International Journal of Psychological Rehabilitation, Vol.24, Issue 2, 2020
ISSN: 1475-7192

Smart Dumpster: Development of Garbage Container Monitoring System to Support The Effectiveness of Garbage Disposal Transport in City (Case Study : Bandung City)

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Abstract: Development of urban infrastructure in Indonesia is followed by the phenomenon of urbanization, where some people hope to have a more prosperous life after moving from their rural. Therefore, there will be an increase in population and garbage production as an effect of urbanization itself. Unfortunately, the government does not provide appropriate facilities to overcome this problem. This has an impact on the deterioration quality of the environment, especially in transporting garbage in cities. Garbage becomes a serious problem that must be dealt with properly. Based on observations, garbage transportation is carried out regularly every day from homes or temporary shelters to final shelters. Basically, the method of transporting garbage is not effective enough in many aspects. The method, truck fuel, and also the type of truck used are several aspects that affect the effectiveness of garbage transportation. From the problems, this research was conducted to create a Smart Dumpster: Garbage Container Monitoring System by using the NodeMCU ESP82866 micro-controller which is integrated with an ultrasonic sensor to identify the height of the garbage container. The data will be sent to the "Garbage Container Monitoring System" then processed and finally it will be visualized on the map, it can also provide notifications. The system can help efficiently transport garbage, by circling the city where the garbage container is full.

Keyword : Urbanization, Garbage Container Monitoring System, NodeMCU, Ultrasonic Sensor, Smart Dumpster

I. INTRODUCTION

The development of urban infrastructure in Indonesia, followed by the migration of a portion of the rural population to the city in hopes of gaining a better life. This will have an impact on increasing the population of the city which is comparable to the garbage that will be produced. The increase is not accompanied by the provision of comparable facilities and infrastructure. As a result, there will be a decrease in the quality of the environment, especially in the problem of transporting garbage in the city. To address these problems, the role of the government is urgently needed, supported by public awareness.

Garbage management is a series of activities ranging from collecting garbage in containers at source, collected to temporary containers, then transported to the final shelter. From the process, every day many trucks are in charge of transporting garbage from homes, temporary shelters, or final shelters. Garbage management does not only cover technical aspects, but also non-technical aspects such as how to organize, finance and how the community as a producer of garbage must participate in the handling.

Bandung city is a city with an area of 167.31 km2. Bandung city consists of 30 kecamatan and 151 kelurahan. Currently there are 2,490,622 residents and become the most populous city in West Java[1].

PD. Kebersihan of Bandung city is a regionally owned business that is engaged in cleaning services in the city of Bandung. Garbage management activities by PD. Kebersihan of Bandung city, includes sweeping, collecting, collecting activities to the final shelter. The area of garbage management services in Bandung city currently covers settlements, markets, business activities, road cleanliness and public facilities. Where the service itself is divided into 4 regions, namely the operational area of North Bandung, West Bandung, South Bandung, and East Bandung.

Bandung city is one of the cities experiencing problems in the field of garbage management with less optimistic conditions for the garbage transportation system. There is still a lot of garbage that has not been transported and there has been accumulation in several areas in Bandung city. Currently the life span of the TPA Sarimukti has diminished, so there is a plan to move to TPSA Legok Nangka located in kecamatan Nagreg, Kabupaten Bandung.

The garbage collection and transport system is the most expensive servant element provided by a city in the garbage management system. Collection and transportation of municipal garbage requires a cost of around 85% of the cost of the garbage management system.

To streamline the transportation of garbage, a tool that can monitor the garbage container is needed, where dump trucks will prioritize garbage container with full capacity so that garbage transportation will be more efficient and can reduce the accumulation of garbage in the city and reduce total transportation costs.

1. Theoretical Basis

A. Garbage Container

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According to the Regulation of Menteri Pekerjaan Umum Republik Indonesia No. 03/PRT/M/2013, Garbage containers are a place to store trash while in a garbage source. Whereas garbage disposal is an activity to collect trash while before garbage is collected, transferred, transported, processed and carried out final garbage processing in TPA[2].

B. Internet of Things

Internet of Things (IoT) is a concept that aims to expand the benefits of continuously connected internet connectivity. An object is said to be IoT when it is on an electronic object, or any equipment that is connected to a local and global network through an embedded and always active sensor[3]. The workings of IoT are by utilizing a programming argument that each command from an argument produces an interaction and communication between one machine that is automatically connected and the connecting media between the devices is the internet. The Internet of Things has the potential to change the world as the Internet has done, maybe even better.

C. Microcontroller

Microcontroller is a simple form of a computer system that is packaged on a chip, in the microcontroller there are already several systems that support the microcontroller can work covering the microcontroller itself, ROM, RAM, I/O and clock as well as that of a computer. A small microcontroller chip has been implanted with a system that can be used as a processor that has features that can be likened to a computer system. The development of a microcontroller strongly supports the development of an automatic control system of a device or device that controls a device that cannot stand alone (standalone), so that a microcontroller can support it as an automatic controller.

NodeMCU is an open source IoT platform[4]. Consisting of hardware in the form of a System On Chip ESP 8266 from ESP8266 made by Espessif System.

Figure 1 - NodeMCU ESP8266[5].

NodeMCU is analogous to an Arduino board connected to ESP8266. NodeMCU has been packed with ESP8266 into a board that has been integrated with various features like a microcontroller and access capacity to wifi and chips that communicate using USB to Serial. So that in the programming you only need a USB data cable.

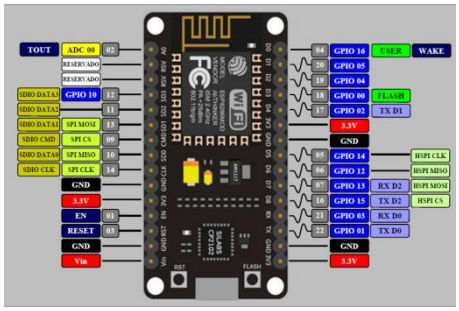

Figure 2 - Datasheet of NodeMCU ESP8266[6].

D. Ultrasonic Sensor

An ultrasonic sensor is a sensor that functions to convert physical quantities (sounds) into electrical quantities and vice versa. The workings of this sensor are based on the principle of reflecting a sound wave so that it can be used to interpret the existence (distance) of an object with a certain frequency. It is referred to as an ultrasonic sensor because this sensor uses ultrasonic waves (ultrasonic sound). In general, this tool will shoot ultrasonic waves towards an area or a target. After the wave touches the target surface, the target will reflect back the wave. The reflection wave from the target will be captured by the sensor, then the sensor calculates the difference between the wave delivery time and the reflected wave time received[7].

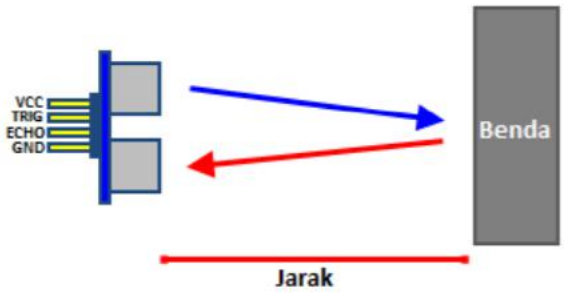

Figure 3 - How to Work Ultrasonic[7].

Because the sound speed is 340 m/s, the formula for finding distance based on ultrasonic is:

$$S = \frac{340 \cdot t}{2}$$

Where S is the distance between the ultrasonic sensor and the object (reflected field), and t is the difference between the time of transmission of the wave by the transmitter and the reflected time received by the receiver.

Figure 4 - HC-SR04 Ultrasonic sensor type[7].

HC-SR04 is an ultrasonic sensor ready to use, one device that functions as an ultrasonic wave sender, receiver and controller. This tool can be used to measure the distance of objects from 2cm-4m with 3mm accuracy.

E. Google Map Service

Google Map Service is a free global virtual map service provided by the google company and can be accessed online. Google Maps also offers a search for a place and route. Google provides an API that can be used by developers to take advantage of the Google Maps feature, hereinafter referred to as Google Maps API[8].

In this study, Google Maps is used as a container to display the position of the trash can containing information from the trash can status.

F. Smart Dumpster

Smart Dumpster is a system that consists of trash bins that have been equipped with hardware to monitor the height level of the trash can, where then the data from the hardware will be sent to be reprocessed by the software. The software on Smart Dumpster is a web based system that has been integrated with the Google Maps Service so that the visual data is located where the garbage container is located.

2. System Design

To be able to meet the needs, a garbage monitoring system will be created. The garbage monitoring system is intended to find out the position of the place where the garbage is ready to be transported, then record data on the areas where there will be a garbage collection site. To analyze the needs of the process, an electronic component is needed to monitor the height of a garbage container, and provide a notification when the garbage is full. The following is a proposed process for the garbage container monitoring system to be built.

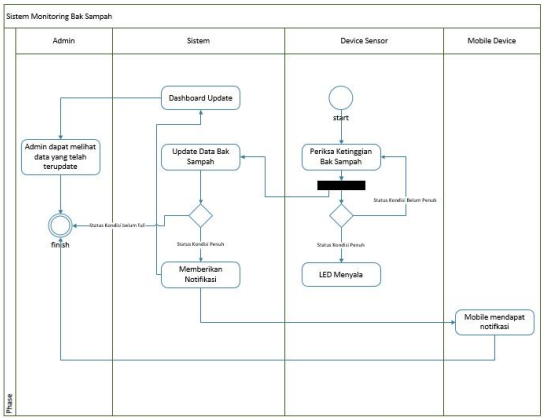

Figure 5 - Activity Diagram of Monitoring System.

The system to be built involves several actors. The interaction between the system and actors can be described as follows:

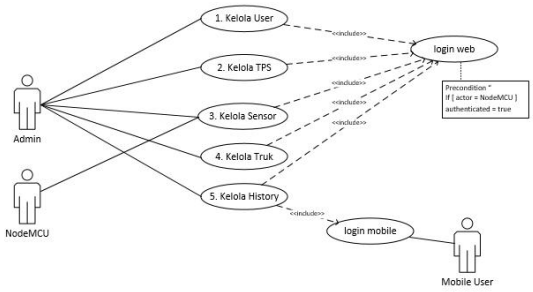

Figure 6 - Usecase Diagram of Monitoring System.

A. Hardware Design

In making a monitoring system for garbage container, several hardware devices are used as follows.

a. Ultrasonic sensor as a height detection device, the sensor to be used is an ultrasonic sensor with type HC-SR04.

b. NodeMCU ESP8266 as a microcontroller device that will integrate sensors.

It is known that in order to work ultrasonic sensors require power 5v while at nodeMCU when viewed from the specifications it can only enter 3.3v as power for ultrasonic sensors, from these problems it will use step-up dc to dc type MT3603 which will help increase the voltage of 3.3 v to 5v so that ultrasonic sensors can work. Below is an image block diagram for the hardware.

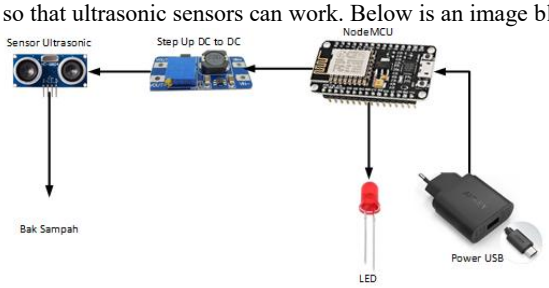

Figure 7 - Block Diagram.

In the block diagram above, a schematic system can be described as below.

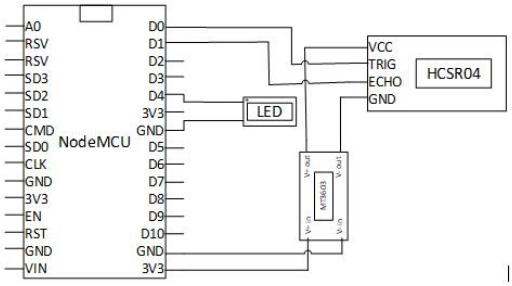

Figure 7 - Schematic Diagram.

In schematic diagrams explain the connection between device pins to other devices.

After the Microcontroller has obtained data from the ultrasonic sensor, then the data will be sent to the trash monitoring system. Data transmission is done by accessing the Web Service Server on the nodeMCU microcontroller.

From the analysis of the device, the general description of the system can be designed as follows:

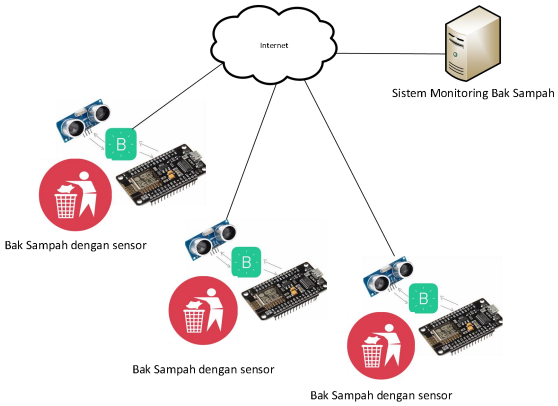

Figure 9 - Overview of Monitoring System.

As for the garbage container design in order to capture the height of the garbage container, the right placement of the sensor HC-SR04 or ultrasonic sensor is needed. Below is a design picture for the garbage container.

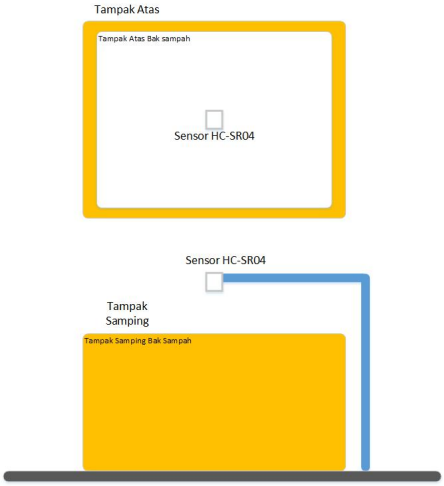

Figure 10 - Design of Sensor Placement in Garbage Container.

B. Software Design

And for the software in this garbage monitoring system, it uses a web-based framework, namely Laravel Framework, where in the Laravel Framework the composers have been supported which will be very helpful in library installers, besides the documentation on Laravel Framework is quite complete. Laravel Framework will be integrated with Pusher as a server notification where when the garbage is fully loaded, nodeMCU will send data to the server, then Pusher will make a notification in the form of notification to the web interface and mobile application.

3. System Implementation

A. Hardware Implementation

Below is the application and installation of NodeMCU in the garbage container.

Figure 11 - NodeMCU Integrated Garbage Container.

B. Software Implementation

The dashboard page displays menus in the form of user, tps, device and truck management. In addition, the Dashboard displays a map where it shows the locations of garbage container with their status. Next, look below.

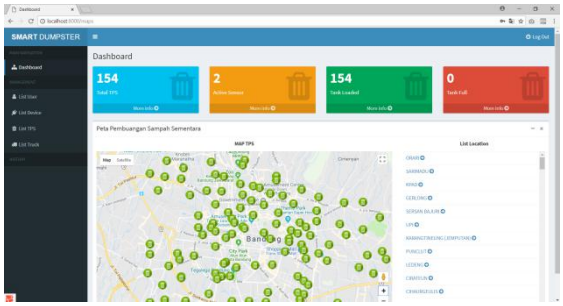

Figure 12 - Application of the Dashboard Interface.

And for the tps management dashboard page, it displays a list of data tps and can add tps, view tps details, update tps, and delete tps. Next, look below.

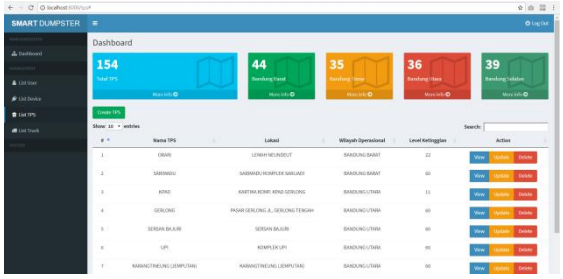

Figure 13 - Application of TPS Management Interface.

4. System Testing

Testing is done by entering something in the garbage container where the microcontroller that has been installed in the garbage container, is given a condition if the ultrasonic sensor provides a distance of less than 10 cm, then the microcontroller will react by turning on the LED light on the gargabe container.

A. Testing in Empty Garbage Container

Below is a picture of an empty garbage container.

Figure 14 – Empty Garbage Container Condition.

When the garbage container is still empty, the indicator on the web monitoring does not bring up a notification because the conditions are still not met to display the notification. As illustrated below.

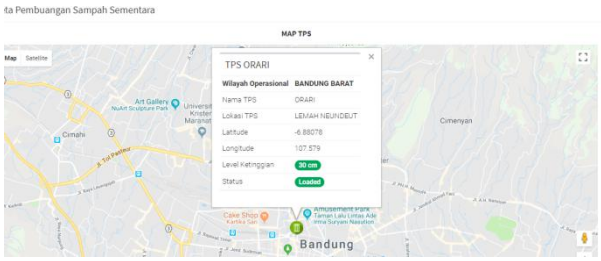

Figure 15 - Conditions on the dashboard.

B. Testing in Half-filled Garbage Container

Below is a picture of the condition of the garbage container filled with half.

Figure 16 - Half-filled Garbage Container Condition.

When the garbage container is still half filled, the indicator on the web monitoring does not bring up a notification because the conditions are still not fulfilled to display the notification where the web monitoring shows that the height is still detected 15 cm. As illustrated below.

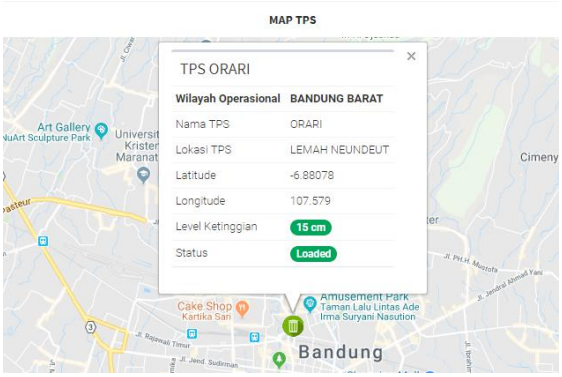

Figure 17 - Conditions on the dashboard.

C. Testing in the Garbage Container is Fully Filled

Below is a picture of the condition of the garbage container that has been fully loaded.

Figure 18 - Fully Loaded Garbage Container Condition.

When the garbage container is fully loaded, the sensor identifies the height already below 10cm, which is 6cm so that on the web monitoring it will display a notification that the garbage container is full of the last height conditions displayed. The following is a notification on the Garbage Container Monitoring System.

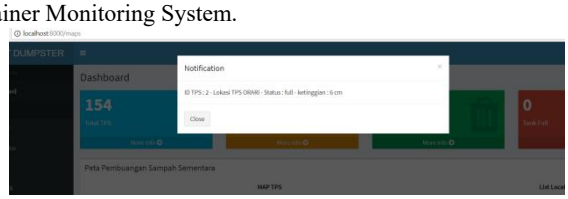

Figure 19 - Conditions on the dashboard.

After the notification appears, the Garbage Container Monitoring System will reload the Web to change the interface contained on the map. Seen in the Garbage Container Monitoring System interface there is an indicator of color change from Green to Red indicating that the garbage container is full and ready to be transported. As illustrated below.

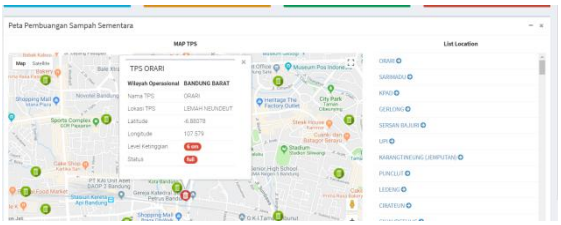

Figure 20 - Notification Dashboard.

II. CONCLUSION

The research of this system can be summarized as follows:

a. By utilizing nodeMCU and ultrasonic sensors, the height level in the garbage container is known.

b. By utilizing data from Bandung OpenData the position of the garbage container is obtained so that the data can be processed.

c. By utilizing Google Maps Service, so that the writer can combine the data obtained in the form of a map so that it can be mapped.

d. By utilizing nodeMCU where it has been integrated with ESP8266, so communication via ethernet or the internet can be done, and the sensor can be monitored by sending the latest data the height of the garbage container .

e. To notify the garbage taker, pusher is used where the pusher will notify the device that is listening to it.

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