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IoT-based Fire Alerting Smart System

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Abstract

Fire alarm systems are critical for warning people before a fire make any damage to people's properties. Currently used fire alarm systems need many resources and a lot of work to install those systems. This deters people from installing them in their homes or companies. To overcome the difficulties of installing the existing systems, we propose an IoT-based fire alarm system that is simple to install in both households and companies. The proposed system is more effective than the existing systems. It is an ad-hoc network with multiple nodes spread around the premises where the system is to be installed. Each of these nodes is made up of an ESP8266 node MCU (programmable micro-controller) that is connected to carbon dioxide, methane, flame, smoke, humidity, and temperature sensors, which continuously monitor the surrounding environment in order to detect the existence of fire. The nodes set up their own wireless network. These nodes connect with a Raspberry Pi-based centralized system micro-controller with a 4G Advance LTE Module. When a node detects a fire, it sends a signal to a central node, which ensures SMS is sent to the fire department and users, this intern results in calls to the company staff and alerts the company by ringing the local alarm. At the same time, the sensing nodes form a mesh network and are connected to the central node through a bridge node. The Message Queue Telemetry Transport (MQTT) protocol will be used to communicate between the sensing node and the bridge node. The proposed system has a prototype that successfully performs the necessary functionality with an average latency and a delay of 20 seconds.

Index Terms: *Fire Alerting System, Internet of Things, MUC Node, Smoke Sensor, Temperature Sensor.*

I. INTRODUCTION

The term IoT, or Internet of Things is a relatively new technology that brings together devices in a network for communication between devices and the cloud. Internet is the base of the IoT concept, and it is portable to cover a whole group of things. This IoT technology power extends beyond telephones and computers. Connected devices can be used to establish a federation for information sharing and authentication [1].

A safe environment is necessary for businesses and people. It is the utmost priority for the workplace to be safe for the employees, therefore, IoT gives an opportunity to enhance existing fire alarm systems. It can help to make the workplace safer for people. This paper proposes an intelligent fire alarm system that uses the IoT to accelerate building evacuation, control/prevent the spread of fire, connect people to rapid and safe escape routes, and provide direct contact between building and security administrators/authorities [2].

In contrast to the two existing worldwide IoT-based smart fire alarm systems; a sealed detector with a fan system that captures air samples to identify potential dangers, and a sensor-based solution; the MUC node sensor, we propose an IoT-based fire alarm system that maintains protocol in a WSN this gives a significant advantage over reconstructing a new topology to meet the requisite strength. We tested the proposed system in a large-scale simulation scenario, the used algorithms produce a new version of the old one every time, so they acquire information from its neighbors. The topology creation protocol is used during the first phase of node connection. When the currently linked topology is no longer ideal, develop a new version of the prior topology based on the data acquired from the nearby topology maintenance method, inserting nodes optimally. It conserves node energy by maintaining critical network features such as coverage and connection during its lifetime. The network begins to fulfill its assigned functions after establishing a minimum topology. Each of the activities is linked to each other, which creates a new one based on past data and assigns the fewest resources possible resulting in minimal network cost. The reason being not all nodes engage in data collection, their energy is conserved by putting them to sleep, which is the goal of this research. The major goal of this study is to combine an IoT-based maintenance protocol with an existing topology construction protocol as an enhanced technique for conserving node energy and extending the lifetime of the monitoring system.

II. PROBLEM STATEMENT

Most companies rely on an old-style safety mechanism, i.e., the mechanism that depends on a set of sensors linked to each other in a particular region to provide an urgent notification in that area, alerting a safety officer to walk throughout the area to locate a fire. It is difficult to locate

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the root source and place of smoke and temperature detection, and extinguishing fire is also a challenging task. A delicate IoT mechanism-based automated fire notification system is the need of time, that has the ability to detect the place and origin of the fire and notifies (in minimal time), the firemen team or safety guards, as well as other people in the danger area.

Another issue is that several individuals are unaware of the different sorts of fire extinguishers, which makes the rapid self-extinguishing process difficult. As there are several types of fire extinguishers, each with its own set of materials that it can be capable of extinguishing, the usage of one of them simplifies the operation. Choosing an appropriate fire extinguisher device as required by the specification based on the type of fire is necessary in some cases.

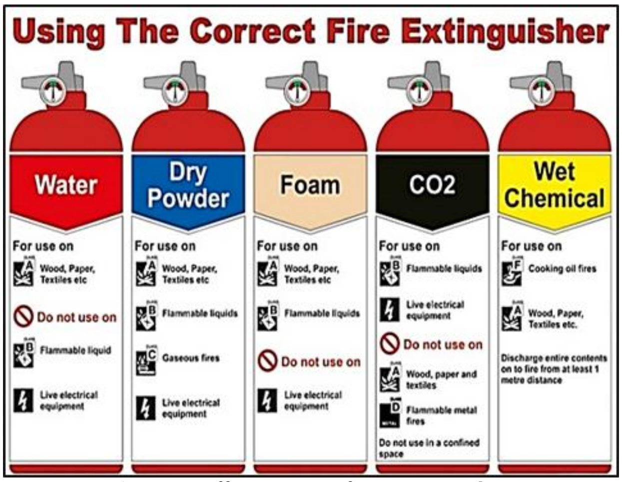

Figure I: Different Types of Fire Extinguishers

The objectives of this study are as follows:

- Compare the existing IoT-based fire detection systems already available in developed countries.
- Analyze and develop an IoT-based network system for companies.
- Develop a prototype of a fire alarm system to evaluate the effectiveness of the proposed system.
- Develop a smart fire alarm application for smart mobile devices.
- Evaluate the prototype and proposed system in the actual environment.

III. LITERATURE REVIEW

Traditional fire alarm systems use a variety of gadgets to notify people through visual and auditory devices in the event of a fire, smoke, carbon monoxide, or another emergency. These alarms are activated manually, such as suction stations, or they can be actuated automatically using smoke and heat detectors. The alarm can come with an electric chime and a horn or wall-mounted speaker that sounds the alarm; for example, you can add an audio evacuation message to warn people about not using the elevator in case of a fire emergency. Fire alarm loudspeakers are always set to a specific sound level with low to high volumes, which is determined by the country and the device's manufacturer. Many researchers have recently identified the major issue with traditional fire alarm systems [2], and [3]. One of the main issues is that current fire detection monitoring systems are resource-constrained and do not cover vast service regions. Secondly, in certain cases, uncertain conditions undermine the fire alert system's ability to detect fire. In recent years, the usage of ICT in fire detection has made its way. The usage of IoT technology in a fire detection system is one example. A fire net is one of the prototypes developed for a lightweight and effective fire alarm system, it detects fire using image processing and a Neural Network running on a Raspberry Pi [4]. The system is believed to be having a high level of accuracy when it comes to detecting fire using picture datasets. Similarly, another system using an android cell phone, which includes three sensors (smoke, light, and temperature), has been used to detect fire. The cell phone alerts the users if the temperature increases, i.e., it helps to prevent a fire if the sensor value exceeds the specified limit [5].

IV. PROPOSED SYSTEM

As shown in figure II the sensor at the fire site is connected to the cloud systems in one of the network domains. In this system, the cloud stores all the information in the database and performs the required action of sending signals to the client's smart device if he/she is online. At the fire's location, the notification appears as a fire icon. This app will be designed to work on all phones, including Android and iOS smartphones.

This IoT design depicts the operation of a connected artificial intelligent enabled fire alarm system. The impulse reader is immediately connected via the cloud. This way the online user will have access to the drawer through the internet using the HTTP protocol. This internet protocol can transfer different types of warning data to the user's smartphone app.

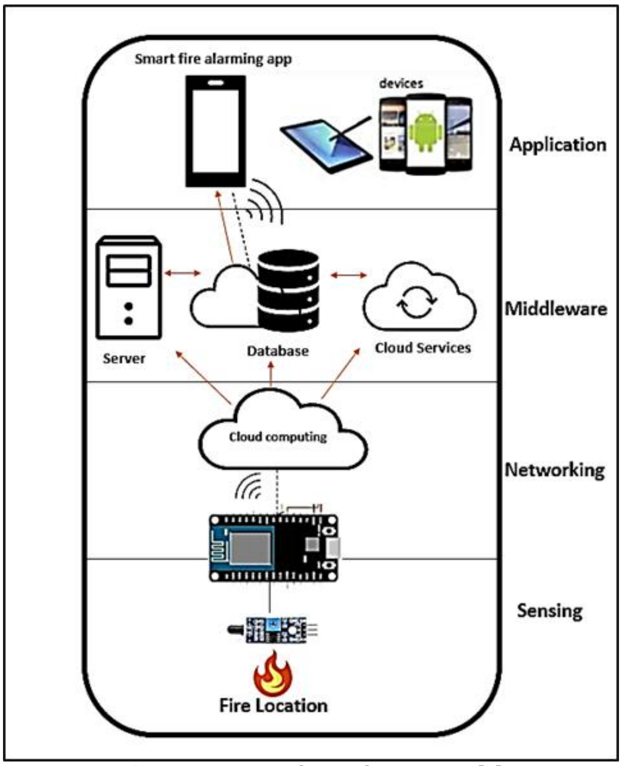

Figure II: IoT-Based Fire Alarm System [6]

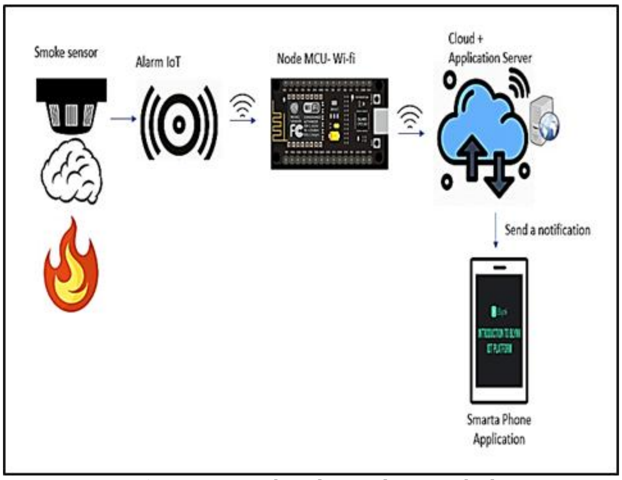

Figure III: IoT-based Fire Alarm Testbed

A. Flame Sensor

The 'Flame Sensor' is a device that detects the presence of fire in its immediate vicinity. Infrared flame sensors, ultraviolet flame sensors, and other types of flame sensors are available to be used, however, an infrared flame detector will be used for this system.

The infrared technology flame detector is made up of a photodiode coating in black epoxy that is responsive to infrared radiations with wavelengths ranging from 700 nm up to 1 mm and can detect fire up to 100 cm distance with a detection angle of 60 degrees. A three-terminal 'YG1006 NPN' Photo-transistor is used in this photodiode.

Fire emits a certain number of infrared photons, which the photodiode detects. To get changes in current voltage, an operating amplifier is connected across the photodiode. Usually, when voltage is zero, the digital output on the amplifier is "1", but if the voltage is detected in case of fire, the digital output value is "0" [7].

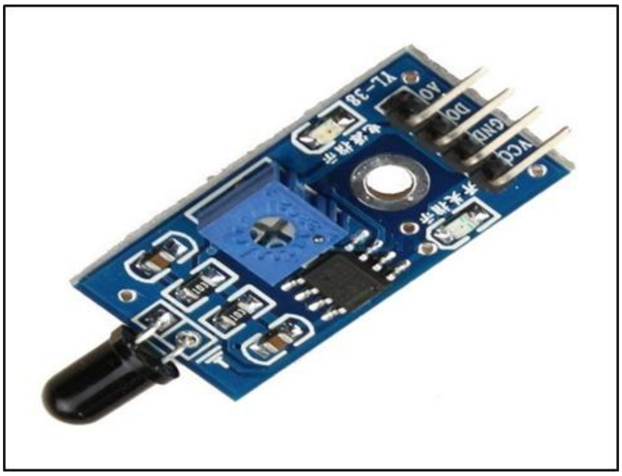

Figure IV: Flame Sensor [8]

B. ESP8266 Node MCU

This is open-source Internet of Things (IoT) environment. It comprises of the software that operates on Express Systems which costs less than Wi-Fi supported 'ESP8266' Wi-Fi SoC and hardware based on the ESP-12 module. SPI, GPIO, ADC, ADC, UART, and PMW pins are integrated for controlling and communicating with other devices. The 'CP2102 IC' on board the node MCU provides USB to TTL capabilities. GPIO pin is used for retrieving digital information from the flame detector in this IoT Fire Alarm [7].

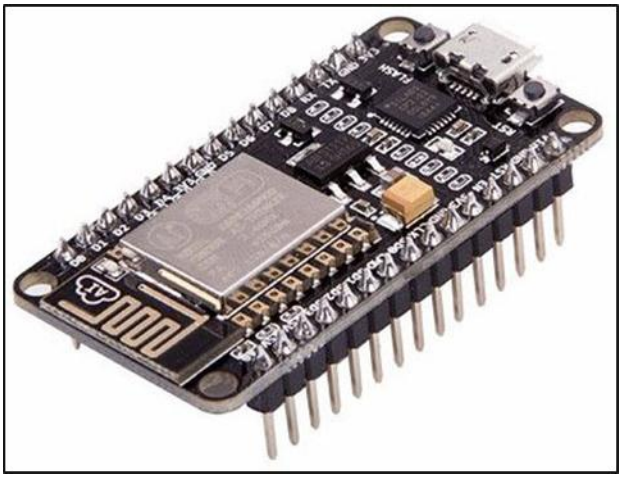

Figure V: ESP8266 Node MCU [7]

C. Cloud Computing

The offering of numerous services over the internet is known as cloud computing.

These resources include data warehouses, servers, databases, networks, and software, as well as other tools and applications [4], and [5].

Figure VI: Cloud Computing [9]

There are three main types of cloud computing services:

- IaaS Infrastructure as a Service.
- PaaS Platform as a Service.
- SaaS Software as a Service.

Table I: Advantages and Disadvantages of Cloud Computing

Disadvantages	Advantages
Often Loss of Security	Usage of a minimized cost of bandwidth savings: After some time, there will be no need to have a budget for servers, other computer peripherals, applications, or information center operations
Technical Issues	Data backup and restoration
Loss Control	Software integration is done automatically
Some Clouds have Limited Features	Mobility

Network Connection Dependency	Reliability: The cloud provides low-cost backups in the event of a natural disaster
	Self-service is provided by the cloud. It can quickly and flexibly utilize a vast number of computational resources

A temperature detector is an electrical device that can monitor temperature using an electrical signal, such as a thermal device or RTD. Dual (T/C) is made up of two different metals that create electrical voltage at a constant rate while temperature changes [10].

V. METHODOLOGY

Providing any kind of services over the internet is termed 'Cloud Computing. Resources, usually include data warehouses, different types of servers, database management systems, computer networks, and a set of software applications, with other types of tools. V-Model (pronounced as Vee Model) is one of the most famous methods of developing software [11]. The full form of the V-Model is Verification Software Development Process Model. This is a step forward from the waterfall model and is analogous to the process of consecutive steps traveling down a linear path. However, after coding, the next step is to do a V-form. The relationship between the stages in Software Development Cycle is shaped in V form [12].

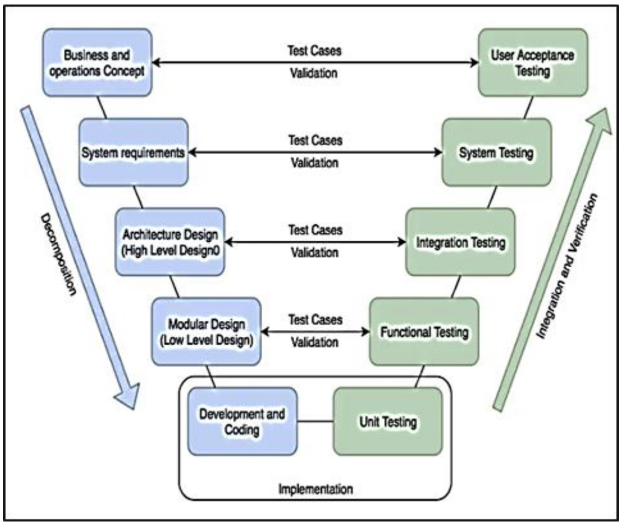

Figure VII: V-Model Phases [13]

The Reasons to select the Methodology to select V-Model are as follows:

- Reduces the amount of rework by catching flaws and problems early.
- Helps with project risk management.
- System validation early in the development process ensures higher quality.
- Other models, such as iterative and agile, can be integrated with the V-Model.
- Creating results is simpler and easier.
- Users can contribute to the development of the system.
- The system can be completed in a timely and cost-effective manner.

VI. RESULT AND DISCUSSION

The major capabilities of the IoT-based Fire Alarm System have been evaluated using a prototype.
Figure VIII shows the system's experimental setup. In the LCD display, the results of all sensors can be seen. When the system detects a fire an SMS and a phone call are made to a registered phone number. At the same time, the buzzer begins to sound.

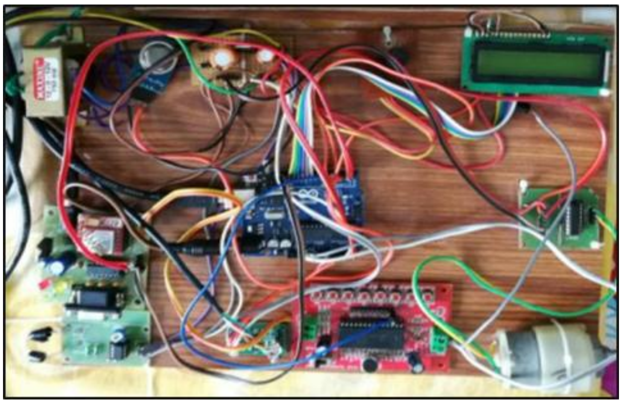

Figure VIII: Experiment Setup IoT-Based Fire Alarm System

To test the functionalities of the IoT-based Fire Alarm System, the following functionalities were tested.

A. User Notification

The developed system was used to test the features of informing the user in the event of a fire, and the latency in calling the user was measured. Table II shows the trail of end-to-end delay measurement. Furthermore, the prototype successfully sent an SMS to warn the user and the fire department, with an average delay of 20 seconds.

Table II: End to End Delay (User Notification)

Trail Number	End-to-End Delay
1	21.50
2	19.40
3	20.00
4	18.50
5	22.10
6	18.20

B. Acquiring Sensor Value

The developed prototype is used to test the features of acquiring the value of the sensor, the system successfully sent SMS to the fire alarm system and acquired the exact value of fire, temperature, smoke, humidity, and flame. The delay of the acquired values is shown in table III below. The acquired values from the sensor show an average of 21.16 seconds.

Table III: End to End Delay (Acquiring Value from Sensor)

Trail Number	End-to-End Delay
1	21.50
2	22.40
3	21.30
4	19.50
5	22.10
6	20.20

C. Ad-Hoc Networking

Wireless communication allows nodes to communicate with each other. The nodes are spread across a large area, to make communication possible. The test was carried out to determine the maximum permissible distance between two nodes, when the walls are present, the maximum distance between the two nodes is 20 m.

D. Scalability and Reliability of the System

The developed prototype worked well and has the capability of scaling up. The IoT-based Fired Alarm System scalability was tested by adding nodes and testing the functionality. A node was removed to test the dependability, and a message and SMS were still successfully delivered to the users to warn them.

E. Sensor Node

The sensor functionality, which includes connecting each sensor node to the 'ThingSpeak' server, will be visible by delivering the sensor reading. The MCU is used in the creation of the sensor node. MQ-2 gas sensor, LDR light sensor, and LM35 temperature sensor were employed. The results of sensor testing utilizing a mesh and star topology are shown in figure III, which can be viewed on the ThingSpeak platform. The goal of this paper is to show the materials that facilitate the process of creating a scheme for implementing a smart fire sensor to reduce huge disasters because of a small fire, which can be controlled through internet-aided notifications and alerts to help send notifications to the fire team faster and to reduce huge losses.

VII. CONCLUSION

In conclusion, the proposed system could meet the primary goal, which was to create an effective IoT-based fire alarm system capable of detecting fire, humidity, temperature, smoke, and flame. It's also capable of sending and receiving SMS and messages, as well as obtaining precise sensor data. The paper discussed and the proposed system is based on the Internet of Things technology. Technology has taken over the globe and people's lives, and we use it in all aspects of our everyday life; it is continuously evolving and giving significant benefits to society. Homes, buildings, and forests can all benefit from the sophisticated fire detection system. This study specifically focuses on universities or government buildings in the Middle East. This system has numerous advantages, including the capacity to reduce the time required for building evacuations, rapid interaction with those engaged in the evacuations, as well as the ability to ensure people's safety by guiding people who are at risk to the nearest exit, this emphasizes the significance of a sophisticated fire detection system.

There are reasons that contributed a lot to the delay of this project. The first reason, Covid-19 contributed a lot to the delay of the project and caused a delay in purchasing physical devices. Secondly, the suspension of the study prevented us from attending and performing practical work.

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Authors Contributions

The contribution of the authors was as follows: Raza Hasan's contribution to this study was the concept, project administration, and correspondence. The methodology to conduct this research work along with data collection, and validation was proposed by Ibtehal Mahfoodh Muhammad Al Hasani, and Syed Imran Ali Kazmi. Reehan Ali Shah facilitated supervision, and compilation along with Saqib Hussain. All authors jointly facilitated the technical implementation and paper writing.

Conflict of Interest

There is no conflict of interest between all the authors.

Data Availability Statement

The testing data is available in this paper.

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