GSM-Based Notification System and Location Tagging Using GPS for Smart Recycle Bin

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***Abstract*—This paper describe the design and development of a system to detect the level of recyclable waste in a smart recycle bin and then send notification signals including the locations coordinate to assist the authority to collect and empty the bin. At present, the current system does not provide a notification system mechanism to inform the waste authority that the recycle bin is full and need to be collected. Therefore, an automatic notification system is proposed as to reduce and optimize the collection time. This could also assist the waste collector to re-schedule the collection time and place depending on the regularity of the signal received. This could also reduce the manual collection process which require time and cost of labor. The development of the system involved the use of GSM module to enable the SMS text notification system and some software to manage all the notification received from the bin.**

***Index Terms*—Smart recycle bin, global system for mobile, waste management, global positioning system.**

I. Introduction

Waste management is a big challenge in urban areas for most of the countries throughout the world [1]. An efficient waste management is a prerequisite for maintaining a safe and green environment as there is an increasing volume of waste disposal. Due to the growth of ICT nowadays, information gathering is crucial for a fast national growth rate. Large and dense residential areas and a pressing demand for urban environmental protection have created a challenging framework for waste management. The complexity of the context and procedures is indeed a primary concern of local municipal authorities due to the problems related to the collection, transportation and processing of residential solid waste. Today, garbage collection is done manually which takes a lot of efforts and is time consuming. Currently, many efforts on utilizing technology have been used in waste management and one of the technologies is presented by [2]. Therefore, there is a need to use of ICT technology in notifying the waste authority regarding the status of the bin. In brief, once the recycle bin has reached the maximum level (full), the sensor will detect and send a signal to the waste authority a SMS text containing the status including a coordinate location that can be mapped on the Google Maps. This mechanism will ease the waste authority to optimize the collection activity.

The main idea of this paper is to develop a system that can provide notification to the waste authority that the recyclable waste in the smart recycle bin is full. The status of a full recycle bin will be determined by a proximity sensor. Once detected, the system will trigger the GSM module to send a signal to the waste authority, and Global Positioning System (GPS) module is used to locate the location of a recycle bin on the Google Maps. This mechanism can reduce and optimize the collection time as the recycle bin is not always full depending on the number of users and location. Fig. 1 illustrates a diagram of the proposed notification system. The sensor will send a signal once the recycle bin is detected as full. The system will update the information into the web server and send a coordinate to the GIS system to tag the location of the bin on the map.

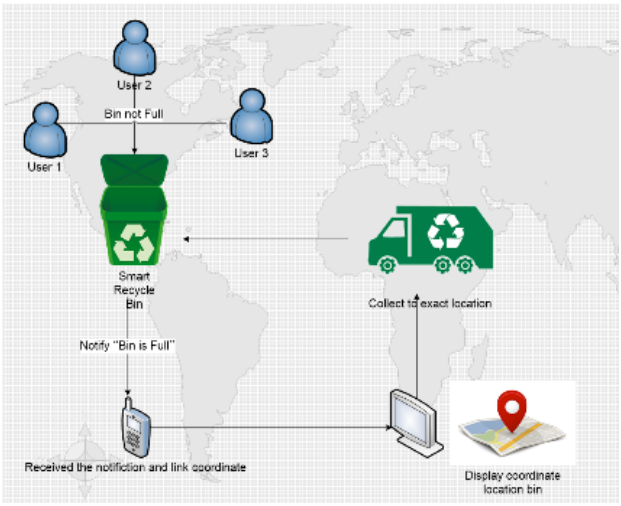

Fig. 1. System architecture.

At present, the current system for the smart recycle bin developed by [2] provides no mechanism to check whether the recycle bin is full and automatically inform the waste authority collector to empty the recycle bin. Therefore, the automatic notification system proposed in this work can reduce and optimize the collection time due to many recycle bin not always full in a short time. This could also assist the waste collector to re-schedule the collection time and place depending on the regularity of the signals received. The use of Google Maps could also assist the waste collector with the location of the bin.

The objectives of this work are to design a mechanism that uses a sensor to indicate that a recycle bin is full, and develop a notification system as an additional feature to be added in smart recycle bin as developed in [2] that sends a signal from the sensor to the web server. This paper also describes a geotag system to detect the location of the bin on the Google

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Maps.

This paper is organized as follows, the related work described in Section II, followed by the development process in Section III. The initial results are discussed in Section IV and finally concluded in Section V.

II. Related Work

This section describes the related work on waste management in general, waste management in Malaysia and the utilization of technology in waste management.

Human activities have always generated waste. Long time ago, waste was not a big issue when human population was relatively small. However, population growth, rapid urbanization and industrialization have contributed tremendously to the generating of municipal solid waste by the society, it has become a concern and this would be a serious matter that impacts human health. The increasing volume of waste and also poor handling of waste can lead to the contamination of water, soil and atmosphere as well as have a major impact on public health. Moreover, as the rapid growth of the technology, generated wastes have become manageable, specialized and complex [3]. According to L. Giusti [3], the characteristics of waste materials evolved in line with the changes in lifestyle, and the number of new chemical substances presented in the various waste streams have increased dramatically. The long-term health effects of exposure to substances present in the waste, or produced at waste disposal facilities are more difficult to measure, especially when their concentrations are very small and when there are other exposure pathways (e.g. food, soil). Nonetheless, lack of evidence can cause public concern. Disaster awaits if there are no actions taken. According to Charlotte Brown *et al*. [4], delays in instant response on clearing debris caused by natural disaster can cause clogged roads. On the other hand, direct physical damage to the environment could increase the vulnerability of environmental pollution and at the same time allows the disease to spread.

In 1998, solid waste in Malaysia was managed by Pihak Berkuasa Tempatan (PBT) of each city. Now solid waste management has been privatized and is controlled by a sector which comprises of Alam Flora Sdn. Bhd. (AFSB), Northern Waste Industries (NWI), Southern Waste Management (SWM) and Eastern Waste Management (EWM). Their services involve the collection process, storage, collection, transportation, and disposal. Furthermore, they implement a recycling program to a minimum and provide cleaning services to roads and rivers [5]. Based on the 2002 report of the Ministry of Housing, the amount of solids in Malaysia was approximately 16,000 tons per day with an average of 0.88 kg per day [6]. In 2005, a total of 7.34 million tons of solid domestic was listed across the country and this number is expected to increase to 30,000 tons per day by 2020. The government has provided many efforts and implementations in order to reduce the cost of solid waste incurred by the local authorities throughout the country [7]. At the initial stage, the Government launched a recycling program in 1993. However, the program did not succeed in achieving its primary goal. In 2000, the government commenced the recycling program again which aimed to achieve an increase of 1 percent in the annual recycling program with an effective implementation of the 3R (reduces, reuse, recycle) concepts and practices in solid waste management [5], [7], [8]. Introducing recycling system is one of the important ways in managing waste. Recycle is a process of reusing the used materials (wastes) into new products to prevent the waste of useful materials.

In 2005, the Malaysian government continued with the campaigns conducted through roadshows and also printed and electronic media. This was further strengthened by the introduction of a set of 3 barrels that were used to raise public awareness of the recycling program that was conducted [8]. The efforts to promote the 3R (reduce, reuse and recycle) program were increased to encourage the reduction of waste going into landfills in order for protecting and conserving natural resources, environment and energy. Throughout 2008, the Solid Waste Management and Public Cleansing Corporation was established to ensure that the management of the solid waste operations were more comprehensive, integrated and cost effective [9].

Fig. 2. One of the ways in solid waste management is through landfill [10].

The generation of solid waste increased to 25,000 tonnes per day of waste generated for 2012 in West Malaysia. Based on Table I, only 5 % of waste was recycled, while 95 % of waste was disposed of through landfills (Fig. 2). Dependence on landfill would increase greenhouse gas emissions up to 50% by 2020 [10]. Hence, this has forced the government to solve the problem of solid waste disposal especially when there is lack of landfills and the increasing rate of population growth.

TABLE I: Malaysia Managing Solid Waste Disposal to 95% in 2012 [8]

State	Landfill Operation	Landfill Non-Operating	Total
Johor	14	***23***	***37***
Kedah	8	***7***	***15***
Kelantan	13	***6***	***19***
Melaka	2	***5***	***7***
Negeri Sembilan	7	***11***	***18***
Pahang	16	***16***	***32***
Perak	17	***12***	***29***
Perlis	1	***1***	***2***
Pulau Pinang	2	***1***	***3***
Sabah	19	***2***	***21***
Sarawak	49	***14***	***63***
Selangor	8	***14***	***22***
Terengganu	8	***12***	***20***
WP Kuala Lumpur	0	***7***	***7***
WP Labuan	1	***0***	***1***
Total	**165**	***131***	***296***

In order to manage all related waste management are through the use of technologies. There are various new technologies that have been invented to complement the needs of daily lives. This includes the recycling program launched by the government. Table II illustrates some examples of human inventions and technologies that aimed to promote recycling in everyday life.

Wireless technology has helped ease the management by allowing multiple network computer users to share resources in their homes or business venues at the same time without adding or disturbing the wiring [14]. Table III shows some examples of available wireless technology and its description.

TABLE II: SOME TECHNOLOGY USED IN MANAGING WASTE

System/ Technology	Description	Year
RF Transmitter and Microcontroller [9]	Developed a system that autonomously carried trash barrels to a residential curb on Trash day	***2009***
ZigBee [10]	The system sent an alarm to the office and information on the location appeared on the LCD for further action towards the full trash bin	***2014***
IoT – Internet of Things [11]	Proposed an Iot based smart garbage system (SGS) to reduce the amount of food waste.	***2014***

TABLE III: LIST OF WIRELESS COMMUNICATION TECHNOLOGY USED

System/ Technology	Description	Year
RFID [2]	When the user threw the waste the smart recycle bin measured the weight of the waste and converted it into points as a reward and stored it in a 3R card	***2012***
BlueSMiRF Arduino [12]	A wireless device in a small system that consisted of hardware and software necessary for receiving data from the sensor for monitoring	***2009***
Xbee and Arduino [13]	Provided a device that used transceivers with two XBeeArduino and Windows platforms to establish wireless communication	***2014***

TABLE IV: WIRELESS APPLICATIONS

System/ Technology	Description	Year
Emdedded Microprocessor and embedded wireless moderm [14]	The system consisted of a single chip embedded microcomputer which was connected to a trash sensor, a Global Positioning System (GPS) sensor, and an embedded wireless modem	***2000***
RFID Emergency Notification System For Fall Accidents At Home [15]	The system consisted of RFID-based home emergency and notification system with GSM and 3G video	***2007***
Parking Status SNS (Social Network Service) Notification System [16]	The collection data from piezoelectric sensor and a PIR sensor to Transmitter sends data SNS via internet which will let users know the status of parking lot and number of available parking spot.	***2013***

One of the objectives of the recycle bin notification system and location tagging is that the output notification needs to send a signal from the sensor to the web server. The automatic notification system objective is to reduce and optimize the collection time. This could also assist the waste collector to re-schedule the collection time and place depending on the regularity of the signals received.

A geotag system is used to detect location of the bin and tag the location to point to the map. Once the sensor is detected, the system will send a signal to authorize, and Geographic Information System (GIS) will indicate the location of the recycle bin on the map. This could reduce and optimize the collection time as the recycle bin is not always full depending on the number of users.

TABLE V: GIS SOFTWARE

System/ Technology	Description	Year
Geographic Information System (GIS software) [17]	The system consisted of a single chip embedded microcomputer which was connected to a trash sensor, a Global Positioning System (GPS) sensor, and an embedded wireless modem	2003
Software application for GPS devices using Google Maps[18]	The application for GPS devices expand the use of GPS devices. User allowed to create his own account and manage his file.	2011

III. DESIGN AND DEVELOPMENT

This section describes the development process of the notification system and tagging process. The overall process can be illustrated in Fig. 3.

Fig. 3. Development phase.

A. Circuit Design

Fig. 4 illustrates the circuit for four (4) input IR sensor connect to AND gate for selection of output send to a BeagleBone Black. The purpose of this circuit is to send data to facilitate selection for each sensor to Beaglebone Black easier. This is because, if any of the four (4) sensors damage, it can be known without modifying the programming of the embedded system.

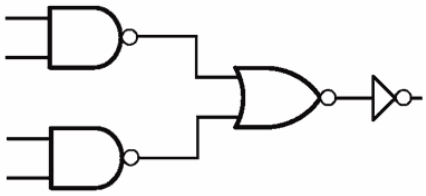

Fig. 4. IR sensors circuit with AND gate.

Motorola M-Wicom Embedded System is used to conFig. and build the software in Linux platform using C++ on PC and

BeagleBone Black processor. The PC is used for software development. The executable file is then downloaded into BeagleBone Black for execution. Fig. 5 shows the flow of the system.

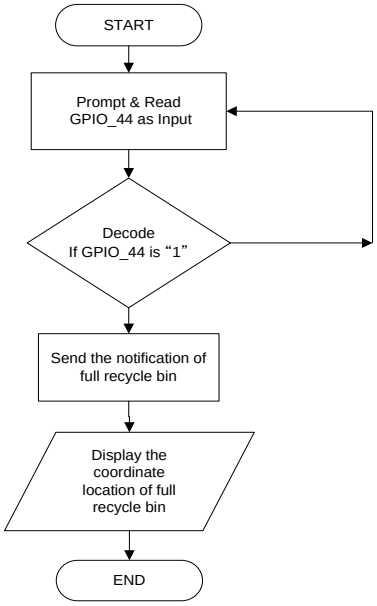

Fig. 5. System flow in beagle bone black.

A proximity sensor is a sensor that can detect the presence of nearby objects without any physical contact. Proximity sensors are used to determine the level of waste in the recycle bin. When the bin reaches its full level, the proximity sensor will send signal for further action. This device is used to send (transmit) and receive (receiver) data from proximity sensor to the BeagleBone Black that needs to decode any future result.

B. Prototype Design

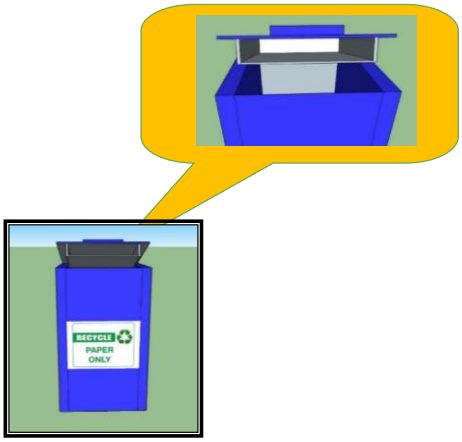

Fig. 6. Prototype design (front view).

Fig. 6 shows a 3D image of the front view of the recycle bin notification system and BeagleBone Black microcontroller position in the recycle bin. The selection for the position of the microcontroller is based on consideration of several aspects such as the safety of the component and microcontroller, signal coverage for GSM and for ease of troubleshoot. Fig. 6 and Fig. 7 show the design and the size of the recycle bin notification system by considering the size of the circuit board for IR sensor and microcontroller.

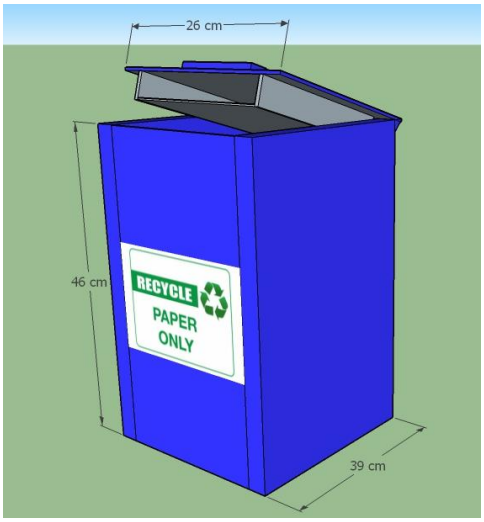

Fig. 7. Perspective view

IV. Results

The prototype has been tested to complete the development of recycle bin notification system and location tagging. Fig. 8 illustrates the integration of circuits on PCB, a program code ranging from get the input until the location coordinate as well as the design hardware of smart recycle bin. Fig. 8 and Fig. 9 show the location of the BeagleBone Black microcontroller installed inside the recycle bin. Fig. 9 also shows the positions of IR sensors at the each corner inside the bin.

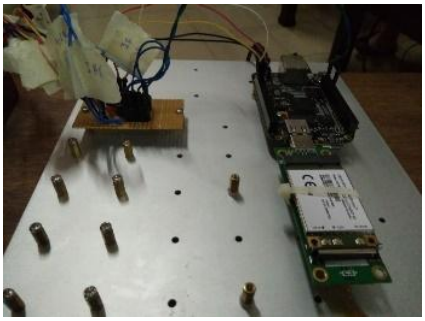

Fig. 8. The circuit on PCB connected with BeagleBone Black.

Fig. 9. Prototype of smart recycle bin notification system and location tagging.

A. The Mechanism Indicate the Recycle Bin Is Full

A program has been successfully developed to connect IR sensor with BeagleBone Black to check the recycle bin is full or not. BeagleBone Black will send the notification via SMS with location to notify the user.

TABLE VI: THE RANGE OBSTACLE DETECTION OF IR SENSOR

Input range(cm)	Level detection
1	High
2	
3	
4	Moderate
5	Low
6	
7	

An IR sensor works by emitting IR radiation signal. Once the radiation signal is bounced back from the surface of an object, the IR receiver on the sensor will receive the signal. Table VI shows the level detection of full trash on the recycle bin in centimeter. Based on the observation, when trash is detected in the area within the range of 1cm to 3cm from the sensor, the sensitivity of the obstacle detection level is high. For moderate level, the sensitivity of the obstacle detection is decreased slightly. Signal detection range from 5cm and above is in very low sensitivity, where there is possibility that IR signal cannot be detected by the IR receiver.

B. The Notification System that Received Signal

Fig. 10 shows an SMS from the proposed notification system received from BeagleBone Black. The SMS result indicates the location of the bin that is full and the time of detection by the sensor. Furthermore, the SMS contains the location of the bin via a link to Google Maps.

Experiments have been carried out to show the performance of the IR sensor to detect the bin is full in three (3) condition during daytime. The recorded time started once the IR sensor detected bin is full. BeagleBone Black processes the data and sends it to the user via SMS. Once the user received the signal, the time difference was calculated. The results of the experiments are shown in Table VII.

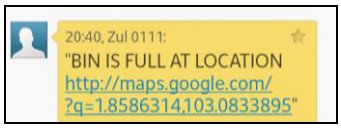

Fig. 10. SMS received from system.

TABLE VII: THE DIFFERENT ESTIMATION TIME SIGNAL RECEIVED

Daytime	Sensor detected	Signal receive	Time difference
Morning	8:00 am	8:08:03 am	8:03 second
Afternoon	14:00 pm	14:13:01 pm	13:01 second
Evening	17:00 pm	17:09:08 pm	9:08 second

Fig. 11. View of location.

C. Geotagging System that Detect Location into Maps

Fig. 11 illustrates Google Maps application to view the location of a recycle bin received through SMS with the number of Latitude and Longitude at 1.858631 and 103.083389. Google Maps can also provide a direction to the recycle bin.

V. CONCLUSION

In conclusion, this project has successfully developed a notification system via SMS to indicate a smart recycle bin is full using a proximity sensor installed on the bin. The system also includes uploading the notification to a web server, as well as tagging the location of the bin using GIS software. For future work, the prototype will be equipped with Wi-Fi network to enable the system to work in buildings such as hyper-market or office building. This could significantly reduce the cost of sending notification via SMS.

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