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Early detection of Forest Fire Using WSNs

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Abstract: A wildland fire is an uncontrolled fire occurring majorly in forest areas, it can even invade urban as well as agricultural areas. Every year millions of hectares of forest are devastated by fire, which causes huge damage to forest and nature[1]. The main causes of wildfires include human factors, that can be either intentional or accidental. A survey has found that 80% losses that are caused due to fire would have been actually avoided if the fire had been detected immediately. Arduino platform based IoT enabled fire detector and monitoring system is the solution to this problem.[3] The number of forest fires and their impact are expected to grow as a consequence of the global warming. In order to fight against these disastrous fires, it is mandatory to adopt a multifaceted and comprehensive approach that enables a continuous situational awareness and instant responsiveness. wireless sensor networks (WSNs) technology is a very promising green technology for the future in detecting efficiently the forest fires[4] when compared with the traditional techniques of forest fires detection.

Index Terms **– Forest Fire, WSNs.**

I. INTRODUCTION

IoT is a leading role in technical advancement around the world. It is another information industry following computer, Internet and mobile communication [9]. Forests are the guardians of natural stability on earth. Unfortunately, the forest fire is usually only observed when it has already spread across a large area, making it difficult and sometimes impossible to control and stop it. [8].
Wireless Sensor Network "WSN" is usually composed of hundreds to thousands of sensors, having the possibility to sense environment measures like temperature, pressure and movement and send the sensed data to a central base station via wireless medium to allow environment monitoring [2].

Fig. 1: Uncontrolled Forest Fire

A wildland fire is an uncontrolled fire occurring majorly in forest areas and the main causes of these fires include human factors, that can be either intentional or accidental. The likelihood of forest ignition is rising sharply due to climate changes and human activities. Forest fires reduce the tree cover and lead to an increase in our planet's gas emissions, and around 20% of CO2 emissions in the atmosphere are due to forest fires[4]. To counter these disasters, a systematic, multifaceted strategy must be followed that allows for continuous situational awareness and instant responsiveness. Our project is aiming to use a hierarchical wireless sensor network aimed at early fire detection in risky areas, integrated with the firefighting command centers, geographical information systems, and fire simulators. There are recent works that describes detection systems based on distributed WSNs. There are few disadvantages observed from the literature and are latency, High Energy Consumption and Centralized system management. The early warning of fire is very desirable to avoid fire propagation which makes its extinction very difficult. The proposed system uses WSN to control ambient temperature and CO2 in forests to detect and send alert about any eventual fire.

1.1 FIRE FACTORS

Forest fires are a recurring phenomenon in many parts of the world, whether natural or manmade. Vulnerable areas are located primarily in temperate climates where their rainfall is high enough to allow for a significant level of vegetation, but summers are very hot and dry, creating a dangerous fuel charge. Global warming will help to make these disasters more numerous and more significant. Every season, not only are thousands of forest hectares destroyed by wild land fires, but also assets, properties, and public resources and facilities are destroyed. In addition, firefighters and civilians are at risk, with an appalling toll every year in human lives..

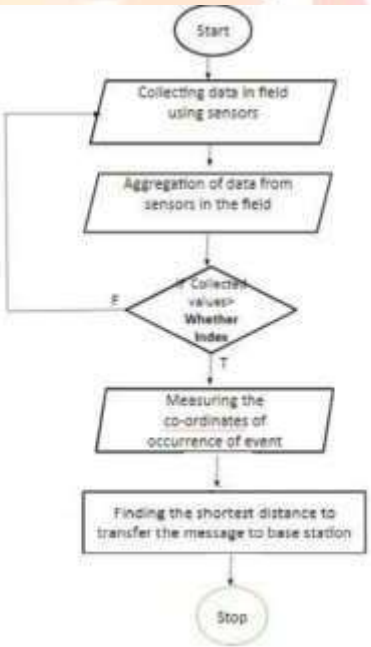
Fig. 3: Fire Factors Triangle

Maintaining a fire[7] requires three elementary factors which must be presented simultaneously. When there is one component missing, otherwise the fire will go out. A source of fuel for combustion must be available, a source of heat for promoting the reaction (the fire itself), and oxygen in adequate concentration to sustain the reaction.

II. RELATED WORK

2.1 An optical sensor and camera surveillance

CCD cameras and IR-detectors are mounted on top of towers in this technology. Those IR detectors and cameras should detect and report suspicious activity to the control center. Those issues may send an alarm in case of fire. The control center will compare the prevailing conditions and provide the smoke position. There are few drawbacks [6]. Accuracy is influenced by climate, environment and time of day. In this method, light-reflections and smoke from factories or pollution operations are more false alarms. This sort of technology just gives



you a line of sight. Smoke can not be observed in this system until it has spread over a wide area until a watchable smoke is present.

2.2 Satellite based system

Usually satellites provide a full picture of the earth every two days, and it takes a long time to inspect and fire is hard to detect. Fire is measurable only when it extends over 0.1 hectares. Two forest fire monitoring satellites deployed are: I Advanced Very High-Resolution Radiometer(AVHRR), deployed in 1998. (ii) High resolution Imaging Radiometer Spector(MODIS), introduced in 1999
Authorities Fire Suppression and Detection Techniques :

The most widely used methods of fire detection and suppression used by authorities can be summed up as follows:

• Controlled burning

• Fire conditions predictions and fuel and moisture projections • optical smoke tracking,

• flash detectors detecting strike co-ordinates,

• mobile / smart phone calls are becoming increasingly popular for early warning of fires, and

• Fire Watch awareness or related schemes for homeowners.

2.3 Mobile Ad-Hoc Network (MANET) Recent MANET[12] routing protocols such as reactive Location-Aided Routing (LAR), constructive Optimized Link State Routing (OLSR) and LAR-based Reliable Routing Protocol (LARRR) are the latest techniques used in forest fire detection. Models of the researchers' findings of the experiments have also been discussed. Studies and summaries of the techniques used in forest fire detection have been published. Surveys of the methods they used in this area were also performed, and the advantages and disadvantages of all the techniques listed above were described and discussed. Based on all these it was discovered that a wireless sensor network would be the best technique for forest fire detection. This has proven itself better than television systems and optical cameras. It revealed that the approach proposed has been able to reduce the dropped average of high-priority results. Its nodes were only able to send the high priority data to nodes with low probability of destruction and thus decreased end-to-end delay.

III. UNDERSTANDING AND MODELING FWI

It is important to detect fires in an early state to avoid uncontrollable large spread of forest fires and to prevent the spread. It is necessary to move appropriate fire equipment and trained operational staff to the source of the fire as quickly as possible.
FWI means the Fire Weather Index System. In relation to weather observation, where the fuel code defines the soil content of forest land, the FWI that provide the moisture content. The FWI index also comprises the probability of fire ignition and the rate of fire spread. And we use the Fire Weather Index (FWI) to measure the risk of forest fires and the pace at which they spread

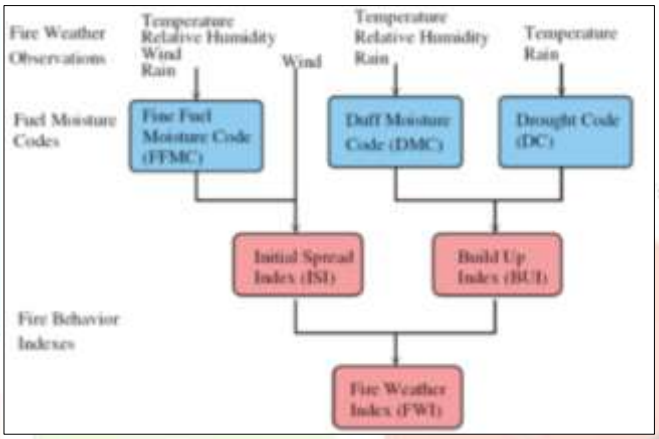


Fig. 4: The Fire Weather Index System

IV. WIRELESS SENSOR NETWORKS

Wireless Sensor Networks[5] are created by haphazardly spreading many limited-capacity, low-power, low-cost, short-range sensors into an area that can not be easily reached and that most of the time is unreliable. Each node has the calculation, sensing, and communication capabilities. These nodes which can be haphazardly distributed in the search environment can get to know each other and can perform calculation tasks in a large region by making joint efforts[12]. Since of these features, they can be used from medical to military, protecting a building to predetermining forest fires, in many fields.
Wireless Sensor Networks allow for

- Data collection
- Information Processing
- Tracking and monitoring of various places for environmental applications

Wireless Sensor Network(WSN)[4] These are small sensors that collect data with low power consumption and transmit it. They can communicate and transmit data effectively with each other. It is technology with low cost and long battery life. Each sensor can be either structured or unstructured, in two ways. Every node is built and is deployed exactly where it is located. A centralized node would be connected to the intermediate node which is connected to the nodes of the child internally. Each node is composed of multiple sensors along with trans receivers. These can detect both solid and gaseous materials, such as CO2, CO and petroleum. There are many methodologies for the sensing and transmitting of the collected data. Depending on the categories, we will discuss every technology: sensing and collecting: we can use the topological structure to collect data in mesh topology. Each node is connected to each other node, and each node has a rooting table, and all nodes are connected to each other and transmit the data using this. We need to look at fire dynamics and reasons to predict the fire. There should be a regular visit to the forest zone.

Fig. 6: Fire Sensing System

We need to control the area of burnt along the border zones. Burning help to avoid forest fire, as this will prevent the unexpected human activities that cause the forest fire to spread completely. The temperature and humidity are regularly measured and the moisture content of the decayed content is checked. The declined matter gives off some gaseous material. This will help to spread forest fire faster. 1) If the trees are dry or dead, then the trees should be removed 2) Lighting is one of the causes of forest fire.

V. FUNCTIONAL REQUIREMENTS OF WSNs

The FWI program includes three fuel codes: Fine Fuel Moisture Code (FFMC), Duff Moisture Code (DMC), and the Drought Code (DC). The three fuel codes reflect the moisture content of forest floor organic soil layers, while the fire behavior is represented in the three fire indexes. Using weather observations the FWI system estimates the moisture content of three different classes of fuel. Fine Fuel Moisture Code (FFMC) is the type of fuel that is of our concern. This code is used to indicate ignition ease and is calculated with the indicated ignition ease and is calculated with temperature, relative humidity, wind, and rain. Both the FFMC code and the FWI index are calculated using four FFMC code, and the FWI index is calculated using four simple weather conditions: temperature, relative humidity, precipitation and wind speed. Measured by sensors installed in wood, these weather cobes.

VI. SENSOR ARCHITECTURES

6.1. Flat Network Architecture

In a flat network, sensors are distributed in a given area without any additional configuration, such that all nodes are equal in roles and each sensor is linked directly to the base station, data is transmitted hop-by-hop until it reaches the base station without any data aggregation mechanism using the underlying routing protocol like DSR[5].

Flat networks are very suitable for a secure environment where the amount of data transmitted is limited as the underlying routing protocol uses flooding to create routes that overhead and consume the network resources.

6.2. Hierarchical Network Architecture

Sensors are organized into clusters or regions in a hierarchical architecture. One of the most efficient nodes is chosen as the cluster head responsible for the neighboring nodes typically referred to as cluster members. The cluster head is responsible for the development, maintenance and connection of its cluster to the base station. Hierarchical architecture significantly minimizes the network overhead using data aggregation since the data collected is sent to the head of the cluster which sends an abstract report to the base station. Hierarchical architecture simplifies network management and presentation of the state of the managed region for the end user, but cluster creation and cluster head selection result in an unnecessary overhead that can affect the lifespan of the network.

VII. HARDWARE DEVICES

A variety of microprocessors and controllers are used in Arduino board designs. The boards are fitted with digital and analog input / output (I / O) pin sets that can be interfaced with various boards of expansion or breadboards (shields) and other circuits. Most Arduino boards are made of an 8-bit Atmel AVR micro-controller. The boards use single or double-row pins or female headers which facilitate programming and integration connections into other circuits. The boards provide interfaces for serial communications like Universal. Serial Bus (USB) on some models which are often used to load personal computer programs. Usually, the microcontrollers are programmed using a function dialect from the programming languages C and C++.

4.1. DHT11 Humidity Sensor

DHT11 is a Digital Optimized Output Moisture and Temperature Sensor. DHT11 can be inter-face to any microcontroller, such as Arduino, Raspberry Pi, etc., and have instant results. DHT11 is a low-cost temperature and humidity sensor that offers high reliability and long-term stability.

Fig 6: DHT11 Humidity Sensor

4.2. Gas Sensor(MQ2) module:

The Grove Gas Sensor(MQ2) module is useful for detecting the gas leakage (home and industry). It can be used to detect H2, LPG, CH4, CO, Alcohol, Smoke or Propane. Calculation can be taken as soon as possible because of its high sensitivity and fast response time. The sensor sensitivity can be adjusted by potentiometer.

Fig. 7:Gas Sesor(MQ2) Module

4.3. Wemos D1 mini:

The Wemos D1 mini made by wemos.cc is a Node MCU board. The Node MCU board that can be programmed cheaply using Arduino environment that can be loaded up with Micro Python ¡- tricky! There are 11 digital input/output pins, all pins have interrupt/pwm/I2C/one-wire supported (except D0) 1 analog input (3.2V max input) a Micro USB connection Compatible with Arduino Compatible with nodemcu 4Meg flash RAM.

Fig 8: Wemos D1 mini

4.4. Arduino IDE:

The Arduino Integrated Development Environment (IDE) is a cross-platform framework that is written in the Java programming language (for Windows, macOS, Linux). The open-source Arduino Software (IDE) enables the writing and upload of code to the board. It can be run on Windows, Linux and Mac OS X. The environment is written in Java based on Processing, as well as other open source software. Any Arduino board can use this program. Writing and uploading programs to Arduino board is available. The Arduino IDE uses the software to translate the executable code into a text file in hexadecimal encoding, which a loader software in the firmware of the system loads into the machine.

VIII. METHODOLOGY

A wildland fire is an unregulated fire that occurs primarily in forest areas and the key causes of such fires are human factors that can be either intentional or accidental. It causes serious damage and destruction of forest resources and lives. Actual equipment on WSN's fire hotspot detection node Current equipment on WSN's network for fire hotspot detection and monitoring can be found in several business forms. And surveillance can be used in many business styles [10]. Where the sensor temperature, moisture, smoke, and carbon is. Where temperature, humidity, smoke and carbon sensor are mounted in the node to detect all the parameters high in the node in relation to the forest fire.

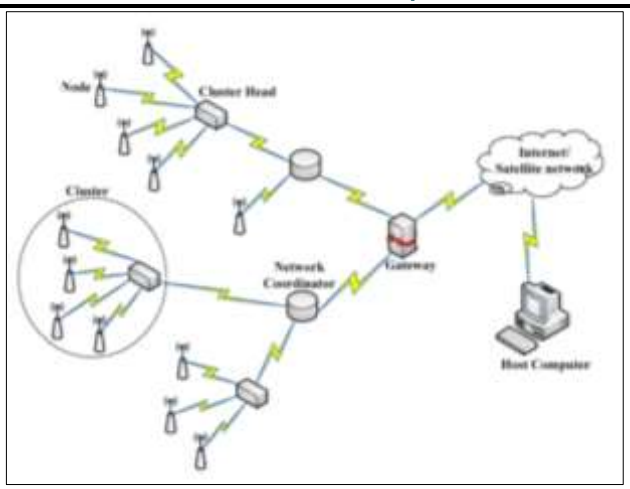


Fig. 9: Master Slave Structure

To fight against these disasters, it is necessary to adopt a In order to counter these disasters, it is important to follow a systematic, multifaceted approach that enables a continuous situational awareness and instantaneous response of master-slave system A system with more than one processor and in which one of the devices is designated as the master and all other processors are slaves. The master unit is capable of acts not done by the slaves. Nonetheless, none of them is detailed and do not work efficiently in the various scenarios with varying climatic and geographical conditions in terms of prompt and accurate fire detection. Our project aims at using a master-slave network, communication architecture, which encompasses a broad variety of communication technologies, including cellular and Internet connectivity. However, the Master Device is only connected to GSM and Internet Technologies, the theory is that the Master Device is located in a location or has access to the Forest Department and short-range Bluetooth communication for the design configuration of Master – Slave Devices. Master-Slave Architecture, for scalable and versatile design. The device functions as an early fire detection system in hazardous areas, integrated with fire control centers, geographical information systems, as it also has cloud connectivity, and the system also sends warning messages through cloud and GSM technology. In addition to that the system uses Open Source tools and Components and very low-cost Sensors .

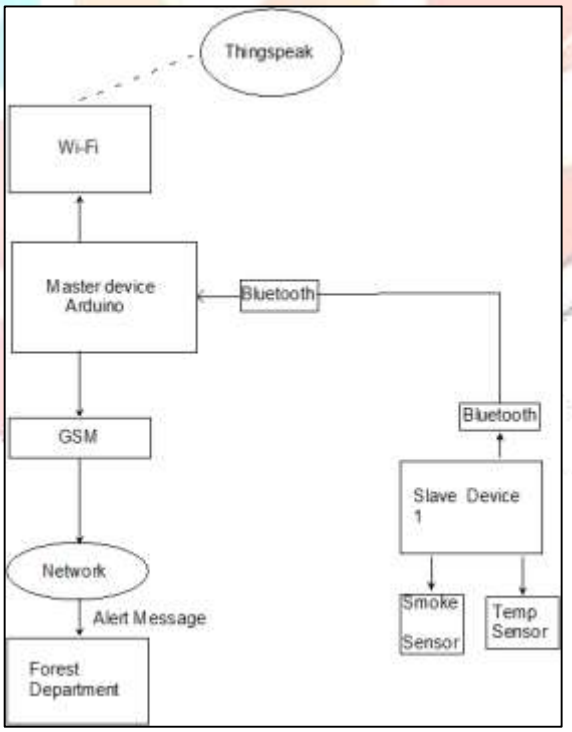


Fig. 10: Proposed Workflow

IX. CONCLUSION

Early warning and prompt response to a fire breakout arethe only ways to avoid major losses and harm to the natural and cultural heritage . Therefore, the most critical fire surveillance objectives are fast and accurate identification and location of the fire. Knowledge about the fire's progress is also highly useful for controlling the fire in all its phases.Once the starting position is known, even when it is in its early stages, it is much easier to suppres a spark. WSN technology is a very promising green technology for the future in the efficient detection of forest fire in our country Using wireless sensor networks, will allow us to determine the position of the fire risk without being physically present at the site, as a node sends temperature and coordinates information, it is easy to determine the spot. Fire detection is very reliable,

so false alarms are unusual long-range communications that work as anticipated and are crucial. Whatever the gap, radio connections are stronger when there is a clear line of sight.

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