Multihop Routing Implementation On Fire And Gas Leakage Detection System

Benediktus Kevin Mulia\textsuperscript{1}, Mochammad Hannats Hanafi Ichsan\textsuperscript{2}, Rakhmadhany Primananda\textsuperscript{3}

\textsuperscript{1,2,3}Brawijaya University, Malang
\textsuperscript{1}benkevin500@student.ub.ac.id, \textsuperscript{2}hanas.hanafi@ub.ac.id, \textsuperscript{3}rakhmadhany@ub.ac.id

*Corresponding Author

Received 25 August 2022; accepted 26 August 2022

Abstract. Fires in the house occur due to several things, such as an electrical short circuit, and another cause is a gas leak from the LPG cylinder. This fire is caused by a lack of security in the house and public knowledge, the dangers of gas levels leaking from LPG gas cylinders, the presence of small fires, and temperatures too high due to these. Fire detectors and LPG gas leaks are provided in the home environment. This detection includes preventive efforts before a fire occurs and can be extinguished immediately. The method of the fire and gas leak detection prototype using the MQ-6 sensor, fire sensor and DHT-22 temperature sensor is multihop routing. This method was chosen because of the large number of sensors used, and in this prototype, there will be five sensor nodes and one sink node. With multihop routing, the prototype of this tool can be placed in various places and is faster in detecting fires if they occur in homes. This method is also used because it can send detection results from one sensor node to the sink node to the website database and the delivery time between these nodes is very short so that fires can be prevented and handled quickly. The test results of the fire sensor used to detect fire obtained an accuracy of 100%, and the detection distance of the fire was between 20 to 100 cm. In data transmission, the number of nodes is 5. The data delivery result is the closest to the end node, the more considerable the amount of data sent, increasing relatively, from around 3017 milliseconds to 575387 milliseconds.

Keywords: fire, gas, multihop routing, LPG gas cylinders, NodeMCU

1 Introduction

Fire is something that should be prevented. Fires occurred due to several things, such as an electrical short circuit [1, 2], and another cause was gas leakage from LPG cylinders [3, 4, 5]. This fire is usually caused by a lack of security in the house and public knowledge about the dangers of gas levels leaking from LPG gas cylinders, small fires and temperatures too high due to the fire [6, 7, 8]. According to data from the Center for Public Policy Studies (PUSKEPI), cases of explosions in household LPG gas cylinders occurred 189 times from 2008-to 2010 in Indonesia [9].

The use of LPG (Liquefied Petroleum Gas) gas in the community is increasingly widespread. Almost all Indonesians use LPG gas, especially 3 kg LPG gas or melon gas [10]. The rise of fires caused by leaks of LPG (Liquefied Petroleum Gas) gas cylinders has recently become frightening for those who use the gas [11, 12]. It caused controversy and threats from various circles against the government for converting gas. If LPG leaks, it will emit an unpleasant odour, quickly evaporate in the air at
temperatures above 24 degrees Celsius and is flammable. The condition is hazardous if a leak occurs in a closed room with a gas content of 30 degrees Celsius and can potentially cause a fire if a spark occurs [13, 14, 15].

Therefore, we need a technology that can detect fires and LPG gas leaks integrated into a system to minimize the occurrence of fires at home and detect gas leaks. Using different sensors and methods, technology to detect fires and LPG gas leaks has been successfully carried out in previous studies. In earlier research, gas detectors used MQ-6 and DHT-22 to catch fire and gas [16, 17, 18]. In other studies, sending data using ESP8266 and NodeMCU because it is powerful enough, such as low power, has routing protocol, and the data is lightweight [19, 20]. The device is very suitable for smart home systems [21]. The transmission method is multihop, where each node will send data to the sensor nodes nearby gradually so that the data can reach the sync node [22, 23]. This can cause the sensor node closest to the sink node to run out of energy faster because it will carry out more activities than the sensor node far from the sink node [24, 25]. Multihop is used because it has a more extended network lifetime when compared to clusters and hybrids [26, 27]. From these studies, the authors see that based on the background factors described, it is necessary to detect fires and gas leaks in homes because of frequent fires unknown to the owner due to gas leaks and high temperatures. This detection aims to minimize the occurrence of fires in homes that occur due to gas leaks.

Therefore, this research was conducted under the Implementation of Multihop Routing on Fire and Gas Leak Detection Prototypes. The choice of this multihop method is because this multihop can use five sensor nodes and one server node and can cover a large area. These five sensor nodes will be placed in different rooms and detect the presence of fire and smoke in the room in the house, and the other sensor nodes will send alternately to other sensor nodes and will be sent back to the server node so that users can know that their home is safe. And free from fire.

2 Method

This research was conducted by conducting a literature study first to collect references to account for the research. Then, system requirements are analyzed to determine what components are needed to build a fire and gas leak detection system. After knowing that elements such as fire, smoke sensors (MQ-6), and temperature sensors are required to get data from the sensors and send it to the website database, the system is designed and implemented in a complete tool. Finally, the system is tested to obtain accurate results and conclusions.

![System Block Diagram](image)

Figure 1. System Block Diagram

2.1 Node Design

In designing a system, a design flow is needed to drive the system so that the
need to detect fires and gas leaks can be met by implementing the multihop routing method. Fig. 1 illustrates the workflow of the system and its components.

This system will be made into five boxes, with each package being one node consisting of 1 NodeMCU ESP8266, one USB cable, and three sensors used in this system. The node contains a fire sensor to detect the presence of fire or not, an MQ-6 sensor to see the value of LPG gas that is detected, and the DHT-22 temperature sensor to detect the room temperature value.

2.2 Hardware Node Design

A device needs to be connected so that a microcontroller can control it to retrieve data from fire, LPG gas and temperature and run the multihop routing method. Fig. 2 shows how the fire sensor, MQ-6, and temperature sensor are connected to pins on the microcontroller.

![Figure 2. Hardware Design](image)

The fire sensor is a sensor that will detect fire from the fire to be detected, the gas sensor used is MQ-6 which functions to detect LPG gas, and the DHT-22 temperature sensor is a sensor that will detect the room temperature. After the three sensors get their values, they will be sent to the NodeMCU ESP8266 microcontroller, and then the results that have been sent to the microcontroller will be forwarded to the next sensor node. The development of the detection system is a laptop serial monitor, which will open five serial monitors from all sensor nodes to the server node.

Twenty kinds of data are obtained from five sensor nodes consisting of three sensors, and each node is given its node id. The fire sensor value data that will use the digital pin from the fire sensor is 0, the MQ-6 gas sensor value data has been calibrated, and the DHT-22 temperature sensor value data has also been programmed according to the DHT-22 module. Each sensor value will be sent to the next sensor node to the server node.
2.3 System Architecture

The design of data transmission was carried out on the prototype. This research is as follows: sensor node five will detect the sensors, then send sensor node four and sensor node four detects, and the results will be sent with the results of sensor node five, which will be sent to sensor node 3 to the node sensor 1. After sensor node one sends a sink node to the website database, it will be displayed. The following in Fig. 3 is a multihop routing system architecture. Each sensor node will function as an STA/station, which will become a client, and the sensor node will also function as an AP / Access Point, which will become a server. This STA and AP function for each sensor node to send sensor data to the next sensor node and can also receive data from the previous sensor node.

![Multihop Routing System Architecture](image)

**Figure 3. Multihop Routing System Architecture**

2.4 System Flowchart

In the program design, each pin was used for each sensor for data retrieval connected to the NodeMCU ESP8266 microcontroller. The program also initializes them. After initializing each node's pins, variables and mechanisms, the station and access point configurations are carried out to run the multihop routing method.
After configuring the station and access point, it's time to start reading the value of each sensor, such as the fire sensor, MQ-6 sensor, and DHT-22 temperature sensor. After reading the value of each sensor, run the multihop routing method by receiving data from the node. Previously, after receiving the previous node, the data from the sensor node will be combined with the data from the last node sensor. After that, the data will be sent to the next sensor node, after which the data calculation process has been carried out. The details of the flowchart can be seen in Fig 4.

3 Results and Discussion

Testing on sensor components, computing time, data transmission time, and data size of each sensor node aims to know the accuracy of each element and whether all of them have been functioned adequately according to their needs.

3.1 Flame Sensor Result

The test of the fire sensor is carried out in the presence or absence of fire. According to the datasheet, the fire sensor only can sense around 100. So this phase is to test the ability of the fire sensor. The test scenario conducted has the maximum result for this sensor; the maximum range only works until 65 centimetres.

<table>
<thead>
<tr>
<th>No</th>
<th>Condition</th>
<th>Distance (cm)</th>
<th>Fire Sensor Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There's Fire</td>
<td>20</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>2</td>
<td>There's Fire</td>
<td>25</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>3</td>
<td>There's Fire</td>
<td>30</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>4</td>
<td>There's Fire</td>
<td>35</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>5</td>
<td>There's Fire</td>
<td>40</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>6</td>
<td>There's Fire</td>
<td>45</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>7</td>
<td>There's Fire</td>
<td>50</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>8</td>
<td>There's Fire</td>
<td>55</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>9</td>
<td>There's Fire</td>
<td>60</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>10</td>
<td>There's Fire</td>
<td>65</td>
<td>1</td>
<td>Fire Detected</td>
</tr>
<tr>
<td>11</td>
<td>There's Fire</td>
<td>70</td>
<td>0</td>
<td>Fire not Detected</td>
</tr>
<tr>
<td>12</td>
<td>There's Fire</td>
<td>75</td>
<td>0</td>
<td>Fire not Detected</td>
</tr>
<tr>
<td>13</td>
<td>There's Fire</td>
<td>80</td>
<td>0</td>
<td>Fire not Detected</td>
</tr>
<tr>
<td>14</td>
<td>There's Fire</td>
<td>85</td>
<td>0</td>
<td>Fire not Detected</td>
</tr>
<tr>
<td>15</td>
<td>There's Fire</td>
<td>100</td>
<td>0</td>
<td>Fire not Detected</td>
</tr>
</tbody>
</table>

From Table 1, which is the result of testing the fire sensor, it can be seen that when testing the fire sensor at a distance of 20 to 100 cm, it can detect fire because, at the time of testing this fire sensor, the fire used as fire, so that the fire sensor was tested 15 times. Get a 100% accuracy value in detecting fire, but if the fire is large, it can detect the fire if it passes the distance range of the fire sensor. The maximum read sensor is only 100 centimeters because the sensor can detect fire as far as 100 cm, according to the datasheet of the fire sensor.
3.2 Gas Sensor Result

The MQ-6 gas sensor was tested using LPG gas by placing the prototype on the stove, and the furnace was rotated slightly to remove LPG gas carefully. The MQ-6 gas sensor was only calibrated based on the sensitivity graph and datasheet of the MQ-gas sensor. The following are the results of the MQ-6 gas sensor test, which can be seen in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>RS/RO Value</th>
<th>MQ-6 Sensor Value After Giving LPG Gas (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.83</td>
<td>2173.77</td>
</tr>
<tr>
<td>2</td>
<td>3.83</td>
<td>2650.17</td>
</tr>
<tr>
<td>3</td>
<td>3.83</td>
<td>3823.04</td>
</tr>
<tr>
<td>4</td>
<td>3.83</td>
<td>6785.46</td>
</tr>
<tr>
<td>5</td>
<td>3.83</td>
<td>9613.43</td>
</tr>
</tbody>
</table>

In Table 2, there is a drastic difference when the MQ-6 gas sensor is given LPG gas; after the MQ-6 gas, the sensor is provided LPG gas. The MQ-6 gas sensor value in Table 2 results from calibration with the MQ-6 sensor sensitivity graph in Fig. 5.

3.3 Temperature Result

This temperature sensor was tested by checking the temperature of the temperature without fire and the presence of fire. The following are the results of testing the DHT-22 temperature sensor, as shown in Table 3.

Based on the test results in Table 3, some results have been read or detected by the DHT-22 temperature sensor. The test of the DHT-22 temperature sensor was carried out under two conditions, namely: a condition where there was no fire and room temperature, and the second condition where the DHT-22 temperature sensor was given a fire condition with a certain distance because if it were too close, the sensor would be...
damaged and melted.

Table 3. DHT-22 Gas Sensor Test Results

<table>
<thead>
<tr>
<th>No</th>
<th>Condition</th>
<th>DHT-22 Temperature Sensor Value (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Flame, Room Temperature</td>
<td>29.70</td>
</tr>
<tr>
<td>2</td>
<td>No Flame, Room Temperature</td>
<td>29.70</td>
</tr>
<tr>
<td>3</td>
<td>No Flame, Room Temperature</td>
<td>29.70</td>
</tr>
<tr>
<td>4</td>
<td>There's Fire</td>
<td>32.40</td>
</tr>
<tr>
<td>5</td>
<td>There's Fire</td>
<td>32.40</td>
</tr>
</tbody>
</table>

After testing the DHT-22 temperature sensor, the DHT-22 temperature sensor value when there was no fire, and the room temperature was 29.40 degrees Celsius, and the temperature sensor value when the fire condition was given a specific distance got a weight of 32.40 degrees Celsius, after testing the temperature sensor DHT-22. The value generated from the temperature sensor with no fire or fire has an accuracy rate of approximately 0.5 degrees C. This accuracy value is obtained from the DHT-22 temperature sensor datasheet.

3.4 Time Computation Result

This test is carried out to determine how fast the sensor's computational time is detecting and calibrating. Each sensor node requires computation time to process data from the sensor detection results, and then it will be sent to the next sensor node, which will later enter the delivery time test. This test aims to determine the speed value of each sensor node to detect the presence of fire, gas, and temperature. In a sensor node five, the test was carried out thirty times, and the average computation speed was 6020.47 ms. The test was carried out thirty times in sensor node four, and the average computation speed was 6022.93 milliseconds. Sensor nodes three and three were performed. Twenty times the test got an average computational rate of 5484.33 milliseconds. On-sensor node two, twenty times, the trial got an average computational speed of 5455.87 milliseconds. On-sensor node one, thirty times, the test got an average computing speed of 5820.6 milliseconds.

3.5 Data Delivery Result

This test is carried out to determine how fast the time is to send the source sensor node to the destination sensor node. In addition to requiring computation time, each sensor node requires data transmission time from the source sensor node to the destination sensor node. This test aims to determine the speed value of sending data from one sensor node to another sensor node. In testing the delivery time of sensor node five to sensor node four carried out thirty times, the average speed in delivery is 3017.53 milliseconds. In testing, the delivery time of sensor node four to sensor node three is carried out thirty times, and the average delivery rate obtained is 2414.76 milliseconds. In testing the delivery time of sensor node three to sensor node two carried out thirty times, the average speed in delivery was 4966.5 milliseconds. In the delivery time testing scenario, sensor node two sends the data to sensor node one. It was carried out thirty times. In the testing to obtain the average transmission speed, the resulting average is 7186.63 milliseconds. The other testing scenario is the delivery time of
sensor node one to the sink node that is performed thirty times; the average transmission rate is 575387.3 milliseconds.

**Figure 6. Data Delivery Testing Scenario**

4 Conclusion and Future Works

This research results on the device design and testing process, conclusions can be drawn on the performance, data delivery time, the amount of data that has been shown by each device and the process of multihop routing that has been run. The sensor node implementation works well and can perform multihop routing. Each payload is filled with data from each sensor, and data from the previous sensor node can be sent and received at the destination sensor node so that all data from the sensor node can be sent to the sink node in the database.

The success rate of the sensor in detecting fire and gas leaks is 100% for fire sensors with a detection distance of fire between 20 to 100 cm, for the MQ-6 gas sensor, the sensor can only detect from 200 to 10000 ppm, and for temperature sensors the accuracy level ± 0.5 degrees C. This sensor also detects fire, gas, and room temperature optimally.

From the results of testing the delivery time and data size, it is obtained that the average data size from sensor node 5 to sensor node 4 is 240 bits with an average delivery time of 3017.53 ms (milliseconds). From sensor node 4 to sensor node three, the data has primarily obtained an average of 488 bits with an average delivery time of 2414.76 ms (milliseconds). Sensor node 3 sends data to sensor node 2 with an average data size of 720 bits with an average delivery time of 4966.5 ms (milliseconds). When sensor node 2 sends data to sensor node 1 with an average data size of 960 bits with an average delivery time of 7186.63 ms (milliseconds). The final testing is when sensor node 1 sends data to a sink node with an average data size of 1176 bits with an average delivery time of 575387.3 ms (milliseconds). Based on that experiment, the time between nodes is slightly increased, the highest time and the most significant data performed by node 1 to sink node, it successfully sent.

For future works, this prototype of a fire and gas leak detector that implements multihop routing is that it can use notification results from sink nodes via webserver or
another platform to present the data to the user or another stakeholders.

References


22 Tianyi Zhang, Geng Chen, Qingtian Zeng, Ge Song, Chao Li and Hua Duan, "Seamless clustering multi-hop routing protocol based on improved artificial bee colony algorithm," *EURASIP Journal on Wireless Communications and Networking*, p. 75. (2020)