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Smart Trash Management in School

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Abstract: Currently, most schools have minimal resources for a cleaner that manages trash. When the number of student increase, this will also increase the total amount of garbage that can accumulate in these schools. These two factors will contribute to a lack of control to manage trash in the school area. We propose a wireless intelligent trash management system to be implemented in schools to solve this problem. This project aims to assist the school in providing a conducive environment for students at school by implementing an efficient trash management system. Our system is equipped with IoT and wireless technology with an intelligent notification feature. The notification feature will help to notify the cleaner when the trash can reach 80% of its total capacity. This system has been developed with green and low-cost IoT devices. Additionally, we can activate the system from anywhere using the provided interface. In schools, there are many trash cans, and usually, depending on the location of the trash can that is located near the canteen, it fills up very quickly when compared to other trash cans. By using the proposed system, the cleaner will be able to identify which trash can has nearly reached its limit and needs to be emptied. Trash collection can be systematically managed only with the small number of cleaners. This integration ties with SDG7, which supports green and clean technology. Indirectly assist SDG4 to ensure quality education by providing a quality, clean school environment. This system will be easily navigated by the cleaners as it uses a simple and well-known social chat platform.

Keywords: Dustbin, Internet-of-Things, SDG7, Sensor technology

1. Introduction

Many countries have aggressively improved their school infrastructure to achieve Global Sustainable Development Goal 4 (SDG 4) to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all [1]. In Malaysia, school garbage management is a critical aspect that needs to be solved [2, 3]. Failure to nurture students to manage the garbage properly causes

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a nasty and dirty school environment, leading to poor school facilities. The lack of workers to manage the garbage in the school area will worsen the condition, where the dirty environment causes health and environmental problems.

To solve the problem, we have proposed a Wireless Intelligent Trash Management In School (WITM) that applies Internet-of-Things (IoT) and wireless technology to assist schools in providing a conducive environment for students at school. Our innovation works as follows, as shown in **Figure 1**.

- **Step 1** - Ultrasonic sensor is connected to Raspberry Pi to detect trash level in the trash bin.
- **Step 2** - When garbage level near overflow level is detected, Raspberry Pi sends a notification to garbage management staff.
- **Step 3** - The garbage collector can prioritize the trash bin; thus, fast action to avoid overflow can be taken.

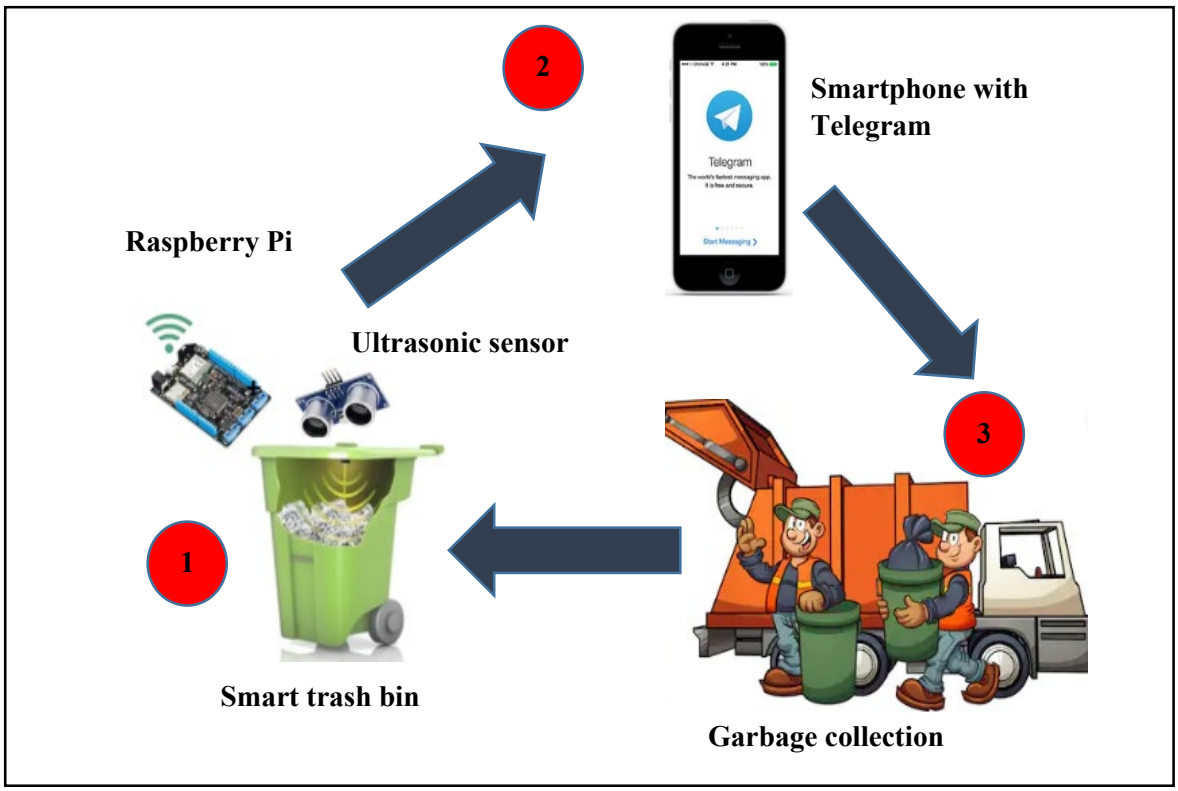


Figure 1: How the Innovation Works

2. Methods and Design

Our innovation is empowered by an Internet-of-Things (IoT) technology, which we have referred to as 3-layer IoT architecture [4], as shown in **Figure 2**. The perception layer refers to the physical layer, consisting of IoT devices to gather information from an environment. In this innovation, an ultrasonic sensor and Raspberry can be classified as IoT devices to collect data on garbage levels. The collected data from the perception layer will be processed and sent to the application layer in the network layer. The Raspberry Pi embedded by Wi-Fi protocol can be considered a device operating in the network layer. The data from the network layer is received and connected to a user in the application layer using the Telegram application.

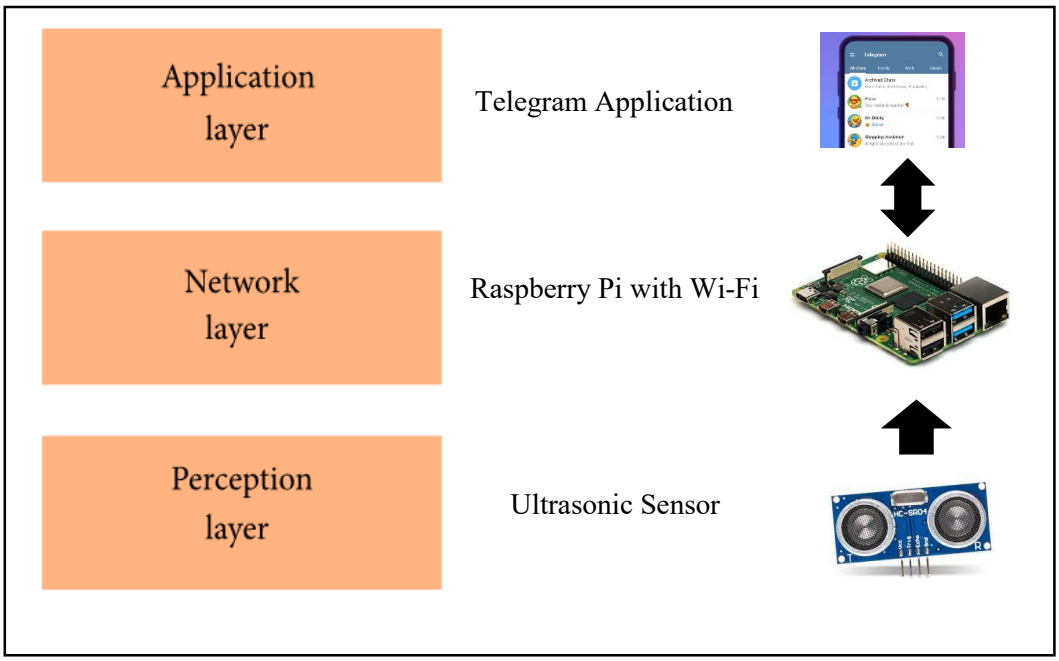


Figure 2: Relation between 3-Layer IoT and Innovation Devices

The use of low-cost and low-power consumption Raspberry Pi [5, 6] for this project supports SDG 7 to ensure access to affordable, reliable, sustainable, and modern energy [7].

Our innovation involves 5 phases: Project Planning, Problem Analysis, System Design, Implementation, and Testing. The following shows detail of each phase:

- Project Planning – In this phase, we have identified the hardware, software, and platform that will be used. Ultrasonic sensors, Raspberry Pi, Telegram, and Node-Red, are used to build this innovation project.
- Problem Analysis – We have interviewed the school cleaner to collect and analyze real-problem that occurs during garbage collection. We have analyzed the problems and proposed possible solutions to solve their problems.
- System Design – We have designed the system to solve the identified problems. We have decided to apply Internet-of-Things (IoT) technology to build an intelligent dustbin. Ultrasonic sensors and Raspberry Pi can be classified as IoT devices in the physical layer, while Telegram can be classified as a user interface in the IoT application layer.
- Implementation – This phase includes the development of the prototype using the Node-RED platform. We have used Node-RED to connect the sensor, Raspberry Pi and Telegram.
- Testing – In this phase, the functionality test consists of garbage level detection using Node-Red and Telegram notification test have been done.

Figure 3 shows how the ultrasonic sensor works to detect garbage levels. The ultrasonic sensor has two pins, which are the trigger pin and the echo pin. Trigger pin sends a wave, and the wave reflects when it hits a solid object (garbage). The reflected wave will then hit the echo pin. The time difference from the transmitted point at the trigger pin to the received point at the echo point can be used to measure distance sound using **Eq. 1**. Please note that, sound speed = 340m/s.

$$\text{Measured Distance} = \text{sound speed} \times \frac{\text{time}}{2} \quad \textbf{Eq. 1}$$

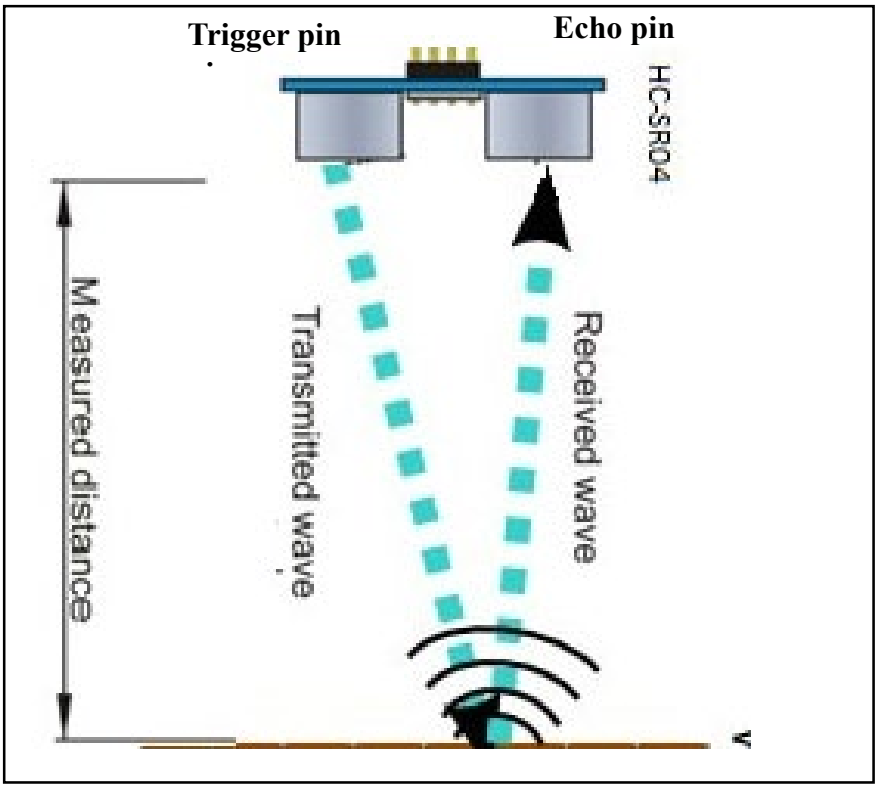
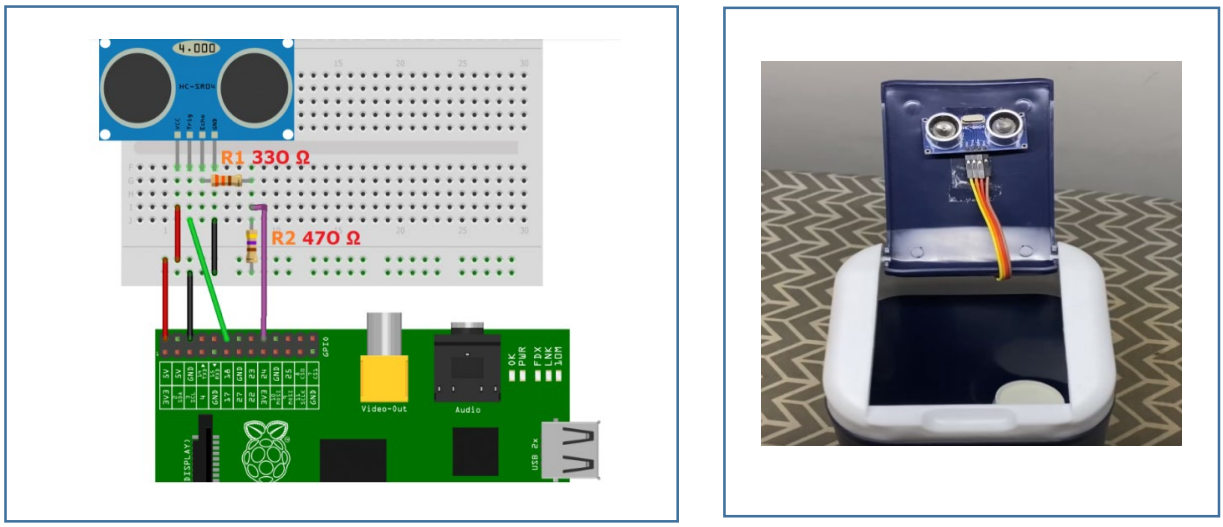


Figure 3: How the ultrasonic sensor works to detect garbage level

Figure 4 (a) shows a schematic diagram for the connection between the ultrasonic sensor with Raspberry GPIO pin and the developed prototype in **Figure 4 (b)**. The data collection from the sensor is done using the Node-RED application, as shown in Figure 5. The received data is processed in the Raspberry Pi to determine the garbage level. The Raspberry Pi will send the alert message to the worker using Telegram, using a Wi-Fi connection.



(a) (b)

Figure 4: (a) Sensor and GPIO connection (b) Developed Prototype of WITM.

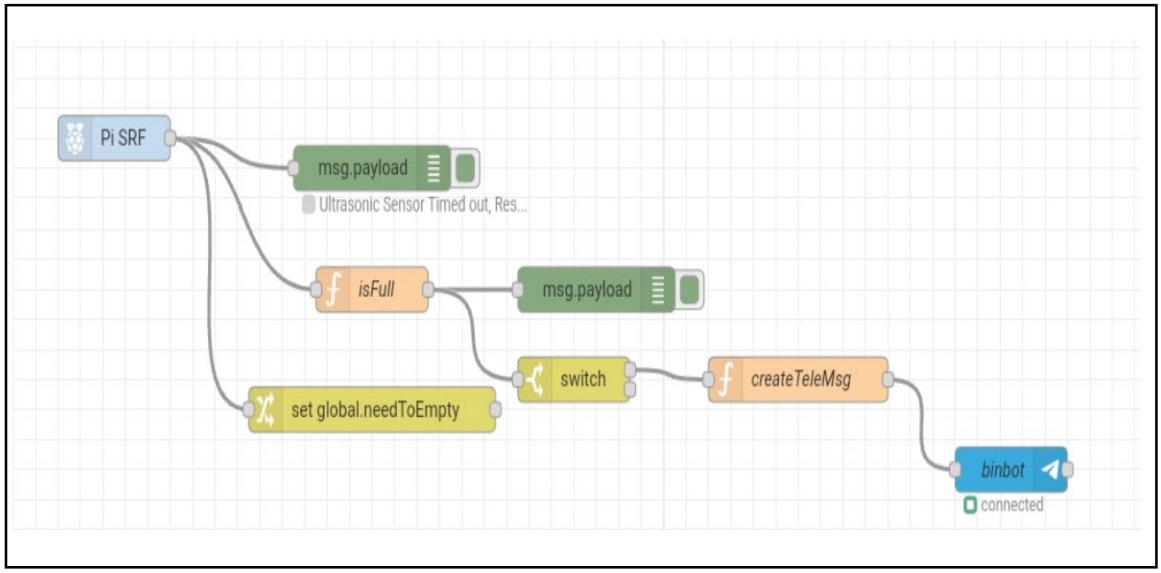


Figure 5: Node-RED to detect garbage level and send an alert message

As previously stated, the garbage level is calculated using an ultrasonic sensor based on equation **Eq.1**. **Figure 6** shows how the threshold value is set. In this project, the threshold value is set to 10mm which the dust bin is considered as full when distance from lid to the garbage is less than10mm.

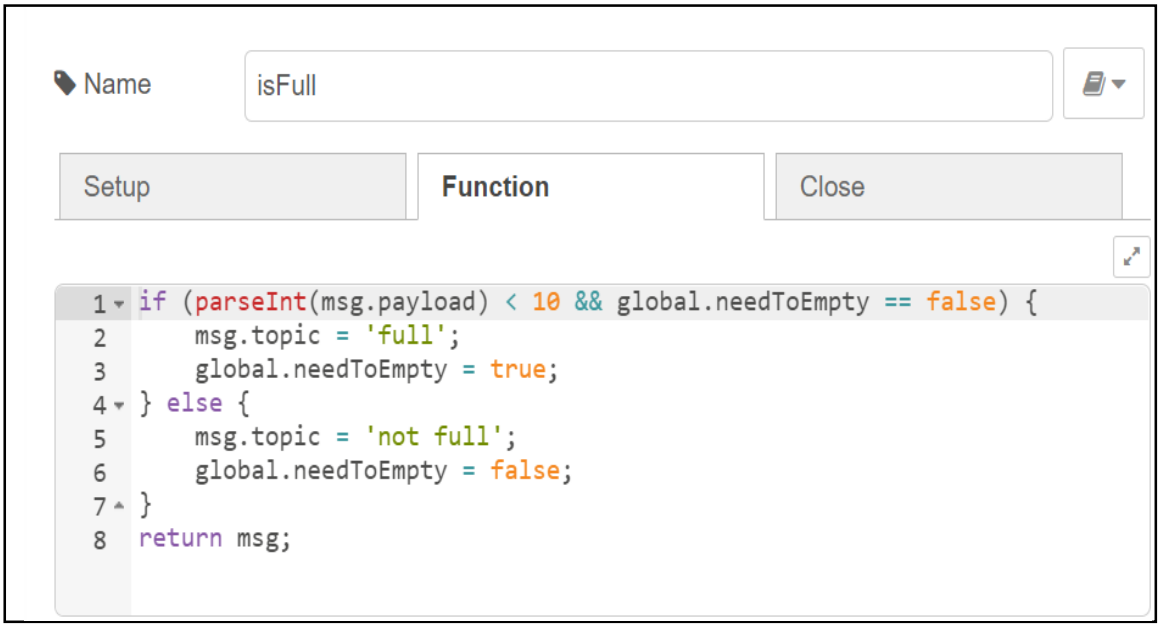


Figure 6: Threshold Value Setup

3. Results and Discussion

The testing of functionality test is done by setting up the garbage level up to the threshold level to trigger a Telegram notification. The testing process is shown in **Figure 7**. In **Figure 7**, the dustbin is filled up with trash and once the level has reached the threshold value, an alert message is sent to a smartphone using Telegram application.

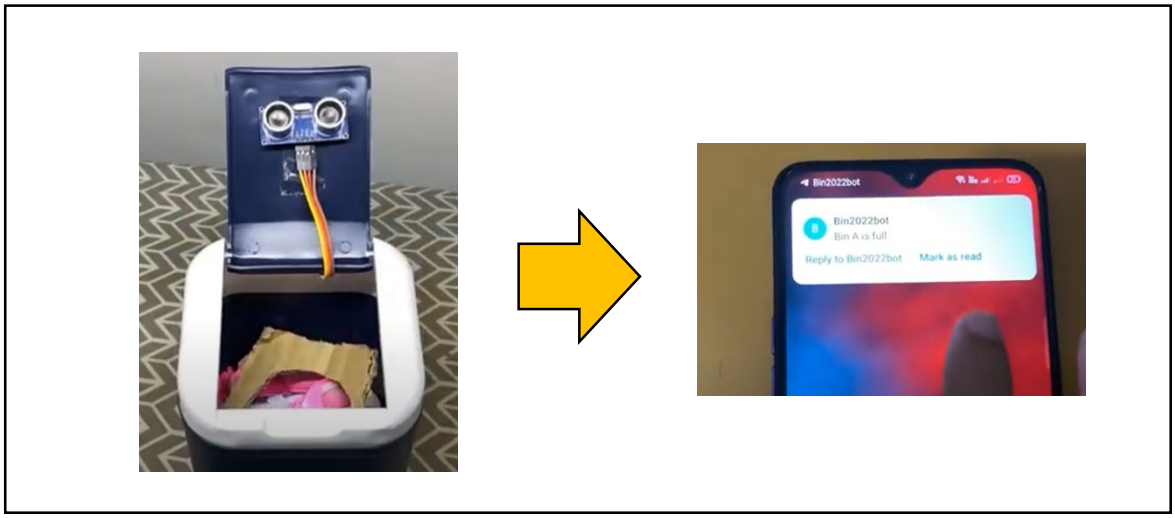


Figure 7: Testing Process

Figure 8 shows a notification message sent by the WITM to the garbage collector using Telegram. From the message, they are able take proper action to systematically manage the garbage collection process. Using the WITM, the worker does not have to check all the trash bins and only needs to collect the garbage from the trash bin notified by Telegram.

Figure 8: Alert Message to the Garbage Collector sent to Telegram.

4. Conclusion

The WITM is developed to help schools manage the school area systematically. The developed WITM is empowered by IoT and Wireless Technology. The ultrasonic sensor detects the garbage level in a trash bin, and a notification will be sent to the garbage collector when it reaches a particular level. The developed system has been tested and verified as discussed in Section 3. The garbage collector does not have to check all the trash bins and directly collect the garbage from the notified bin. The systematic flow will help the school to reduce costs since fewer workers need to be hired to manage trash. Using the developed WITM, the school to increase productivity since more time can be spent on student education matters and provide a healthy, green, and clean environment to school citizens. Students can enjoy school life in a green and clean environment. They are also nurtured by the clean and green environment, indirectly educating them to keep the school clean and healthy. The systematic flow provided by the WITM can help the student to focus on their academic matter.

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