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Real-time monitoring of waste management

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ABSTRACT

The Real-time Monitoring of Waste Management is a new approach to help reduce the overflow trash in the garbage bin. The traditional waste management are still applied in Malaysia and it is not efficient to alert the worker in a wide range of area. As an alternative, this system has been integrated with Internet of Things (IoT) in order to monitor the trash level through a cloud database called Ubidots platform. IoT approaches provide the user a real-time monitoring system. Therefore, the user can monitor the trash level from the office without the need to check the garbage bin one by one. This project utilized an ultrasonic sensor to detect the trash level in the garbage bin. In addition, the Wemos D1 mini was used as a microcontroller that will process the input and output of the system. Then, the processed data will be sent to the Ubidots platform. By utilizing this system, the waste monitoring system was successfully implemented in a real-time monitoring and the warning message could be sent to the workers that in-charge in collecting the trash. This system should benefit the community and authorities because of the cost efficiency and reduced man power in managing the waste.

Keywords:
real-time monitoring waste management, Internet of Things (IoT), ultrasonic sensor

1. Introduction

The Internet of Things (IoT) is a communication technology that had been envisioned near the future. This means that the embedded system that consists of the microcontroller, transceiver for the digital transmitting and IP protocol will communicate with each other which can be described as Machine to Machine (M2M) and Machine to Human through an internet. In IoT, the devices communicate and exchange data or information to provide an advanced intelligent service to the users. On top of that, IoT also has gained considerable academic interest as it communicates together with the communication network technologies such as Wi-Fi and LTE. By implementing the IoT, a

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positive impact on environment is created which includes communication, control and cost saving. The field of IoT is expanding its wings in all domains like medical, industrial, transportation, education and mining, among others [1, 2].

Another potential field in applying the IoT is the waste collection management. The waste management is a major concern in the whole world. Every city, regardless of size, geographical location or economic level, spend huge amount of money every year for waste collection. Based on the statistic that had been carried out in Malaysia, 16,000 tons of the domestic waste per day are generated and the amount per capita vary from 0.45 to 1.44 kg per day count on the economic status of the area concerns. On average, 50% of the municipal operating cost is spent on the waste management system and 70% is spent on the collection of waste [3].

Using the conventional waste management, the number of bins located in the streets and the number of vehicles used to empty them are generally estimated based on the number of citizens, but the resulting estimation is sometimes either too high or too low. Furthermore, the collection of waste is typically fixed weekly without taking into account the actual state of the level of fullness for each bin. The result is the collection of semi-empty bins or the trash accumulation degrading the conditions of hygiene of the city. Therefore, there is a crucial need to develop a real time monitoring system that provide users the capability of knowing the fill level of the waste container so that they can take data-drive actions ahead of time [4, 5] . It has been reported that the transformation into "zero waste cities" can be assisted by strategies based on tools, systems, and technologies, provided that they must be affordable, practicable, and effective within their local regulatory framework [6]. A traditional reductionist approach is unsustainable as it lacks flexibility and long term thinking. Therefore, a greater sophistication in waste management is required in order to move to a more sustainable society [7].

Previous research on IoT based waste management for real-time monitoring with different IoT protocols have been reported such as the cellular network [8], Zigbee, wireless mesh network [9] and wifi [10, 11] with utilization of RFID [12], GPS[10] and ultrasonic sensors [8].

This project introduces the implementation of real time monitoring of waste management using Wifi as the IoT protocols that interacts with the ultrasonic sensor via the Ubidots as the IoT platform. This system can minimize the municipal operating budget and cost of collection waste. Moreover, this project should be able to minimize the garbage disposal problem by providing a real-time monitoring system. The Wemos D1 mini has been utilized as the microcontroller board and ESP-8266EX as its IoT devices. The microcontroller board will be interfaced to the Ultrasonic sensor. Notification to the disposal company will be sent through an alert message once the dustbin is full.

2. System Overview and Methodology

Figure 1 illustrates the overview of the system prototype. The process of the system will repeat continuously until the power supply is shut down. Based on the circuit operation, an Echo pin will send a signal to determine whether the full or not. If there is a signal that returns back, it indicates that the garbage is full. Then, the triggered pin will send a pulse for the sensor to go into the range mode for the object detection. The data will be sent to the microcontroller which is Wemos D1 Mini in order to interpret it to the digital signal. Then, the digital signal will be sent to the Ubidots platform through ESP 8266 to visualize it through a graph. The ESP 8266 is a low-cost Wi-Fi chip with full TCP/IP stack and MCU (microcontroller unit) capability. Meanwhile, Ubidots is a codeless IoT Platform which provides a friendly, customizable Application Enablement Platform that provides users with real-time data and visualization of sensor inputs using a secure cloud [13].

This real-time waste management will visualize the output in two different approaches. First, the system uses a wireless module to monitor the garbage based on the IoT cloud database in a real-time system. The online concept will enable the responsible authorities to monitor the garbage level themselves. By using an Ubidots platform, an alert message will be sent through an email and messages. On the other hand, this system also used LED indicator to alert the user when the garbage is full.

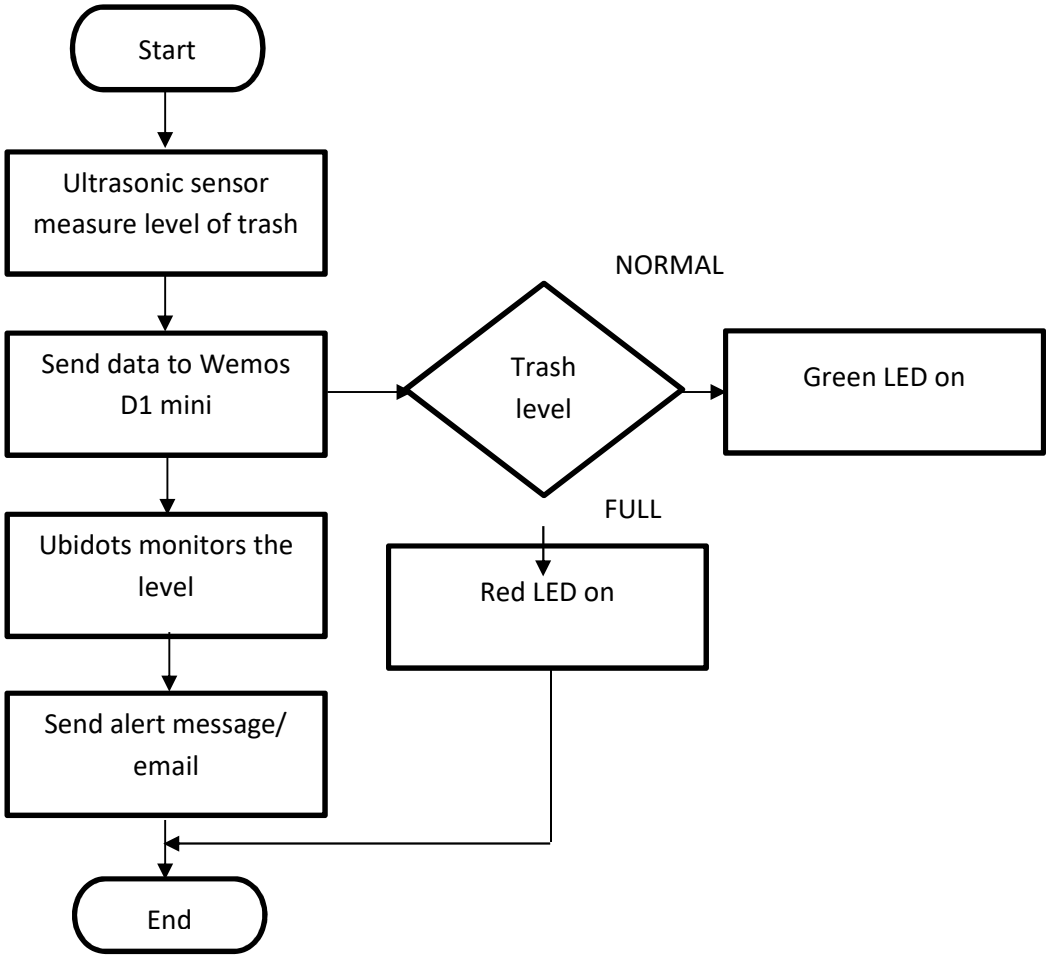

Fig. 1. Block diagram of the system

3. Results and Discussion

Upon completion of the sensor testing, it was integrated with the microcontroller board to develop the complete system. The system will inform the user about the current level of the trash in the garbage bin and send the data of the trash level to the Ubidots platform which acts as an IoT channel for this project. The system will detect the level in the garbage bin with the two condition which is normal level and the secondly is when the trash is full.

3.1 Normal Trash Level

The green LED will light up when the system in the normal state which it detects the trash level about 5 cm and above. The LED is used in order to alert the public user about the condition of the trash level. Figure 2 shows the condition of the garbage bin when it is in the normal state, which means that the trash level is below the maximum level indicated in the figure. In this state, the green LED will be lit on.

Fig. 2. Normal condition of trash level

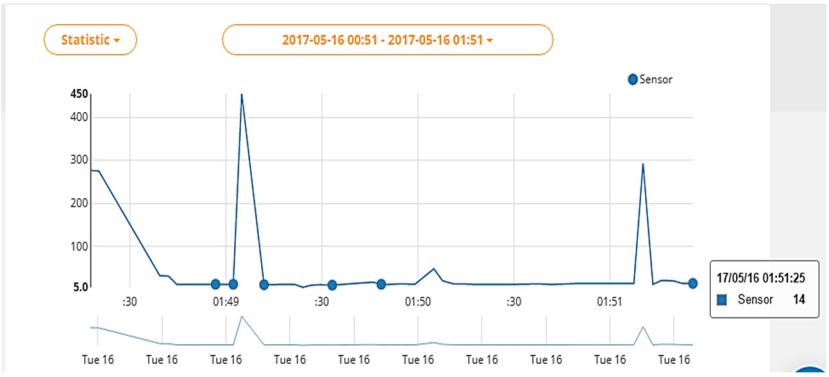

Fig. 3. Graph monitoring on normal trash level

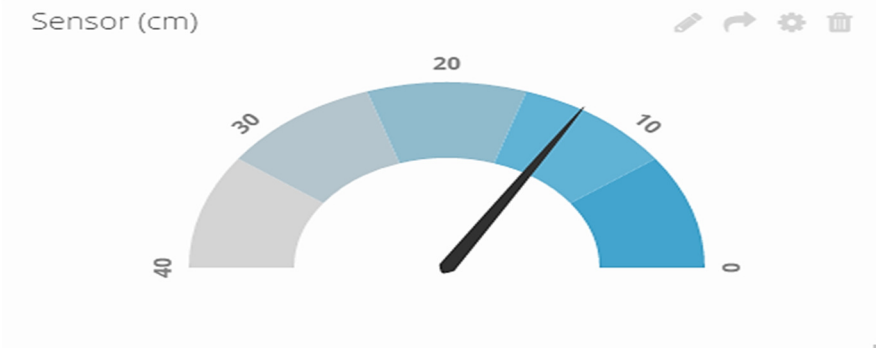

Fig. 4. Indicator level monitoring on normal trash level

In addition, the system will send the data to the Ubidots platform and the trash level can be monitored by the graph as in Figure 3 and the indicator as in Figure 4. The graph will allow the user to monitor it for the whole month or a week because it will save the data of the trash level in the database. Meanwhile, the indicator is used for the user to monitor the condition of the trash level in a real-time monitoring system.

3.2 High Trash Level

The red LED will be lit on as shown in Figure 5 whenever the distance of trash level is getting near to the sensor in a distance of 4 cm to 0 cm. This indicates that the garbage bin is full. As depicted in Figure 6, the monitoring graph will plot the data that is very close to 4 cm on the graph while the indicator will point almost to the 0 when the trash level at 4 cm and below as shown in Figure 7.

Fig. 5. High condition of trash level

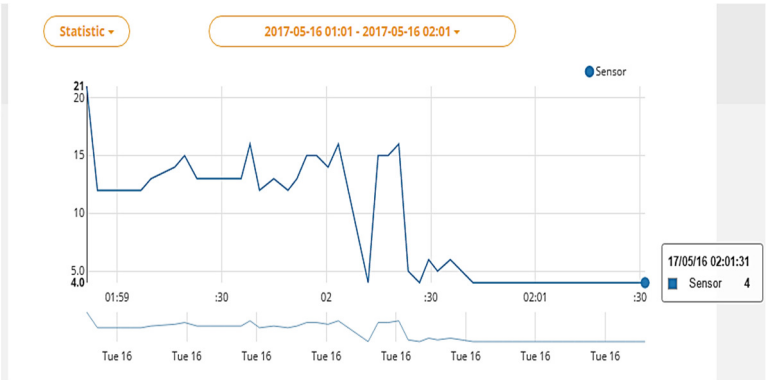

Fig. 6. Graph monitoring on high trash level

3.3 Internet of Things (IOT) Implementation

The IOT implementation was done utilizing the Wemos D1 mini as a microcontroller board and ESP-8266EX as its IOT devices. The microcontroller board will be interfaced to the Ultrasonic sensor.

Once the garbage bin is full, the ultrasonic sensor will detect the trash level and it will transmit the output to ESP 8266. The ESP 8266 will send the data to the Ubidots platform and a notification in the form of an email will be sent to the server as visualized in Figure 8 while the message will be sent to the collector workers, in order for them to collect the garbage that is full as depicted in Figure 9.

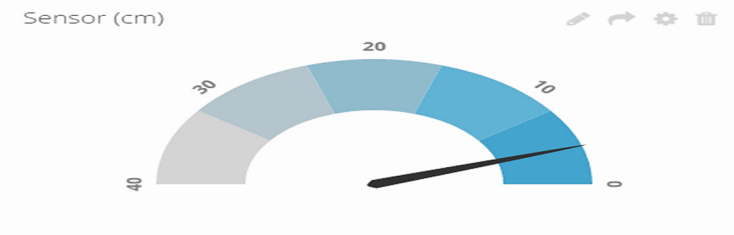

Fig. 7. Indicator level monitoring on normal trash level

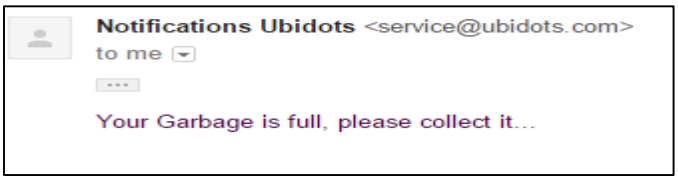

Fig. 8 Notification via e-mail

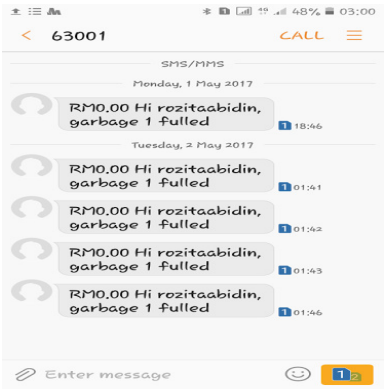

Fig. 9. Notification via message

4. Conclusion

This paper reports the implementation of IoT for waste management. It incorporates wireless module to monitor the garbage based on the IoT cloud database in a real-time system. The low cost online concept enable the cleaning operators to better plan when they should send their cleaners to empty the bins, and they are also able to plan which routes their cleaners need to take. This approach may assist in developing a more sustainable society.

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