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Forest Fire Monitoring System Using WSNs Technology

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Keywords: WSNs, Forest Fire, Sensors, Detection.

Abstract: Forest fires contribute to air pollution, which is one of the disasters, and adversely affects the environment because foggy particles along with carbon particles in a fire. Forest fires in the dry season occur in most of Indonesia's forestry areas. Riau Province is located on the island of Sumatra, Indonesia, in an area with a high likelihood of forest fires due to typical peatlands. The purpose of this research is to design and contribute to new technologies for fire detection using Wireless Sensor Networks (WSNs) Technology and intelligent software for accurate fire detection. This study proposes WSNs for the detection of forest fires in peat areas using sensor nodes with several embedded sensors for accurate fire detection. The sensor node prototype was designed and tested in a laboratory to check results and calibrate it to the real environment. Four sensors are embedded with temperature and humidity sensors, fire and smoke detection sensors and particle sensors. It analyses with intelligent software to get accurate information and data from the fire, including location, detection of values from all sensors. The results show that WSNs sensor nodes can detect fires and send information about all parameters that indicate forest fires. The design and development of WSN sensor nodes is to assist local governments or institutions to overcome existing problems, particularly in Riau Province and Indonesia, due to forest fires.

1 INTRODUCTION

In Indonesia forest fire is a disaster that incident most of every year occur, especially in dry season. According to the data, the total loss because of forest fire in year 1997 is USD2.45 billion (Yulianti et al., 2012), but this loss of data still less than compare to previous year in 1995, the total loss is USD19.1 billion. Riau Province in Sumatera is one of the areas with the greatest risk of suffering from this disaster due to peat and types of flammable soil. According to government agencies, the total loss in economic in year 2016 for Riau province was due to forest fires of up to US $ 1,650 million. Apart from economic losses, most activities stopped due to bad environment (fog) and the closure of all schools, and there were no activities in government offices and other institutions. The forest fire impact applies is not only to Indonesia or the Riau province, but also to other countries, such as Singapore and Malaysia, because Riau directly limits these countries. The satellite uses current procedures to obtain data on forest fires to identify critical points, then the information collected is sent to the authorities and the team goes to a place to take the steps needed to stop the fire; Because peat swamps can have their own fires in the area, they must socialize and campaign.

In this research focuses on development of intelligent on the surface and level monitoring systems for detection forest fires, WSN smart sensor nodes with new designs and smart systems to collect accurate fire data. The integration of WSN sensor nodes and information exchange will benefit local communities and to local authorities to access the information through sophisticated real-time databases. He hopes this will be a fast and cheap solution then obtaining ordinary satellite data, and this will certainly benefit to community and economic enhancement. Furthermore, development of a real-time monitoring system will involve the backing of the government as the person responsible for policy formation to apprehend how does the system run and at the same time understand the behavior of the results to take appropriate steps.

2 RELATED WORKS

WSNs applied for many uses, for example applications in remote environments, automatic industrial control, remote sensing and targets. Applications that are similar to environmental monitoring systems for forest fire detection are capable of real time monitoring and detection. In most scenarios, WSNs consists of several small number of nodes where the nodes are placed in far location and unreachable hostile locations or in large geographical areas. A number of WSNs nodes to detect the changes in the environment and provide information to the master cluster node or sensor base station, then through the gate and for data transfer to the server, which should be easily maintained and scaled (Kadir et al., 2019; Kadir et al., 2018a).

A new method for action in the forest fire monitoring and detection as elaborate in (Liu et al., 2018) is using data aggregation in WSNs. The proposed method can be providing a faster and more effective reaction to forest fires by consuming validated WSNs energy that is confirmed in large number of experiments in simulation. WSNs can deliver better solutions for managing disaster and operations rescue, such as alarm systems, flood detection, earthquake detection, forest fire detection, and landslide detection, water level sensors used to measure various parameters. and discussed in (Pant et al., 2017; Aranzazu-Suescun and Cardei, 2017).

Several research on WSNs as discuss in (Kadir et al., 2018b), The WSN simulation addresses key design issue, such as the monitored area related to the sensor's initial position, the number of sensor required for a particular application and changes in coverage over time. WSN uses an algorithm to identify the injection of malicious data and provide measures that are unaffected to various sensor and even when they are hide in attack. The methodology for applying this algorithm in this different contexts and also evaluation of results in three different data sets from different WSN distributions. (Illiano and Lupu, 2015; Kadir et al., 2016).

Another research that already did in this application of WSN in prediction of natural tragedies such as hail, rainfall, fire etc. WSN is rare and also stochastic (Kansal et al., 2015). WSN implementation in energy savings reduces delays in data transfer and extends network life. The routing agent chain (CCMAR) is used for the adaptive hierarchy of energy saving clusters (LEACH) and energy saving collections in sensor information systems (PEGASIS) (Sasirekha and Swamynathan, 2017).

3 WSN IN FOREST FIRE DETECTION ANALYSIS

Some of the fictitious satellite forest fires observed in Riau province extend to most areas, especially in the south. Figure 1 shows the number of critical points in accordance with the distribution plan distributed in all regions of Riau province.

Figure 1: Number of fire hotspots in Riau Province based on satellite image.

The access point coverage estimate that a series of WSNs sensors are installed in a environmental area in Riau province to monitoring this area. The function of coverage is P given as:

$$P = f(x,y,t) = \{(x_1,y_1),...(x_n,y_n)\}, \quad (x_k,y_k) = f(t), k = 1,2,3,...,n \tag{1}$$

(x, y) is the sensor coordinates in the area of monitored and t is the time. This model uses 2D spatial projection from the fire control area, 3D sphere. In this issue, the networks do not move except the WSN cellular sensor, but the position of the sensor depends on time, because the sensor node must stop working from time to time. There may be different reasons for completing this process: hardware failure, accident, battery consumption and accidental sensor removal, etc.

Assume that you specify the scope of the IP matrix as a value of scalar that represents of percentage in coverage area observed in a certain time:

$$IP = \frac{\text{area covered with sensors}}{\text{the total area of the surveillance region}} 100\% \tag{2}$$

The basic component of model can be write in WSNs as sensor node for defined a vector:

$$S = (d, E(t)) \tag{3}$$

the area covered can write as d by radio signals that exchange data with neighboring nodes when the

sensor is in the transmission range or transmission range. E (t) is the available energy to power the sensor. Assume that there is a homogeneous of sensor network to n integrated type sensors concentrators to communicate with distribution nodes (Kadir et al., 2019).

The parameters of network can be described in the vector as:

$$M = (n, f_0, \Delta E) \tag{4}$$

n can be defining as the number of sensor; for normal transmission frequencies and the consumption of energy per transmission and transmission. Assume that the sensor node period sends to the collected of data to adjacent of nodes. Consumption of energy is ΔE include the spent energy in data collection and process. In each node has 2 parts:

(a) feel the transmission and environmental data.

(b) receives data from the neighboring and forwarding nodes.

The function of WSNs sensor center nodes is to collects data from each of sensor nodes then send it to the data coordination center or base station. Data packets received and sent by the coordinator node, which contains the measurement values and address (humidity, temperature, and CO_2) of the original sensor node. WSN central nodes have uninterruptible power supplies and communication channels between the central node and the unlimited coordination center. Therefore, the simulation regards the sensor center as "always available". Main purpose of this simulation and measurement is for optimizing the networks path to send data from the sensors node to the hub (Aksamovic et al., 2017).

4 DEVELOPMENT WSN NODE FOR FOREST FIRE DETECTION

Forest fire is a natural or man-made events in several cases throughout the global. Fire areas are found major in climate, then the rainfall is high to provide a important amount of vegetation, but in summer very hot and in dry environments can create hazardous fuel loads. Global of warming will assist to growth the number of importance of this phenomena. Every dry season a forest fire is destroyed not only by thousands of hectares of forest land, but also by public assets, goods, resources and facilities. In addition, firefighters and civilians face the risk of facing horrific victims every year. Figure 2 shows a diagram of a series of WSNs sensor used in the forest area for the detection purposes of fire.

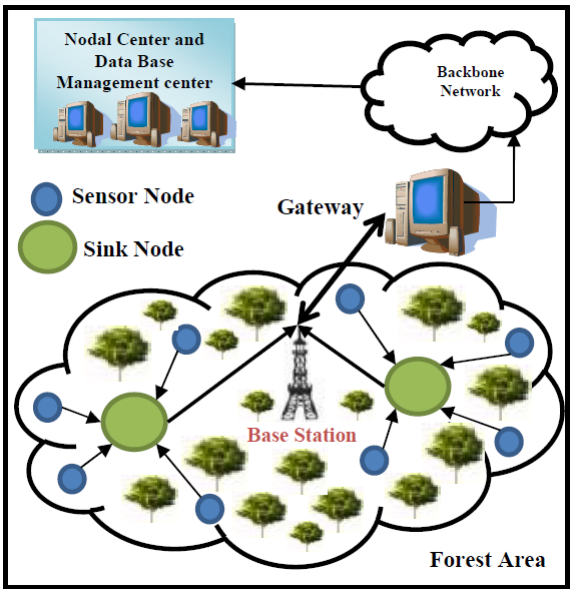

Figure 2: The sample of topology in the WSNs sensor nodes deploy in a forest for disaster detection.

Forest fires are a common and active phenomenon that can change their nature and behavior from one place to another and over time. The truth is that in some places there is limited fuel for forests, so fires that continue to burn must spread to the nearest fuel. The achieved by spreading to the complex heating to neighboring in housing and community obtained from the complex behavior of the fire. Another case to approach is based on the WSNs paradigm designed and developed in a research project involving all key players in the forest and firefighters for operations.

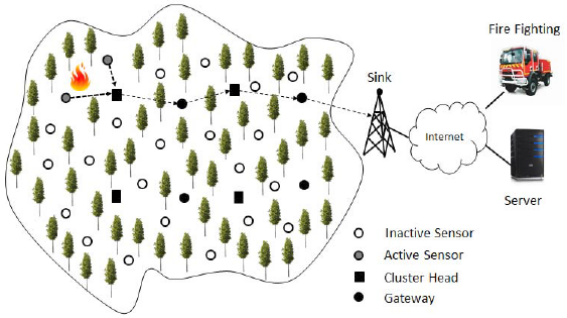

Figure 3: A WSNs sensor nodes propose use ZigBee standard.

Another scenario in Figure 3 illustrates the proposed schematic structure for multi sensors node, controllers, routers, cluster heads, and remote servers for the application WSNs based systems

for protection management and forest fire detection and. Decision making This tree topology network cluster structure proposes a project to reduce energy loss and data packets during transmission. The standard of ZigBee technique is a widely standard based on IEEE 802.15.4, applicable to low-level PAN (Wireless). ZigBee is one of the wireless network standards for low-power sensors that is applied at 868/915 MHz and multi-frequency 2.4 GHz. The technical advantage recommended by ZigBee is that ZigBee offers a battery system that is durable, small, and low battery. Cost, automatic or semi-automatic installation, and high reliability. Therefore, in the development and of WSNs node design is used by multisensory systems to get the most appropriate choice for the detection and monitoring of forest fires (Kadir, 2017).

The hardware used to detect and monitor fires at WSN nodes is available in many kinds on the market. Where humidity, smoke, temperature, and carbon sensors are positioned at the node to detect all parameters that are strongly associated with forest fires. Figure 4 shows the actual formation of the sensor in the environmental parameter calibration test, before the sensor node is positioned in the field, the sensor node must be configured according to design and requirements. All nodes send data or messages to the coordinator WSNs, which has the function of receiving all information from the scattered nodes.

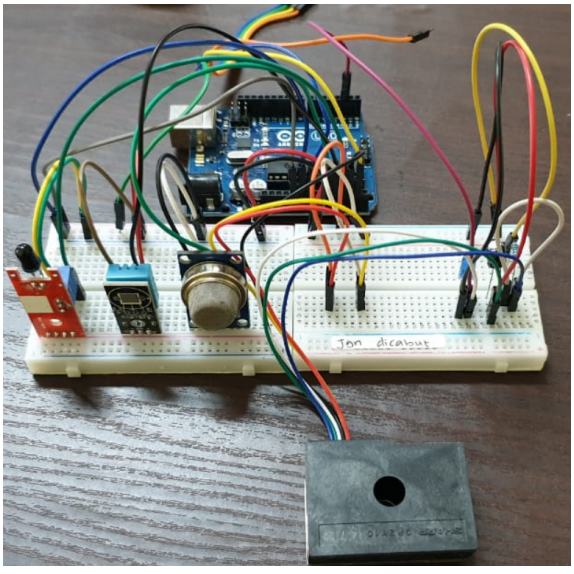

Figure 4: A Prototype of WSNs sensor nodes with multiple sensors use Arduino processor.

5 CONCLUSIONS

It has been proposed to develop a WSN node to detect fires and monitor from various sensors for correct detection. Projects that include mathematical analysis and regional approaches must cover the entire Riau province. Sensors of humidity, temperature, smoke, and carbon are the focus of attention in this issue of these parameters are the main parameter for fire conditions both on land and in the forest. Recommended sensor nodes using the low-power ZigBee model, sensor nodes can be used as long battery-powered nodes. At least in each region, a network coordinator must be formed to cover the entire Riau province and the gateway must be available to hospital the server (cloud database) and monitor the computer. The highly applicable WSN concept proposed to detect forest of fires in province of Riau is very useful for preparing presentations.

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