Volume 6, Issue 9, pp. 22-26, 2022.
International Journal of Scientific Engineering and Science
ISSN (Online): 2456-7361

Monitoring Carbon Monoxide (CO) Gas Levels using IoT

Ummiati Rahmah[1], Mahmud Mustapa[1], Putri. I S, Samad[1], Ainun. M[1]
[1]Electronic Engineering Education, Makassar State University, Makassar, Indonesia
Corresponding author: Ummiati Rahmah
Email: ummiati.rahmah@unm.ac.id, mahmud.mustapa@unm.ac.id, putri.ida@unm.ac.id

Abstract— *Carbon Monoxide is one of the most severe air pollutants. The reduction in ambient air quality caused by CO pollution will have an effect on health. CO gas is toxic in blood because it binds easily to hemoglobin. It can even be fatal because it deprives the heart, central nervous system, and respiratory tract of oxygen. The goal of this study is to determine the development of stage an IoT-based tool for monitoring and detecting Carbon Monoxide (CO) gas. The research method is a research and development method that refers to a spiral development model that generates four syntaxes, namely requirements analysis, design, construction, and testing. The MQ-7 sensor was chosen to detect the presence of CO gas. The controllers Arduino Nano and ESP32 receive gas data from the sensor, send it to the smartphone application, and display the data on the LCD. The sensor can be used as a CO gas detector, according to a comparison of data from the MQ-7 sensor and COmeter test results, with an average data difference of 4.99 ppm for Carbon Monoxide testing in vehicle exhaust gas and 3.76 ppm for Carbon Monoxide testing in cigarette smoke. The study yielded a Carbon Monoxide gas detector and a monitoring app for an IoT-enabled smartphone. Testing of tools to test functionality reveals that the function's feasibility is 100%. As a result, the developed monitoring tool is suitable for use as a Carbon Monoxide gas detection tool*.

Keywords— *Carbon Monoxide, Internet of Things, monitoring system, MQ-7 sensor, spiral model.*

I. INTRODUCTION

Air is a gas group that is essential for the respiration of all living things. Air quality has deteriorated in the current era of rapid development. According to Air Quality Index or AQI (2021), Indonesia is ranked 17th out of 118 countries globally in air pollution, with an average PM2.5 concentration of 40.7 micrograms/m^3 in 2021, rising from 34.3 micrograms/m^3 in 2020[1].

The reduction in ambient air quality caused by CO pollution will have an effect on health. CO gas is toxic in blood because it binds easily to hemoglobin. It can even be fatal because it deprives the heart, central nervous system, and respiratory tract of oxygen[2]. In line with this, WHO also raises negative impacts for people living in areas where air pollution exceeds the threshold, which will shorten their life by about 1-2 years[3].

In Indonesia, the number of motorized vehicles grows year after year, and the exhaust gases produced by these vehicles contribute 70 to 80 percent of air pollution, while industry contributes only 20-30 percent. According to estimates, the amount of CO in Indonesia is close to 60 million tons per year. One-eighth of this amount comes from gasoline-powered vehicles, while one-third comes from stationary sources. Despite the fact that Carbon Monoxide is a flammable gas that is extremely toxic to humans[4].

Carbon Monoxide is colorless and an odorless gas that can be harmful if inhaled in large quantities[5]. Inhaling high concentrations of Carbon Monoxide reduces the amount of oxygen that needs to be delivered to the organ. And can be dangerous to cause death. The rate of speed in which the carboxyhemoglobin (COHb) forms is dependent on how much of the toxic gas is breathed by a person, which is measured in per particle million, PPM. The higher the concentration of PPM consumed, the higher the human mortality rate due to the lack of oxygen in the organs. Without the presence of a gas detector, it is not possible to detect hazardous gas. Since it has no color or taste, its deadly presence could not be detected by humans without monitoring and detection systems[6].

Internet of Things (IoT) is the most innovative resource in manufacturing, commercial and residential structures every day, playing an important role[7–9]. The proposed system will first of all be more functional than the existing detection systems on the market. In addition, the IoT platform is the current industrial revolution technology trend, there are not many Carbon Monoxide detection systems that take full advantage of the IoT platform. Current detection systems available on the market have limited functionality. Some of the functions include basic detection of an increase in harmful gases and simple warnings such as the colored changes of the LEDs to indicate rising gas concentrations. In the proposed system, other functions are added, such as a buzzer that sounds immediately when the gas concentration reaches a dangerous level, as well as a system that sends a warning message to the user. Then the IoT platform is not used even though it is the technology trend of the current generation. Current systems most of don't implement IoT platforms like mobile app monitoring etc.

Research related to the detection and monitoring of air pollution like as CO gas has been carried out by Serban *et al.* [10]. The research proposed making a system that monitors the concentration of Carbon Monoxide and temperature within a close space, but not yet IoT for Carbon Monoxide detection. Hadj Irid *et al.* [11] proposed an Atmospheric Air Surveillance System (AASS) that allows the concentration of Carbon Monoxide and carbon dioxide to be monitored using the web. Besides that, the author used a microcontroller, multiple sensors and a Global Positioning System (GPS) on the device. Rivai *et*

International Journal of Scientific Engineering and Science
Volume 6, Issue 9, pp. 22-26, 2022. ISSN (Online): 2456-7361

al. [12] proposed an air pollution monitoring system based on IoT, notably Carbon Monoxide and Sulfur Dioxide caused by vehicles in Indonesia, with CO-B4 and SO2 -B.F. electrochemical sensors, Blynk application on the smartphone, and ESP8266 NodeMCU board. Singh *et al.* [13] proposed a system of monitoring and detecting the carbon monoxide gas concentration remotely locations where data is transferred using the means of IoT.

Therefore, the purpose of this research is hoping to develop a hardware device capable of detecting CO gas levels in real-time and connecting it to an air quality monitoring system. This research builds on previous research by creating a Carbon Monoxide (CO) gas detector with the MQ-7 sensor, Arduino Nano, and ESP32. This tool can transmit real-time data on the Carbon Monoxide (CO) gas levels detected by the sensor. The sensor's data is sent to an Arduino Nano, then to an ESP32, and finally to firebase, where it can be analyzed to learn more about Carbon Monoxide gas level.

II. Research Methods and System Implementation

A. Spiral Model

In accordance with the purpose of this study, which is to produce and test a specific product, the research method used is Research and Development (R&D)[14]. The Spiral Model used in the development model for this research is a hybrid of the Waterfall Model and the Model Prototype. This model employs a highly adaptable and systematic risk management strategy[15].

According to the findings of the analysis, the adjusted stages included four stages: needs analysis, design, construction (coding and testing), and testing. Design is used in all activities to ensure that they run smoothly, such as creating block diagrams and designing tools and applications.

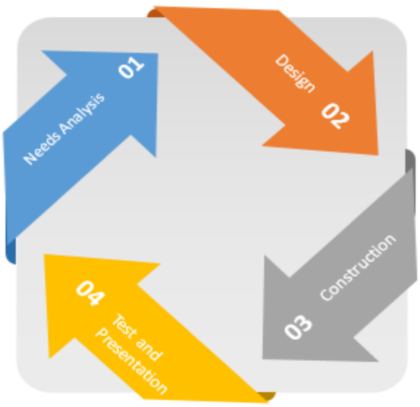


Fig. 1. Conceptual Framework for Research

B. Overall Diagram of Blocks

According to the block diagram below, the workings of this carbon monoxide gas monitoring tool are as follows: the Arduino Nano reads the data sent from the MQ-7 sensor and sends it to the ESP32, which then sends the data to the firebase and displays it on the LCD. When the data from the sensor changes, the data on the server is updated. Figure 2 depicts the data on the server in real time.

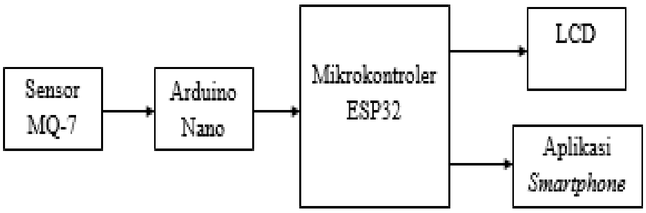


Fig. 2. Diagram of Blocks

C. Design of a Tool

The first step in manufacturing this gas monitoring system is to design the tool. The ESP32 and Arduino Nano microcontrollers are used in this system, as well as a power supply, stepdown regulator, and MQ-7 sensor. The data sent from the MQ-7 sensor is read by the Arduino Nano and sent to the ESP32. Then the ESP32 microcontroller sends the data to firebase for display on the LCD. The power supply acts as a voltage supplier for the monitoring tool so that the monitoring tool can function. Stepdown regulator to step the voltage down from 12V to 5V and MQ-7 sensor to detect the presence of ambient Carbon Monoxide (CO) gas.

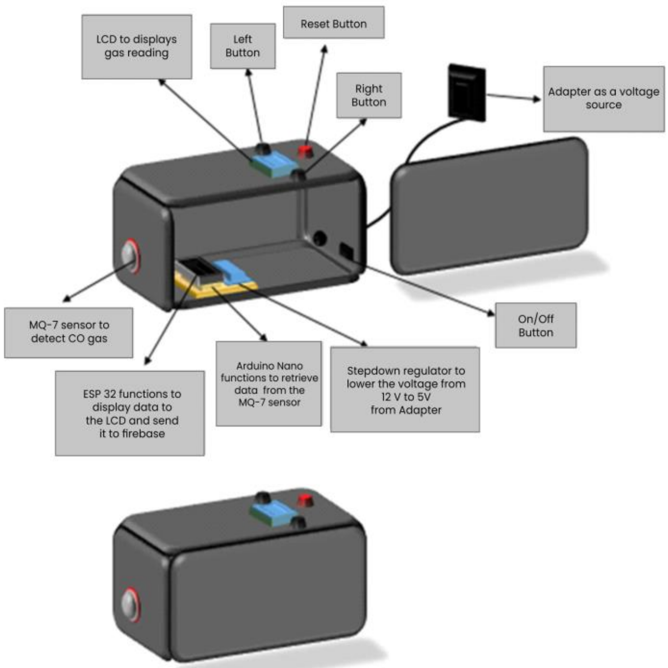


Fig. 3. Tool Design Application Design Illustration

D. Design of Software

The design process is carried out on AdobeXD for the first monitoring application design. A smartphone application that uses the IoT (Internet of Things) feature to monitor Carbon Monoxide (CO) levels in a microcontroller-based automatic control system programmed in Android Studio.

IJSES
Volume 6, Issue 9, pp. 22-26, 2022.
International Journal of Scientific Engineering and Science
ISSN (Online): 2456-7361

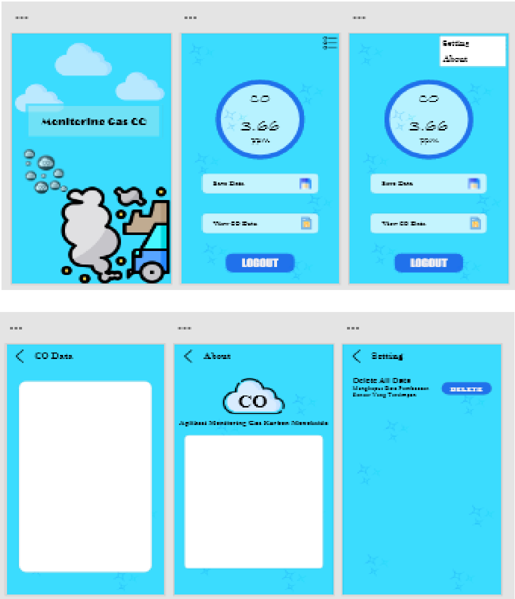


Fig. 4. Applications Design

III. Testing and Result of Application Design

A. Adapter Testing

This test is designed to establish whether the adapter is capable of reducing the voltage from the power source by 220 V to 12 V and providing voltage and electric current to the circuit. An avometer is used in this test to determine how much voltage the adapter will deliver. In this test, good results were obtained, and the tool given by the power supply can function properly, as evidenced by the operation of the components immediately connected to the adapter.

B. Stepdown Regulator Testing

This test determines whether the stepdown regulator is performing its duty, which is to reduce the 12V voltage from the adapter to the 5V voltage required by Arduino. This test is performed with an adapter and a voltmeter to determine the resulting voltage. In this test, good results are indicated by the stepdown regulator providing an output of 5 Volts for the required voltage for Arduino.

C. Arduino Nano Testing

The purpose of the Arduino Nano testing is to establish whether Arduino can read MQ-7 sensor data and send sensor data to ESP32, allowing it to be asserted that Arduino can be used and works properly.

```
void loop() {
  adc = analogRead(sensor);
  Serial.print("ADC = "); Serial.println(adc);

  VRL = adc*5.0/1024;
  Serial.print("VRL = "); Serial.print(VRL); Serial.println(" Volt");

  Rs  = (Vc*RL/VRL)-RL;
  Serial.print("Rs = "); Serial.print(Rs); Serial.println(" Ohm");

  ppm = 100*pow(Rs/Ro,-1.53);
  Serial.print("CO = "); Serial.print(ppm); Serial.println(" ppm");
  Serial.println();
  delay(1000);
```

Fig. 5. Listing Programme Arduino

D. ESP32 Testing

The testing on the ESP32 microcontroller seeks to verify whether the ESP32 can communicate data to the firebase and show gas data to the LCD, allowing the ESP32 to be utilized and run properly.

E. Equations Style

The MQ-7 sensor was put to the test to see how accurate it was in measuring carbon monoxide gas. The MQ-7 sensor is tested by comparing the gas value displayed on the LCD and the COMeter measuring device with the gas value on the COMeter.

Carbon monoxide levels in ppm are calculated by comparing the resistance of the sensor to detect CO (Rs) with the resistance of the sensor in clean air (Ro), as shown below:

$$VRL = \frac{ADC \times 5.0\ V}{1024} \quad (1)$$

$$Rs = \frac{Vc \times RL}{VRL} - RL \quad (2)$$

$$Ppm = 100\sqrt{\left(\frac{Rs}{Ro}\right) - 1{,}53} \quad (3)$$

where:
VRL = Output Voltage
Rs = Resistance of sensor detect CO
Vc = voltage on sensor
RL = The value of the load resistance on the sensor
Ro = Sensor resistance in clean air

The measurements yielded two distinct results: a test to detect carbon monoxide in vehicle exhaust gases and a test to detect carbon monoxide in cigarette smoke. Table 1 shows the test results for carbon monoxide-containing exhaust gases.

TABLE 1. Comparison Result for Detection of CO Gas in Vechicles.

No.	Rated Sensor MQ-7(ppm)	Factory-Made Measuring Tool (ppm)	Difference
First Test			
1	33.76	32	1.76
2	32.91	35	2.09
3	34.64	33	1.64
4	32.70	35	2.30
5	35.75	38	2.25
Second Test			
1	37.61	46	8.39
2	32.91	42	9.09
3	34.06	39	4.94
4	34.06	38	3.94
5	37.37	42	4.63
Third Test			
1	42.60	50	7.40
2	43.13	45	1.87
3	40.54	48	7.46
4	43.67	51	7.33
5	43.13	48	4.87

Based on in Table 1., the results of the comparison between the MQ-7 sensor and the COMeter measuring instrument for testing carbon monoxide in vehicle exhaust gas, the largest difference in measurement ratio is 9.09, while the smallest

International Journal of Scientific Engineering and Science
Volume 6, Issue 9, pp. 22-26, 2022. ISSN (Online): 2456-7361

difference is 1.64, with an average number of errors of 4.99. Table 2 shows how to test for carbon monoxide in cigarette smoke by placing a measuring instrument near a cigarette that emits smoke to obtain carbon monoxide.

TABLE 2. Comparison Result for Detection of CO Gas in Cigarette Smoke.

No.	Rated Sensor MQ-7(ppm)	Factory-Made Measuring Tool (ppm)	Difference
First Test			
1	46.72	46	0.72
2	46.72	43	3.72
3	46.72	42	4.72
4	56.06	48	8.06
5	56.06	57	0.94
Second Test			
1	58.12	50	8.12
2	58.12	52	6.12
3	58.12	51	7.12
4	58.12	52	6.12
5	50.27	50	0.27
Third Test			
1	76.10	73	3.10
2	76.10	75	1.10
3	73.86	77	3.14
4	73.86	76	2.14
5	77.01	76	1.01

Table 2., The largest measurement difference between the MQ-7 sensor and the COMeter measuring instrument for testing carbon monoxide in cigarette smoke was 8.12, while the smallest difference was 0.27, with an average number of errors of 3.76.

The difference in the amount of gas that is read when detecting carbon monoxide gas in vehicle exhaust fumes and smoke resulting from data collection on gas sources. In vehicle exhaust, the distance is ±100 cm, while at the time of data collection on cigarette smoke the distance is ±10 cm.

Because the tolerance of conventional measuring instruments is 10% of the 1000 ppm measurement capability, or about 10 ppm, the difference in measurements obtained from the two experiments above can be affected. Following a comparison of the MQ-7 sensor and the COMeter measuring instrument, and with a small number of errors, the MQ-7 sensor is declared feasible for use as a Carbon Monoxide gas measuring instrument.

F. LCD Testing

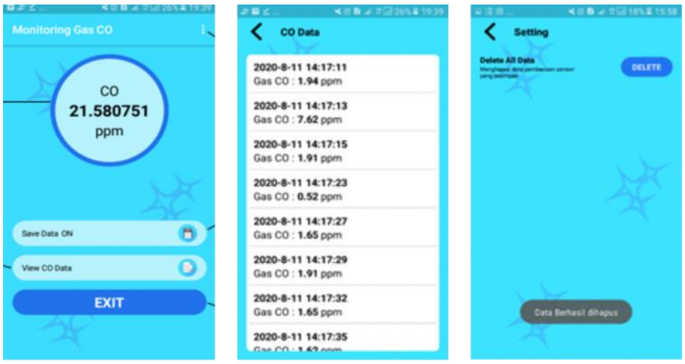
LCD testing is designed to ensure that the LCD works properly. For this test, a program in the form of a command is provided to display gas data on the Arduino IDE. After uploading the program, the LCD will display the program code. Based on Figure 6, the LCD successfully displays characters indicating that the LCD is working properly and can be used to display CO gas data.

G. Application Testing Monitoring

The monitoring application is tested by observing the capabilities of various features contained in the gas monitoring app on smartphones. Testing will be done to see if each feature that has been determined can run as expected.

Fig. 6. LCD Display

According to the test results for the features contained in the monitoring application, all features can function properly, including the main feature of being able to display gas data that has been detected by the tool in real-time, another supporting feature of being able to store gas data that has been read and sent to the application, capable of displaying gas data, and also capable of deleting gas data that has been stored in the application.



(a) (b) (c)

Fig. 7. Application result display (a) gas data has been detected by the tool in real-time (b) store gas data that has been sent to the application (c) deleting gas data that has been stred

H. Functionally Testing

The functionality aspect will be evaluated based on the ability of each component in the detector and the features contained in the application to perform their respective functions, which will ultimately determine whether the tool is capable of reading carbon monoxide gas levels and is safe to use. If the system detects carbon monoxide gas, then all aspects of the tool's functionality are said to be operational. If the system is unable to take gas readings, it is deemed necessary to conduct tests to be repaired/revised until it is suitable.

The instrument created by the researcher was used for testing the functionality aspect. According to the suitability of the tool's function and performance, as well as the application that occurs, the carbon monoxide gas level monitoring tool system produces a good product that is in accordance with its function. Component testing analysis using the descriptive analysis method, where:

$$Percentage\_eligibility = \frac{Observed\_score}{Expected\_score} \times 100\% \quad (4)$$

Then the value of all test case items is obtained, namely:

$$\text{Egibility Percentage} = \frac{14}{14} \times 100\%$$
$$= 1 \times 100\%$$
$$= 100\%$$

Based on the function performance test calculation, the results of the descriptive analysis on the functionality test obtained the percentage of the tool's feasibility being 100%, and it was stated that the tool could work entirely according to their respective functions.

IV. Conclusion and Suggestion

In this study, a device for monitoring Carbon Monoxide gas in the form of a gas detector was created, as well as an application for monitoring gas that is read by the tool. Based on the study's findings, the following conclusions were reached: (1) A Carbon Monoxide gas level monitoring system based on IoT is produced as a result of research using this spiral development model, the development of which lies in the monitoring application used, which can transmit gas data in real-time to facilitate the detection of invisible CO gas levels and odorless around so that the presence of gas can be detected. (2) There are three testings this research. The first test in this research is to test the gas detector by testing each component, and the results show the tool works well because all functions on the components work as expected. The monitoring application was tested in the second test. The last test is functionality testing to determine how feasible the tool can be used, with 100% results indicating that the monitoring tool can function and be used.

Given the above research findings, the following suggestion is proposed: (1) As a community alternative, use technology to detect harmful gases in the vicinity, mainly Carbon Monoxide (CO) gas. (2) Further development of the application or Carbon Monoxide gas detector can include adding features such as notifications to the application or alarms on the device. (3) It is hoped that future research will be able to improve this research by using more accurate sensor readings, resulting in more appropriate gas data readings.

References

[1] IQAir.com, “Indonesia Air Quality Index (AQI) and Air Pollution information | IQAir,” 2022. [Online]. Available: https://www.iqair.com/indonesia
[2] J. J. Rose *et al.*, “Carbon monoxide poisoning: Pathogenesis, management, and future directions of therapy,” *Am. J. Respir. Crit. Care Med.*, vol. 195, no. 5, pp. 596–606, Mar. 2017, doi: 10.1164/RCCM.201606-1275CI/SUPPL_FILE/DISCLOSURES.PDF. [Online]. Available: /pmc/articles/PMC5363978/
[3] WHO, “Air Quality and Pollution,” 2021. [Online]. Available: https://areahub.com/knowledge-center/pollution/how-to-understand-air-quality
[4] B. Michael Greenstone and Q. Fan, “Indonesia’s Worsening Air Quality and its Impact on Life Expectancy,” Chicago, 2018.
[5] A. A. Ibrahim, “Carbon Dioxide and Carbon Monoxide Level Detector,” *2018 21st Int. Conf. Comput. Inf. Technol. ICCIT 2018*, Jan. 2019, doi: 10.1109/ICCITECHN.2018.8631933.
[6] M. N. Mohammed, Y. Ghanesen, S. Al-Zubaidi, M. A. M. Ali, O. Ismael Al-Sanjary, and N. S. Zamani, “Investigation on Carbon Monoxide Monitoring and Alert System for Vehicles,” *Proc. - 2019 IEEE 15th Int. Colloq. Signal Process. its Appl. CSPA 2019*, no. March, pp. 239–242, 2019, doi: 10.1109/CSPA.2019.8696001.
[7] A. M. Samson, R. Dhakshyani, and R. Abdulla, “IoT based sustainable wallet tracking system,” *Int. J. Adv. Sci. Technol.*, vol. 29, no. 1, pp. 1301–1310, 2020.
[8] T. Eldemerdash, R. Abdulla, V. Jayapal, C. Nataraj, and M. K. Abbas, “IoT based smart helmet for mining industry application,” *Int. J. Adv. Sci. Technol.*, vol. 29, no. 1, pp. 373–387, 2020.
[9] R. Abdulla and C. Nataraj, “WHEELCHAIR-PERSON FALL DETECTION,” *Solid State Technol.*, vol. 63, no. 1, pp. 911–922, 2020.
[10] A. A. Şerban, A. Drumea, and C. Marghescu, “Electronic Module for Carbon Monoxide Monitoring and Warning,” *SIITME 2019 - 2019 IEEE 25th Int. Symp. Des. Technol. Electron. Packag. Proc.*, pp. 146–150, Oct. 2019, doi: 10.1109/SIITME47687.2019.8990824.
[11] S. M. Hadj Irid, M. Hadjila, and H. E. Adardour, “Design and Implementation of an IoT Prototype for the Detection of Carbon Monoxide,” *Proc. - 2019 6th Int. Conf. Image Signal Process. their Appl. ISPA 2019*, Nov. 2019, doi: 10.1109/ISPA48434.2019.8966882.
[12] M. Rivai, H. Rahmannuri, M. Rohfadli, H. Pirngadi, and Tasripan, “Monitoring of Carbon Monoxide and Sulfur Dioxide Using Electrochemical Gas Sensors Based on IoT,” *Proc. - 2020 Int. Semin. Intell. Technol. Its Appl. Humanification Reliab. Intell. Syst. ISITIA 2020*, pp. 61–65, Jul. 2020, doi: 10.1109/ISITIA49792.2020.9163731.
[13] H. Singh, R. Abdulla, and S. K. Selvaperumal, “Carbon monoxide detection using IoT,” *J. Appl. Technol. Innov.*, vol. 5, no. 3, p. 7, 2021 [Online]. Available: https://www.researchgate.net/publication/352645021_Carbon_monoxide_detection_using_IoT
[14] Sugiono, *Metode Penelitian Kuantitatif, Kualitatif dan R&D*, 25th ed. Bandung: Alfabeta, 2017.
[15] Pressman and S. Roger, *Rekayasa Peragkat Lunak*, 7th ed. Yogyakarta: Andi, 2012.