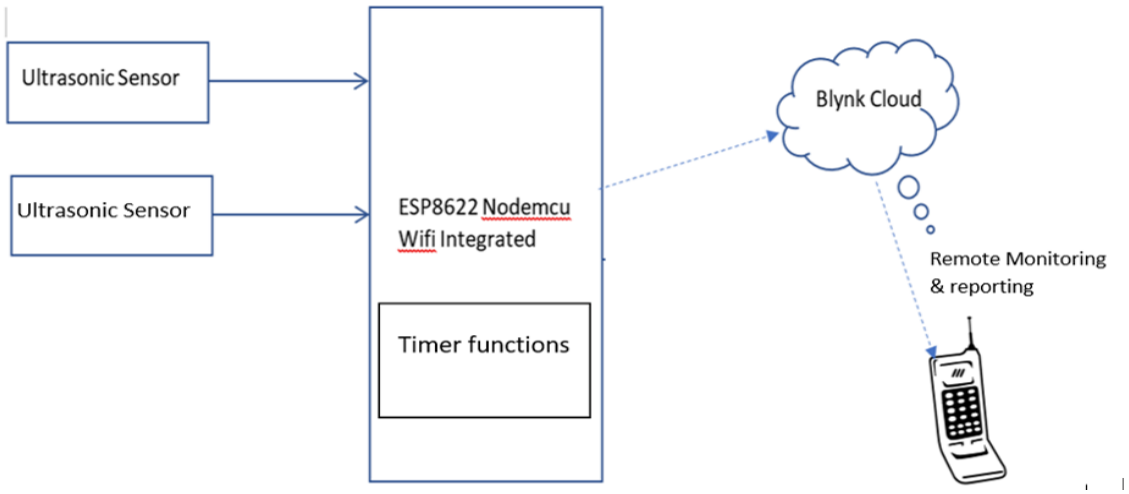

Figure 5: Block Diagram of the New System

III. METHODOLOGY

The methodology adopted is Object-Oriented Analysis and Design Methodology (OOADM). Its development activity consists of objects, classes, frameworks and interactions. The use of this methodology helps to produce a better-quality software product for embedded systems and Internet of Things (IoT) in terms of documentation standards, acceptability to the user, maintainability and consistency of software. The methods of data collection employed are internet, observation and brainstorming. This microcontroller was been programmed to collect waste level data from a given detection point, do all required analysis and computations and then triggers the corresponding output units. The system was designed by interfacing of the various sub parts. The entire system interfacing has been shown and the individual modules. The following components were interconnected ESP8266 Nodemcu (x1), Ultrasonic sensor (x2), Android Phone & Blynk IoT App, Breadboard (x1), Light Emitting diodes (x1), 9v battery and connector (x1), 100ohm resistor (x1) and other Miscellaneous parts.

IV. RESULTS AND DISCUSSION

This Figure 6 diagram shows the interaction between the Smart System and the outside world using Use Case. Here, the smart system and the user are the actors. The project title is housed in the outermost compartment while the individual use cases are housed in the inner rectangular boxes. The system is required to monitor the waste levels at various strategic points in the area. It determines when the waste levels exceed threshold and hence sends notification to the management. This is also required to use logic time functions to determine whether the waste disposal agents are doing their work timely and effectively. The system then uses its integrated WiFi technology to send sensor real time readings to the management's android phone through the blynk cloud. The arrows show the flow of interaction and dependencies among the individual objects of the classes. The "detect waste levels" and the "Determine disposal time" actions will trigger the "Send notification" use case. When the waste levels exceed threshold and the disposal

agents do not arrive on time. The system will send IoT notification to the management agency remotely. The "view sensor reading" use case enables the user to view the reading from the both sensors. The user is represented as the object that looks like human being while the new system is represented as a computer system.

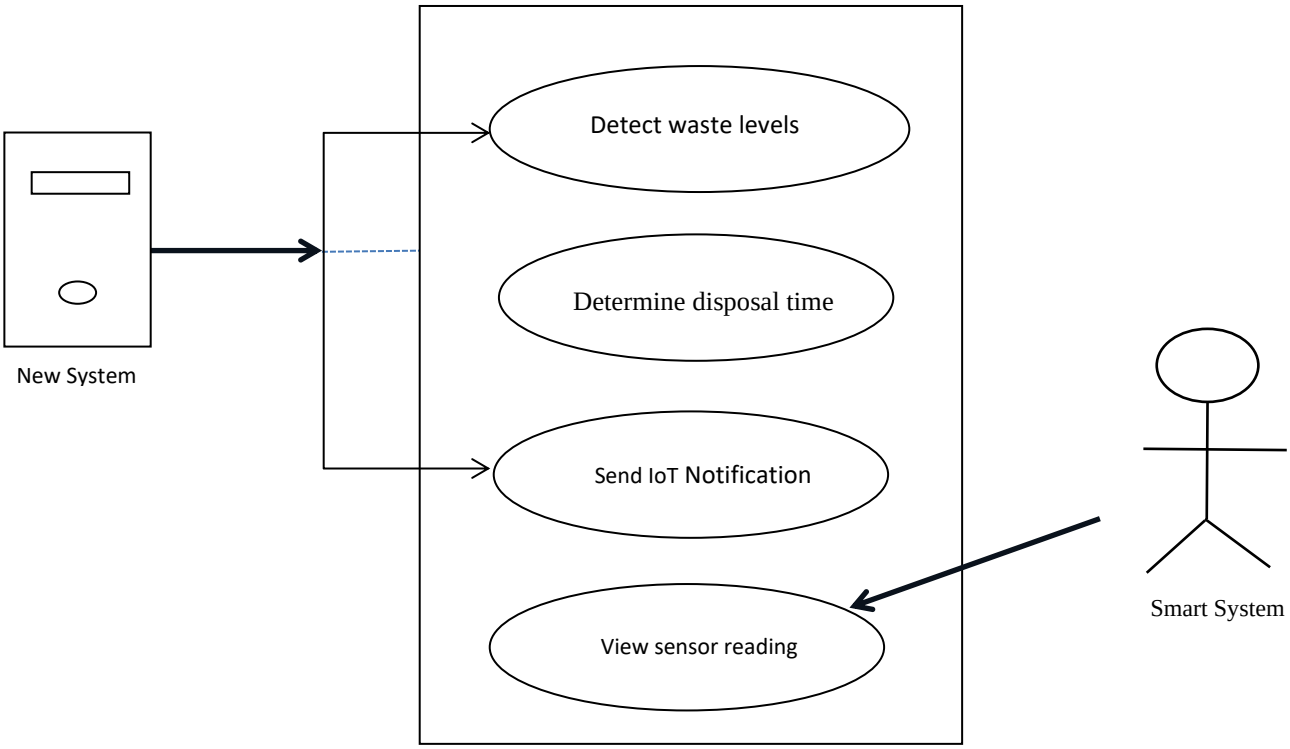

Figure 6: The Use Case Diagram of the New System

The communication diagram shows how classes of the system interact to produce overall results. Figure 7 shows the communication diagram of the new system.

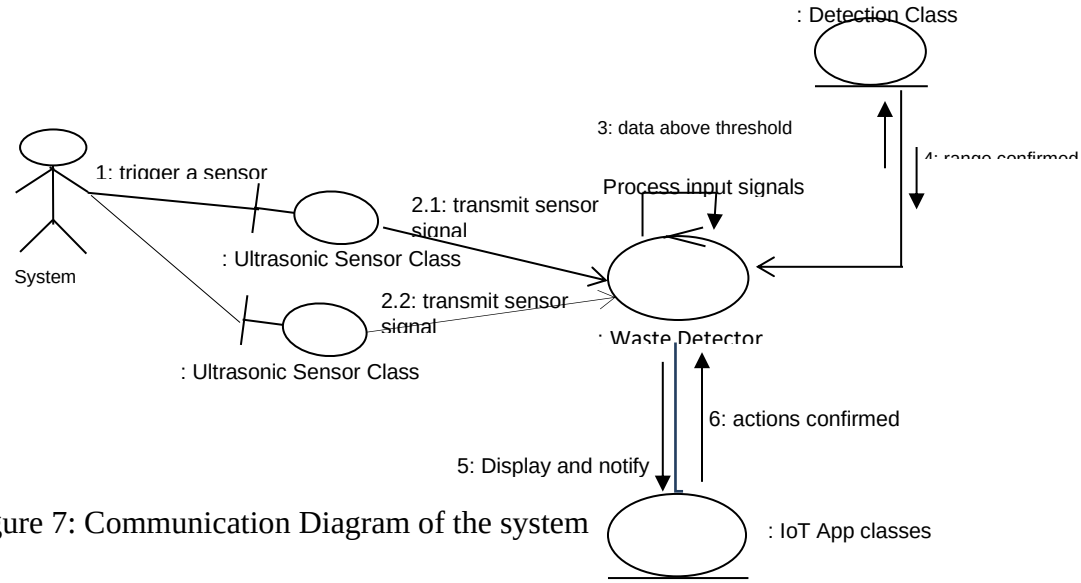

Figure 7: Communication Diagram of the system

The communication diagram (Figure 7) shows what objects are present and how they interact with other objects in the whole system. The two Ultrasonic sensors are triggered by the system. They transmit their sensor output signals to the processing unit. The processing unit confirms that the signals value meet set condition and triggers the feedback units to takes actions. The arrows show the flow of control from one object to another. Each process is numbered from 1 to 6. The name of the classes is preceded by a colon (:).

The sensor readings are stored and managed in the cloud server owned by Blynk Company. But the most recent readings in the online server will be displayed on the user's android app.

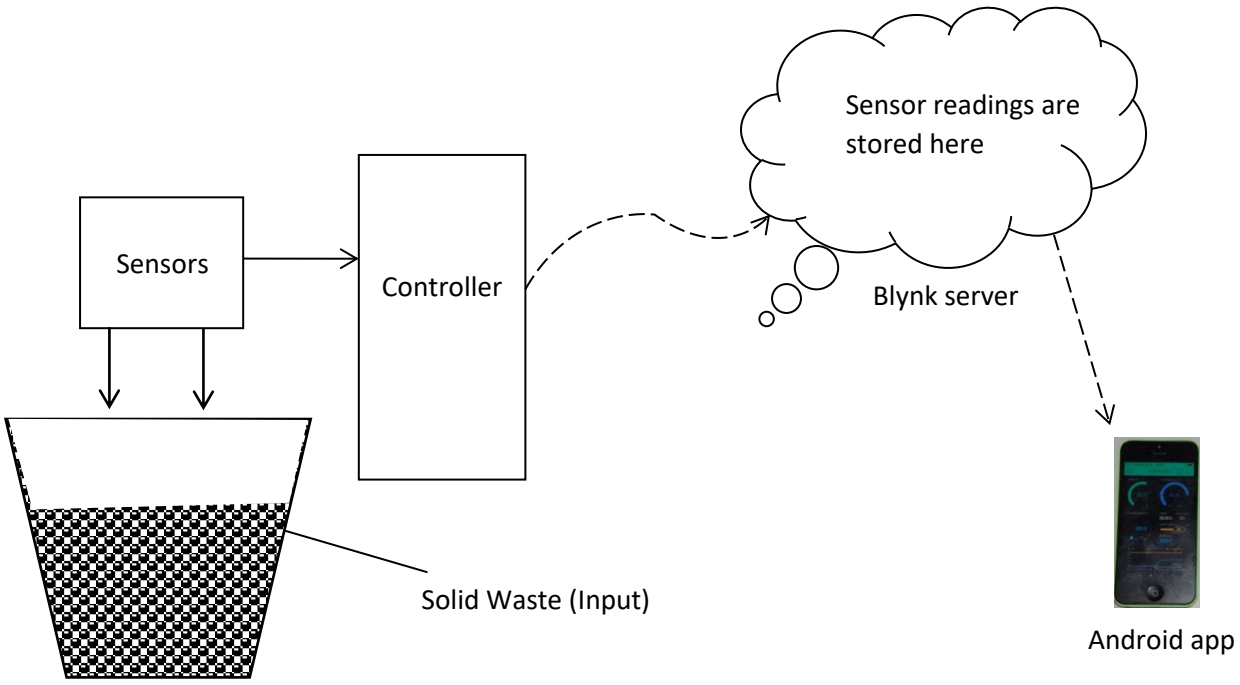

Figure 8: Sensor data stored on the Blynk server

To set up a Blynk IoT App for the smart system, the app is first downloaded from the Play Store for Android users and the App Store for iOS users. Once the installation is complete, open the app and sign-up using your email address and password following these steps.

1. Click on create a new project
2. Provide the Name of your project **as "Waste Management"**
3. Choose NodeMCU Dev Board

4. Select connection type as Wi-Fi, and then click on Create Button**.**
5. The Blynk authentication token is sent to your email address.
6. Configure the Blynk App
7. Upload the code to enable ESP8266 connect to the Blynk server.
8. Check the Blynk App on your Mobile Phone as shown in Figure 9

Figure 9: Configuring Blynk App continued

The system shall be used as stated below:

1. The user presses the ON switch on the system to power it.
2. The system boots for few seconds and the sensors get activated.
3. The system monitors the waste levels at specified points.
4. The user turns on his WiFi hotspot and the smart system automatically connects to the internet through the network.
5. Once connection is enabled, the sensor data will be sent to the user's mobile app interface in real time. The information will be displayed using gauge gadgets. In case, waste levels above threshold are confirmed and or the time for waste disposal delayed, the management receives notification remotely.
6. The system only displays the most recent value of the sensors on the mobile interface.

V. CONCLUSION

The waste management approaches in Ebonyi State has actually improved due to the ideas initiated by the management agency. However, since the approach is still traditional, it is not yet very efficient and effective. The cost and stress of moving from one point to another for waste disposal

is very high. Also, some of the existing automated systems focused on the waste management but not monitoring the management agents themselves. So, it is possible for the agents not to meet up with time and go unnoticed. The developed system monitored two or more different points at the waste disposal sites and determined the levels of the wastes and report to the management agents for evacuation if the threshold is exceeded. So, this system is will be able to reduce reasonably the rate of environmental pollution and health hazard due to poor waste management approaches. It is recommended that this system can include sensors with the ability to detect the kinds of wastes and carry out separation based on the types and the system can use a longer ranged sensor to enable longer distance coverage.

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