Development of E-Waste mobile application System Using Integrated Location-Based Approach

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Abstract: Solid waste disposal in the urban areas had rapidly increased due to the translocate of the human population from rural to urban. The reasons for population growth in urban areas were due to migration for learning purposes, employment opportunities, and excellent infrastructure facilities. In urban areas, one of the focus areas of population growth is in the university's area. Universiti Kebangsaan Malaysia (UKM) is one of the top research universities in Malaysia that faces the increasing capacity of students every year. Various initiatives had been taken by the local authority and UKM management to solve the problem due to waste disposal. Among the undertaken efforts were locating more dustbins at the hotspot area and organized the disposal schedule. Despite all the efforts, the problems of waste management were still not solved properly. This study aims to build effective waste management by using the mobile application with a combination of geospatial technologies called e-Waste Mobile application and e-Waste Management System; as a main tool for UKM citizens and students to contribute information due to waste disposal problem in their area. This application consists of three parts, namely users, management, and contractors who carry out the repair work. From the usability testing results shown that the query of dustbin location area transferred smoothly to administration and the contractor can get the information of problem location dustbin from administration quickly based on two ways communication through the application. By using this application, quick action can be taken by the local authority and UKM management to solve issues due to solid waste management.

Keywords: Solid waste system; Mobile Application; Web-GIS; Internet of Things; Geospatial

1. INTRODUCTION

The importance of waste management (WM) was crucial since the capacity of the population increased year by year, especially in urban areas (AlHumid et al. 2019; Mani & Singh 2016; Othman et al. 2013; Chandra et al. 2011; Faccio et al. 2011; Liao & Chiu 2011; Ogra 2003; Younes et.al 2015a; Younes et.al 2015b, Younes et.al 2015c. Failure in WM could cause water pollution as well as groundwater pollution, lead to air pollution (eg. bad odors and chemical gas released)(Liu et al. 2019), diseases spread (eg. dengue & diarrhea) (Patonah 2012), and chemical pollution in soil (eg. batteries). Local councils are still facing the problem of monitoring the waste

collection contractor and breach of the contract by the services provider (Omar et al. 2016; Younes et.al 2015c). Based on the United Nations 2030 Agenda for Sustainable Development, to achieve the objective of sustainability is to improve the effectiveness of WM.

The use of geospatial technologies in WM can no longer be denied. The spatial analysis had been used in WM for decision making, to identify the best and fastest route for garbage trucks pathway to landfill, the suitability of the landfill location (Chandra et al. 2011), smart bin management, and environment. The information must be mapped spatially to obtain information about the location for better analysis and decision making of certain issues (Wadember & Ssewanyana 2014). Geographical Information System (GIS) was introduced as an innovative tool to solve a problem related to any spatial event and solid WM (Kontos et al. 2003; Younes et.al 2015b; Nasir et al., 2016). GIS is capable of identifying the proper location for waste landfill site and analyzing existing maps and information to access the optimal route for collecting waste (City 2016; Thirumalai et al. 2010; Muhammad Aqiff Abdul Wahid et al., 2018; Mohd Aizat Saiful Bahri et al., 2019). Indirectly, GIS help to speed up the acceleration process of the decomposition and stabilization of the biodegradable component in the WM system. GIS can visualize the real solid waste situation through mapping (Vaishampayan 2016). The visual report gained from the geospatial system could aid in a better understanding of the processes and effectiveness of WM. Global Positioning System (GPS) was an important component to obtain the location of the information (Djuknic & Richton 2014). To date, many of the GPS applications had the ability to locate and know the position accurately through Global System for Mobile communications (GSM) which has been implemented in a smartphone (Damani 2015; Pooja 2013). A smart waste complaint system requires the use of GPS comprehensively to identify the exact location of the dustbins (Ogra 2003) and distance from landfill to residencies areas, water resources, and road (garbage trucks routing).

A combination of the GIS and a variety of advanced modeling framework in decision making could improve the efficiency of WM (Chalkias & Lasaridi 2009). Selection of the landfills sites which did not pollute water, air, land, and the environment, the appropriate distance from the housing area, and the creation of a collection schedule that saves cost and able to collect the waste optimally are features of the wise decision-making based on the use of geospatial technology (Mehra 2017; City 2016; Mani & Singh 2016; Vaishampayan 2016; Abdulai et al. 2015; Danbuzu et al. 2014; Suresh & Sivasankar 2014; Faccio et al. 2011; Kanchanabhan et al. 2010; Kyessi & Mwakalinga 2009; Taleb 2007; Kontos et al. 2003).

Several mechanisms and methods were introduced to get the best solution for the WM. One of the common practices of managing WM was by combining mobile applications with a geospatial approach and crowdsourcing which was a familiar approach in this IoT era (Wadembere & Ssewanyana 2014). Mobile application technology changes the phenomena on how the technology move forward as one of the crucial need by the citizen. The mobile application has brought out to the community a new way of better communication (Mavropoulos, 2015). In India, also known as the second-largest telecommunication market in the world, showed that mobile phones were used by people from the age of 12 years old (Vaidya & Vaidya, 2016). However, there are some limitations on mobile phone facilities such as small display, limited input function, and

small memory. For this reason, it is crucial to have a deeper understanding of the user interaction on the mobile application so that the usage of the application for waste management can be done optimally (Oinas-kukkonen, 2014).

The expanding of the internet applications encouraged information sharing among the people without restrictions and tough effort (Ghezzi et al. 2018). Via crowdsourcing more information and new ideas (eg. suggestions and complaints) could be gained from the public (Liu et al. 2019). Crowdsourcing can be regarded as one of the support tools to get information to improve the performance of WM (Ghezzi et al. 2018). A simple method for more suggestions and complaints gathering, an easy platform must be provided for the public to give information. The easier platform is through apps on a mobile phone so that the public can easily access and more crowdsourcing data could be gained (Pandey 2018).

Recently, the complaints system has been made through mobile applications as it facilitates users to make complaints and identify problems more precisely because pictures can be attached to the particular complaint (Nagendra et al. 2019). In addition, the combination of GPS / GSM in the mobile application facilitates the location of the complaints. The potential is to minimize the cost and time, efficient services on the WM, and increase the quality of life by using those approaches (Li et al. 2018; Reffell 2017; Taleb 2007).

There were extensive initiatives that had been taken by the government and agency to handle this problem. Guidelines had been introduced to the agency and government to solve the solid waste problem. One of the standard practices was waste disposal scheduled arrangement and online system. However, solid waste often out of the dustbins, especially uncollected waste in urban areas due to poor WM (garbage trucks did not follow the prescribed schedule), the capacity of dustbins that could not accommodate waste (Mani & Singh 2016), and animals (eg. strays cats, dogs, and monkeys) digging in overflowing waste in search of food. The WM online system has been implemented to a certain agency but it was only recorded contractors details who responsible for handling the waste complaints. Unfortunately, this record did not show the visual of the waste situation, condition, location of the dumping area, and verification of problem-solving by the contractors. Universiti Kebangsaan Malaysia (UKM), faced the same WM problems**.** Various initiatives have been undertaken to address the problem of waste disposal, but there are still inefficiencies in its implementation.

The objectives of the paper are (1) to develop an effective mobile application for the WM complaints system for better WM and (2) to produce a conceptual framework of the WM.

2. METHODOLOGY

The complaint system has been applied in the UKM for a number of years. Based on complaints made through the Complaints and Feedback System, the WM categories were not cleared or easily accessed for complainants. Complaints could only be made through the web and discourage complainants to lodge complaints because of the web interface and method were not user friendly. The current complaint system can only be managed to record textbase complain with no pictures

and geolocation facilities. Thus, it could mislead the troubleshooting and slow down the problem-solving processes, as the actual problems did not deliver efficiently.

2.1 Conceptual Framework

To ensure the WM system more competent, a conceptual framework has been developed (Figure 1). Complaints will be made through mobile applications to facilitate the complainant. An easy method encourages complaints been established and subsequently assist in managing WM (Idowu et al. 2012). When more complaints data received, the contractor can monitor the garbage collecting work and garbage maintenance can be done indirectly. The contractor selection could be done based on complaints. For example, the conversion of the defect dustbin can be done by contacting the particular supplier who can supply the new dustbin. If the garbage was littered out of bin due to animals, the responsible party for the job is the cleaning contractor. Reports sort by category of complaints can be generated and facilitate decision-making and cost management.

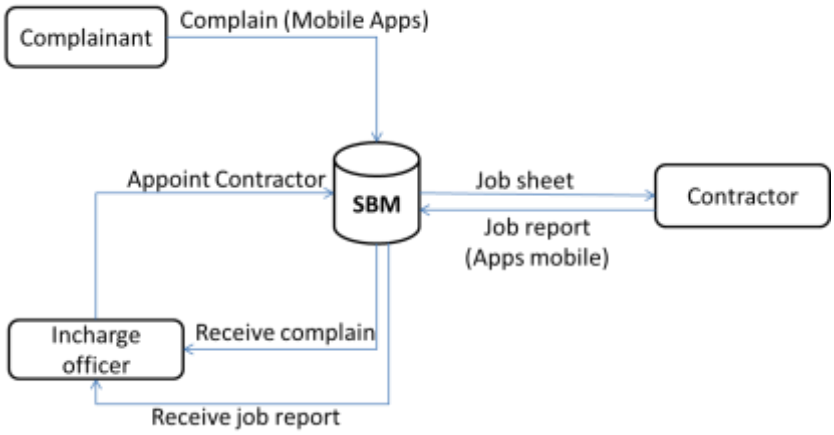


Figure 1: Smart Bin Management Conceptual Diagram

2.2 Data Collection

Before the system was developed, the location of the dustbins and dumping area was identified and collected using GPS devices. The coordinates of each dustbin were recorded. The dustbins category have been identified according to dustbins type: outdoor and main dustbins data collected for the system (Figure 2).

Figure 2: The location of dustbins in UKM.

2.3 Server

The role of a server is to store all the information. The cloud hosting server has been used for better systems integration and maintenance. Data of all dustbins and dumping areas geolocation, complaints, contractors' details, and job sheets will be recorded in the database in the cloud.

2.4 Web and Mobile Application Development

Web (E-Waste Management System) and mobile application (E-Waste Mobile Application) (Figure 3) has been developed for the user. Three main functions have been developed; the user (complainants), contractor, and administrator. The administrator could monitor the contractor's work progress after assigned the job to the contractor. The assigned contractor must respond and update the progress of the job until completed.

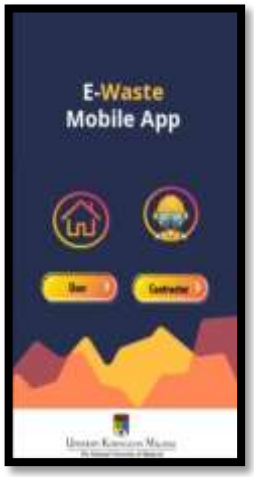


Figure 3: E-Waste Mobile Application Interface

2.5 Development of the Conceptual Framework

2.5.1 User

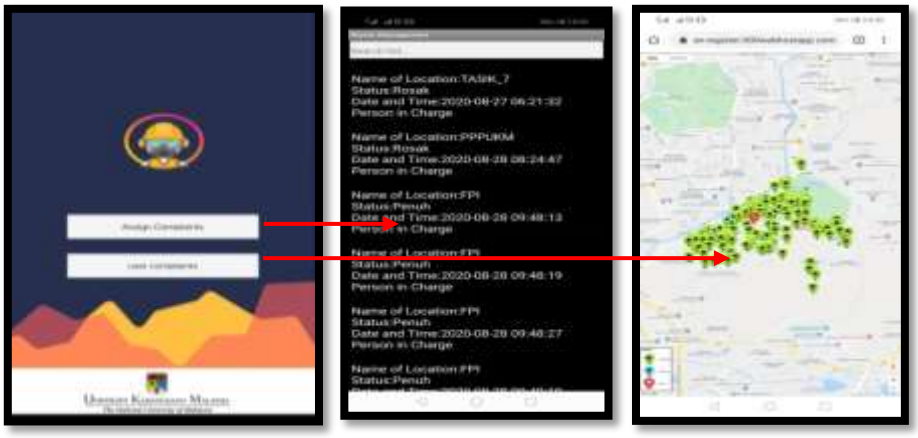
Users could make a complaint based on the location of the problematic dustbins or dumping area by using the E-Waste Mobile Application (Figure 4). Based on the dumping area or dustbins predefined location, users can make complaints based on the location and could include pictures. The user was able to capture the image of the problem and send the complaint to the responsible administration. The geolocation picture add-on function was developed for a better explanation and to show the exact problem. The geospatial interface helps the user to make a complaint effectively. Every new complaint was indicated in a green-colored point symbol (Figure 5).

Figure 4: Mobile application complaint interface

Figure 5: Green colored point symbol indicate user complaints

2.5.2 Contractor

The contractor could easily be assigned using the application (Figure 6a). By referring to the assigned complaints, the contractor can manage to solve the problem based on the complaints categories such as defect bins and full bins (Figure 6b). Each contractor would be assigned according to their job scopes. By using the geospatial interface via the mobile application, the contractor could know the exact location of the complaints and can update any complaint based on the complaint point (Figure 6c). The contractor was required to provide a picture of the job that been done or in progress as a proved of job. The point color will change to red if the job is still in progress or blue for the completed job.



(a) **(b)** **(c)**

Figure 6: (a) e-Waste mobile application interface for a contractor , (b) Assigned complaint list and, (c) Green colored point symbol indicate user complaints

2.5.3 Administration

Figure 7: Administrator interface in the e-Waste management system

The E-waste management system was a web-based application developed for the administration and management organizing complaints from the user (Figure 7). The administrator was able to assign a person in charge and appoint a dedicated contractor to solve the complaint (Figure 8). Job progress done by the contractor or person in charge could be monitored efficiently using the system (Figure 9).

Figure 8: Assign the compliant interface

Through the web, the administrator can manage the dustbins and dumping area location and manage to view the most problematic dustbins and dumping area based on the complaint reports.

Figure 9: Job progress monitoring interface

3. Conclusion

Waste is one of the critical problems in the world. By using technologies, WM could be implemented efficiently. Geospatial technologies could be used to manage all complaints and monitoring jobs effectively. Even though IoT was proven to ease the WM process such as a smart bin, unfortunately, it could not be implemented thoroughly because it is costly. The cheaper and more effective solution to counter the waste problem is through the recommended mobile application complaint system. Besides that, the crowdsourcing method (eg. public complaint) is reliable these days because people still dependent on the mobile phone for their daily routine. Mobile application helps complaint to be made easily. The importance of the crowdsourcing is to assist complaints such as dustbins damaged by natural disasters (eg. storm), garbage strewn all over the yard and sidewalk due to animals getting into the trash bin, and bins loss. Both crowdsourcing and IoT required good internet services and devices. Without the facilities, real-time WM could not be done. These issues should be taken care of before any mobile application can be implemented.

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