IoT Based Smart Fire Monitoring System

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Abstract
Fire is one of the natural disasters which is very harmful. Fires mostly are caused by unforeseen situations such as electric leakage, gas leakage, neglection, etc. They are ignited by uncontrolled combustion of solid, liquid or gas substances. Flames, high temperature, and humidity are results of the fire. Moreover, a fire was observed to spread to the entire room within three minutes. So, when a fire occurs, it must be identified as quickly as possible, people must be evacuated, and the fire must be intervened. Late extinguished fires could cause loss of property and life. Therefore, early intervention in fires is very crucial. According to this, early fire detection systems are used to detect fires. For this reason, temperature, flame and smoke sensors are placed in settlements, and the system gives an alarm when a fire breaks out. Current conventional fire monitoring systems warn for the people, call the fire brigade, and initiate fire extinguishing system after detecting a fire. Unfortunately, they don't provide location information where the fire starts. Therefore, using a fire detection system which can identify fire on its first stages and show the fire location is very important. In this paper, an Internet of Things (IoT) based smart fire monitoring system including temperature, humidity, gas and flame sensors is proposed to identify fire efficiently and cost-effectively. The system is not only detecting fire and alarming, but also it informs both the fire department and predefined users when a fire breaks out.

Keywords: iot, fire monitoring system, single board computer, soc, mqtt.

1.Introduction

The Internet of Things (IoT) is a new technology that makes it possible to collect and analyze data from anything located anywhere without any limit [N. Shahid and S. Aneja]. This was due to the increase in wireless communication technologies and computing capacities and inexpensive costs [Godfrey and A. M. Abu-Mahfouz, 2018]. Wearable technology, smart city, and smart industry are some of the IoT applications [Keyur K Patel and Sunil M Patel]. Wearable technology is used for healthcare, entertainment, and advanced textile. Smart city applications are used to improve the management of resources in big cities. Industrial IoT instruments are used for uninterrupted, cooperated and optimized process controls. IoT leads to transformation of everything to a smart with high control. IoT allows physical objects to see, hear, smell, think and execute tasks thereby lowering human intervention in basic everyday activities by having them "speak" together, to share information and to coordinate decisions [Ashton, 2009], [S. Vashi, 2017]. IoT aims to build "a better world for human beings" in which interconnected items around us know what we like, want or need, and when. Thus, act accordingly without any explicit instructions [B. V. S. Krishna and T. Gnanasekaran, 2017]. For these abilities, the Internet of Things becomes the most significant innovation after smartphones [H. Yousaf, 2017]
Fires are ignited by uncontrolled combustion of solid, liquid or gas substances. Flames, high temperature, and humidity are results of the fire. The fire was observed to spread to the entire room within three minutes. So, when a fire occurs, it must be identified as quickly as possible, people must be evacuated, and the fire must be intervened. Therefore, using an efficient and effective fire detection system which can identify fire on its first stages is very important. We proposed a smart fire monitoring system to detect fire and inform both the fire department and predefined users when a fire breaks out. The paper is structured as follows. Section II materials and methods. Section III discusses the results of the system. Section IV discussion. Section V discusses the conclusion.

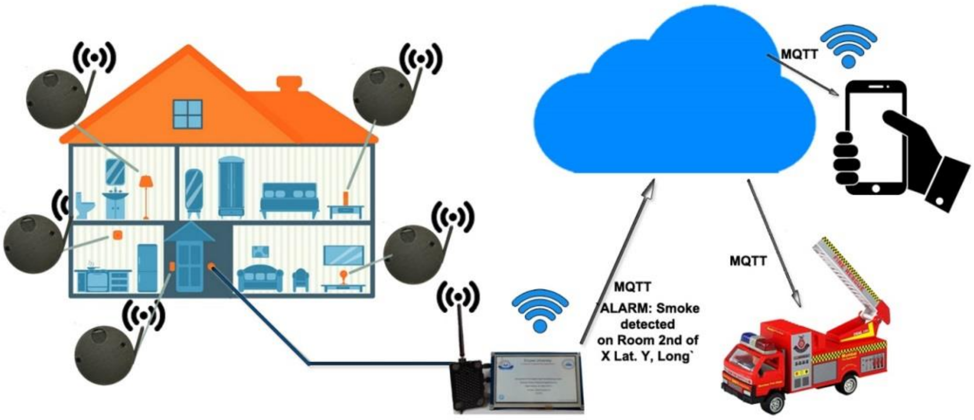


Figure 11. Schematic of the proposed IoT based Fire Alarm System.

2. Materials And Methods

The schematic of the proposed system is given in Figure 1. The implemented system consists of hardware and software parts. The sensor node and base station are the hardware part, including sensors, actuators, and LCD display. Sensor node device shown is in Figure 2(a) is used in each location to sense the situation of that place. Flame, gas, humidity, and temperature sensors are used in the node device. Each node sends periodic and triggered data to the base station with radio frequency. The second hardware part is the base station shown in Figure 2(b) which displays data collected from nodes wirelessly. The base station includes a single board computer and it is connected to the server system with the internet.
The software part of the system contains the cloud applications which are database server and MQTT message broker. The data sent from the base station are stored in the database. MQTT message broker sends notifications which published by the base station to the subscribers. These notifications include warning messages and alarm messages.

2.1 Methodology

A. Sensor Node: the first step of the system is to design and implement nodes that can effectively detect fires. So, in order to achieve this goal, we've implemented a complete circuit that contains ICs like sensors, actuators, and transceiver. The main IC of the node is a microcontroller (ATMega328P) which is programmed and used to coordinate all the processes in the node section. The sensors used in the node include temperature/ humidity (DHT11), gas (MQ7), and flame (IR Led) sensors. A radio transceiver IC (NRF24L01) is used to communicate with the base station. Each node establishes a connection with the base station by using a custom protocol to distinguish from other nodes as shown in Fig 3(a). Multiple nodes connected with the base station is given in Fig 3(b).
B. Base Station Device: The main central device of the system is a single board computer (Raspberry Pi) which communicates through RF and Wi-Fi. The base station controls nodes and collects data with RF IC. It uses Wi-Fi communication to send data to cloud with MQTT and REST API. A custom protocol is defined in order to communicate with the nodes. Each data packet consists of a header and payload. Each node is recognized with device ID which is given in the header. Base station transceives data with 6 nodes because of the limitation of the NRF24L01 IC.

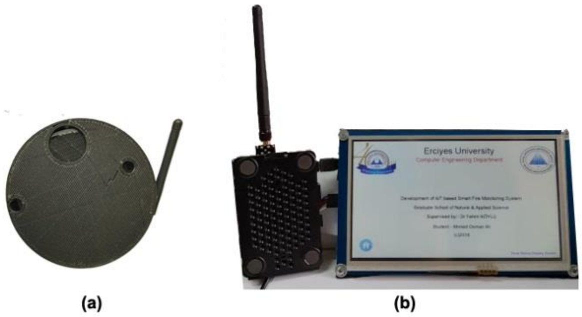
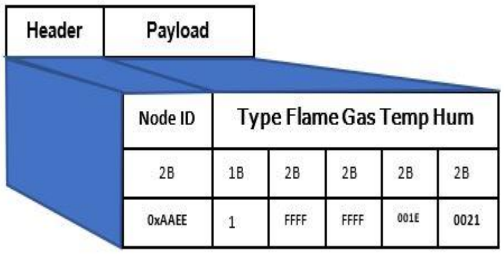


Figure 12. (a) The sensor node, and (b) base station of the proposed IoT based Fire Alarm System.



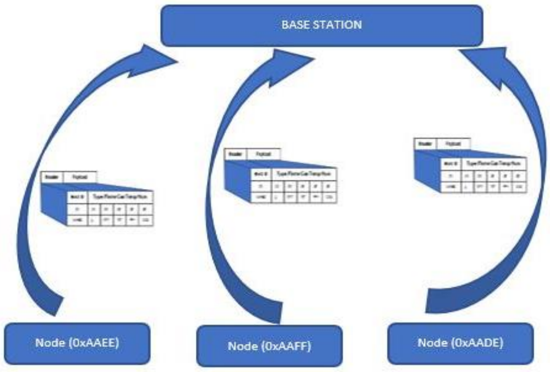


Figure 13. (a) Protocol Definition **Figure 14.** (b) Combination of Nodes

3. Results

Smart Fire Monitoring System is designed and build successfully. The system has software and hardware parts. The proposed system can effectively detect fire and monitor the physical environment where the data is shown on the screen and sent to some predefined users. As shown in Fig 3(a) each node has its own RF to send its value to base station independently from other nodes. Fig 3(b) shows the overall execution of the RF subsystem. The display systems interface screenshots in action are shown in Fig 4(a) and Fig 4(b). The interface displays all data coming from different sensors and making a warning if one of the sensors detects a fire. In general, the system monitors the surrounding sensitivity and informs as soon as possible if a fire breaks out wirelessly. Different tests on the system have emerged that the system is working effectively as designed.

4. Discussion

It can be identified from the tests and results that the proposed system detects fire efficiently and effectively, cheap and affordable to customers, and very easy to use. Also, the system can be installed in every building such as homes, universities, hospitals, etc. The system will have a wide applicable market and prospects. On the other hand, NRF24L01 IC has a drawback which has maximum 6 simultaneous connection. Installing of multiple base stations can be used to increase the number of sensor nodes.

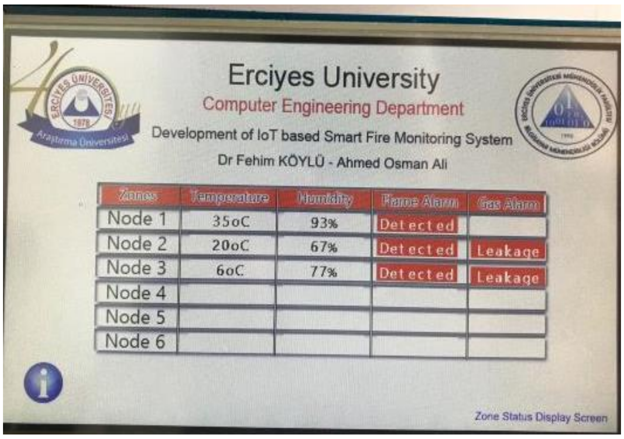


Figure 4. (a) Base Station Screen

Figure **4.** (b) Notification in Users' mobile phone

5. Conclusion

An effective wireless fire monitoring system is significant for securing many properties and saving humans' life. Different systems are developed towards this domain by using different technologies and methodologies. But most of them are not affordable economically and technically. Therefore, we've developed a complete wireless fire monitoring system for detecting fires efficiently to protect any property loss or human loss from a fire incident. The developed system is driven by ATMEGA328P microcontroller that is very cheap (less than 3 dollars) and can installed in every building. The system is using different sensors such as DHT11, MQ7, Flame to sense the physical environment and send the data to the base station through NRF24L01. Base station also sends important data such as alert messages to cloud using MQTT protocol. The range of the system is tested, and it is seen that the implemented system can provide coverage up to 1km square area in outdoor and 700 m square area in indoor. A 360-degree camera can be added to the system to reduce false positive alarms as future work, so that when a fire alarm is received the camera will be checked to make sure whether a real fire exists or not which will decrease the costs caused by unnecessary false positive alerts.

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