Designing smart waste management under a wireless communication system

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***Abstract*—The purpose of this research is to design a smart waste management under a wireless communication system. To achieve this goal, a smart controller is designed by Arduino Uno and sensor ultrasonic to control the filling level of waste in the bin based on the real time. All data are collected and processed in a smart controller to inform all users accurately. Therefore, all users are able to easily and effectively access the information about the waste level accurately and in real time.**

Keywords—controller, management, sensor, waste, wireless

I. INTRODUCTION

Increasing population accompanied by rapid urbanization and industrialization has brought both positive and negative impacts of development. The positive impacts are an increase in economic activity, changing lifestyles and food consumption. On the negative side, modern society generates a high volume of waste. Consequently, it has brought huge environmental impacts, including causing serious problems for public health and the environment.

Human activities generate growing amounts of waste. There are many materials disposed of in general waste that can survive in the environment for a long time. According to [1] there are some environmental waste impacts, such as: pollution, global warming, water depletion and fossil resource depletion. The impact of waste not only affects human beings but can also significantly impact plants and animals. For example: disrupting animal reproduction due to rotting food in landfills and liquid pollution for plants due to toxic pollutants.

A number of researchers have been assessed to solve the problems above, such as: self-reported data and the optimization of disposal methods and recycling. To reduce waste, self-reported data is a potential means of reducing food waste. Author in [2] illustrated the effect of self-reporting on food waste generated by four hotel kitchens in Germany. In this study, a food waste tracking system has been developed to facilitate self-reporting. To improve the operational kitchen process, refilling the breakfast buffet with less food occurred during 30 minutes of breakfast time. This method has been utilised by kitchen staff over one year. In the first five months it was revealed that the quantities of food waste decreased and remained relatively constant for the next period. As a result, this method can significantly reduce the breakfast buffet leftovers. In addition, breakfast buffet leftovers were reduced on average by more than 64.3% of mass.

According to [3] to reduce volume of high level waste an optimization disposal method is required. In this study, the disposal methods accompanied by some scenarios are optimized. The horizontal and vertical emplacements concept was adopted to investigate the level of waste reduction. Based on the result of optimization, the horizontal emplacement can reduce 20% of the repository footprint in direct disposal. Moreover, the footprint can be reduced up to 50% by extending the cooling time 40 years before disposal. In addition, this disposal method can be applied to manage bio-medical waste. According to [4] this disposal method is safe and hygienic for bio-medical waste. This is because this assessment was evaluated according to a number categories, such as: social acceptance, technology, environmental protection, cost, noise and health risks.

Other research has been developed by [5] by applying innovative technology for recycling concrete waste. This paper illustrates the advanced dry recovery and heating air classification system technologies to recycle end-of-life concrete to be coarse, fine and ultrafine particles. Based on the research results, both methods can potentially reduce the heavy traffic related to construction activities so that it can support the increasing sustainability and greening of the construction sector. These technologies have been effectively applied as they are designed to be mobile.

In addition, this recycling method has been developed by [6] to ensure a circular economy for plastic. Ten recycling technologies have been applied to evaluate the environmental impact of 25 polymer models. The life cycle assessment (LCA) model is designed to simulate realistic plastic challenges. The research results indicated that the LCA model in Europe can reduce 73% of CO_2 emissions from plastic.

However, the proposed method has developed an innovative technology to solve the impact of waste on the environment, and humankind's sustainability. The proposed method allowed the whole community, waste officers and local government to manage and control waste levels in smart bins.

II. Related Work

A. Waste Management system

A number of research studies have assessed waste management systems. For example: an intelligent waste management system is based on deep learning and Internet of things (IoT) paradigm [7]. The proposed model describes the architectural design of smart bins with using a microcontroller accompanied by multiple sensors. For monitoring and processing data with real time, the IoT was required to control all data from anywhere through an application under an android program. In this research, a convolutional neural network was applied to sort digestible and indigestible waste. The accuracy of waste labels has been developed by a sensor data and system usability scale. The result of research indicated that the accuracy of the proposed model was achieved at 95.3125 %.

Author in [8] applied the reliability analysis method to control the uncertainties for a multiple stage solid waste management system. To optimize the reliability system, an optimization model was used to optimize the allocation of waste treatment demand between facilities. The proposed method was applied in Hong Kong to investigate the effectiveness of this methodology. A case study was examined to evaluate the risk of the solid waste management system. As a result, under the optimization method, the risk can be minimized and provide the best solution for sustainability.

According to [9] waste management is an important step towards an energy and material sustainable society. The issue of municipal waste is a huge serious problem in the world. The possible solution to get an efficient waste management is the Pay-As-You-Throw model. This program considers each agent responsible for reducing waste production. The proposed method applied an incentive mechanism to non-domestic sectors, such as: hotel enterprises in Funchal Portugal.

Other researchers applied Household electronic waste management in Malaysia [10]. Under the IoT paradigm, waste management was applied to collect electronic waste. In order to support the smart city concept for sustainability, this method applied the e-waste program for every house, namely: using an e-waste collection box and e-waste level sensor. To simplify the collection of data, a mobile application was developed for all users. The results indicated that the proposed system was successful and effective for collecting electronic waste in Malaysia.

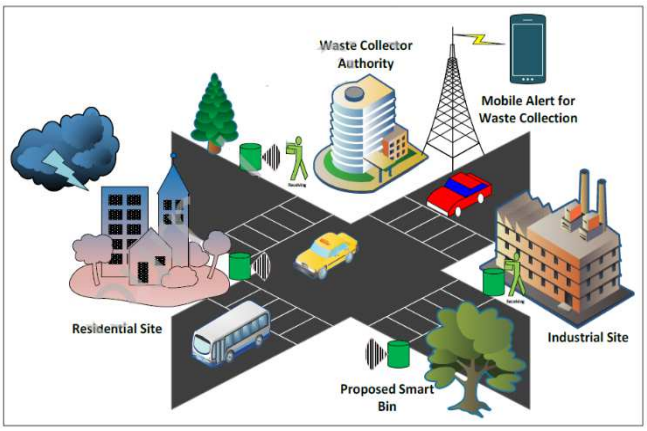

Fig. 1 An example of waste management system [11]

Figure 1 above illustrates an example of a waste management system. The proposed method illustrates a complete scenario of smart waste management under a smart garbage management system. This method has been proposed by [11] with applied four system under an Arduino Uno microcontroller. The function of the Arduino Uno is to synchronize each task with the other systems. The four systems are identification, an automated lid, display and communication systems.

B. Wireless communication system

A wireless communication system transfers electromagnetic information between two or more points without an applied electrical conductor. Today, a wireless communication system is not just applying to send general information but also to use this to support some intelligent communication in transmitting physical or chemical variable data. The following research illustrates how the wireless communication system has been applied to support the waste management system.

Ref [12] illustrated an intelligent concept to monitor the amount of waste in disposal of integrated solar energy. A wireless communication system was applied to send information about the level of waste in the container. To simplify communication, all smart bins had installed a Wi-Fi hotspot. Therefore, it is easy to access data for any type container, such as: small and large containers. The result of the research indicated that intelligent concepts can reduce the operation costs by up to 80%, assist waste officers in utilizing fewer trucks, reduce fuel consumption and take less time for waste collection.

Ref [13] developed a new concept of waste management for smart cities with integration to a wireless cloud. Under an applied wireless system, the proposed model could monitor the temperature, humidity, smoke fire detection and volume of waste in the bin. All communication from the sensor to central station is conducted by existing GSM/GPRS wireless infrastructure. The result of research indicated that the proposed concept could minimize the cost and efficiency in solving the waste problem in modern society.

Other research has been developed by [14] to monitor garbage under a wireless integrated to IoT. To avoid excessive operation costs and direct contact with the employees who monitor garbage, remote monitoring by software system is applied. The technical proposal can improve the intensity and efficiency of the waste monitoring system.

III. Proposed Design

To design a smart waste management system, four systems are synchronized by the control system. These four systems are: smart bin, control system, mobile phone and server. In addition, to create the control system, two main components are required: Arduino Uno and sensor ultrasonic. Figures 2 and 3 illustrate the kind of components used to manufacture a control system.

A. Arduino Uno

According to [15] Arduino is a single board micro-controlled based on the ATMEGA 328 chip created to process an applied electronics system in multidisciplinary research. The Arduino board was chosen to control and synchronize all systems as it is popular, economical, and

easy to implement and is an efficient open-source single board microcontroller. The Arduino has a communication protocol to connect with a computer system. Figure 2 (below) illustrates the Arduino board used in this study.

Fig. 2 Arduino Uno board [16]

B. *Ultrasonic Sensor*

Author in [15] sensor is a device which permits the measurement of physical or chemical variables transforming to be an electrical signal. In this study, an ultrasonic sensor was applied to measure the position or level of waste in the bin. This is because the ultrasonic sensor has a high accuracy in millimetres to measure the position and level of physical objects [17]. In addition, ultrasonic sensors are usually used to sense automation to measure distance, position and level [18]. The kind of ultrasonic sensor applied in this research is SRF08, as illustrated in Figure 3 below.

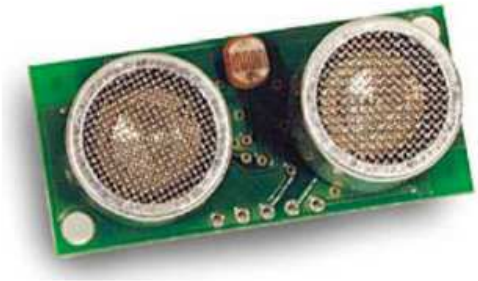

Fig. 3 Ultrasonic sensor SRF08[18]

C. *Control design*

Figure 4 (below) illustrates that control systems are designed to control and detect the position of waste levels in the smart bin. The task of the control system is not just to measure the level or detect waste in the bin but also to send a message directly to a mobile phone and website through an android application. To accurately gauge the level, the control system position is located in the bin. In addition, to protect this system, users put it on the side of the safety box integrated with the bin.

Fig. 4 The control system

The flowchart diagram of the proposed method is shown in Figure 5 below.

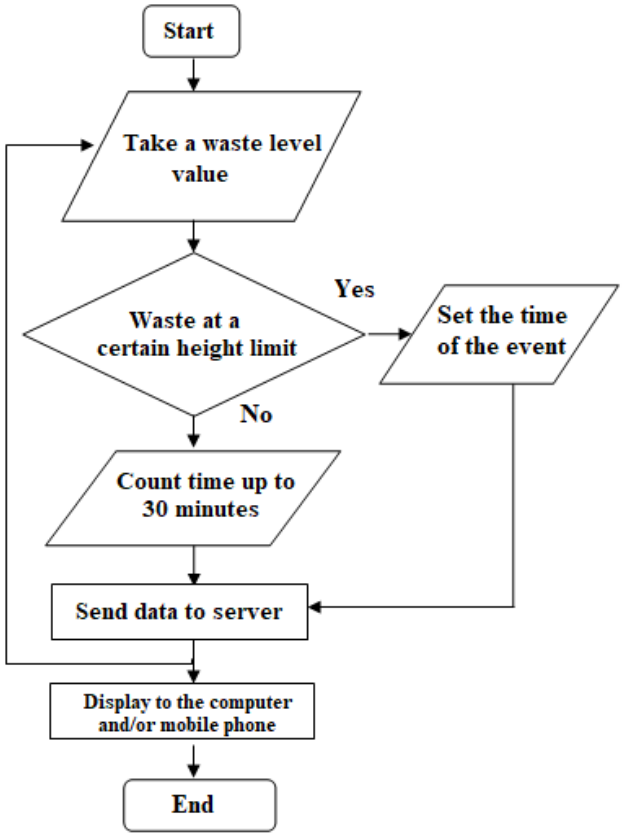

Fig. 5 Flowchart diagram

IV. Result and Discussion

A. *Architecture design*

Figure 6 (below) illustrates the architectural design of a smart waste management system.

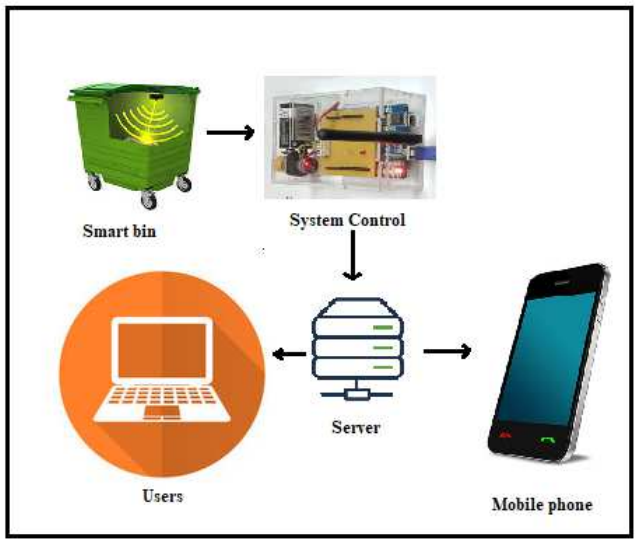

Fig. 6 The architectural design

Figure 6 (above) illustrates that the level of waste in the smart bin is controlled by control system. The control system sends information to the user regarding the position of the waste level. This is to make it easy for the users to control/monitor according to the tools available, for example:

mobile phones or computers. This is also to make it easier for the local government and waste officer to control the smart bin based on the status of the bin. In this study, the status of bin is full or not full. If the status is full then the waste officer picks up the waste to avoid garbage buildup, maximizes the pick-up time and reduces operation costs. In addition, the proposed method can assist all consumers to recognize the status of the waste bin when they want to drop their waste near their homes.

To synchronize between all functions and users, a microcontroller is used to send information for all users. All data are stored and the process under the existing control system sends the bin status to the users. There are two kinds of tools for all users to get information of bin status, such as web interface and a short message service.

B. *Web interface*

Figure 7 (below) illustrates a web interface if the consumer accesses via computer. In this web interface, there are two main menus available: the main menu and the announcement. In the main menu there are three options available: Home, news and monitoring. The home tab is the basic unit of the application (the default menu in this system). News consists of notification from the operator about some information related to the waste management system. Tab monitoring contains the main task of the system. All users can access the status of the bin by this tab.

In this study, the web interface is applied to bring information to all users that can be easily accessed regarding the status of the container. There are two kind of bin status: "PENUH" (known as 'Full') and "BELUM PENUH" ('not yet full'). 'Full' occurs when the volume of waste has reached the maximum level. Alternatively, when the volume of waste is under the maximum level, it is called 'not yet full'.

Fig. 7 Web interface design

C. *Short message service*

Figure 8 (below) illustrates the result of monitoring by a mobile phone.

Similar to the result above, the status of the smart bin is sent directly to the mobile phone if the smart bin status is PENUH. On the other hand, the consumer can recognize the status of the bin if the smart bin is still available with "BELUM PENUH".

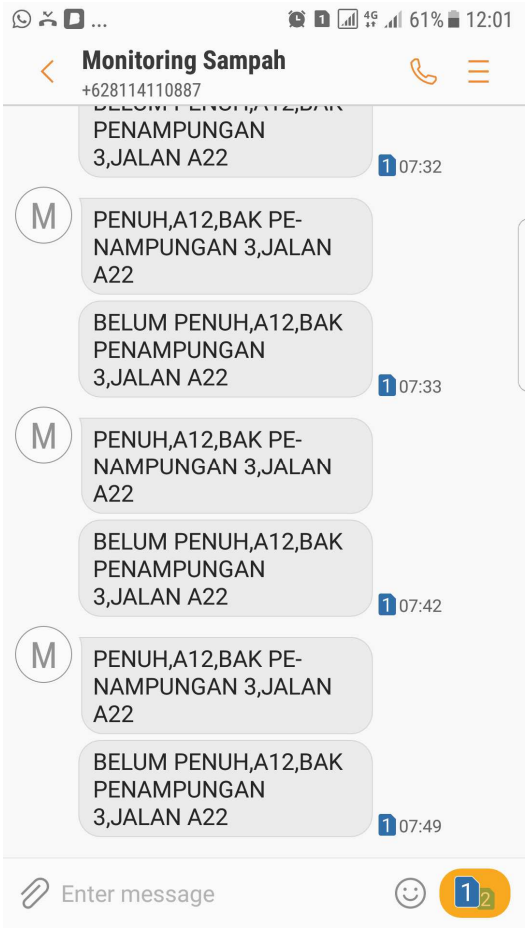

Fig. 8 A sample message on a mobile phone

Based on the Figure above, all consumers are allowed to check the status of the bin in real time for every street. Therefore, it would assist all users to monitor the status of the bin directly. In addition, it would be assist the waste officer to directly control and pick up the bin if the status is full. As a result, it can protect the environment from the negative impact of waste and reduce many different environmental problems due to air and landfill pollutions.

V. Conclusion

The results of this research illustrate that a control system can control the waste level in the bin based on real time. A smart controller is designed by Arduino Uno and ultrasonic sensor not only measures the level or detects waste in the bin but also sends a message directly to a mobile phone and website through an android application. Consequently, all users can get information easily and accurately regarding the bin status (PENUH or BELUM PENUH). In addition, it is recommended to develop this proposed research to support developing smart cities in the future.

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