Fire protection system based on the Internet of Things

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ABSTRACT

Fire is a significant threat to life and property safety, especially with the increasing risk due to rapid technological and infrastructure developments. This paper proposes an Internet of Things (IoT)-based fire protection system that utilizes an ESP32 microcontroller for automatic monitoring and response to potential fires. This system integrates various sensors, namely a DHT22 sensor to measure temperature, an MQ-02 sensor to detect hazardous gases, and a fire sensor to identify the presence of fire. When there is an increase in temperature, gas detection, or fire, the system automatically activates devices such as water pumps, fans, and APAR valves that are connected via relays, and sends real-time notifications equipped with location data via the Telegram application. Through this IoT-based approach, the system can be monitored and controlled remotely, providing a fast and effective response in fire mitigation efforts. The implementation of this system is expected to minimize the impact of fires by detecting and addressing potential hazards automatically and in real-time.

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1. INTRODUCTION

Fire is one of the tragedies that cannot be predicted, which can happen anytime and anywhere. Fire incidents are very threatening and disruptive to people's lives and livelihoods caused by natural factors, non-natural factors, or human factors, resulting in loss of life, environmental damage, loss of property and psychological impacts [1]-[3]. With the increasingly rapid development and progress of construction, the risk of fire is increasing [4]. In residential and urban areas, fires are often triggered by various factors, such as short circuits, human negligence, the use of flammable materials that are not properly supervised, and the use of several tools and burning that is not careful [5]. Meanwhile, in forest and land areas, fires can occur due to climate change which causes a longer dry season or due to human activities, such as land clearing by burning [6].

In responding to this fire, the community's response tends to be slow. This is due to a lack of knowledge about fire prevention, and not everyone knows the nearest fire department telephone number, making it difficult for victims to ask for help [7]. In addition, the address information provided by the reporter to the firefighters is often inaccurate, which hinders the extinguishing process and makes it difficult for the firefighting team in their efforts [8]. As a result, the firefighters only arrive after the fire has burned down the house. Preparedness in reducing fire risks can provide an appropriate response and rapid recovery [9]. From the situation described above, a system is needed that can provide fire warnings to homeowners or officers at connected companies or universities, so that fire incidents can be detected and handled quickly and effectively [10]-[13].

One of the systems that can provide fire warnings is the Internet of Things (IoT) based fire protection system, where this tool can be integrated online so that it can facilitate information to be delivered quickly, with the note that there is an internet connection. IoT itself is a concept or scenario where an object has the ability to send data over a network without requiring human-to-human or human-to-computer interaction [14]-[15]. The term IoT describes the real world into cyberspace with the method used being wireless and automatic control without knowing the distance. This IoT-based fire protection system uses fire, temperature, and gas detection sensors as the main components in detecting potential fires. Relays that can regulate Water Pumps, Fans, and Valves connected to APAR In addition, this system is integrated with the Telegram application to send real-time fire alarm notifications to users [16]. In an emergency, the system can also automatically activate the water pump to flow water to the area where the fire is detected, so that extinguishing efforts can be carried out faster and the impact of the fire can be minimized.

IoT (Internet of Things) based fire protection systems are expected to provide faster and more effective detection and response to fires, detecting signs of fire quickly, such as increased temperature, smoke, or the presence of hazardous gases [17]. The sensors used are able to transmit data in real-time, enabling early detection so that fires can be controlled before they get bigger. With these features, it is expected to not only function as a prevention tool, but also as a proactive solution to improve safety, reduce losses, and provide higher security for the community and the environment.

2. METHOD

In making a tool, the first thing that must be done is designing. Tool design is a planning process before making the tool. The purpose of this design is to facilitate the manufacture of the tool. Because in the design, the selection of the right circuit and calculations and selection of components will be carried out. In principle, systematic tool design will provide convenience in making the tool. Figure 1 shows a block diagram of the proposed fire protection system.

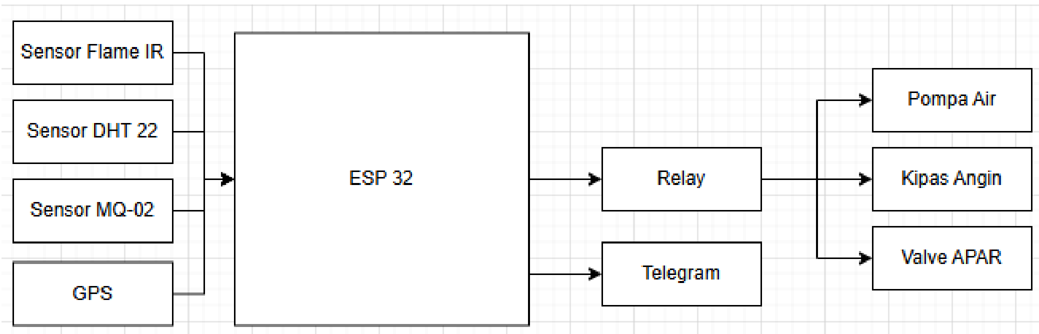


Figure 1. Block diagram of IoT based fire protection system

The block diagram consists of inputs in the form of : 1) Flame Sensor IR which functions to detect the presence of fire. If fire is detected, the system will activate the APAR valve via a relay to spray fire extinguishing media, 2) Sensor MQ-02 which functions to detect the presence of gas which can indicate a leak or the presence of flammable materials. If gas is detected, the fan will be activated via a relay to increase ventilation and reduce gas concentration, 3) Sensor DHT 22 is used to measure temperature and humidity. If the temperature exceeds 40°C, the water pump will be activated via a relay to help lower the temperature in the area, 4) GPS module is connected to provide the location of this system. This location is then sent via Telegram to notify users of the exact location of the incident or emergency.

The output block diagram consists of: 1) Relay as an output to turn on and off the fan and water pump. The relay contact used to turn it on is the NO contact, 2) Water pump which is activated via a relay if the temperature reaches or exceeds 40°C, to help cool the area, 3) The fan will be activated via a relay if gas is detected, to improve ventilation and reduce potential hazards, 4) The light extinguisher valve will be activated via a relay if fire is detected, so that the extinguishing media can be sprayed automatically to extinguish the fire and 5) Telegram. If an emergency occurs such as fire or gas is detected, or the temperature is too high, the ESP32 sends a notification to Telegram using the available internet connection. This notification includes: Data from sensors (temperature, presence of gas, and fire), GPS location to make it easier for users to find the location of the system that detects an emergency, Warning messages indicating the type of emergency condition detected.

After reading data from the sensor, the ESP32 processes the information based on predetermined conditions or limitations: 1) High temperature: If the DHT22 sensor detects a temperature above 40°C, the ESP32 considers this an emergency condition that requires action, 2) Gas concentration detected: If the MQ-02 sensor detects the presence of gas in the air, the ESP32 will activate the fan to reduce the gas concentration, and 3) Fire detection: If the Flame IR sensor detects the presence of fire, the ESP32 considers it a fire emergency.

Figure 2 is a flowchart of the IoT-based Fire Protection System, starting from Initialization which will activate the ESP, gas sensor, temperature sensor, fire sensor, and GPS Module, then according to the predetermined conditions and will end.

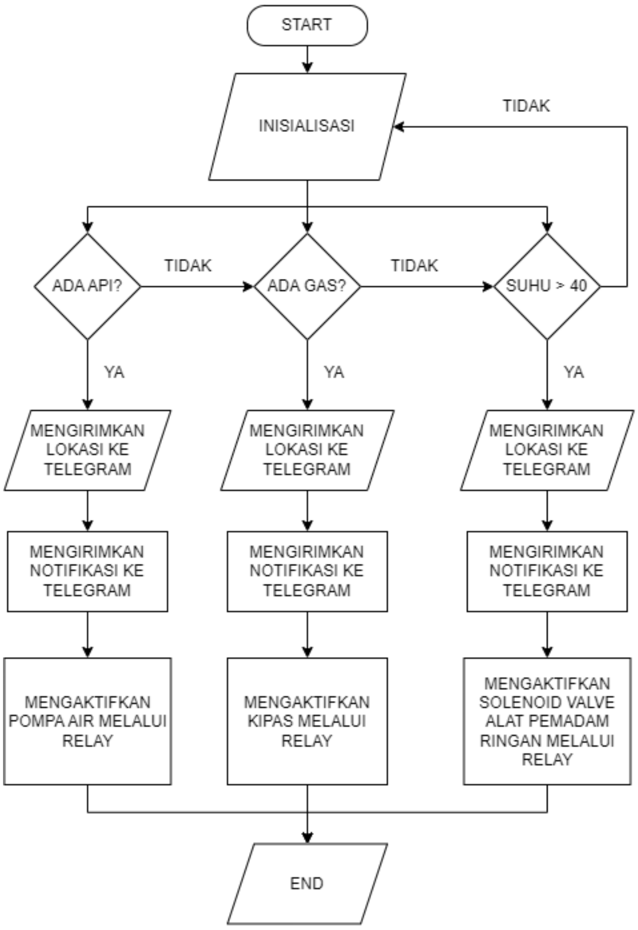


Figure 2. Flowchart of IoT based fire protection system

Figure 3 is a combination of all the used components when assembled with each other. In the picture you can see the PIN that connects the ElSP32 to the Relay PIN, DHT 22 Sensor, MQ-02 Sensor, Fire Sensor, and GPS Module.

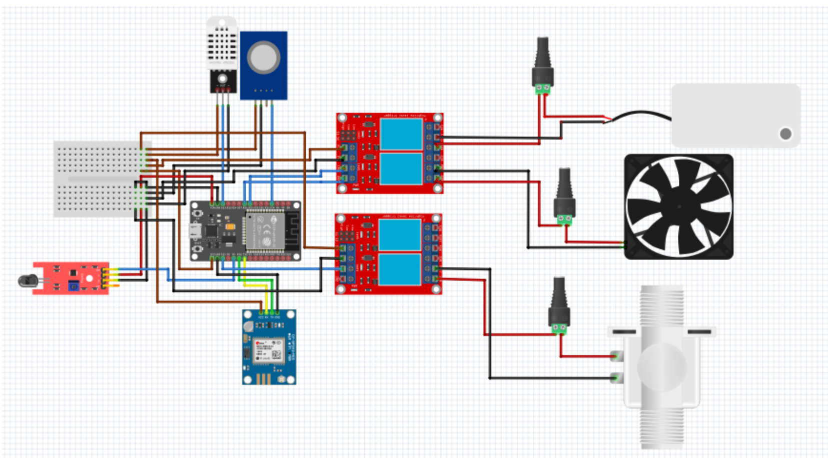


Figure 3. IoT based fire protection system control circuit

The tool for the IoT-based fire protection system is made in the form of a mini house. Figure 4 below shows the design of the IoT-based fire protection system.

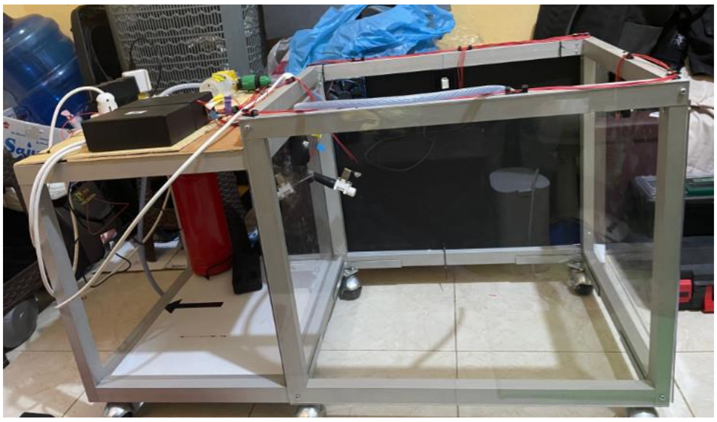


Figure 4. Mini house design

3. RESULTS AND DISCUSSION

The program design is done using the Arduino IDEL application. The program that has been created on Arduino IDEL will be uploaded to ElSP32 using a USB cable. Program testing is done to prove whether the program created is in accordance with the plan. Testing is carried out on all components connected to ElSP32. The components are DHT 22 sensor, MQ-02 sensor, flame sensor, and relay. After the program is uploaded, ElSP32 can directly connect to the Wifi that has been determined in the program created. With that, ElSP32 can connect to the Telegram application on the smartphone. The first program testing on the module was carried out for the cell, DHT 22 sensor, MQ-02 sensor. Figure 5 shows the sensor data in telegram application.

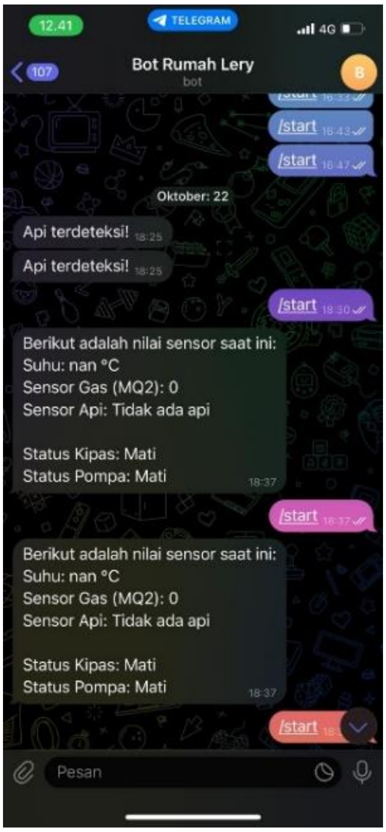
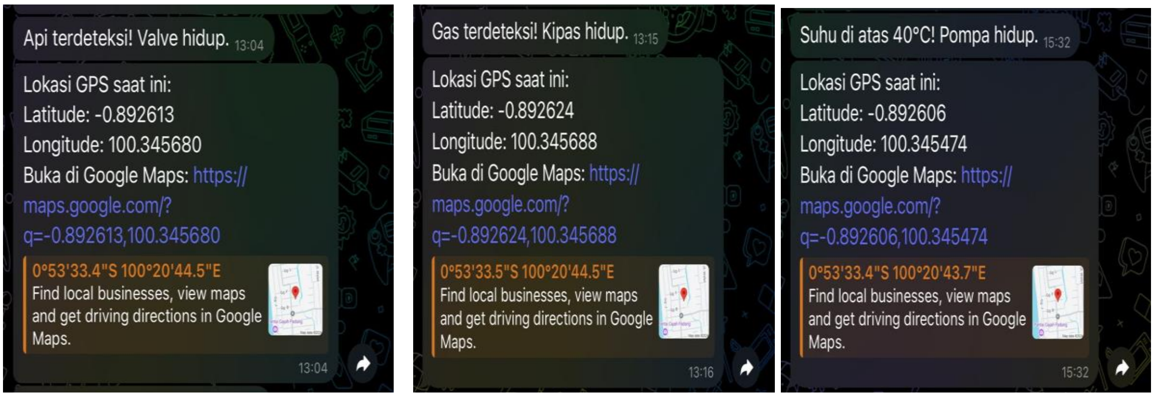


Figure 5. Sensor data in telegram application

This test is done to see the results of the Fire sensor, Temperature sensor, and gas sensor functioning when used by giving a temperature above 40 C, giving gas, and making fire. Figure 6 is a notification from the test of the IoT-Based Fire Protection System using Fire Sensors, Gas Sensors, and Temperature Sensors and measurement data from the sensors will be sent to the Telegram application. In Figure 6 it can be seen that the measurement data displayed is functioning properly.



(b) (c) (c)

Figure 6. Overall test results, (a) fire sensor notification test, (b) gas sensor notification test, (c) temperature sensor notification test.

4. CONCLUSION

Design and implementation of a fire protection system on a miniature house prototype that utilizes ESP32 with various sensors (DHT22, MQ2, and Flame Sensor) and actuators to reduce the potential risk of fire. This system is able to detect temperature increases, the presence of flammable gas, and fire. Based on data from the sensors, the system will activate the appropriate actuators, such as a water pump to lower the temperature, a fan to remove gas, and a solenoid valve on the APAR to extinguish the fire. In addition, with the integration of Telegram Bot, this system provides real-time notifications equipped with sensor data and GPS location, so that users can receive immediate warnings if dangerous conditions occur. With this design, a responsive and automatic fire protection system has been successfully realized, which is expected to be able to minimize the impact of fire on the prototype environment being tested.

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