Design of IoT–Based Smart Bins Integrated Monitoring System Using Blynk

T Juwariyah¹, L Krisnawati², S Sulasminingsih³

¹,³Department of Industrial Engineering, Universitas Pembangunan Nasional Veteran Jakarta, Jakarta, Indonesia
²Department of Electrical Engineering, Universitas Pembangunan Nasional Veteran Jakarta, Jakarta, Indonesia

juwariyah_tj@upnvj.ac.id; krisnawati71@gmail.com; sulasminingsih59@gmail.com

Abstract. Waste management has always been an important topic of studies. One of the efforts to handle waste in the Era of Industrial Revolution 4.0 was to start by designing a smart bin. The purpose of this study is to design an integrated monitoring system of several IoT-based smart bins. The hardware and software components used in system design were Wemos D1 Mini Pro Microcontroller, HC-SR04 ultrasonic sensor, DHT22 temperature-humidity sensor, Blynk and Arduino IDE. Blynk was used in building an integrated monitoring system for several garbage bins. In this study two samples were monitored through the Blynk application. The height value of the garbage was measured by an ultrasonic sensor while the humidity and temperature values were measured by the DHT22 sensor. In realtime, every measurement results of rubbish height, temperature and humidity were displayed by the Virtual Level of Blynk application on the smartphone. Graphical measurement results could also be displayed on Blynk.

Keywords : Blynk, integrated monitoring system, smart bins

1. Introduction

Waste management has always been an important topic of studies. In many countries, waste management is one of the global problems of special concern. The Tangerang City Environment Agency noted that the volume of waste produced in the past year reached 2,278,715 tons [12]. In fact, waste management is not as simple as imagined. Many stages need to be passed to lead to ideal waste management.

One of the efforts to handle waste in the Era of Industrial Revolution 4.0 was to start by designing a smart bin. More effective and efficient waste management can be realized by the presence of a smart bin that is connected via an internet connection. The management is related to the possibility of obtaining information data regarding the volume of waste, the type of waste that can later be monitored in an integrated manner by the waste superintendent authorities. If managed in a planned manner, waste management will become a new business for society of the Era of the Industrial Revolution 4.0. IoT-based waste management is one of the forerunners to the establishment of a smart city that is a dream in the future. The purpose of this study is to design an integrated monitoring system of several IoT-based smart bins using Blynk. Measurement of height, temperature, and humidity of each garbage bins can be displayed in realtime in one display application on the smartphone.

2. Literature Survey
Several studies related to the design of IoT-based smart bin include research entitled "Garbage monitoring system using IoT" by Anita A, 2017 [1]. In this study a remote monitoring system was designed to monitor the condition of the trash bin. In the trash bin, an ultrasonic sensor is installed to measure the height of the garbage volume in the bin connected to the Arduino microcontroller and ESP8266 as a WiFi connection. The garbage height detection system is connected with the Blynk application on the smartphone. The results of the study show that the Blynk application installed on the smartphone can monitor the condition or volume of garbage in the bin whether the bin is still empty or has been filled with garbage. When the garbage in the bin is full, the notification is sent via smartphone. The limitation of the study is that the monitoring system was built only for one garbage bin unit. The research did not yet reach how to monitor several garbage bins at once. Kusum Lata, et al. conducted a study related to "IoT Based Smart Waste Management System Using WSN and Embedded Linux Board" [8]. One of the results of the study is that data about the condition of empty or full garbage can be sent to the authorities in waste management. Research related to IoT design by utilizing Arduino Mega2560, ESP8266, various sensors and Blynk applications on smartphones has been conducted by Juwariyah T., et al [6]. The results of the IoT design research was monitoring the early detection of potential fire can be displayed through the Blynk application on a smartphone.

In this study the HC-SR04 ultrasonic sensor is used as a distance measuring sensor. How this sensor works in more detail is explained as shown in Figure 1. The basic concept of the HC-SR04 Ultrasonic proximity sensor is a sensor consisting of two ultrasonic transducers. One of the transducers acts as a transmitter that converts electrical signals into 40 KHz ultrasonic sound pulses. Other transducers act as receivers of signals or pulses sent by the transducer transmitter. When receiving a signal, it produces an output pulse whose width can be used to determine the distance traveled by the pulse. How this sensor works is explained as follows. Initially a pulse of 10 μS is raised to the trigger pin. Next the sensor transmits eight pulses at 40 KHz. The eight-pulse pattern creates a unique "ultrasonic signature," allowing the receiver to distinguish transmitted patterns from environmental ultrasonic noise pulses. As explained in Figure 1 the transmitter emits eight ultrasonic pulses, the eight ultrasonic pulses interact with air particles away from the transmitter at 340 m/s. Since then the Echo pin voltage has been HIGH. If the eight pulses at 40KHz are not reflected back then the Echo signal will run out after 38 mS (38 milliseconds) and the Echo pin voltage returns low. So the 38 mS pulse shows there are no obstacles in the sensor range. If the pulse is reflected back, the Echo pin will drop immediately after the signal is received. This produces pulses whose width varies between 150 μS to 25 mS, depending on the time taken to receive the signal [3].

![Figure 1](image-url)

**Figure 1.** The process of transmitting and reflecting signals by the HC-SR04 ultrasonic sensor [3]

The pulse width in this case the time span received by the receiver is then used to calculate the distance between the reflecting object and the ultrasonic sensor. The distance is determined based on formula (1).

\[ s = \frac{vt}{2} \]
where \( s = \) distance; \( v = \) speed of sound in the air, 340 m/s or 0.034 cm/µs; \( t = \) the duration of the response time the signal is emitted - received by the ECHO PIN.

![Internal Structure of Humidity sensor](image1)

**Figure 2.** Internal Structure of Humidity sensor [3]

In the air humidity sensing component there are two electrodes and a moisture retaining substrate as shown in Figure 2. These substrates are usually made of conductive plastic salts or polymers. The ions are released by the substrate when water vapor is absorbed by it, which results in increased conductivity between the electrodes. The ions are released by the substrate when water vapor is absorbed by it, which results in increased conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. When relative humidity is higher it results in reduced resistance between the electrodes, whereas when relative humidity is lower it results in increased resistance between the electrodes. In addition, this device has an NTC or thermistor temperature sensor for measuring temperature.

![NTC Thermistor with Characteristic Curve](image2)

**Figure 3.** NTC Thermistor with Characteristic Curve [3]

As shown in Figure 3, a thermistor is a type of thermal resistor, whose resistance changes based on changes in temperature. Basically, all resistors are thermistors because the resistance of the resistor material depends on the temperature. In other words the resistor works when there is a slight change in temperature on it, but the change is usually very small and difficult to measure. The thermistor material is made so that the material resistance changes drastically with temperature changes. Changes in the value of the thermistor resistance can reach 100 ohms or more for changes per degree Celsius. The term "NTC" means "Negative Temperature Coefficient", which means the resistance decreases with increasing temperature [3].

3. **Materials**
   
The software and hardware components used in the system design are described below.
3.1. Wemos D1 Mini Pro Microcontroller

The microcontroller is based on ESP8266 which is a wireless (Wifi) 802.11 microcontroller module that is compatible with Arduino IDE. It has the same capabilities as NodeMCU but is smaller and has more memory than NodeMCU. Another uniqueness is the availability of 3.3 Vcc and 5 Vcc pins allowing various sensors to be directly connected [10].

3.2. Ultrasonic Sensor and DHT22 Sensor

The ultrasonic sensor is used to measure the full condition of a garbage bin. The HC-SR04 ultrasonic sensor uses sonar to determine the distance to an object [9]. The operation of this sensor is not affected by sunlight or dark colored material, but is influenced by acoustic material. DHT22 sensors that are classified as digital sensors are used to measure the temperature and humidity of the surrounding air [4].

3.3. Blynk

Blynk is one of the server service platforms used to support the Internet of Things project. This platform is used in Android and iOS mobile user environments [2]. The Blynk application can be downloaded on the Google play store. It supports a variety of hardware used for the Internet of Things project. Blynk is a digital dashboard with graphical interface facilities for making projects. It was created with the aim of remote control and hardware monitoring using internet or intranet data communication (LAN network). Blynk's ability to store data and display data visually using numbers, colors or graphics makes it easier for beginners to use in making projects of the Internet of Things. There are three main components of Blynk: Blynk Apps, Blynk Cloud Server and Blynk Library [10].

3.4. Arduino IDE

The Arduino integrated development environment (IDE) is an Arduino board programming language application that can operate on Windows, macOS, or Linux [4]. Arduino IDE is written in functions from C to C++. Programs written using Arduino IDE are called sketches [5].

4. Proposed Architecture

The design of smart bins integrated monitoring system is as shown in Figure 4.

![Figure 4. The smart bins integrated monitoring system architecture](image-url)
The system consists of two garbage bins placed in two rooms separated by walls. Based on the Figure 4 the microcontroller and sensors attached to the garbage bin. Meanwhile, in the building there is a modem / router that functions as a connecting device and then passes system data to the Blynk Cloud Server. The results data are then displayed via the Blynk application on a smartphone.

5. Algorithm
The algorithm of smart bins integrated monitoring system is as shown in Figure 5. The algorithm is coded in Arduino IDE sketch.

![Algorithm Diagram]

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6. Results and Discussion
In this paper the Fritzing software used to create a system wiring scheme as shown in Figure 6. Based on Figure 6 it appears that the HC-SR04 ultrasonic sensor consists of four pins. The trigger pin which is responsible for triggering sensors to generate ultrasonic signals is connected to the D2 pin of the Wemos D1 Mini Pro board, while the ECHO pin is connected to pin D1. The other two pins are the Vcc and GND pins for power supply. On the DHT22 sensor there are three pins that are connected to the Wemos D1 Mini Pro board. Two pins supply the Vcc and GND, while only one digital data pin is connected to the D4 pin of the microcontroller board.
The results of the system design in the form of a smart bins prototype are shown in Figure 7. As shown in Figure 7, the HC-SR04 ultrasonic sensor and the DHT22 temperature and humidity sensor are attached to the inside of the garbage bin while the Wemos D1 Mini Pro board as a microcontroller is attached to the outside of the garbage bin. The each garbage bins used as a sample has a height of 60 cm. The result of the monitoring system when each empty garbage bin without trash is shown in Figure 7. The system response appears through the Blynk application in the form of a virtual level. The results of the system response to the bin I are shown by the virtual level image at the top and the results of the bin II are shown below. The relative temperature and humidity values are displayed to the right of the virtual level. Meanwhile, Figure 8 shows the results of a trial when one of the bins was filled and the other bins was empty. In the garbage bin that was filled with garbage the temperature and relative humidity value was measured at 33.3°C / 42.5% while in the empty bin it was measured at 30.5°C / 49.8%. This means that in a bin filled with garbage the room temperature is higher than in a room without garbage. Likewise, the value of relative humidity in garbage bins is filled with higher value bins.
Figure 8. The result of the system when one of the bins is filled and the other bins is empty.

Figure 9 shows the results of a monitoring system when each garbage bin is filled with a different height. Based on Figure 9, it appears that the Blynk application is able to display the condition of the height of waste in each trash bin. In addition, a graph of waste height as a function of time can be displayed. These graphs can be displayed in real time through the Blynk application.

Figure 9. The result of the system when each garbage bin is filled with a different height.

7. Conclusion
The prototype monitoring system for several garbage bins can be designed based on the IoT concept. The prototype design consisted of Wemos D1 Mini Pro Microcontroller, ultrasonic sensor, DHT22 temperature-humidity sensor, Blynk and Arduino IDE. The design test results show that the garbage bin monitoring system is capable of displaying the height of garbage, the temperature and humidity of several garbage bins in real time through the Blynk application on a smartphone. The results of monitoring the height of waste data at any time can also be displayed in the form of a graph of the relationship of height to time.

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