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LPWAN Based IoT Surveillance System for Outdoor Fire Detection

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ABSTRACT Many fire situations have represented the loss of lives and material costs due to the lack of early fire detection through smoke or gas sensing, which can become complex and critical. Meanwhile, engineers worldwide develop and test multiple systems for smoke and gas detection, commonly based on sensor networks, digital image processing, or computer vision. Furthermore, the detection system must work thoroughly with alarms and warnings that aware of a risk situation for prompt evacuation of the population in the surroundings based on a reliable data network topology with adequate device deployments that will let us know the moment a fire outbreak. This paper presents a low-cost Internet of Things (IoT) prototype for fire detection in outdoor environments based on sensors and Low Power Wide Area Network (LPWAN), focused on the accuracy in the temperature and gas measurement at the moment a fire starts. For its achievement, we integrated wireless components, development boards, and electronic devices, following the management of information updates through a database schema for the alarm settings based on the data gathered from the sensors.

INDEX TERMS Database systems, emergency services, gas detectors, sensor systems, temperature measurement.

I. INTRODUCTION

Wildfires burn and consume everything along at fast speeds by rolling flames traveling up to 14 miles an hour, equivalent to a four-minute mile pace [1], affecting land populated with flora, fauna, and humans, which represents problems from a social and environmental viewpoint [2]. They come from natural phenomenons as well as from human activities such as farming, logging, or civil constructions, leading to forest devastation and its consequences.

In the United States, the destruction caused by wildfires has increased in the last two decades, with an average of 72,400 wildfires cleared an average of nearly 7 million acres of land each year since 2000, doubling the number of acres scorched by wildfires in the 1990s [1]. Similarly, the Amazon region has experienced a rise in fires during recent years. Based on information supported by satellite data reports from the Brazilian Institute for Space Research, more than 74,000 fires were registered between January and August 2019. As the largest rain forest worldwide, this region is a vital carbon store that slows down the pace of climate change [3]. Also, most Latin American countries lack adequate fire aerial suppression capabilities and mainly use ground suppression techniques. Besides, many of these countries do not have professional ground crew firemen, counting with voluntary brigades from local communities with firefighter-oriented training.

False wildfire alerts result expensive due to logistic deployments. They could turn into contrariness for fire departments, because of tie-ups caused during a commotion that could lead to a panic [4], especially if they are the result of human actions that generate dust, pollen, fog, or smoke [5]. Therefore, a reliable fire detection system is essential for fire protection in both indoor and outdoor situations.

Satellite-based monitoring has been a popular method for wildfire detection, but due to the long scan period and low resolution, its effectiveness is limited. For example, satellites such as the AVHRR and the MODIS, were deployed for forest fire detection. Unfortunately, they provide earth images intermittently and are susceptible to weather conditions that can affect the given image quality [6].

The progressions in other wireless technologies, such as wireless sensor networks (WSN), have contributed to the development of IoT solutions aimed at several industries.

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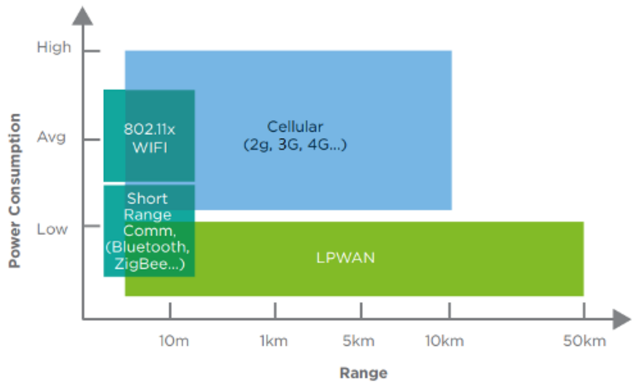

FIGURE 1. Wireless technologies comparison.

TABLE 1. Gas tolerable critical values for short-term exposure.

Compound	Formula	Values for Human Escape (ppm)
Hydrogen cyanide	HCN	80-100
Hydrogen chloride	HCl	50-1000
Benzene	C_6H_6	1500-4000
Nitric oxide+Nitrogen dioxide	$NO+NO_2$	100
Sulfur dioxide	SO_2	150
Chlorine	Cl_2	50
Cobalt chloride	$CoCl_3$	12.5
Amonia	NH_3	2500
Carbon monoxide	CO	1500-4000
Carbon dioxide	CO_2	40000-80000
Oxygen	O_2	60000-100000
Temperature	C	140
Smoke	OD	0.22 m^{-1}

Additional technologies and devices like barcoding, smartphone, social networking, IPv6, mobile communication, radio frequency identification (RFID), WiFi, WiMax, and cloud computing support IoT applications [7]. Further, WSN usually deploys a large number of autonomous and resource-limited nodes that cooperate to perform sensing tasks into a specified area. The sensor features include sensing, processing, and conveying of data to a central station [8]. A suggestion to use applications based on WSN is that they are becoming attractive for monitoring, measuring, and controlling real-time situations, including prediction features. Besides, self-organized sensors approach efficiently to algorithms interfacing with other technologies aiming to protect the wildlife, human life, and assets [6].

A term that arises is LPWAN, which covers several technologies oriented to connect low-power devices that integrate sensors and controllers in IoT scenarios. The IoT communications require a WSN that fulfills requirements, such as long-range, long-battery life, and low-end point cost [9], [10]. Moreover, the junction of two features in communications: low power (regarding the consumption of energy) and wide area network (regarding long-range during the conveying of information) composes LPWAN. Those features define its two intrinsic characteristics, such as a small power budget (i.e., longer battery life) and an extended range of transmission. It also highlights the low cost and the low data rate it needs to operate, which are much-needed features for IoT applications. In theory, it provides long-range communication up to 10–40 km in rural zones and 1–5 km in urban zones [11].

LPWAN is not a single technology because it embraces a wide range of technologies that operate through either licensed or unlicensed spectrum, and comprise of proprietary, alliance or open standard options. Furthermore, engineers and scholars use it to implement WSN for IoT applications according to conditions, such as cost, coverage, and power consumption during transmission [9], which are features to consider at the moment of designing a proposal for sensing and monitoring. Fig. 1 [12] presents a comparison of wireless technologies based on their power consumption and coverage range.

A reliable fire detection mechanism requires multiple sensors to perform functions for detecting heat, chemical compound-smoke, and flame. The reliability of our proposal lies in the solar panel energy feeding option provided to the sensors in case of battery life issues, considering that most of the time outdoor scenarios do not count on either fixed or intermittent of electricity sources. In addition, the characteristics of the combustion materials were well determined in the sensors configuration to trigger an alarm when a risk situation was high enough, considering the threshold values for a tolerable human short-term exposure depicted in Table 1 [13].

This work is organized as follows: Section I provides a brief introduction that clarified the background for implementing this proposal. Section II presents the related work, describing what other authors have developed regarding this topic and the progress in fire detection systems. Section III presents the prototype development, addressing the deployment aspects of the electronic devices involved and the budgeting with cost details of the components employed. Section IV describes the system integration through a methodology that includes sensor threshold calculations and database management information. In the end, Section V presents a discussion based on the proposal development and potential enhancements to pursue.

II. RELATED WORK

Literature regarding the development of fire detection and prevention systems is available to compare the progress achieved in practical approaches for monitoring and control solutions. For example, the authors in [14] presented the integration of data regarding fire risk assessment, fire detection, safety situation awareness, among other aspects for the displaying of alerts through smartphones for underground miners optimize an evacuation process. Their proposal consisted of a wireless network system structure based on an IEEE 802.11 backbone, composed of several Wi-Fi nodes for communication with a surface control center and the fire safety system. They used smart technologies for a continuous information flow for the improvement of fire safety, detection, and evacuation procedures as a framework for this type of industry.

Another prototype oriented solution is presented in [15], where the authors focused on early fire detection and monitoring based on WSN deploying four sensors to measure parameters such as temperature, air humidity, carbon monoxide, and smoke in a home environment. This prototype communicates a Raspberry Pi with a database through Internet connectivity as well as with end devices that monitor the parameters previously mentioned. The data collected calculated a fire probability value using rule-based fuzzy, testing simulating environment conditions based on programming.

Different approaches and how different components integrate for the detection, either indoors or outdoors, are available for comparison, too. For example, a proposal focused on the measurement of smoke in indoor environments is available in [16], where the author implemented a fire detection system for houses by smoke sensors that communicated to a central station for monitoring through active devices using alarms and speakers appointed into the rooms. The Arduino technology and microcontrollers to interface with servers based on PHP and MySQL were the tools conceived for the monitoring station. Their objective was to contact a fire department once the fire outbreak could not be suppressed by a robotic arm connected to water suppliers.

Comparably, the authors in [17] present an example of fire detection in both indoor and outdoor plots using WSN based on a ZigBee RF module. This proposal included a system performance portraying error testing and time delay recovery, as constraints during the performed scenarios. Furthermore, their design included temperature sensors, smoke sensors, an LCD circuit, and an XBee device, showing results of working steadily in distances of approximately 30 meters for indoor and 100 meters of outdoor measurements. Even though ZigBee is a short-range communication technology in the unlicensed spectrum of 2.4 GHz, scholars use it for establishing communication proposals, because of its easy integration with interactive graphical interfaces, its low transmission rates, and its low power consumption [18].

Furthermore, review papers are available to realize the importance of recent progress in this topic, where researchers present the trending state of knowledge in fire detection systems and techniques. For example, in [19] the authors analyzed the current forest fire detection techniques based on WSN, remarking advancements, contributions, and benefits. They recommended an efficient early detection system deploying sensor nodes in high-risk areas, with the presentation of components for implementation in harsh environments. They considered the size of the sensors, energy-efficient analysis, cost/benefit relationship, which leads to technical challenges in IoT solutions, such as government regulations for spectrum allocation, security, battery issues, costs, and privacy [7].

Another review is given in [20], where the authors presented an overview of the up-to-date practices of sensing and fire control. Here, the authors addressed the need to reduce the detection of false positives through reliable systems that warn to a fire department by controlling functions. In addition, they discussed aspects related to different types of fire sensing techniques, classifying them in the sensing by heat, gas, smoke, flame, and others, including a summary and description of existing fire sensing technologies and their characteristics. At the end of their review, they presented a fire sensing and control system using a sensor array to measure heat, smoke, flame, gas sensing, and temperature from the surroundings by online sensor calibration techniques and GSM alerting. Their system measures electrical cable temperature and loads conditions in real-time when the fire outbreaks, collecting data from sensors and cable measuring parameters, allowing remote monitoring and control using IoT techniques.

III. PROTOTYPE DEVELOPMENT

The focus of our prototype is oriented to an early smoke detection in outdoor environments to reduce hazards to the minimum an affected area by prompt and reliable alarm notifications, following the premise that outdoor fires are widely uncontrollable, turning into high-risk situations [5]. Our proposal approaches Sigfox, a provider that commercializes proprietary Internet of Things (IoT) solutions by a partnership with several network operators.

In Europe, Sigfox uses the bands of 868.00 MHz–868.60 MHz and 869.40 MHz to 869.65 MHz for transmission in uplink and downlink, respectively. Meanwhile, in the American continent, the 902 MHz band is preferred [21] by most nations according to the policies dictated by regulatory agencies. In addition, Sigfox allows a sleep mode by default in IoT to minimize energy consumption [21], working asynchronously to bypass issues like interference, multipath, and fading in either unidirectional or bidirectional communication over unlicensed spectrum. Nevertheless, it cannot guarantee the same Quality of Service (QoS) [22] as the solutions that use licensed spectrum or LTE-based synchronous protocol [11].

An IoT deployment for fire situations deals with a large amount of data, especially when a high number of fire monitoring sensors could be involved [7]. For our case, the relatively low data rate of SigFox, between 100 kbps and 1 Mbps, was not a concern given that only two numeric values, such as temperature and CO concentration, are sent from the nodes to the back-end. Sigfox's customers can implement their IoT oriented applications [23] in both small and medium scale. The system uses a Thinxtra Xkit module as a SigFox communication device to provide LPWAN connectivity support as well as infrastructure management. Another aspect that we considered beneficial was the use of an unlicensed spectrum of less than 1 GHz frequency. The absence of hefty spectrum fees allows lower implementation costs compared to cellular technology [12].

The deployment location is in the forest, where device maintenance and power supply could become a shortcoming. Thus, it is recommendable these applications require low power and long-range connectivity using devices that allow a longer battery life, especially if they are deployed in remote

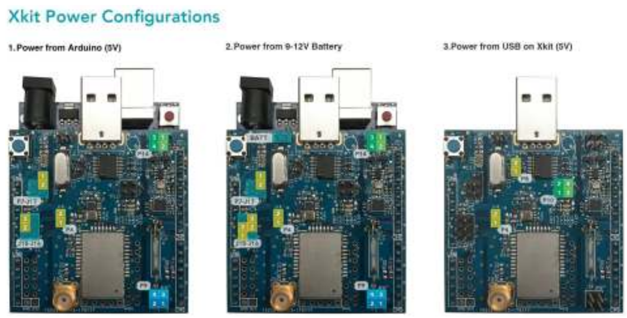

FIGURE 2. Thinxtra Xkit power configuration capabilities.

areas, some of them of difficult access and lack of electricity supply. One reason to assure the energy consumption is due to sensors are usually equipped with a capacity-limited battery that withstands depending on the energy usage pattern and state of the sensor nodes [24]. LPWAN can fulfill its lifetime through the adequate energy consumption management, deemed as a fundamental aspect in the context of availability and security of the sensor network. A definition for the lifetime can be the minimum time when either the percentage of alive nodes or the size of the largest connected component of the network drop below a specified threshold [25].

Our prototype manages a sleep mode option to save energy and electronic data processing. A battery supplies of power to the system in the evenings and cloudy days, while the battery charging circuit based on solar panel supports both purposes to improve energy autonomy as the system reaches production states. A generic image from vendors that shows the power supply configurations of the Thinxtra Xkit module is depicted in Fig. 2.

We used a library for setting the Arduino into various low power modes, configuring the SM[2,0] bits of the controller to '000' to call the Arduino into the idle sleep mode, in which the CPU stops but allows the operation of the SPI, 2-wire serial interface, USART, Watchdog, counters, and an analog comparator. The idle mode stops the CLKCPU and CLKFLASH as well and allows the Arduino to be awakened by any time using an external or internal interrupt [26]. Besides, the function LowPower.idle() sets the Arduino in idle mode for power optimization with the fastest wake-up time compared to other sleep modes [27].

The Arduino board runs at 100 mW during the monitoring loop. When it is in sleep mode, the power consumption drops to a negligible value. Since the prototype did not have the power constraints in the final implementation, the delay function handles the timing of the algorithm. Replacing this delay line with the code in Fig. 3 allows the Arduino to get into a sleep mode for half a minute and then resume its loop algorithm. This action halves its power consumption as it remains in sleep mode for the loop time. Further improvements allow interrupt to wake up the Arduino, as shown in the example of Fig. 4 [26]. Utilizing this techniques we can expect a single 3400mAh 18650 battery to power a node for at least 10 days without the solar panel subsystem.

```
LowPower.idle(SLEEP_30S, ADC_OFF, TIMER2_OFF, TIMER1_OFF,
TIMER0_OFF, SPI_OFF, USART0_OFF, TWI_OFF);
```

FIGURE 3. Arduino sleep mode command.

```
void loop()
{
    // Allow wake up pin to trigger interrupt on low.
    attachInterrupt(0, wakeUp, LOW);

    LowPower.powerDown(SLEEP_FOREVER, ADC_OFF, BOD_OFF);
    // Disable external pin interrupt on wake up pin.

    detachInterrupt(0);

    // Do something here
}
```

FIGURE 4. Arduino sleep mode with interrupt.

TABLE 2. MQ9 module specifications.

Item	Parameter	Min	Typical	Max	Unit
VCC	Working voltage	4.9	5	5.1	V
PH	Heating consumption	0.5	-	340	mW
RL	Load resistance	-	adjustable	-	Ω
RH	Heater resistance	-	32+5%	-	Ω
RS	Sensing resistance	2	-	20000	Ω
CO/CH4 /LPG	Detecting concentration	200	-	1000/10000 /10000	ppm

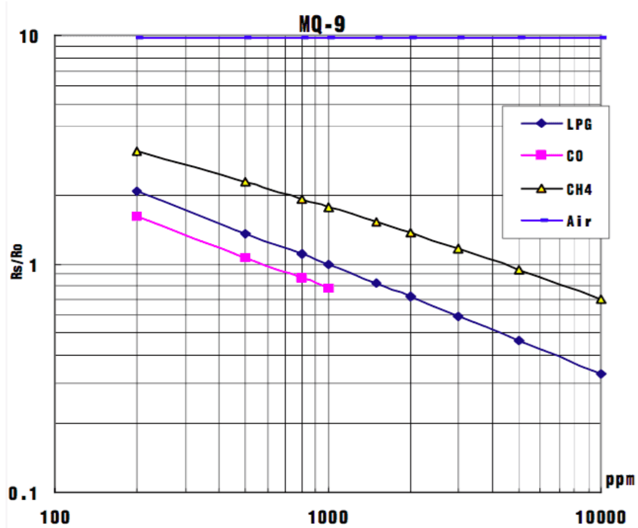

FIGURE 5. Gas concentration values.

Two sensors are requested for measuring temperature and smoke, respectively. A better monitoring routine can be set up with more sensors implementation into the system for providing accurate fire detection. To implement the automated mobile call, a single Arduino with a GSM shield and an MP3 shield functioning as the automated emergency call system outside the monitoring area will react to the alert generated in the SigFox's backend. Mainly, this node dials to the fire department and loops an emergency message, specifying the location where the fire outbreak was detected.

This prototype deploys an MQ9 sensor [28] for measuring gases, such as carbon monoxide (CO), coal gas, and liquefied

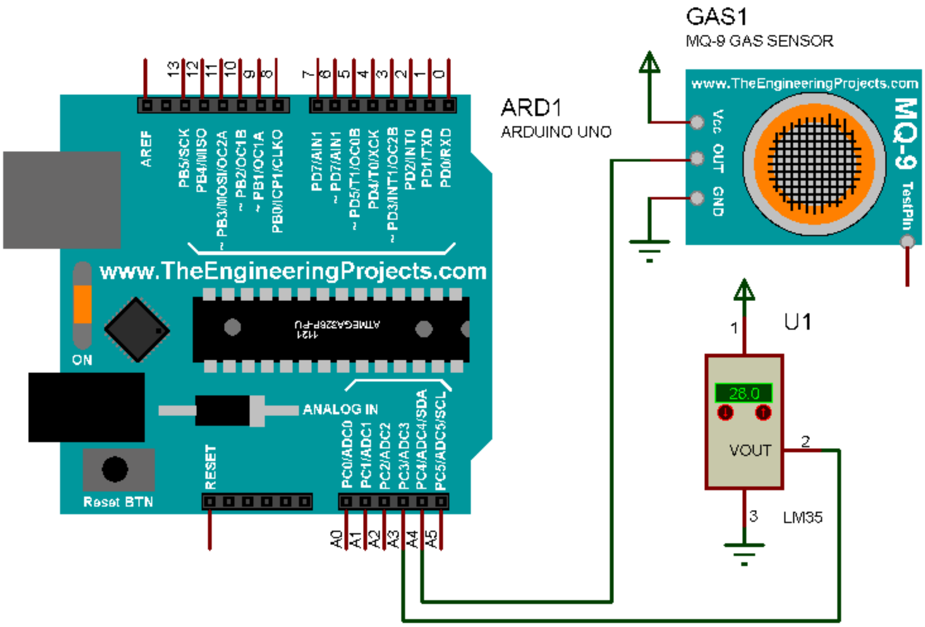

FIGURE 6. Integrated connection.

petroleum gas. It boasts an adjustable sensitivity and a small package size. Also, this module is easy to attach to any project due to its adjustable threshold comparison and analog outputs. The specifications for this sensor can be consulted in Table 2, while Fig. 5 plots the gas concentration sensed with this module.

The LM35 sensor [29] is a single component of a three-terminal analog sensor that monitors temperature. This sensor is a precision integrated-circuit that does not require external calibration because it is internally calibrated. It delivers an output voltage proportional to the temperature measured [30], producing 10 mV for each centigrade temperature degree [31] following the Celsius scale depicted in equation (1).

$$V_{out} = 10mv/^{\circ}C \times T \tag{1}$$

The connection between the Arduino UNO with both the MQ9 carbon monoxide sensor and the LM35 temperature sensor ends up in the IoT circuit framework shown in Fig. 6 for sensing their immediate surroundings. Nevertheless, the distance between neighboring sensor nodes is significant to the system performance [32]. As the distance among the sensor nodes increases, it also does the average time of detection since the fire ignites [33]. However, the more nodes deployed, the higher the complexity and cost of the system, which leads to a trade-off between reducing the detection latency and the implementation complexity and maintenance costs.

The relation of the average distance between sensor nodes with the average distance between the fire ignition location and nearest sensor node, and the fire reaction delay, is depicted in Fig. 7 and Fig. 8, respectively [34]. Based on this, we recommended a 25 meters distance between nodes, giving us an average of 16 minutes of response time since the fire ignition. Comparing this to current satellite-based monitoring systems, we can say this is a huge step in reducing

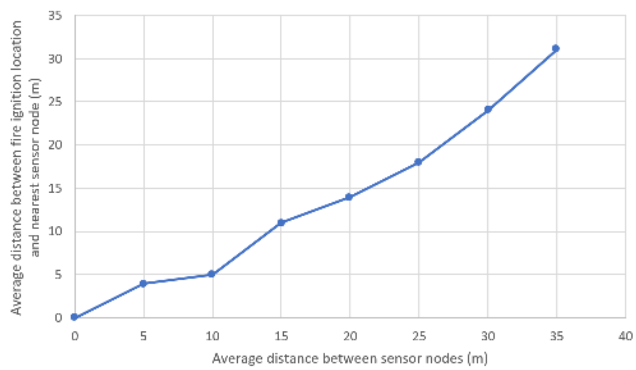

FIGURE 7. Distance from fire to the nearest sensor given the distance among sensors.

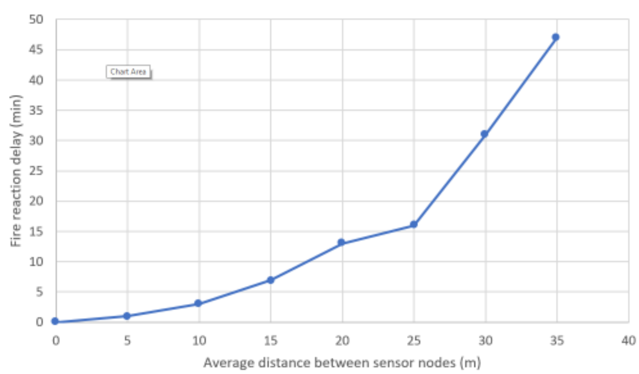

FIGURE 8. Reaction delay given the distance among sensors.

TABLE 3. Budget description (in USD).

System	Item	Units	$/Unit	Subtotal
Sensor nodes	Arduino UNO R3	5	10.00	50.00
	MQ9 sensor	5	3.50	17.50
	LM35 sensor	5	2.00	10.00
	Power supply	5	9.00	45.00
	Thinxtra Xkit	5	50.00	250.00
	Thinxtra Xkit case	5	10.00	50.00
	Solar panel	5	6.50	32.50
	Solar power module	5	13.00	65.00
	14500 battery	5	4.50	22.50
	GSM shield	1	15.00	15.00
	MP3 shield	1	7.00	7.00
Database server	HP Proliant DL360p G8	1	206.00	206.00
	CAT 6 cable 15m	1	10.00	10.00
Alert system	Alarm horn 100w	1	22.00	22.00
	Fire alarm lights	1	14.00	14.00
			Total($):	816.50

the warning time delay at the starting moment of the fire outbreak.

For large-scale implementations at more extensive outdoor areas, it becomes necessary a deployment with multiple devices, which may increase the network costs [11]. It is possible to host multiple sensors using an Arduino and a Thinxstra module to reduce the cost of each sensor node but taking into account it could trigger scalability problems in case the number of devices in the network increases [35]. Besides, a central database server requires to host the data read from the nodes in the sensor database, which involves stored data and sensor data [36]. Then, the server runs on MySQL as a database tool to set off alarms and to store past event logs automatically.

A reason to work on MySQL is due to its features as open-source, scalable, and mobile, based on the proven Sequel Query Language (SQL), with a strong capability of interfacing with PHP server applications. In addition, MySQL databases consist of multiple tables for storing data, activity logs, and announcements [37]. Table 3 presents a tentative budget for a medium-scale implementation as a cost alternative. Given this budget and the recommended distance between nodes, an area of near 2500 m^2 can be monitored with this system. It's important to note that these are the retail prices of the items and will become cheaper as more nodes are required in a medium scale implementation.

IV. INTEGRATION AND RESULTS

The system needs to set off the alarm at the moment the LM35 sensor records a threshold temperature [4], [38]. It is necessary a threshold temperature to set up a threshold output voltage, which has to be linearly proportional to the Celsius temperature [31]. Most of the outdoor applications configure a 50 °C threshold. Subsequently, the LM35 equation (2) calculates the output voltage.

$$\begin{aligned} V_{out} &= 10mv/°C \times (50) \\ &= 500mv \end{aligned} \tag{2}$$

The Arduino programming code (see Appendix A) is loaded for testing the LM35. Thus, the temperature in either Celsius and Fahrenheit can be consulted as a text result, as shown in Fig. 9.

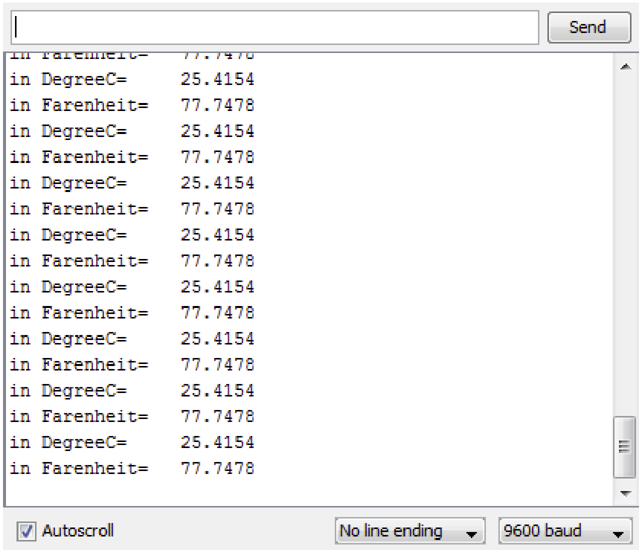

FIGURE 9. Temperature results from the LM35 test code.

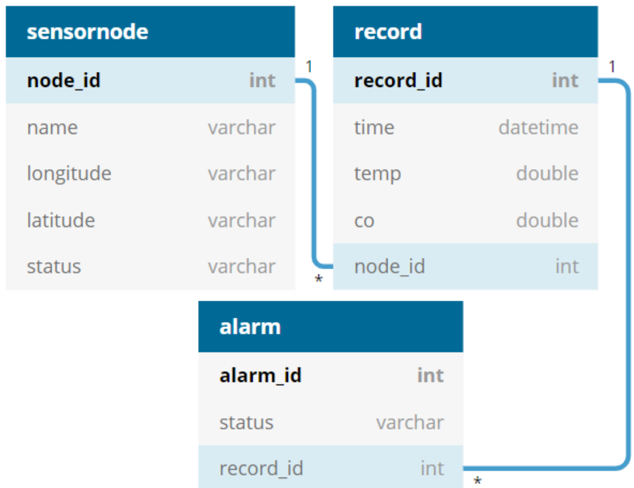

FIGURE 10. Database schema.

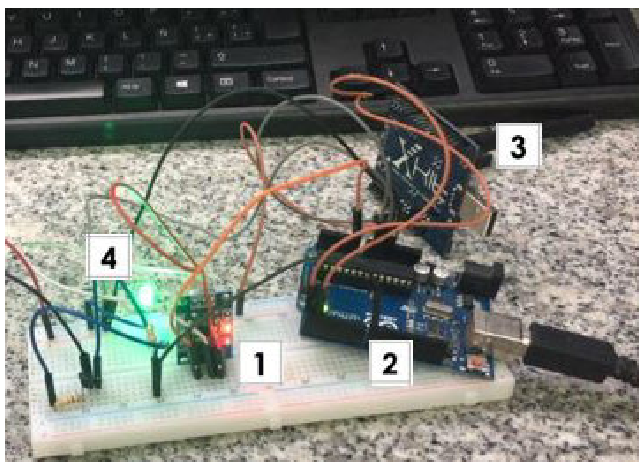

FIGURE 11. Low scale prototype circuit.

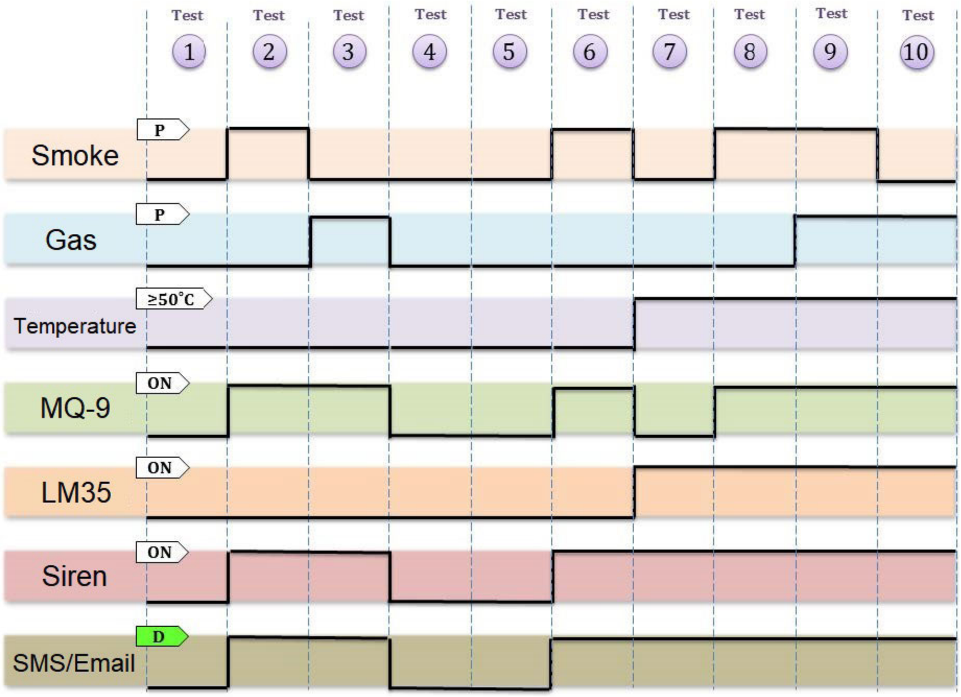

FIGURE 12. Digital response timing according to different conditions.

The process consisted of a periodical data collection by sensors to bear it through the LPWAN to a database server similar to [39] with a structure depicted in Fig. 10. At the moment of exceeding the threshold values represented in Table 1, the alarm exception is triggered for sending an emergency alert by email and SMS with settings comparable to the cases shown in [40] and [41]. Then, an emergency call launches a prerecorded message with an MP3 audio player shield after the answering of the mobile, indicating the sensor geographic coordinates that triggered the alarm.

The system uses the SigFox back-end for sending the warning email and SMS through a callback done by the Ubidots platform. Through the integration of this platform, we collected the data generated by the nodes for allowing data storage in the cloud, providing at the same time dashboard options for consulting recorded information by visual interfacing through a website. As an IoT cloud service-oriented platform, it allows the connection of devices to its API (application programming interface) to interact with its elements, such as data source, variables, values, and events to either create, modify or remove them [42], [43]. Different researches and examples with practical approaches and descriptions, such as in [44]–[47], and [48] present literature about this topic.

The MySQL server running on in an offsite system queries the back-end database to import the produced data for information management [49]. A log file generates through the local database after the reception of an alert to verify the incident. The server runs an Apache web service and stores the PHP programming code (see Appendix B) in the designated directory for accessing this information via a web browser [50]. Table 4 shows the results after setting the code, including parameters such as date, the temperature in degrees Celsius, and carbon monoxide concentration level.

TABLE 4. Sensor record sample.

SENSOR RECORDS			
No.	Date-Time	Temperature	CO level
1	2019-06-26 14:16:27	25.35	0.40
2	2019-06-26 14:16:57	25.29	0.40
3	2019-06-26 14:17:27	25.33	0.40
4	2019-06-26 14:17:57	25.43	0.42
5	2019-06-26 14:18:27	25.62	0.41
6	2019-06-26 14:18:57	25.99	0.41
7	2019-06-26 14:19:27	25.83	0.41
8	2019-06-26 14:19:57	25.73	0.41

After the completion of the system configuration, the low scale prototype deployed to perform the analysis on different test scenarios is depicted in Fig. 11, detailing the parts labeled numerically as 1. MQ-9 sensor, 2. Arduino UNO board, 3. Thinxtra XKit module, and 4. LED alert indicator. Finally, Fig. 12 depicts a timing diagram that plots the results as a digital input-output relationship, where we obtained multiple outputs from the tests performed.

V. CONCLUSION

This functional prototype can be scalable at different stages for its enhancement, taking into account scenarios either with unstable weather conditions, different forest densities, or relevant information management. In this project, the integration of low-cost electronic devices allowed a real measuring of the temperature and gases without restricting the implementation, plus the inclusion of the solar panel turned the system self-powered to become attractive for stakeholders at the moment of saving operative costs and assets. In addition, this system experienced better performance over satellite-based monitoring systems due to the lower delays attained for triggering the emergency alert before a fire spreads uncontrollably, which ensures prompt action for the safety of the monitored area.

Several long-range protocols allow the integration of IoT solutions. However, we did not consider proprietary options that may be equally effective based on the know-how and the engineering support available but limited for developing because of factors asocciated with costs and their configuration restrictions. Besides, roaming options have to be appraised for a mobile coverage potency, mainly if the monitoring is performed from abroad.

The database complemented the access to the information, verifying the measurements obtained from the sensors to confirm that the response times were lower enough. We can remark that the features and aspects that involve the database management could become a start point for a deep learning project to improve the recognition of fire events. In overall terms, the solution presented comes as a valid proposal for scholars that want to develop IoT techniques approaching problem solutions based on low budgets and the ease of the integration of components.

APPENDIX A
ARDUINO PROGRAMMING CODE

```
const int sensor=A1; // Assigning analog pin
    A1 to variable 'sensor'
float tempc;  //variable to store temperature
    in degree Celsius
float tempf;  //variable to store temperature
    in Fahreinheit
float vout;  //temporary variable to hold
    sensor reading
void setup()
{
pinMode(sensor,INPUT); // Configuring pin A1
    as input
Serial.begin(9600);
}
void loop()
{
vout=analogRead(sensor);
vout=(vout*500)/1023;
tempc=vout; // Storing value in Degree Celsius
tempf=(vout*1.8)+32; // Converting to
    Fahrenheit
Serial.print("in␣DegreeC=");
Serial.print("\t");
Serial.print(tempc);
Serial.println();
Serial.print("in␣Fahrenheit=");
Serial.print("\t");
Serial.print(tempf);
Serial.println();
delay(1000); //Delay of 1 second for ease of
    viewing
}
```

APPENDIX B
PHP PROGRAMMING CODE

```
<html>
<head>
<title>
Sensor node 1 records query
</title>
</head>
<body>

<?php
$con = mysqli_connect("localhost","root","
    root1234","sensors");
?>

<table border="1">
<tr>
<td colspan="4">SENSOR RECORDS</td>
</tr>
<tr>
<td>record_id</td>
<td>date-time</td>
<td>temperature</td>
<td>co</td>
</tr>

<?php
$result = mysqli_query($con, "select␣
    records_id,date_time,temperature,co␣from␣
    records␣where␣node_id=1");
while($row = mysqli_fetch_array($result)){
?>

<tr>
<td> <?php echo $row["records_id"]; ?> </td>
<td> <?php echo $row["date-time"]; ?> </td>
<td> <?php echo $row["temperature"]; ?> </td>
<td> <?php echo $row["co"]; ?> </td>
</tr>

<?php
}
?>
</table>

<?php
mysqli_free_result($result);
mysqli_close($con);
?>

</body>
</html>
```

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