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Disaster Management Using Multi-Hop ADHOC Wireless Sensor Network and IOT

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Abstract: Natural disaster, as we know is too unpredictable in nature. We cannot bring the occurrence of natural disaster under our control. What all we can do is to minimize the disastrous after-effects of a natural catastrophe by initiating a rescue operation as fast as possible in the affected area. In this paper, we have proposed the Multi-Hop Ad-hoc Wireless Sensor Network (WSN) and the Internet of Things (IOT) to build up a system that would detect the kind of disaster and then inform the disaster management team. The system would notify the disaster management team about the location, kind and scale of the disaster. The faster the disaster management team gets the information, the more accelerated will be the relief action. A faster evacuation process will help to curtail down the loss of life and property.

Keywords: Disaster Management, WSN, Multi-hop, Ad-hoc, IOT, Auto Fault Detection

I. INTRODUCTION

Wireless Sensor Network (WSN) [1] [2] refers to a network comprising of a group of spatially dispersed sensors that are intended to monitor certain physical and environmental conditions like temperature, vibration, humidity, etc. This paper uses the WSN as its main building block. We have used temperature sensor, vibration sensor, and water level sensor that are designed respectively to monitor disasters like forest fire, earthquake, and flood. These nodes will be wirelessly connected using the Multi-hop Ad-hoc Network Technique (MANET) [3].

The network is completely ad-hoc in nature as it does not depend on any pre-existing infrastructure like routers or access points. Instead each node participates in routing by dynamically forwarding data to the base station. If node B, for example, receives a data from another node, A, and continues to receive the same data from same node within 10s interval, then it will consider it to be multiple copies of the same data and discard the duplicate copies instead of flooding the network with redundant data. And since the data packets will be forwarded through multiple paths, no data packet will be lost in this process of discarding.

The IoT enabled base station receives the data from all the nodes and after checking whether it is a valid disaster or not, it informs the disaster management team about the type, location and intensity of the disaster. A fault detection algorithm is employed that will help the base station to differentiate between a real and a false trigger. The IoT connectivity provides an interface to monitor the health of the nodes from anywhere across the world. The base station will log the data that it receives from the WSN nodes into the server and that same server account is also monitored by the IoT enabled device provided to the disaster management team. In literature, many techniques have been described for disaster management using IoT and WSN.

Prabodh Sakhardande et.al [4] has proposed disaster management system using IoT based interconnected network with smart city monitoring. Concepts of data mining and Machine learning have been applied for distributed event detection of meteorological natural hazards and wild and residential fires [5].

Rone Ilido da Silva et.al [6] has proposed the system for disaster management using WSNS to detect disasters, carried not only on rectangular regions but also regions with irregular shapes. This paper uses simple low cost and low power consuming microcontroller ATTiny 85 [7], low cost sensors, and thus the overall complexity as well as cost of building the model is greatly reduced.

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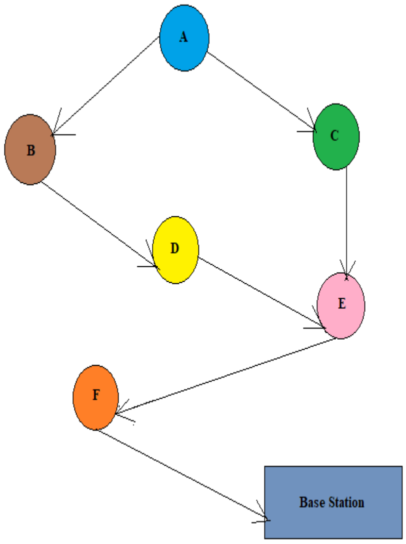

Fig. I: Diagrammatic view of the system

II. METHODOLOGY

A brief diagrammatic view of the system is illustrated through an example, as shown in Fig: I. A wireless sensor network is considered which comprises of three earthquake nodes, two flood sensing nodes, and one forest fire sensing node. The algorithm proceeds as follows:

a. Suppose the earthquake node B senses an earthquake, it will immediately broadcast it to the network.

b. All the nodes in reach of node B will receive the alert message and broadcast it in turn and this will continue till it reaches the base station.

c. As soon as the base station receives the earthquake alarm, it broadcasts a query message requesting all other nodes to send their reading.

d. The nodes D, F on receiving the request, broadcast their report in turn to the network. The base station decides it to be valid earthquake if all or some other earthquake node in the same locality have confirmed the same.

e. The base station on confirming it to be valid earthquake, reports it to the disaster management team using the IoT.

f. The base station in turn is connected to the IF THIS THEN THAT SERVER (IFTTT server). Through this server we send SMS to the disaster management team, notifying them about the location, type and scale of the disaster.

III. IMPLEMENTATION

There are four sensor nodes, and one base station, out of which two are vibration sensing nodes (for earthquake detection), one is temperature sensing node (for forest fire detection) and one is water level sensor node for flood type of disaster. The wireless sensor network is built using NRF24L01+ [8] and controlled by ATtiny85. It is a highly integrated, ultra-low power (ULP) 2Mbps RF trans receiver IC for the 2.4GHz ISM (Industrial, Scientific, Medical) band. With peak RX/TX currents lower than 14mA, a sub uA power down mode, advanced power management and a 1.9 to 3.6V supply range, the NRF24L01 provides a true ULP solution enabling months to years of battery lifetime when running on coin cells. The microcontroller that we have used to weave the sensor and the NRF24L01 together is ATtiny85. It is a low power, 8-bit AVR RISC architecture-based microcontroller with 8KB ISP flash memory, 512 EEPROM and 512-byte SRAM. The base station is an ESP8266-12E [9] module powered by an external 5V supply and uses a NRF24L01 to communicate the WSN. The base station can be connected only to some of the selected Wi-Fi networks to prevent any sort of unwanted control over the network. The base station cis provided with AES encryption to provide best in class security for the earthquake node we have used the sw18010p sensor [10], which is a spring type, non-directional vibration sensor which can be triggered from any angle. The temperature node uses the LM35 [11], which is directly calibrated in Celsius and rated from -55 degrees Celsius to 150 degrees Celsius. For the water level sensor, we have used a contact sensor. The microcontroller ATTINY 85 continuously monitors the output from the sensor. On reading a value, beyond the threshold, it will start a process to notify it to the base station. It will first wake up the NRF module, which is otherwise inactive. The NRF module will deliver this report to the network and it is the task of the network to deliver it to the base station. The base station will now run the fault detection algorithm to check

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whether the received disaster alert is valid or not; using the fault detection algorithm. The fault detection algorithm is proposed to avoid unwanted triggering of the sensor nodes, which might be caused due to any human intervention also. This paper demonstrates the fault detection algorithm using two vibration sensor nodes. To confirm it to be a valid earthquake, data is collected from more than one node and only if all the nodes send the same result, it is confirmed that in that region an earthquake has broken out in actual and it is not the case of false triggering. In reality, there could be as many numbers of nodes as possible, and more the number of nodes, more is the accuracy and less chance of fallacious alerts. If it is a valid one, the base station will send an SMS to the disaster management team using the IFTTT server. The general block diagram of a WSN node and that of the base station are respectively shown in Fig II and Fig III.

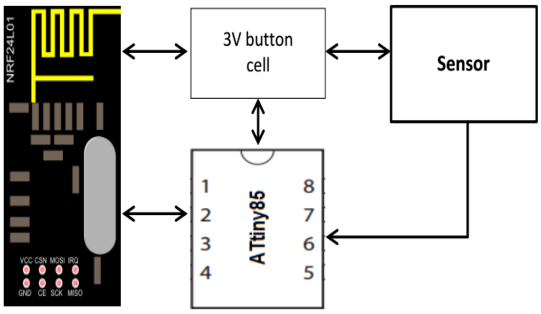

Fig. II: General block diagram of WSN node

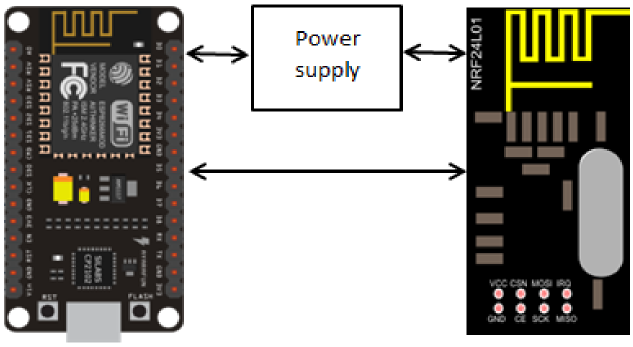

Fig. III: Base station

IV. BLOCK DIAGRAM OF THE SYSTEM

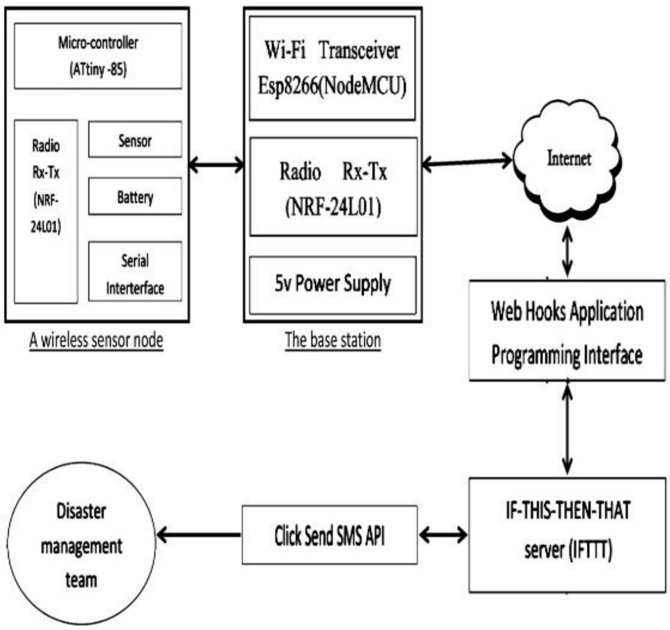

Fig. IV: General block diagram of the system

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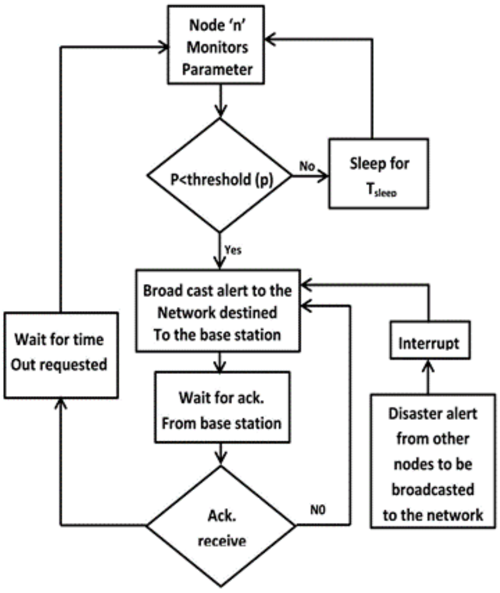
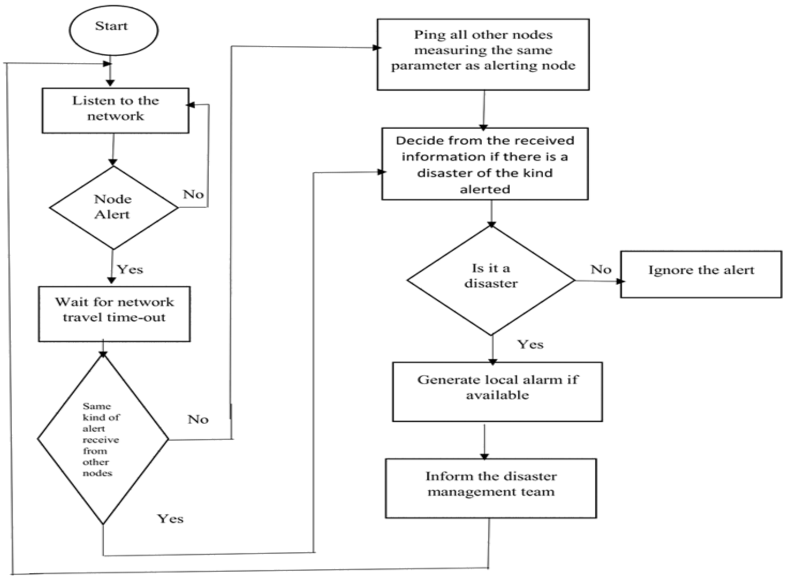
V. ALGORITHM

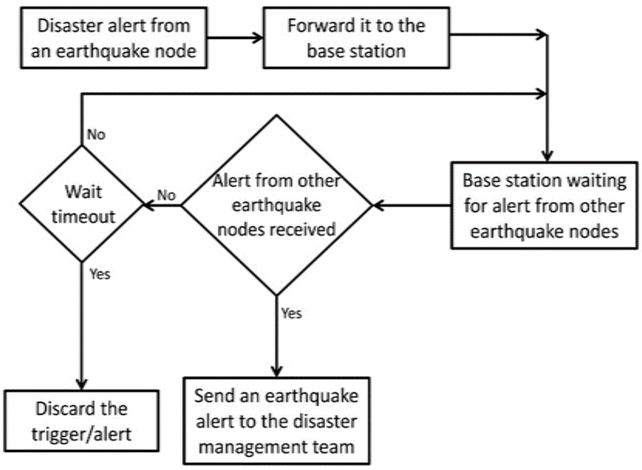
A. Working of WSN



B. Working of Base Station

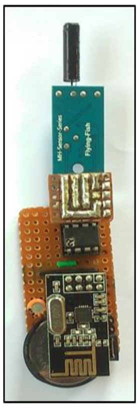


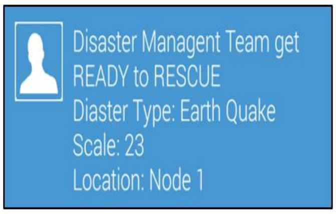
C.. Auto Fault Detection



VII. RESULTS

The WSNs have successfully recorded the data and have broadcast it to the network. After receiving an alert from one earthquake node, the base station waited for a specific time window, and within that when it received the same alert from another earthquake node within that area, the base station sent that alert message through an SMS notifying the disaster management team about the location, type and scale of the disaster. Every node is equipped with a separate ID, which is available to data base of the disaster management team. This unique ID would help the team to immediately get the location of the corresponding node. The experimental snapshot of an SMS received due to earthquake alert from the vibration sensor is shown in Fig V.





Sms to the Disaster Management Team in case of Earthquake

Earthquake Sensing Node

Fig V: Snapshot of SMS received due to earthquake

CONCLUSION

This work has successfully used the wireless sensor networks to monitor physical parameters like vibration, temperature and water-level. These WSNs being very small can be easily deployed and used in a distributed way. The IoT connectivity has given the system an added dimension. It has allowed the system to send the alert to the disaster management team which can be housed anywehere across the world. But we have implemented only four types of sensors. Variety of other sensors can be used as there are a wide spectrum of natural disasters which endanger our planet. Other methods like image processing techniques can be employed to detect disasters like landslides and tornedo. Due to the computational limitations of the microcontroller, we have used; advanced encryption algorithm cannot be used. So, further modifications can be made to incorporate encryption into the wireless sensor network.

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