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Research Article

Design of Monitoring System for Hazardous Gas and Fire Detection In Building Based On Internet of Things

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ABSTRACT

Fires and gas leaks are events that still occur frequently. This incident is usually caused by various factors including leakage of LPG gas cylinders, cigarette butts that are disposed of carelessly, short circuits of electric current and so on. Generally, fires and gas leaks can only be detected if the fire has already grown or a lot of smoke comes out of the building. Therefore, a monitoring system for detecting dangerous gases and fires in buildings based on the Internet of Things was created that can monitor the condition of the building through a website as well as send notifications to the Telegram application on smartphones. The detection system implemented uses a flame sensor as a fire detector, an MQ-2 gas sensor as a detector of hazardous gases (CO, CO2, and CH4), and NodeMCU as a module to transmit data. Gas sensors and fire sensors connected to the NodeMCU will work continuously in real time to check the gas content in the air and the value of the flame in the building, if gas exceeds the threshold or a fire is detected, the system will send a notification to Telegram (in the form of hazard warnings and website links), and the website will display sensor values and status as well as a map of the area where a fire or gas leak occurred. The results of the detection system created to be able to provide solutions so that cases of fire and gas leaks can be handled early by detecting signs of fire or gas leaks and sending the information to users via the website and notifications.

INTRODUCTION

Building is one of the primary needs that can never be separated from human life, especially as a means of security and safety. Security and safety are important aspects of a building. Because these places are prone to gas leaks or fires. Fires often occur due to human negligence caused by several factors such as leakage of LPG (Liquid Petroleum Gas) gas cylinders, due to cigarette butts being disposed of carelessly, short circuits of electric current that cause fires and spread to other parts, and so on. The occurrence of fires and gas leaks will certainly harm many parties both morally and materially, and not a little bit also threatens the safety of life [1].

So far, cases of fire or gas leaks in buildings are still difficult to detect quickly due to a lack of public knowledge about the signs or symptoms of a fire or gas leak in a building or building. On the other hand, in the case of gas leakage, it is difficult to identify visually, and it is also difficult to estimate the leak rate [2]. From some of the descriptions above, a real time fire and gas detection system was made using the MQ-2 sensor and flame sensor. The thing that distinguishes this research from previous research is that this system will show where the location of the fire area and gas leaks occur, especially in high-rise buildings. So that this system is expected to be able to detect signs of fire or gas leaks quickly and send information to users through a website and notifications so that cases of fire and gas leaks can be handled early.

Building Automation System (BAS)

The Building Automation System (BAS) is a system installed in buildings that is useful for controlling and monitoring building services and is responsible for heating, cooling, ventilation, air conditioning, lighting, life safety, security systems, and others [3]. BAS is intended for automatic control of all aspects of utility, energy, security, and safety of the building.

Building automation systems that are composed by computer aided networked electronic devices are mostly used for improvement of the individual quality of life, for example in providing automatic controlling of blinds based on sunlight intensity. They are commonly applied in providing better safety as well, such as automatic alarming when fire in the building detected by smoke detector [4]. The presence of IoT (Internet of Things) in BAS systems advances building automation beyond optimization. IoT in BAS makes data collection and analysis simple and cost-effective, and improves performance such as remote data monitoring, pooling data from disparate sources (sensors), and cataloging and analyzing data for actionable perceptions. This allows building managers to be more fluent and

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faster in their ability to respond to certain conditions and save costs [5].

Internet of Things (IoT)

IoT is defined as a technology that allows for control, communication, collaboration with various hardware devices, sharing data, virtualizing all real things in the form of the internet, and others through the internet network [6]. The Internet of Things (IoT) refers to the evolutionary stage of the internet, which makes a global communicating infrastructure between humans and machines. IoT is constructing the global infrastructure which will change the fundamental aspects of our lives, from health services to manufacturing, from agriculture to mining. [7].

Flame Sensor

The flame sensor is used for detecting flame. The flame sensor comes with digital filter for digital output and it also reserve the original analog output [8]. The flame sensor is an intelligent sensor system that is able to detect flames with high accuracy using a flame sensor and servo motor. This sensor consists of a photodiode sensor which is designed to detect sparks and a microcontroller-based module which is used to control the work of the servo motor, take sampling of sensor data, and set the interface with other systems. The flame sensor has four legs, each of which functions as a 5V DC voltage source, ground, analog output, and digital output. The flame sensor used in the system can detect flame where the sensor will read infrared light on the flame with a wavelength of 760 nm to 1100 nm [9].

MQ-2 Gas Sensor

The MQ-2 gas sensor is a sensor that is usually used to determine air quality or to determine the content that occurs in the air. The MQ-2 sensor is made of a gas sensitive material, SnO2. If this sensor detects the presence of gas in the air with a certain concentration level, the sensor will assume that there is cigarette smoke in the air. When the sensor detects the presence of these gases, the electrical resistance of the sensor will decrease. By utilizing the working principle of the MQ-2 sensor, the gas content can be measured. MQ-2 gas sensor has high sensitivity to LPG, propane, hydrogen, methane, CO, and other combustible means [10].

NodeMCU V3 Lolin

NodeMCU V3 Lolin is a microcontroller equipped with 8266 Wi-Fi module. NodeMCU is basically an expansion of ESP8266 with e-Lua based firmware. NodeMCU uses the Lua programming language, which is a package from ESP8266. The Lua language has the same logic and programming structure as C, only the syntax is different [11]. NodeMCU also supports Arduino IDE software by making a few changes to the Arduino IDE board manager.

Telegram Messenger

Telegram is a direct messaging service application that is free and can be used by users to communicate online. Telegram is available for mobile phone devices (Android, iOS, Windows Phone, Ubuntu Touch) and computer system devices (Windows, OS X, Linux) [12]. Telegram Messenger uses the proven MTProto protocol with a level of security due to the end-to-end encryption process used. Just like similar applications, Telegram Messenger can share messages, photos, videos, location tagging between users.

The advantage of telegram that is useful in this research is the bot feature that has artificial intelligence. This bot feature is a feature that can be integrated with various services via the internet. Telegram bots can be used to run commands automatically [13]. Bot is a program that runs on the server side to get information by using the Telegram Client that has been installed on the server admin mobile device. The use of Telegram Client serves as an interface that displays certain information. In order for the bot to work optimally, good internet access is needed to connect all components to the telegram server [14].

Ngrok

Ngrok is an application that makes it possible for one to expose a local server to the internet public. Ngrok provides a monitoring UI, so that all access traffic running on the server path can be monitored properly [15]. The created database is linked with ngrok so that it can be accessed on other devices. The result on the implementation of the ngrok is that other devices can access the local server and database on mysql that was created previously without using a web hosting service. Localhost on the computer to be addressed can be accessed by using ngrok and connected to the internet network [16].

The benefits of ngrok include:

a. Run a private cloud service from home.
b. Testing a mobile app connected to a locally running backend.
c. Stable addresses for connected devices used in the field.
d. Debugging and understanding any web service by checking HTTP traffic.
e. Running network services on machines that are firewalled off from the internet.

METHODS

The research carried out is the design of an existing system based on what has been done by previous research, it is expected to optimize the use of human resources and maximize the safety and comfort of building users by implementing the Building Automation System.

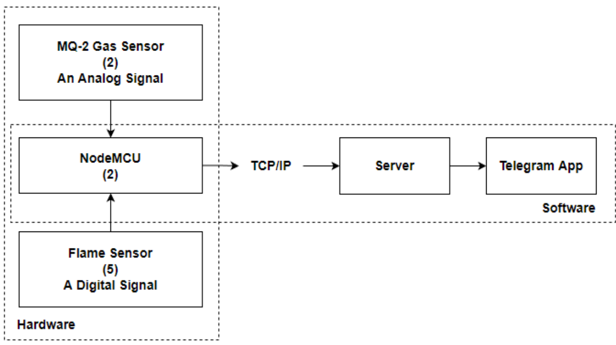


Figure 1. Block diagram of system design

In Figure 1, the MQ-2 gas sensor will read data in the form of hazardous gases in the form of an analog signal and the flame sensor will read data in the form of a flame value in the form of a digital signal. Furthermore, the data read by each sensor will be sent through the NodeMCU which is then sent to the server via a WiFi connection. The server will process the data into a database so that the web server can provide information to users. NodeMCU also sends notifications to the Telegram application with the help of the internet as a warning of the presence of dangerous gases and the value of the detected flame.

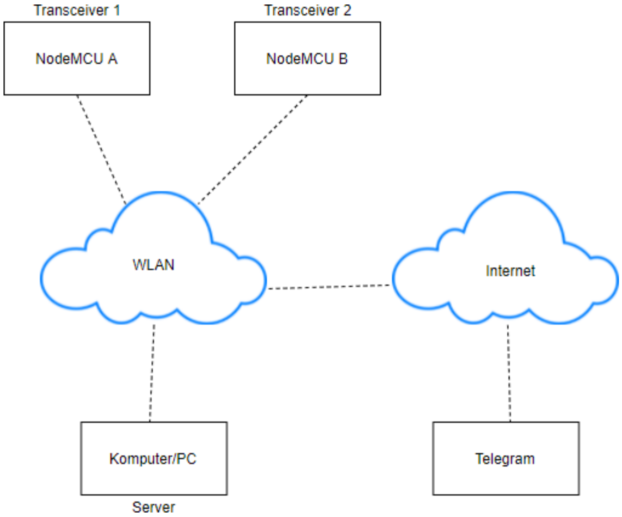


Figure 2. Diagram of the monitoring system for gas and flame detectors

In Figure 2, the gas sensor and flame sensor connected to the NodeMCU A and NodeMCU B devices will continuously work to check the gas content in the air and the value of the flame in the building. When the gas content in the air obtained from the gas lighter exceeds the threshold (that is, with concentrations > 100 ppm for CO, > 5000 ppm for CO2, and > 1000 ppm for CH4) and a flame is detected with a wavelength of 760 - 1100 nm obtained from the candle flame, the sensor will send data to the NodeMCU. NodeMCU that has been connected to the server will send the data obtained from the sensor via a WiFi connection, then the data will be processed and stored in the MySQL database.

To send data from NodeMCU to the MySQL database, the HTTP GET Request method is used to access PHP files on the computer/PC server. The stored data will then be displayed by the web server on the server computer or client computer by accessing the website page that has been created. NodeMCU will also send notifications to the user's device via the Telegram application by adding a bot that has been created.

The system flowchart can be seen in Figure 3 above. The first step is to initialize the NodeMCU, fire sensor and gas sensor. Then the system will detect changes in levels of CO gas, CO2 gas, CH4 gas, and/or fire. If the condition exceeds the threshold limit that has been set, then the system is in a "Yes" condition, then data is sent based on sensor readings to the database to be displayed by the webserver and also sent notifications to users who have the Telegram application. If the system is in the "No" condition, i.e. when no flame and hazardous gas values are detected that do not exceed the threshold, the data will also be sent to the database to be displayed by the webserver without notification to Telegram.

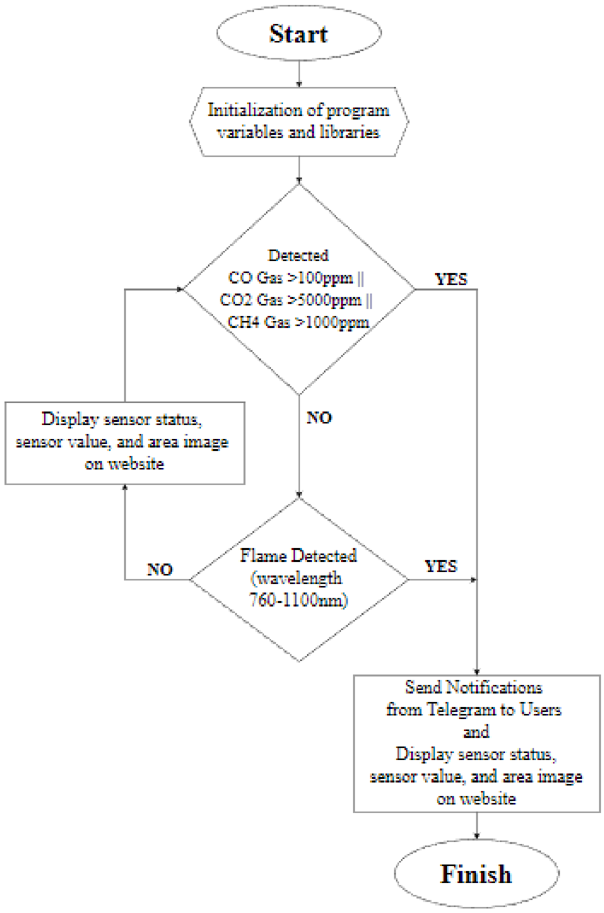


Figure 3 System flowchart

Figure 4 shows a flowchart from the server side. The webserver will wait for a request from the client (or from the NodeMCU side). The request is in the form of sensor value data and an area plan (according to sensor value data) that will be displayed. When the request is received, the server will process the data from the sensor sent by the NodeMCU via the WiFi LAN network. Then the data will be displayed on the website using the HTTP GET method of sending data.

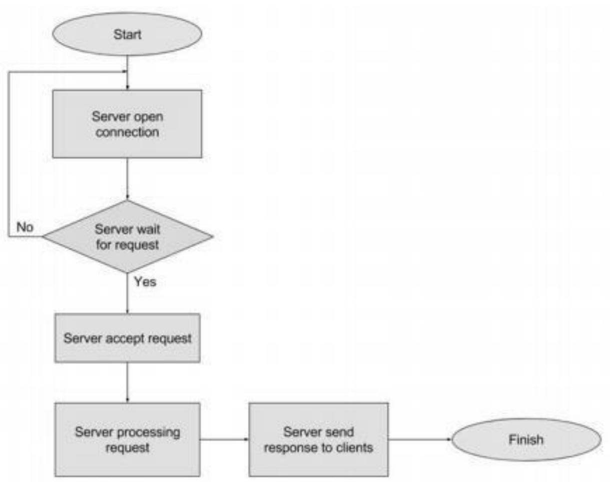


Figure 4. Server flowchart

RESULTS AND DISCUSSION

The toolkit for area A consists of three fire sensors, one MQ-2 gas sensor, and one NodeMCU. As for area B, there are two fire sensors, one MQ-2 gas sensor, and one NodeMCU. The toolkit for area A can be seen in Figure 5 below.

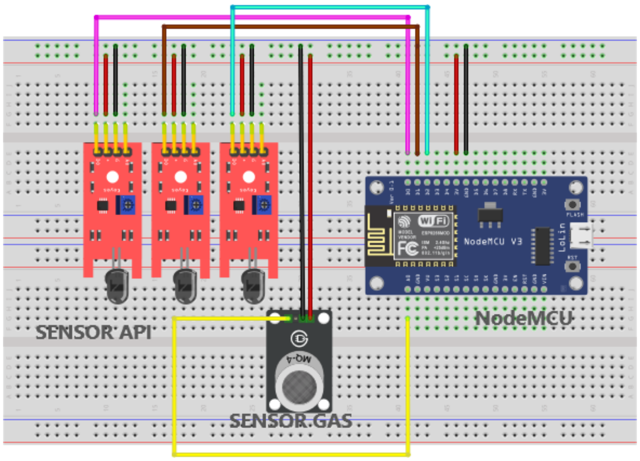


Figure 5. Toolkit for area A

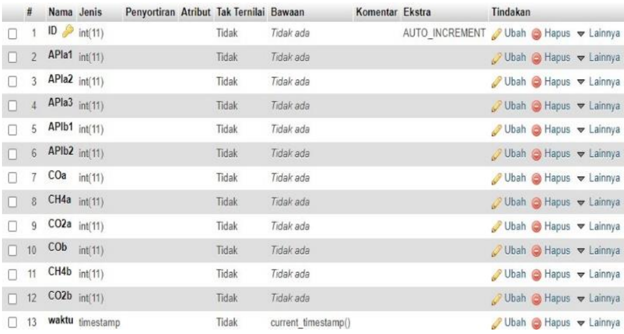
Toolkit A and toolkit B will send data via WLAN to a laptop that functions as a computer/PC server that has been connected to a LAN network.

Website Builder

In this study, a website designed with the XAMPP application was used. The first step is to install the XAMPP application, then run Apache and MySQL. After the Apache and MySQL connections have been successfully executed, the next step is to create a database by typing the address http://localhost/phpmyadmin in the browser. The following names, tables, and fields from the database that will be used in this study can be seen in Table 1 and Figure 6 below.

Table 1. Database Specification

Database Name	Table Name	Field Name	Description
monpiga	tabel_sensor	ID	Data sequence from sensor reading
		APIa1	Value of flame sensor 1 in area A
		APIa2	Value of flame sensor 2 in area A
		APIa3	Value of flame sensor 3 in area A
		APIb1	Value of flame sensor 1 in area B
		APIb2	Value of flame sensor 2 in area B
		CO2a	CO2 gas concentration in area A
		COa	CO gas concentration in area A
		CH4a	CH4 gas concentration in area A
		CO2b	CO2 gas concentration in area B
		COb	CO gas concentration in area B
		CH4b	CH4 gas concentration in area B
		waktu	Time of sending sensor value to database



#	Nama	Jenis	Penyortiran	Atribut	Tak Ternilai	Bawaan	Komentar	Ekstra	Tindakan
1	ID	int(11)			Tidak	Tidak ada		AUTO_INCREMENT	Ubah Hapus Lainnya
2	APIa1	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
3	APIa2	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
4	APIa3	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
5	APIb1	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
6	APIb2	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
7	COa	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
8	CH4a	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
9	CO2a	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
10	COb	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
11	CH4b	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
12	CO2b	int(11)			Tidak	Tidak ada			Ubah Hapus Lainnya
13	waktu	timestamp			Tidak	current_timestamp()			Ubah Hapus Lainnya

Figure 6. Database that has been created

Then the website that has been created will be online using the ngrok application. Ngrok will expose local servers behind NAT or Network Address Translation and firewalls to the public internet through a secure tunnel. This tunnel is used as a path to access the Localhost URL. When ngrok is run, it will display a random link from ngrok to access the local webserver or SSH.

The website display can be seen in Figure 7, Figure 8, and Figure 9 below. In Figure 8 the website displays the value and status of each sensor used, and in Figure 9 the website displays area plan of area A and area B before the detection of hazardous gases and fire.

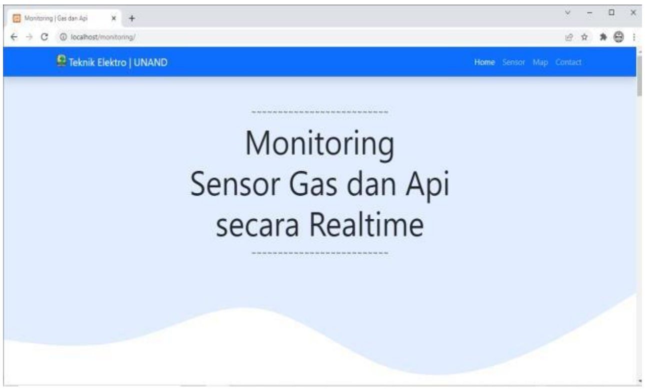


Figure 7. Website display

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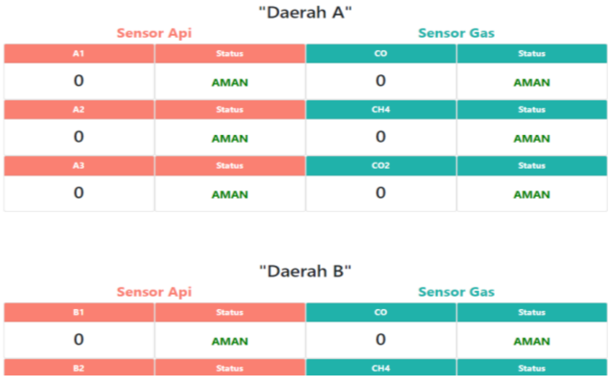


Figure 8, Sensor value and status display

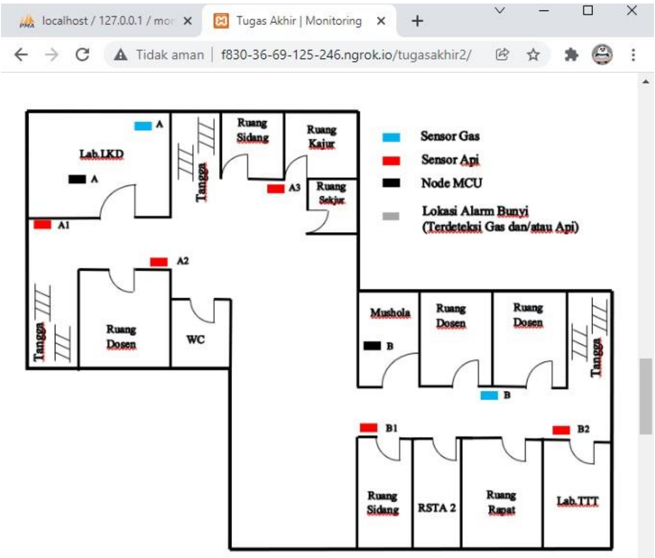


Figure 9. Display of area plan

Telegram Bot Builder

In this study, the Telegram application was also used to send notifications to users. First download and install the Telegram application on your smartphone. After that, open the Telegram application that has been installed, search for "BotFather" in the search field in the Telegram application or open the t.me/botfather link in the browser. After that type /start as the command to start the bot (the bot in question here is BotFather). Then type /newbot as a command to create a new bot, then enter the bot name and bot username. In this study, the name of the bot is "monitoring_kebakaran" and the username of the bot is "firefan_bot". After that, a message will appear containing a link to access the bot that has been created and the token needed for NodeMCU to interact with the bot.

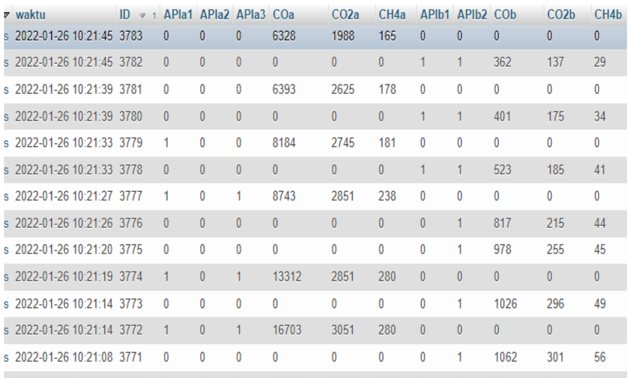
To send messages from NodeMCU to Telegram, a Telegram user ID is required who will receive messages. To get a user ID, search for "IDBot" in the search field in the Telegram application or open the t.me/myidbot link in a browser. After that, type /start as the command to start the bot (the bot referred to here is IDBot). Then type /getid as a command to get the user's Telegram account ID, and a message will appear containing the user ID.

To be able to receive notifications from Telegram, users must install the Telegram application on a computer or smartphone. Next, the user adds a bot that has been created, namely "monitoring_kebakaran" which can be searched in the search field in the Telegram application. If the bot has been added, click /start as the command to start the bot. Figure 10 shows the bot's appearance.

Figure 10. Bot display

Gas Detector Monitoring Test

At this stage, a gas detector monitoring test is carried out which has been designed by placing the gas source in area A and area B. The gas source is in the form of gas from the lighter. In the pictures and tables below, you can see some of the results of the gas detector monitoring tests carried out. In Figure 11 can be seen the database of the tests carried out. Table 2 for gas sources is given only in area A, Table 3 for gas sources is given only in area B, and Table 4 for gas sources is given in area A and area B.



waktu	ID	APIa1	APIa2	APIa3	COa	CO2a	CH4a	APIb1	APIb2	COb	CO2b	CH4b
2022-01-26 10:21:45	3783	0	0	0	6328	1988	165	0	0	0	0	0
2022-01-26 10:21:45	3782	0	0	0	0	0	0	1	1	362	137	29
2022-01-26 10:21:39	3781	0	0	0	6393	2625	178	0	0	0	0	0
2022-01-26 10:21:39	3780	0	0	0	0	0	0	1	1	401	175	34
2022-01-26 10:21:33	3779	1	0	0	8184	2745	181	0	0	0	0	0
2022-01-26 10:21:33	3778	0	0	0	0	0	0	1	1	523	185	41
2022-01-26 10:21:27	3777	1	0	1	8743	2851	238	0	0	0	0	0
2022-01-26 10:21:26	3776	0	0	0	0	0	0	0	1	817	215	44
2022-01-26 10:21:20	3775	0	0	0	0	0	0	0	1	978	255	45
2022-01-26 10:21:19	3774	1	0	1	13312	2851	280	0	0	0	0	0
2022-01-26 10:21:14	3773	0	0	0	0	0	0	0	1	1026	296	49
2022-01-26 10:21:14	3772	1	0	1	16703	3051	280	0	0	0	0	0
2022-01-26 10:21:08	3771	0	0	0	0	0	0	0	1	1062	301	56

Figure 11. Display database that has been filled

Table 2. Results of gas detection monitoring tests in area A

NO	Area			
	A		B	
1	CO	Status	CO	Status
	3372	DANGER	42	SAFE
	CH4	Status	CH4	Status
	129	SAFE	48	SAFE
	CO2	Status	CO2	Status
	622	SAFE	284	SAFE
2	CO	Status	CO	Status
	6940	DANGER	15	SAFE
	CH4	Status	CH4	Status
	208	SAFE	61	SAFE
	CO2	Status	CO2	Status
	1204	SAFE	236	SAFE

Table 3. Results of gas detection monitoring tests in area B

NO	Area			
	A		B	
1	CO	Status	CO	Status
	12	SAFE	1228	DANGER
	CH4	Status	CH4	Status
	1	SAFE	52	SAFE
	CO2	Status	CO2	Status
	8	SAFE	300	SAFE
2	CO	Status	CO	Status
	22	SAFE	2721	DANGER
	CH4	Status	CH4	Status
	3	SAFE	1090	DANGER
	CO2	Status	CO2	Status
	13	SAFE	223	SAFE

Table 4. Results of gas detection monitoring tests in area A and area B

NO	Area			
	A		B	
1	CO	Status	CO	Status
	1578	DANGER	3379	DANGER
	CH4	Status	CH4	Status
	73	SAFE	104	SAFE
	CO2	Status	CO2	Status
	36	SAFE	656	SAFE
2	CO	Status	CO	Status
	189	DANGER	3372	DANGER
	CH4	Status	CH4	Status
	15	SAFE	126	SAFE
	CO2	Status	CO2	Status
	70	SAFE	656	SAFE

For each condition that can be seen in Table 2, Table 3, and Table 4 above, the changes in the image area on the website can be seen in Figure 12 for area A, Figure 13 for area B, and Figure 14 for area A and B.

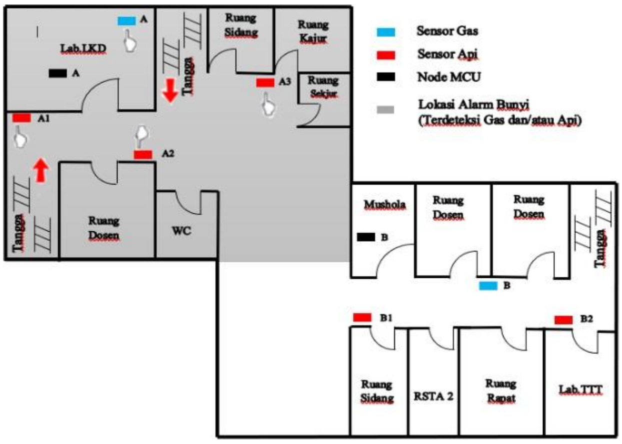


Figure 12. Hazardous gases and fire detected conditions in area A

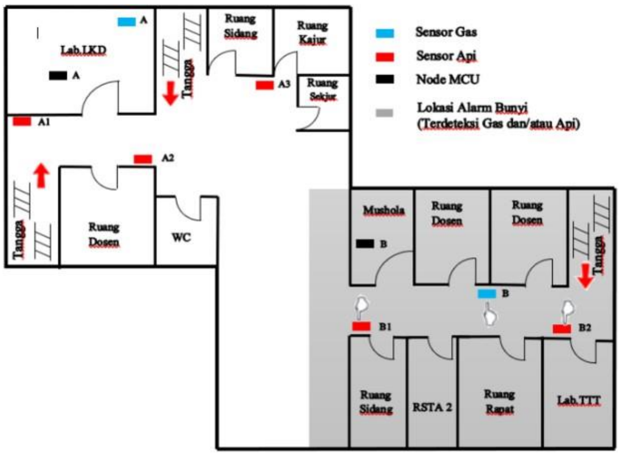


Figure 13. Hazardous gas and fire detected conditions in area B

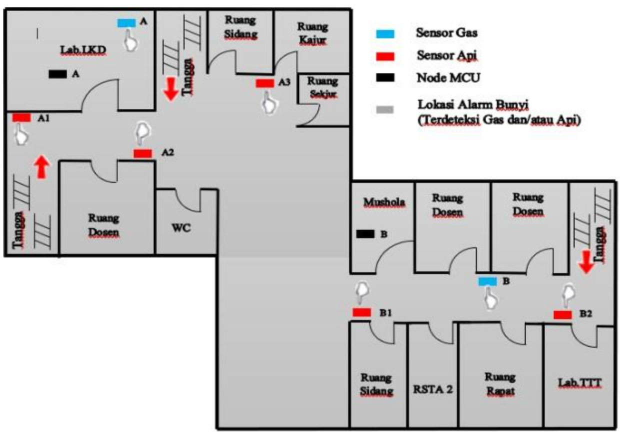


Figure 14. Hazardous gases and fire detected conditions in area A and area B

When the system does not detect any gas that exceeds the threshold, the website will display a "safe" status for each gas value. Meanwhile, when the system detects the presence of gas that exceeds the threshold, the status of the gas value will change to "danger" and the map of the area on the website will change, depending on which area is detected the presence of hazardous gases as shown in the table above.

Fire Detector Monitoring Test

At this stage, a fire detector monitoring test that has been designed is carried out. The test is carried out by using a flame on a candle. In the table below it can be seen that some of the results of the fire detection monitoring tests carried out are shown in Table 5 for fires detected only in area A, Table 6 for fires detected only in area B, and Table 7 for fire was detected in area A and area B. The database view can be seen in Figure 11 earlier.

Table 5. Results of fire detection monitoring test in area A

NO	**Area**			
	A		**B**	
1	A1	Status	B1	Status
	1	DANGER	0	SAFE
	A2	Status	B2	Status
	1	DANGER	0	SAFE
	A3	Status		
	0	SAFE		
2	A1	Status	B1	Status
	0	SAFE	0	SAFE
	A2	Status	B2	Status
	1	DANGER	0	SAFE
	A3	Status		
	1	DANGER		

Table 6. Results of fire detection monitoring test in area B

NO	**Area**			
	A		**B**	
1	A1	Status	B1	Status
	0	SAFE	1	DANGER
	A2	Status	B2	Status
	0	SAFE	0	SAFE
	A3	Status		
	0	SAFE		

Table 7. Results of fire detection monitoring test in area A and area B

NO	**Area**			
	A		**B**	
1	A1	Status	B1	Status
	1	DANGER	0	SAFE
	A2	Status	B2	Status
	0	SAFE	1	DANGER
	A3	Status		
	0	SAFE		
2	A1	Status	B1	Status
	1	DANGER	1	DANGER
	A2	Status	B2	Status
	0	SAFE	1	DANGER
	A3	Status		
	1	DANGER		

For each condition that can be seen in Table 5, Table 6, and Table 7 above, changes in the image area on the website can be seen in Figure 12, Figure 13, and Figure 14 before. When the system does not detect a flame, the website will display a "safe" status for each fire sensor value. Meanwhile, when the system detects a flame, the status of the fire sensor value will change to "danger" and the the map of the area on the website will change, depending on which area is detected a fire as shown in the table above.

Telegram Notifications

Telegram will also send a notification containing a warning and a website address to be accessed when the system detects the presence of hazardous gas content that exceeds the threshold limit and/or the presence of a fire. Notifications on the Telegram application can be seen in Figure 15 below.

Figure 15. Telegram notifications

CONCLUSIONS

From the results and tests that have been carried out on the monitoring system for detecting fire and hazardous gases, several conclusions can be drawn, namely the monitoring system for detecting fire and hazardous gases that has been made has been running well. This can be seen from the success of sending notifications to Telegram and the website. It is hoped that this monitoring system will be able to provide a solution so that cases of fire and gas leaks can be handled early by detecting signs of fire or gas leaks and sending the information to users via the website and notifications.

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