A Wireless Sensor Network Architecture for Forest Fire Detection

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***Abstract*— This paper presents the initial steps towards the development of a forest fire detection system based on a wireless sensor network which can measure parameters such temperature, relative humidity, and send the data immediately to their respective cluster nodes that process the data by constructing a neural network. The neural network takes the measured data as input to produce weather index, which measures the probability for the weather to cause a fire. Cluster headers will send weather indexes to a manager node via the sink. Then the manager node predicts based on received weather indexes. Sometimes sensor nodes may detect smoke or abnormal temperature. They will directly send an emergence report to the manager node. Our proposed system can make a quick and accurate assessment of a possible fire danger.**

***Keywords*— Neural network, weather index, cluster header, forest fire.**

I. Introduction

The forest industry is of a major economic and social importance in every country [8]. Due to the size of the forest industry, all sort of companies participate in the industrial sector producing not only wood and lumber for export, but also manufacturing pulp, paper, panel products, and fibreboards, among other goods [6][3]. When forests are destroyed by natural and/or man-made disasters, the entire production chain is broken, the economy of those countries depending on the forest industry becomes severely damaged, and the environments as well as the human population living in areas surrounding the forests are negatively affected as well.

According to the Chilean Wood and Lumber Corporation, the most frequent disasters destroying Chilean forests are wildfires and 85% of those wildfires are ignited by human beings [2][4]. Unfortunately, in spite of the efforts made by authorities to prevent forest fires, they keep increasing in number. To reduce the frequency of forest fires and minimize the economic and social impacts of fires [5] on the land, population, and forest industry authorities are thrusting novel initiatives for real-time monitoring forests and accurate detection of fires.

This paper proposes a large number of sensor nodes that are densely deployed on the forest. These sensor nodes collect measurement data such as relative humidity, temperature, smoke, etc and all these factors are required for determining the forest fire danger rate.[1] The sensor nodes are fixed in the forest to detect the forest fire and these nodes are formed into clusters where each node has a corresponding cluster header. It can also be detected by finding out the location using the GPS system .The cluster header calculates the weather index using the neural networks. And on further process the cluster header sends the weather index to the manager node through the sink. The sink is connected to a manager node through a wired network. A few sensor nodes are manually deployed over the forest and connected to the sink through the wired networks to detect wind speed.

The manager node provides the two types of information to the users; one is emergence report for abnormal event for detecting smoke or extremely high temperature and the other one is real time forest fire danger rate for each cluster based on the weather indexes from the cluster header. Each node can generate three classes of data packets, the first is regular report second is query response and the third is emergence report [1].

The algorithm used here is clustering algorithm as the routing protocol in wireless sensor networks [10] .Sensor nodes, cluster header as the input layer nodes. This algorithm is used to balance the energy consumption of all sensor nodes to dynamically select the cluster header based on the residual energy. The cluster header performs most of the in-network processing task.

The emergence report is given the highest priority. When an emergence report is generated the cluster header immediately sends the packet to the manager node and considered as a potential danger.

The proposed system can detect forest fire more promptly and forecast the forest fire danger rate accurately. These features make our proposed paradigm superior to traditional based approach.

The remainder of this paper is organized as follows. In section II we discuss the related work. Section III describes the network model for forest fire detection and present how to process the collected data efficiently. Section IV shows the performance evaluation. Section V concludes the paper.

II. II. RELATED WORK

Here we are categorizing the related work into two different classes. In-network processing and forest fire detection.

1. In-networking Processing

In this work a new security mechanism that can be used to provide secure *in-network processing* in wireless sensor networks. In particular, this means that the designed security mechanisms with both aggregation and dissemination in mind [9]. Secure aggregation implies that data is forwarded from the sensors in a secure and authenticated way. Thus an adversary cannot issue false data into the network unless of course a particular sensor node has been compromised. Secure dissemination requires that lower level nodes are able to authenticate commands issued by their parents in the hierarchy.

For both directions, protection is also provided against eavesdropping and tampering of data. The protocol is simple and scalable and most importantly offers resiliency against node capture and replication as compromised nodes cannot be used to populate and eventually take over the network. Furthermore, it requires minimal key material for the majority of the sensors. As a result the proposed protocol can be applied to both broadband sensor networks, where more resources are available, but also to traditional sensor networks, where more constraints do apply [6].

In this paper, a new type of in-networking processing is used where from the vast raw data all the high level information is extracted. This is more efficient approach considering certain other scenarios.

2. Forest Fire Detection

Most of the existing systems mainly rely on satellite imagery. Moderate-resolution Imaging Spectrometer (MODIS) [7] is an instrument which is used to evaluate data to detect plausible fire in the forest. The precision of MODIS is better than that of AVHRR . The Land Surface Temperature (LST) is measured and the precision of MODIS is around 1 K. here a neural network is used as a method to reduce the complexity of the data as the contribution of each data is not known. The accuracy of the satellite imagery is reduced due to weather conditions such as storms, cloud etc.

In this proposed system we make use of inexpensive sensor nodes. In comparison with the satellite imagery, the proposed system can detect the forest fire rapidly and more accurately.

III. PROPOSED SYSTEM

The factors determining to the potential threat of forest fires are temperature, relative humidity, smoke etc... The nodes densely deployed in the forest measure these factors [11]. There are many other factors such as lightning and man- caused but these factors are not considered in our project.

The proposed network paradigm is described:

Many sensor nodes are densely placed in the forest. The sensor nodes are made to form into clusters and each cluster has its own cluster header. Sensor nodes measure temperature and abnormal events like smoke etc. The data measured by the sensor nodes are collectively sent to the cluster header. With the received data the cluster header calculates the weather index using a neural network method. The cluster header sends the weather index to the manager node via sink.

Two types of information are provided to the users: 1) An emergence report for abnormal event and 2) Weather index from each cluster header providing the actual environmental conditions of the forest.

A. Clustering

The clustering algorithm is also used as the routing protocol [10]. By using this algorithm we are also able to meet demand of the neural network. Sensor nodes, cluster headers are considered as input layer nodes. The activity of each cluster is to send weather index to the sink is used to dynamically select the cluster header. It also balances energy consumption based on residual charge.

B. Data Collection

Three classes of packets are generated by each node (1) Regular Report (RR), (2) Query Response (QR) and last (3) Emergence Report (ER). Each report is given a tag. The node collects the data and encloses those data into an RR packet. After receiving the query packet from the sink, QR is generated which is send to the sink back. Emergence Report is given the highest priority. If a node detect abnormal event it generates an ER packet and send directly to the sink.

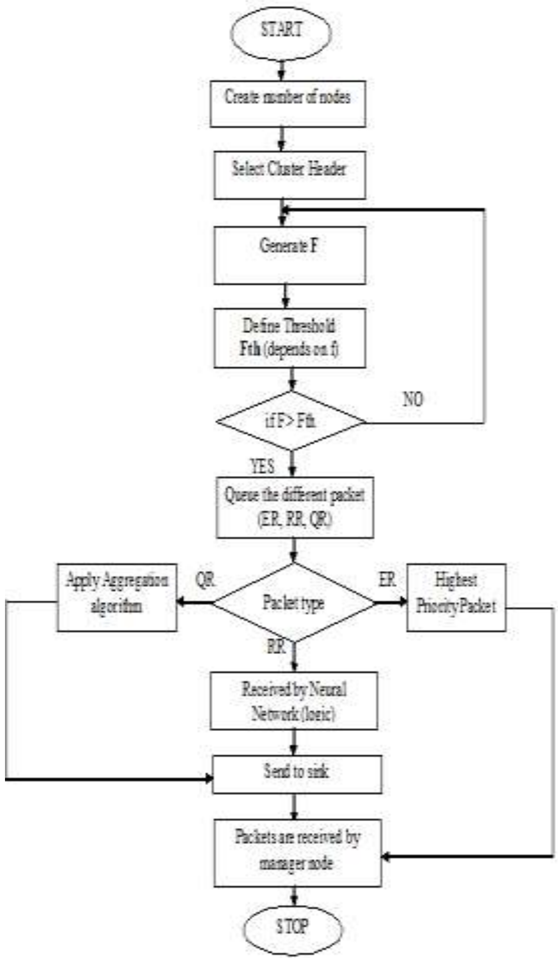

Figure 1. Forest Fire Detection Architecture

C. Data Processing

Upon receiving a packet from other nodes the cluster header starts processing the packet. When the cluster header receives an ER packet with abnormal event, the ER packet is sent to the sink as early as possible [1]. Since ER packet is given the highest priority the ER packet is sent to the sink immediately via intermediate node. When each intermediate node receives an ER packet, the node will insert a new ER packet ahead of any packets.

As the cluster header receives a QR packet, the cluster header apply aggregation algorithm [9] to process it.

The RR packets are processed by constructing a neural network. The neural network takes all data the data received and generate a metric called the weather index. A processed report (PR) contains the encapsulated weather index.

D. Cluster Header Selection and Parameter Handover

We use the clustering algorithm in order to balance the energy consumption of all the sensor nodes [10]. This is done by dynamically selecting the cluster header based on the residual charge and few other parameters.

The cluster header gets exhausted because it performs most of the in-network processing tasks. Because of this there arises a necessity to shift the workload from a overloaded cluster header to a newly dynamically selected one.

An announcement is sent by the newly selected cluster header before replacing the previous one. After receiving the announcement, the overloaded cluster header is supposed to send a handover packet containing all the parameters for the in-networking process . The newly selected packet may receive handover packet from various overloaded cluster header. It can choose the right one by measuring the minimum Euclidean distance away from the ne cluster header.

IV. Performance Evaluation

We evaluate the performance of optimizing communication load, we used neural network logic. Initially Network model is created with 30 nodes approximately. Cluster is formed with particular number of nodes. Each cluster contains cluster header. Communication takes place between node and cluster header. Cluster header receives packets from all nodes. cluster header with neural network is compared to another cluster header without neural network value to show which is effectively optimizing load , consumes less power and produce better performance.

As in simulation of OPNET, each node is applied with traffic. Transmission occurs from node to respective cluster header. Neural network value should be kept reasonable scale. Because the big threshold value Fthd would reduce the accuracy of collected data. one cluster header holds the optimal Neural Network value 0.2 for Fthd threshold produce optimized communication load. Whereas the another cluster header holds 0.2 without Neural Network logic produce inconsistent communication load as resulted in graph.

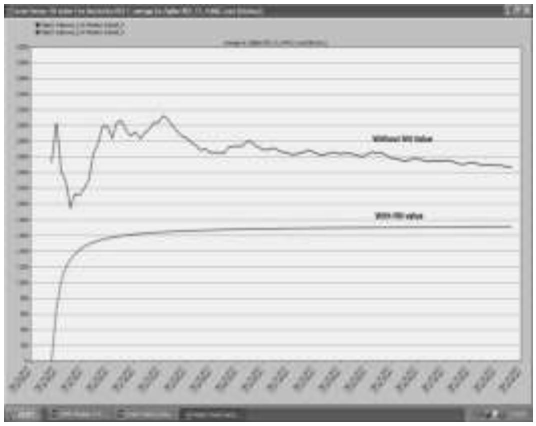

Figure 2. A graph showing performance of NN value in CH

The side effects of not using the NN value on the long run will affect the performance of the sensors. The inference we can make from this implementation is that by using a NN value for F*thd* optimizes the performance of the sensors and also holds good for less energy consumption which results in the long battery life of the sensors.

V. CONCLUSION

In this paper the proposed system gives an efficient network paradigm for forest fire detection. The precision acquired through the proposed work is very accurate and prompt. The system is also available for several enhancements

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