A New Smart Waste Managing System

Hassan Jabar
Faculty of Computer and Information Technology, University of Wasit,
Wasit, Iraq.
hassanjabar82@gmail.com

Rosilah Hassan
Faculty of Information Science and Technology, Universiti Kebangsaan,
Selangor, Malaysia.
rosilah@ukm.edu.my

Abdulrahman Sameer Sadeq
Faculty of Information Science and Technology, Universiti Kebangsaan,
Selangor, Malaysia.
rahmansameer32@gmail.com

***Abstract*—The continuous growth of the generated volumes of waste and garbage grasps the attention of researchers and experts in various fields. The collection and management process of this massive and distributed amount of waste presents a challenge, as it needs to be collected and processed as fast as possible. The accumulated amounts of waste can be a fundamental source for emitting poisonous gases and producing toxic material to the soil which leads to deadly consequences for the environment and causes serious health issues for humans so it is critical to collect it as fast as possible. To handle this scenario, this study proposed an online waste management system to monitor the status of generated trash all-around smart cities then distribute and schedule available garbage trucks accordingly. The proposed solution provides a web-based system and a mobile application to manage the organization of these wastes and facilitate the garbage collection by the drivers. The proposed solution provides an 80% faster convergence system in comparison with traditional garbage collecting method. The mobile application makes the waste pick up easier for the drivers and enable them to use better roads. Therefore, garbage collection costs and efforts have been saved, while less consumed energy is required.**

Keywords— Waste management, monitor garbage, smart cities, Arduino

I. INTRODUCTION

Internet of Things (IoT) is related to innovation. It is a smart concept of the Internet where things surrounding us are linked to the Internet, and it is probable for them to arrange data and exchange it. Various studies have been proposed regarding IoT technologies to show the increasing demands to use this technology in various new platforms' development [1]. IoT includes a wide set of devices that can connect with the Internet throughout system networks, microcontrollers, and other physical devices to collect and exchange data. To gather the existing information, each device is distinguished by the Unique Identification (UID) code for making the communication possible and easier as for a Machine-to-Machine (M2M) [2]. Internationally speaking, a large amount of information is gathered from several devices and then stored in a cloud.

In Malaysia, the Ministry of Housing and Local Government specified that the quantity of waste affects the environment and has severe medical issues of networks and blocks in commercial growth [3]. The efficient management of waste highly contributes to global energy-saving [4]. Sustainable waste management chiefly consists of recycling, composting and converting waste into energy [5]. In other words, waste management can include all the required activities to manage the garbage from its source to its final destination. Smart waste systems are mandatory to reduce the impacts of garbage on general well-being. Several researchers proposed various methods to find out a new approach to control waste contamination [6].

In addition to that, numerous methods have been set up to dodge the stuffing of litter bins. Most of them focused on the procedures to manage the wastes such as the incineration process in Langkawi Island in Malaysia [7]. Due to the significant and fast development of the population, the difficulties faced by the government to manage and monitor the garbage have efficiently increased. A huge number of containers are overfilled with waste materials everywhere around them. Those improperly settled junk then becomes the source of place for several dangerous bacteria, bugs, and mosquitoes to breed on [8].

Lately, urban communities are equipped with various dustbins in terrible conditions. The trash in the trashcans is drowned and floodlit. Individuals are stirring garbage on the litterbin although it is full. As a result, poisonous gases are released, and a terrible stink is made. Those communities try to manage this problem by following a standard methodology, and various trucks are directed to collect the waste. The garbage is filled in the truck and shifted to pre-determined zones. Hence, the assigned people for garbage collection and transportation may not ensure the success of this activity. Fig. 1 demonstrate the expected increasing in garbage size from 2005 to 2020 [9].

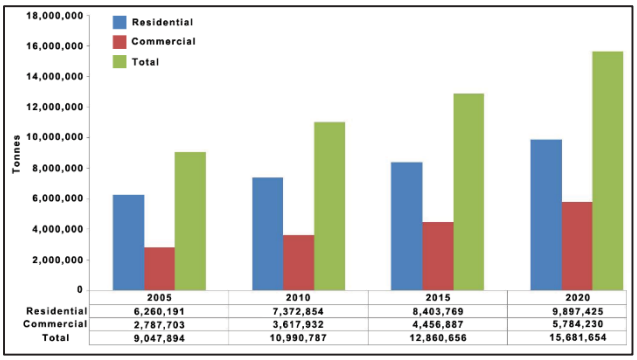

Fig. 1. The Expected Increasing in Garbage Size (2005-2020)

The litter gathering manual and the monitoring method are aware of numerous challenges such as the absence of data regarding the time and spot collection.

Waste management is another promising application area of RFID technology. Systems for the measurement of trash bin fill level must be augmented with the implementation of RFID technology. The augmented system must be realized so that there will be exchange of information between cloud and trucks for waste disposal or directly for the trash bins where the information from each bin would be conveyed to the cloud

978-1-7281-5249-3/20$31.00 ©2020 IEEE

Authorized licensed use limited to: SUNY AT STONY BROOK. Downloaded on July 17,2020 at 22:57:23 UTC from IEEE Xplore. Restrictions apply.

and the product life cycle management could be realized and recycling process could be eased [10]. RFID technology can increase the rate of recycling of different types of waste of components such as batteries, electronic waste, hazardous substances and valuable recyclables. Sorting different types of batteries could be cheaper and easier with the use of an RFID tag that is placed on the battery. RFID tags placed on electronic equipment could contain information about the possibility of dismantling, the content and type of constituent elements, the method of selection of components in dismantling and recycling possibilities of individual elements of electronic devices [11].

This study will be a factor to ensure secure garbage management through the development of a new web-based system. This system will offer a compelling option to control garbage. This monitor uses sensors and an Arduino microcontroller. The rest of this paper is recognized as follows: the next section demonstrates the design and the implementation of the proposed method. Then, the testing and evaluation procedure are presented. Finally, the results and the discussion are listed to demonstrate the efficiency of the proposed mechanism.

II. METHODOLOGY

In this section, the detailed components and implementation components of the monitoring system are demonstrated including various details. The used programming language and data transmission protocols are also described in detail. In the end, the system testing and evaluation are discussed as well.

A. Monitoring System Components

The suggested system proposed a novel solution to control and monitor garbage. The proposed solution mainly depends on using Arduino microcontroller and sensors as shown in Fig. 2. The monitoring system includes different types of sensors and microcontrollers and mainly utilizes the Global System Mobile Communication (GSM) module to assure the dustbins' vacuuming quickly once the trash level reaches its maximum. It then notifies the person to stop filling and to start collecting it. If the litterbin is not cleaned on time, a report is sent to take appropriate actions.

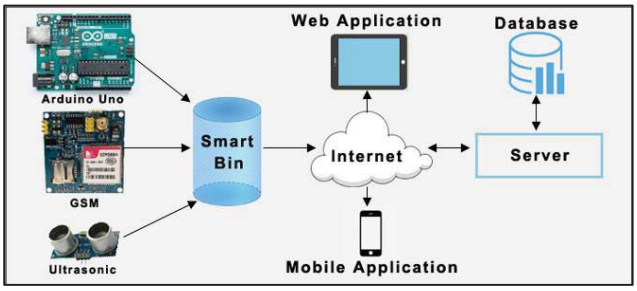

Fig. 2. Garbage Monitoring System Flow Chart

The main parts of the monitoring system include two main components: the hardware part and software part. In the hardware, different devices have been used including:

- Arduino**:** it is a programming group and a computer tool, an endeavor, and a client group producing microcontroller parcels for programmed devices and smart object making. It mainly allows communication between PC and a wide range of sensors and microcontrollers as shown in Fig. 3.

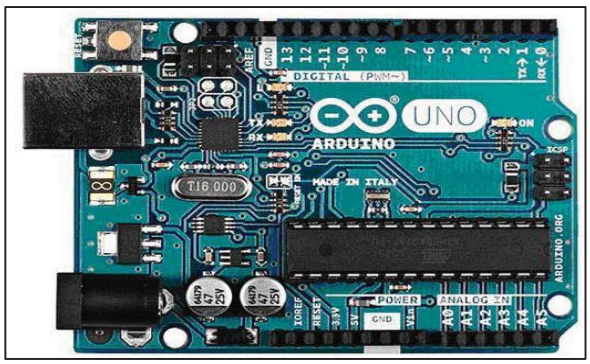

Fig. 3. Arduino Uno

- ESP8266: as shown in Fig. 4 , it is a Wi-Fi module that provides access to a Web mission as shown in Fig. 3. It may operate with any microcontroller and performs the task distantly. It remains running at 3.3 volts and will be damaged at 5 volts. The ESP8266 includes eight sticks. VCC and CH-PD will be related to 3.3V for Wi-Fi permission. The RX and TX bolts will be responsible for the communications between the ESP8266 and Arduino. RX picks up a shot of 3.3 volts.

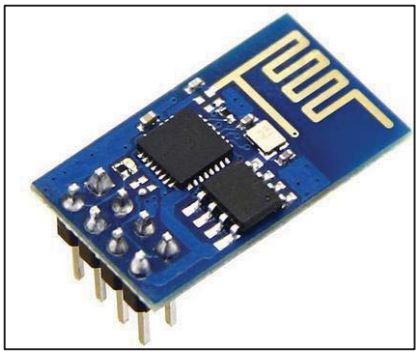

Fig. 4**.** ESP8266

- Ultrasonic sensor: The sensor is another main component in the design used to measure the distance with high precision as shown in Fig. 5. The distance is measured from 2-400cm. It reveals an ultrasound wave at 40 kHz frequency. The time it takes to hit and return the body can measure the distance as per "(1)":

$$\text{Distance} = \text{time} * \text{audio speed} / 2 \qquad (1)$$

Where time = time is obtained between ultrasound and turns. This sensor has four pins, two VCC and GND, connected to Arduino's 5V and GND. The others are Trig and Echo pins which will interrelate with any digital Arduino pin. The pin sends a trigonometry signal, and the echo pin receives it. The ultrasonic signal production requires the Trig pin to be high for approximately 10us, which will send it to eight audio cycles.

Authorized licensed use limited to: SUNY AT STONY BROOK. Downloaded on July 17,2020 at 22:57:23 UTC from IEEE Xplore. Restrictions apply.

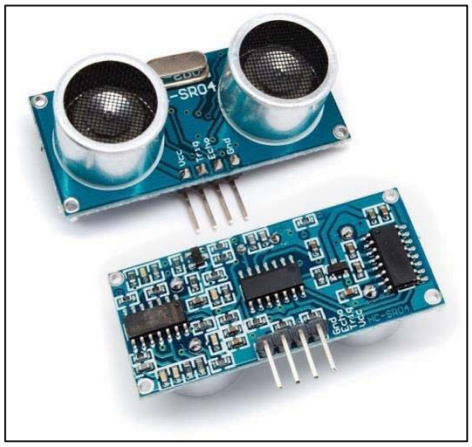

Fig. 5. Ultrasonic Sensor

- Jump wires and the breadboard: these staffs are essential to complete this design. The breadboard can route the components by its slots. The sides of the breadboard represent electricity soar wires and divisions usually used to create connectivity with breadboard as shown in Fig. 6.

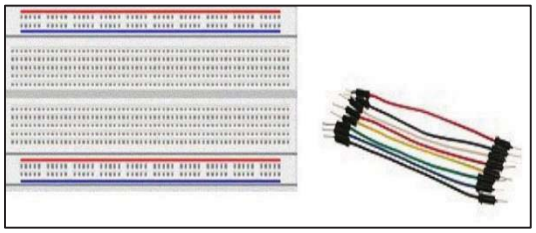

Fig. 6. Board and Jump Wires

The implementation will start by setting up the ESP8266 by flashing of the newest version of the firmware. This allows the Blynk libraries to communicate and to dodge error making. For the flashing, the ESP8266 flasher tool and the newest firmware should be downloaded. Once the ESP8266 flashing is done, other components are added to the configuration. The breadboard to connect the microcontroller, the buzzer, the ultrasonic sensor, and the ESP8266 are connected through jumper wires. For the software part of the proposed solution, a mobile application has been developed using suitable programming language and data transmission language as described below.

- Programming language: For the mobile application, Java and XML will be used. However, for the Web service, it will be programmed with C++ net and Framework 2.0. Mobile 4G technology for quality images communication involves REST-XML and AES hybrid technique. This technology guarantees a secure transmission. PHP code is either implanted into HTML code or used in combination with several web content management systems, web template systems, and web frameworks. It is managed through a PHP interpreter executed either as an executable Common Gateway Interface (CGI) module on the web or as a server.

- Data Transmission Language: XML and Gson: In this approach, both XML and GSON data transmission language have been used. XML is a universal language used as a data exchanger. Several improvements have been made concerning XML to improve its protection. The encryption feature of XML is embraced when the application necessitates both secure and insecure communication [12]. On the other hand, Gson is an open-source for java library processed by Google. It consists of an API for replacing a java object by a JSON illustration and vice versa. It is a requisite to swap a Java or existing objects to ISON and vice-versa, to support universal objects, and to explain fields of conversions.

- Step Application Programming Interface: The Step Application Programming Interface is an arrangement of instructions and guidelines allowing one piece of a software application to connect with another including create, read, update, and delete operations. Using API strategies and XML parser assist in the continuous sending and receiving of both the medical information and the pictures. REST API is compulsory since it is the easiest method to create, read, update, and erase the data among numerous applications in the web or HTTP, as shown in Fig. 7. The data is instantly revealed to the client, mainly through the off chance using JavaScript to provide the information in a page's site.

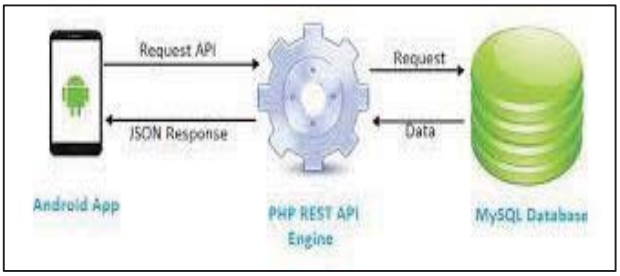

Fig. 7. STEP API Workflow

B. *System Testing and Evaluating*

The last phase of the proposed methodology is evaluation. The consumer checks out, and additional refinement is performed before issuing the model. The functionality of the system is tested and evaluated by comparison with previous systems. The mobile application user interface provides the functionality by showing the smart bin location in the map, along with the garbage levels which are shown in Fig. 8.

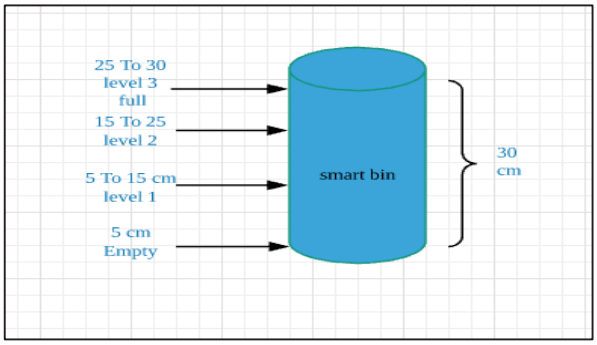

Fig. 8. Smart Bin

III. SYSTEM IMPLEMENTATIO AND TESTING

The details of the systems architecture profoundly are discussed in this section including the design of the proposed system and the implementation process which include three main tasks. The component of the system design and the role of each component is investigated are also presented

Authorized licensed use limited to: SUNY AT STONY BROOK. Downloaded on July 17,2020 at 22:57:23 UTC from IEEE Xplore. Restrictions apply.

A. System Architecture

The system is developed for smart and urban cities. Fig. 9 shows the IoT structure of the waste collection system based on the cloud, including the cloud service provider to store the information.

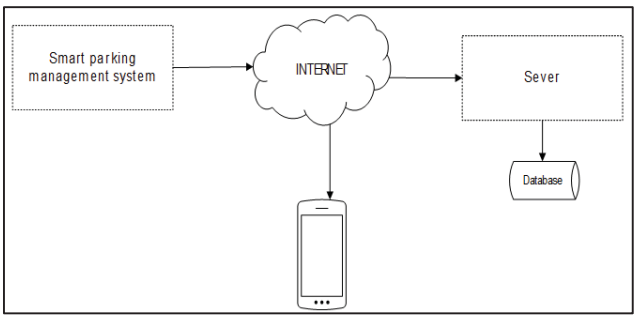

Fig. 9. Garbage Monitoring System

The central server deals with the volume of the accumulation information such as the number of waste loads. This information is accessible through secure network portals. This smart system consists of various components including the central server for the information regarding the waste location, the Arduino connected to sensors which consist of a precise control device for garbage collection system implementation, and the Android application.

Description of the design Components: The main components of the design can be divided into three units and are summarized in TABLE I. The use of IoT is seen where Arduino is connected to the ultra-sonic sensor to collect data from the waste bin and to send data back to the cloud. As for the android application, it is developed to monitor the container status at the client-side. And finally, a server is set to control the client notification and store the required data.

TABLE I. DESCRIPTION OF THE STRUCTURE COMPONENTS

Components	***Description***
The use of IoT	An Arduino connected to an ultrasonic sensor module to receive data from the waste bin and ESP8266, which is used to send data to the cloud.
Android App	The app will show all of its empty and full container storage using any Android OS phone
Server	An HTTP server generally named web server, is characterized as a data innovation that forms demands by means of the HTTP organize convention used to spread and share data on the World Wide Web. This server will be in charge of perusing the HTTP demands sent by the ready notice them and send a communication message to the client.

On the other hand, Fig. 10 shows the Arduino loaded scripts that perform the required function of retrieving the sensor data and forwarding it to the cloud server to notify all the concerned clients. Scripts are developed using the Arduino IDE interface.

B. The Design of the Proposed System:

The connection between the hardware components of the proposed system is shown in Fig. 11. The Arduino Uno

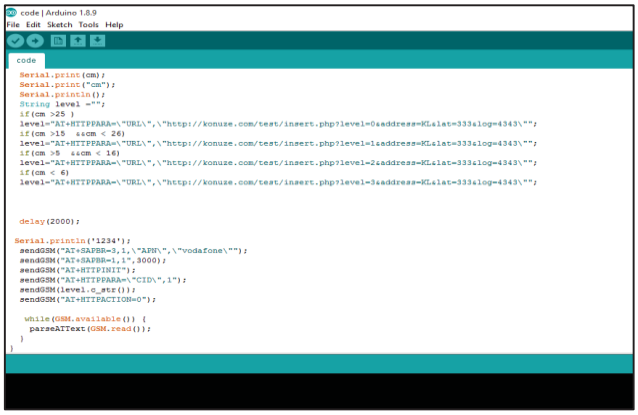

Fig. 10. Arduino IDE Interface

controller is connected to the ultrasonic sensor and sends a 40 kHz ultrasonic wave. The period it takes to hit the body and return to the sensor is important for the distance's measurement in Arduino Uno. The EPS8266 sends the received data to the Internet database and is received through the mobile application.

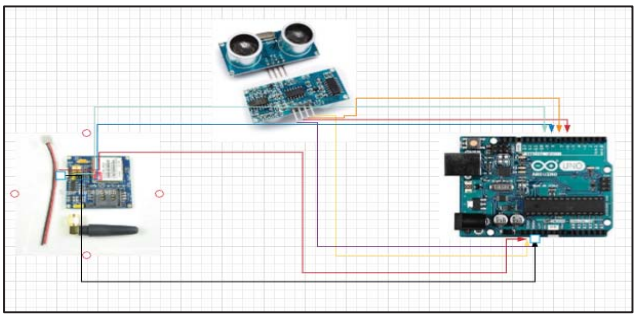

Fig. 11. IoT Design

The hardware connection of the other bins is demonstrated in TABLE II. The Arduino Uno is used to achieve the processing process, the Ultrasonic Sensor to determine the remaining distance of the device volume, and ESP8266 to transmit data.

The GND is connected by Arduino, and two VCC and GND are connected to 5V. Each Arduino pin will be connected by an Echo and a trigonometric. The function AS of each pin is responsible for receiving and sending the signals.

The RX and TX functions are connected to the Arduino through the EPS8266 and operate only at 3.3V for each of the eight pins. For Wi-Fi enabled, the CH-PD and VCC are connected at the same voltage as ESP8266. TABLE II shows the interconnection among devices.

Authorized licensed use limited to: SUNY AT STONY BROOK. Downloaded on July 17,2020 at 22:57:23 UTC from IEEE Xplore. Restrictions apply.

TABLE II. INTERCONNECTION AMONG DEVICES

Main Part		
In sensor	**In Arduino Uno**	**Sensor Type**
Ultrasonic Sensor	GND	GND
	ECHO	~6
	TRIQ	7
	UCC	5U
ESP8266	R23	~9
	R8	8
	+	5U
	-	GND

C. *Implementation Proposed System:*

The implementation process includes three main steps. The central part of the Arduino Uno controller is connected to the ESP8266 and receives the garbage level information from the other parts. The Arduino Uno is also connected to the ultrasonic sensor to determine the level of waste at steady delivery and high accuracy. In the sensor, when it collides with the waste, it corresponds to the time required for the object to return to the device, where distance is calculated. The distance may be measured, and data is sent to Arduino. However, the console sends this data to ESP8266 alone. Data is sent from the database to the mobile application to display the basket in its new or complete state. The drivers may consult them by clicking on the Trash Site through Maps. Thus, drivers can take shorter routes, and fuel and voltage are reduced.

For server management, a web page is created and uploaded to the server; it is connected to the database to store the required information. This page contains the addition and deletion of the waste containers, their location, and the container information modification. The waste level is added to each box. Thus, garbage management will be easier. The administrator can manage the page for a better follow up and notify if any defect occurs. The employees working in the organization can manage the web page as well. This one consists of login as shown in Fig. 12.

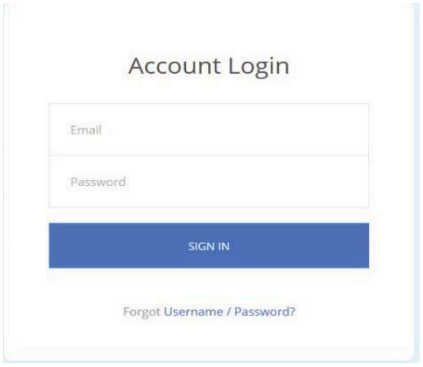

Fig. 12. Login Interface

Once logged in, a new web page appears as in Fig. 13 allowing the ability to add another smart waste bin. Once the waste bin is added, a new window appears to enter the information about the container including the region where it is located, the level of waste in the litterbin, and the latitude and longitude to locate the bins.

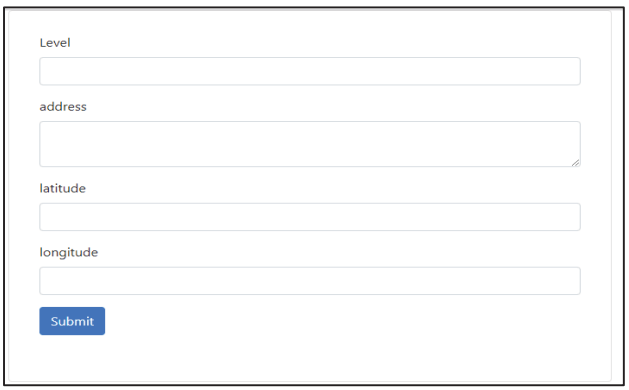

Fig. 13. Adds New Garbage

Once the required information is entered, a new web page is displayed to determine the level, the location, and the possibility of deleting or changing the location of the bin. All this data permits the administrator to follow the litter bin and send notifications in case of any defect. PHP administrator helps in creating and uploading the database to distribute data to the mobile applications.

i. Android Studio: To develop the mobile application, the Android Studio, which is the official Integrated Development Environment responsible for android application creation, is used. It is based on a Java integrated development environment or Intelli J IDEA. Java Scrabble is used to design the application for this study. It includes the number of containers and litter size in the bin. Besides, it shows the briefest way for fuel-saving and voltage reduction.

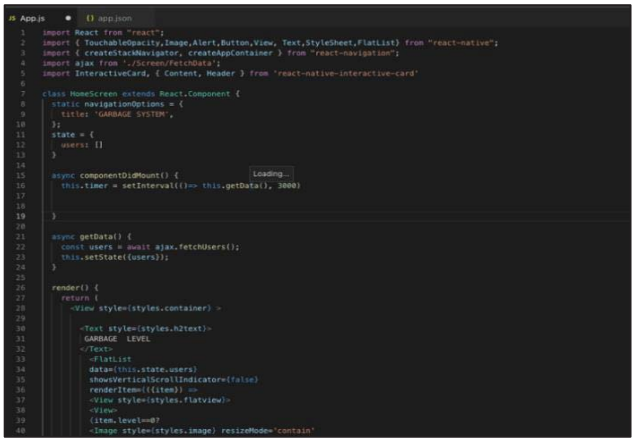

Fig. 14. Android Studio Interface

ii. Application Testing: The implementation of the elaborated system is done at the Universiti Kebangsaan Malaysia in Malaysia. In the case of an empty basket, the level starts at 25 cm, in which the bin is said to be at the first level. The system is said to be in dormancy, and data is not sent. The first level of container size starts from 25 to 15 cm, the second level starts from 15 to 5 cm, and the last level-full container starts from 5 to 0 cm. Once the bin is full, the driver clicks on the web button to find the location of the container and shows the shortest way to it for fuel usage and voltage reduction. Once the garbage collected, the litter bin is cleaned, and a new page of an empty bin appears.

Authorized licensed use limited to: SUNY AT STONY BROOK. Downloaded on July 17,2020 at 22:57:23 UTC from IEEE Xplore. Restrictions apply.

Fig.15. The Waste Fund is in Full Condition

A comparison is done with previous researches and the highest ratio obtained is 80%. The analysis of the proposed system shows that time is reduced since the litter bin location is already determined as well as the waste level. Knowing the location will enable us to decide which route to take as shown in Fig. 16, and knowing the level of waste will avoid additional trips to collect the garbage of an empty bin. Another advantage of this system will be the energy saving. Reducing the number of trips not only contributes to the economy, but also to energy-saving since the amounts of fuel and human energy are lessened.

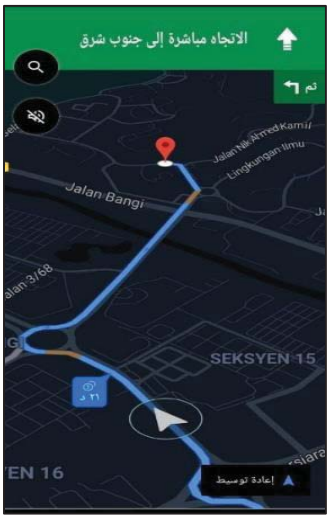

Fig.16. Interface the Map

IV. CONCLUSION

The purpose of this study was to elaborate an effective garbage management system based on the Internet of Things concept for the management of all litter containers with proposed features such as optimal resources, less time, and reduced voltage. An Android mobile application has also been designed. The peak convergence with previous traditional garbage collection approach was 80%. Real-time information about the garbage is presented graphically on the map for an easier garbage collection. Google Map API has been found to be useful to determine the routes to the bins. The system is environmentally friendly and fuel and human energy saving. The system is distinguished by an Arduino connected to an ultrasonic sensor and an android mobile application.

Thus, this project significantly ameliorates professional health care since it helps in reducing the possible diseases resulting from waste and maintains human health by overcoming the spread of waste disposal by using the sensor technology and smart devices to record the litter bin information in a safe and a secure manner.

ACKNOWLEDGEMENT

We would like to acknowledge through this paper the Network and Communication Technology Research Group for providing us with the necessary support and assistance, FTSM, and UKM (Grant DIP-2018-040) for guaranteeing all the facilities necessary for this study.

REFERENCES

[1] R. Hassan , S.S. Nori , N. Othman , Arba'iah Inn, "The improvement of the protection for 6LoWPAN in IoT through non-causal hash function scheme," in ECTI-CON 2018 - 15th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, Chiang Rai, 2018.

[2] S.Paul, S. Banerjee, & S. Biswas, " Smart Garbage Monitoring Using IoT.," in IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), 2019.

[3] M. Mustafa, & K. N. Ku Azir, "Smart Bin: Internet-of-Things Garbage Monitoring System.," in MATEC Web of Conferences 140: 01030., 2017.

[4] N. Othman, L. Mohd Sidek, N. Ahmad Basri., M. Muhd Yunus , "Electronic plastic waste management in Malaysia: The potential of waste to energy conversion," in ICEE 2009 - Proceeding 2009 3rd International Conference on Energy and Environment: Advancement Towards Global Sustainability., Malacca, 2009.

[5] R. M. Rodzi , Z.M. Nopiah , and N.E. Basri , "Analysis of solid waste generation and composition in Malaysia TVET campus," International Journal of Integrated Engineering, vol. 11, no. 2, pp. 158-170, 2019.

[6] A. Castro Lundin, A.G. Ozkil & J. Schuldt-Jensen, " Smart Cities: A Case Study in Waste Monitoring and Management.," in Proceedings of the 50th Hawaii International Conference on System Sciences, 2017.

[7] F. Shamshiry, M. Mokhtar, & A.M. Abdulai, "Investigating the standard process of incineration in Langkawi Island, Malaysia," American Journal of Environmental Sciences., vol. 10, no. 3, pp. 260-276, 2014.

[8] A.H. M. Hassan , J. Srinivasan , L. K. Bharadwaj , H.Ganesan , and S. Sudha "IOT based Garbage Management System for Smart Cities," International Journal of Science Technology & Engineering, vol. 3, no. 04, pp. 120-124, 2016.

[9] A. Periathamby, F. S. Hamid, and K. Khidzir, "Evolution of solid waste management in Malaysia: impacts and implications of the solid waste bill, 2007," Journal of material cycles and waste management, vol. 11, pp. 96-103, 2009.

[10] R. Latih, R. Hassan, and Z. M. Ali, "Teaching and learning tool for data communication course," Asian Social Science, vol. 8, p. 111, 2012.

[11] N. E. Othman and R. Hassan, "Agent-based modeling of tag-based cooperation in mobile environment," Journal of Theoretical and Applied Information Technology, vol. 95, pp. 777-787, 2017.

[12] A. Selkirk, "XML and security.," BT Technology Journal, vol. 19, no. 3, p. 23–34, 2001.

Authorized licensed use limited to: SUNY AT STONY BROOK. Downloaded on July 17,2020 at 22:57:23 UTC from IEEE Xplore. Restrictions apply.