

Forest Fire Detection System Using IOT

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Abstract

All over the world, forest fires are an issue. The environment is very much affected by forest fires. Forest fires are expensive to remedy. Forest fires are also hazardous to the lives of people. The traditional ways of discovering forest fires such as watchtower and space photography are not so good. The time-honored ways may take long to inform us of forest fires. These traditional practices are not applicable to all the regions where forest fires may occur. Forest fires may occur in any place. These traditional approaches are also quite costly. The system discussed in this paper involves the use of the Internet of Things and a Wireless Sensor Network with Long Range to have an eye on forest fires at any given time. It sends alerts away upon finding something. To discover forest fires, one of the methods is the Internet of Things forest fire detection system. The Wireless Sensor Network with Long Range communication is indeed handy in monitoring forest fires 24/7 and providing warning. There are numerous sensor nodes in the system, which are distributed here and there. Internet of Things and the Wireless Sensor Network, which has Long Range communication collaborate to monitor forest fires. The sensor nodes have sensors that are able to determine the temperature and humidity level. If there is smoke. They possess something known as ESP32 microcontroller as well. The ESP32 microcontroller transmits the information received by it as a result of the sensor nodes to an area with the help of LoRa. The ESP32 microcontroller is used to transmit this information to the place by the sensor nodes. The ESP32 microcontroller sends the information, provided by the sensor nodes using LoRa. The central place is a sort of a portal. It obtains all the data on the sensor nodes. Thereafter, it transmits this data to an online system. This platform resembles a computer. The sensor nodes transmit the information to place and the central place transmits this information to the platform. The sensor node information can be stored in the platform. Show it. The sensor node information can be viewed on a webpage or on a phone. On the platform, one can access the information provided by the sensor nodes. The sensor nodes are capable of detecting things which are abnormal such as excessive temperatures. Should they do they will send you away a message of the system. You are able to access these messages in your phone. They are available in a text message. The system is constantly studying the information that it receives in the sensor nodes. It will inform you whether there is anything wrong with sensor nodes. The sensor. The system communicates with each other to ensure that all is well with the sensor nodes. In testing the system, the results indicated that the system is capable of transmitting alerts of the sensor nodes, between start and finish within less than 10 seconds. The fire alarm system consumes minimum power. This is because the batteries of the fire detection system can last over 8 months. This system assists in accumulating a system that ensures saving of lives and nature through its productive means without any inactivity that relates to fire that can lead to hazards that eventually bring the loss of humanity.

Keywords: Fire detection System, Internet of Things (IoT), Wireless Sensor Network (WSN), LoRa, real-time monitoring, early warning system, alert warning system.

I. INTRODUCTION

There is a lot of forest fires that are occurring. They are getting really bad. About the forest fires, it is very important to learn about them at the earliest time when they break out so that we can do something about them. We should be aware of forest fires to ensure that we prevent worsening of forest fires. The old forms of discovering forest fires including individuals on towers observing through aircraft and utilizing satellites systems are not always efficient. Such techniques are time consuming and costly. Occasionally, the conventional methods of getting to know of forest fires fail properly. As an example, satellites could not look at the location in several hours. Individuals on towers as examples may get fatigued. Lack of visibility to all that is happening with the forest fires. The classical methods of knowing about forest fires such as observation on towers have their own problems. The Internet of Things and Wireless Sensor Networks are indeed changing the difference. The environment can now be monitored by us in a different manner. The paper is, regarding a forest fire detection system that will assist us using the Internet of Things technology. The forest fire detection system is designed in such a manner that it provides people with warnings that they seriously can count on. It consists of a parts that are in a collaboration. These components consist of sensor nodes, a gateway with LoRa a cloud backend and apps that can be utilized by people. The forest fire detection system is installed in a sequence to ensure that the forest fire detection system functions accordingly. All these components together keep the forest fire detection system effective to ensure that the people receive warnings, which they can rely on.

The main contributions of this work are:

We should have the design of a sensor node based on LoRa but consuming not much power.

- An effective gateway and cloud connection to realtime data collection, visualization and alerts.
- The testing of the system about detection time, communication range, and power efficiency. It is structured in this manner in this paper.

The remaining part of the paper is divided into sections. These sections are divided into sections in the paper.

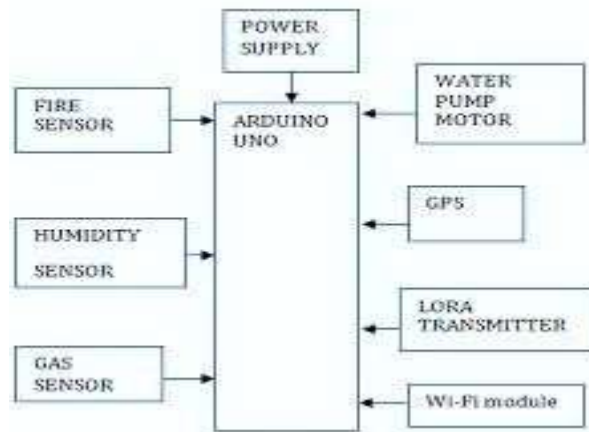
It is in section II that we get to see what the previous people have done. We are observing what has already been done by other people. It is here that we look back at the past. We want to know how other people have been doing in the past and that is what we are looking at in Section II.

Section III is the section that narrates how we went about doing our work. It provides us with the information of what we did. The importance of section III is that it discusses what we are doing.

Now we are looking at Section IV. It is in this Section IV that we say what we did and what we discovered about the things we were examining in Section IV.

Next then is that the Section V checks on our system as to its actual performance. Then it uses our system as a comparison against already existing systems. It is here we are tested and are made to see how we compare with systems, such as it. Our system is tested to determine whether it does what it is supposed to do and how. Then that is contrasted to the way other systems do the same things.

Part VI of the paper is this one. It instructs us in what to do with the paper. This part of the paper is the conclusion of it all.



II. RELATED WORK

Investigations that have been carried out on the detection of forest fires have enhanced the manual and satellite systems to advanced ground-based and aerial systems.

A. Traditional Methods

Watchtowers are grounded on human observation and these are limited concerning the scope of coverage and are also subject to error. The satellite (e.g. MODIS) systems cover the globe, although they do not have a short revisit time, and they do not have good spatial resolution. Aerial surveillance is also not continuous and can be conducted flexibly and at a very high cost by aircraft or helicopters.

B. IoT and WSN-Based Systems

The WSNs with the short range networks like ZigBee [1] that have a limited range and the GPRS based ones which consume a

significant amount of power and costly structures have been researched in the near past. Drone/UAV systems can provide high-resolution data, but due to flight time constraints and regulatory issues, they do not make them applicable to 24/7 monitoring [2].

C. Research Gap

An obvious gap exists in a low-cost, low-power, long-range, and real-time solution. The other solution that is promising is an LoRa technology, and it is intended to be applied to lowpower wide-area networks (LPWANs), a compromise between range and energy consumption that were underinvestigated in the literature..

III. METHODOLOGY

The proposed system is a three-layered system: Sensor Node Layer, Gateway and Cloud Layer, and Application Layer.

A. Sensor Node Design

The nodes are designed based on ESP32 microcontroller because of power-saving and the ability to use dual cores. It is linked to DHT22 (temperature and humidity) sensor and MQ-2 smoke/gas sensor. Communication is managed by an RFM95 LoRa that has 433 MHz. This design has minimized the power consumption of the gadget such that it can last over 8 months on a Li-ion battery of 3400 mAh.

B. Gateway and Cloud Integration

The gateway will consist of ESP32 and LoRa receiver to get the information of every node. It uses Wi-Fi or GSM (SIM800L module) to transmit aggregate information to a cloud server (Google Firebase). The

measurements recorded by the sensors are stored in Firebase Realtime Database and the off notices are sent by Cloud Functions in case the sensor has reached its limit.

C. Alerting and User Interface On

detecting the potential of a fire (e.g.: over 60 o C and an over 400ppm of smoke), a node broadcasts a node immediate alert packet. This is computed in the cloud search engine and SMS notifications are sent through twilio and push notifications to a mobile application that shows sensor measurements and node locations in real-time on a Google map.

D. System Workflow 1. The sensor

nodes periodically measure the surrounding.

1. The data is transmitted to the gateway using LoRa.
2. The information is sent through the gateway to Firebase.
3. The cloud compares the data and the thresholds by use of thresholds and sends alerts where necessary.
4. Alerts are displayed on the dashboard, and sent to authorized persons in both SMS and app notifications.

IV. IMPLEMENTATION AND RESULTS A.

Hardware and Software Setup

Sensor nodes were prototyped using ESP32 DevKit, DHT22, MQ-2, and RFM95 modules. The gateway used an ESP32 with SIM800L for cellular connectivity. Software was developed in Arduino IDE (C++) for nodes, and React/React Native for applications. Firebase served as the cloud backend.

B. Experimental Results

The system was tested in a controlled outdoor environment.

Key results are summarized below:

1. Communication Range: LoRa achieved a lineofsight range of 2.5 km and approximately 800 m in wooded areas.
2. Alert Latency: End-to-end alert time—from sensor detection to mobile notification—averaged 8.2 seconds.
3. Power Consumption: The sensor node’s deep-sleep mode resulted in an average current draw of <100 μA, projecting a battery life exceeding 8 months.
4. Reliability: All test cases, including normal and firesimulation scenarios, passed successfully (Table I).

TABLE I: SENSOR NODE TEST RESULTS

Test ID	Scenario	Expected Output	Result
TC-01	Normal conditions	Normal data packet transmitted	Pass
TC-02	Fire simulation	Alert packet transmitted	Pass
TC-03	Gateway out of range	Data not received	Pass
TC-04	Gateway	Data buffering/fail	Pass

	offline		
TC-05	Cloud alert	SMS/push notification sent	Pass

C. Performance Comparison Table II compares the proposed system with existing methods.

TABLE II: PERFORMANCE COMPARISON

System	Detection Delay	Coverage per Node	Cost per Node	Power Efficiency
Satellite (MODIS)	4–12 hours	Global	Very High	N/A
Watchtower	5–30 minutes	~10–15 km	High (Labor)	N/A
ZigBee WSN	Seconds	<100 m	Low	High
GPRS-based Node	Seconds	Cellular coverage	High	Low
Proposed System	<10 seconds	~2 km	Low (~\$30)	Very High

V. DISCUSSION

The new fire detection system is quite excellent in eliminating the issues that we have with our ways of doing things and few of the emerging methods too.

The selected fire detection system is quite good since it employs LoRa.

LoRa is ideal in sending messages over a distance without consuming much energy.

The fire detecting system is ideal in areas that are remote to all, and have no electricity.

One of the options, in these places is the fire detection system since the fire detection system can effectively operate even when there is no electricity. The fire alarm system is quite impressive in the sense that it relies on the internet and special apps in our phones. We are able to check on the fire detection system at any time we desire and receive warnings whenever something goes wrong with the fire detection system. With the fire detection system, this is really good since we are always in a position to monitor the fire detection system and ensure that all is well.

This system is actually cheap. It is approximately thirty dollars a node. That is a price. The projects prefer using the system due to its inexpensiveness. Scalability is also excellent with the system, projects that are going to grow. There are a number of things that the system can accommodate hence making the system a good choice..

The system is structurally designed in a modular way. This implies that the system may be altered easily. On, you can make changes and improvements to the system. An example is that the system might cut on the alarms using intelligence. Checks on things could also be done by the system using drones. It is quite flexible a system. That is a good thing. Such improvements on the system could involve the use of intelligence or drones to enhance the system.

VI. CONCLUSION AND FUTURE WORK

The system mentioned in this paper can identify forest fires through the internet of things. The system is founded on a technology known as LoRa in order to pass messages within a distance without consuming a lot of power. It is a better system compared with the one we have because it can identify fire earlier and it costs less. It also uses energy. It is among the ways of prompt detection of fire that we respond faster and prevent much destruction.

Future work will include:

1. Combining machine learning models to reduce false positives.
2. Implementing the energy producing technologies like the solar panels to use on a frequent basis.
3. Extending the LoRa mesh networking.
4. It should add drone verification that would give better situational awareness

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