# Smart Waste Management System (SWMS) based on Internet of Things (IoT)

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**ABSTRACT** – This research deals with the challenges in innovation of an IoT-enabled solution in monitoring and management of the environment. Waste collection utilizing the Internet of Things (IoT) with the technology of smart wireless sensors will enable us to gather field-level data from waste containers hence providing a waste monitoring solution that brings up a routing for waste collection. This paper proposed the web-based IoT solution by using NodeMCU and ultrasonic sensor to create a wireless prototype device to monitor waste bin level in real-time and route optimization solution by using Dijkstra's algorithm which embedded in the Google Maps APIs.

## 1. INTRODUCTION

Malaysia is a fast-developing country in terms of economically and socially. However in this country, quite frequently can see that some recycle or garbage bins in public areas, especially cities, are usually overflowing because of high waste disposal [1]-[3]. This is because of the high density of residential areas and industries. Traditional way of waste management is old-fashioned which has resulted in an unstable and extravagant method for waste collection. As an example, weekly basis waste collection not effective because some places need frequent collection to avoid overflow and some places do not required daily collection. Based on the pervious pilot project in MP Sepang and MD Kuala Langat, the hardware from outer source and they implement the system in Malaysia. This project is about smarter way of waste management based on IoT which is helps to minimize the waste disposal problem by providing shortest route for the waste collection areas with low cost hardware set up. Besides the microcontrollers, sensors selection is equally important to achieve the objective of the projects [4]. Regarding the route optimization, this research shows the way to bring new idea for the route optimization problems in waste-collection [5]. This project provides experimental set-up of Dijkstra's algorithm used in the simulation [4, 5, 8, 9] by using Google Maps API.

## 2. METHODOLOGY

### 2.1 System Flowchart

In this section, Figure 1 shows the overall system flowchart. The flowchart is about a single device(node) and the sequence of system until display the optimal route with other nodes.

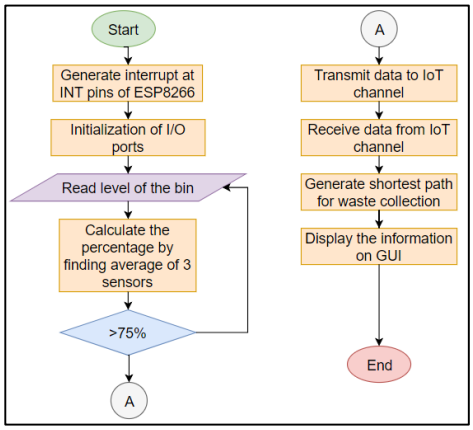


Figure 1 System flowchart

### 2.2 System Architecture

The physical architecture is designed in three main sections from a bin to the control station such as smart bin, gateway and control station as shown in Figure 2. The jobs are to acquire various bin condition data in real time, to transmit the data to the control station via gateway and to represent the data in a user-friendly manner to monitor the bin status. The system is based on web-access architecture of a network for distributed bins. The central server also hosts web-based user interface for bin status monitoring, updated route presentation and user interaction with the system.

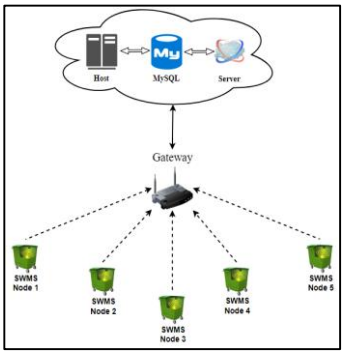


Figure 2 Architecture of the Smart Management System

## 3. RESULT AND DISCUSSION

### 3.1 System Implementation

The hardware consists of NodeMCU ESP8266, HC-SR04 ultrasonic sensors, L7805CV and LM1117T voltage regulators. Ultrasonic sensors detect the distance between the sensors and the waste inside the bin and send its information through the wireless network directly to the server. There are criteria of sensor selection for ultrasound sensor. The sensor can continuously measure the fill level, the sensor works with any type of bin materials and the sensor able to measure without physical contact with materials. Figure 3 show prototype of the device during testing.

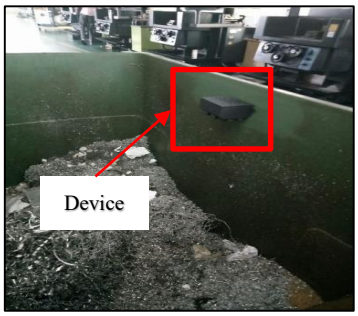


Figure 3 SWMS prototype in 1000L waste bin

### 3.2 Software development

SWMS web application is web browser-based application as shown in figure 10. PHP, HTML, JavaScript and CSS are used to design and develop the webpage. Besides to plot real time graph based on the collected sensor values as shown in Figure 4.

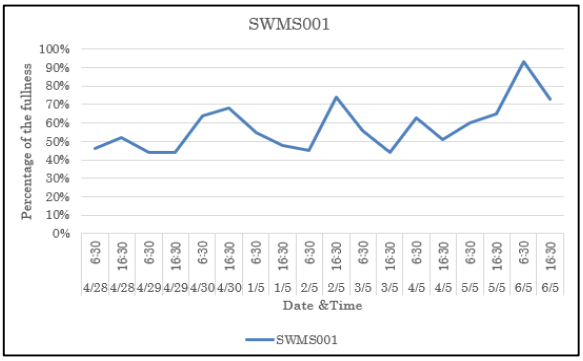


Figure 4 Result of the SWMS implemented in real time

Meanwhile, the received data from the prototype device will be processed and stored in form of table in MySQL database. Then, this process data will be used to show with markers the real-time filling level of the bin. Figure 6 below shows the percentage of the filling level of a prototype device (SWMS001) with three different color of marker. Green shows waste level under 30%, red to indicate more than 75% while yellow to indicate waste level in between 30-75%.

Finally, by using Google Distance and Google Distance Matrix APIs a shortest path calculation had performed route optimization solution. Dijkstra Algorithm is implemented in this project. Figure 5 is also shows the route optimization webpage. The alphabetical order is to indicate the short path for collect waste bin more than 75%.

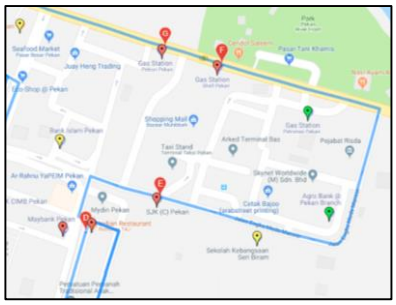

Figure 5 Route optimization result using Google Map

## 4. CONCLUSION

The contributions of this project seem to be small but efficient step towards cleanliness would encourage people to further discuss on the similar topics. The SWMS prototype has successfully developed and tested with the result obtained was encouraging. Thus, it may encourage the local authorities to transform this prototype into product and further implement the system.

## ACKNOWLEDGEMENT

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## REFERENCES

[1] Nagalingeswari K.& Satamraju K. P. (2017) Efficient Garbage Management System for Smart Cities. International Journal of Engineering Trends and Technology 50(5), 260–265.

[2] Nirde, K. Mulay, P. S. & Chaskar U. M. (2017). IoT based solid waste management system for smart city. *2017 Int. Conf. Intell. Comput. Control Syst. 6(2)*, 666–669.

[3] Patil, S. Zavare, S. Parashare, R. Rathod, P. & Babanne, V. (2017). Smart City Waste Management. *Int. J. Eng. Sci.* 3990(1), 3990–3991.

[4] Dhananjaya, M. Priyanka, K. E. Nidhi, R. & Pooja, K. (2017). Smart Garbage Monitoring System Using Node MCU. International Conference on Signal, Image Processing, Communication and Automation 2017, 865-872.

[5] Sahoo, S. Kim, S. Kim, B. I. Kraas, B. & Popov, A. (2005). Routing optimization for Waste Management," *Interfaces (Providence)* 35(1), 24–36, 2005.

[6] Selvaraj K. (2017). Internet of things for smart cities," *Waste Manag.*, 27(4), 1286–1297, 2017.

[7] Nuortio, T. Kytöjoki, J. Niska, H. & Bräysy O. (2006). Improved route planning and scheduling of waste collection and transport. *Expert Syst. Appl* .30(2), 223–232.

[8] Lu, J.-W. Chang, N.-B. Liao, L. & Liao, M.-Y. (2015). Smart and Green Urban Solid Waste Collection Systems: Advances, Challenges, and Perspectives. *IEEE Syst. J.*, 11(4), 1–14.

[9] Singh, G. Singh, B. Rathi, S. & Haris, S. (2016). Solid Waste Management using Shortest Path Algorithm. *Int. J. Eng. Sci. Invent. Res. Dev. I 2(1),* 2–7.