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Wireless Sensor Network in Disaster Management

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Abstract

Background/Objectives: This paper proposes efficient disaster detection and alerting system to reduce losses due to the occurrence of natural disasters worldwide. Wireless Sensor Networks (WSN) helps in disaster management to reduce the mass destruction and huge loss due to climatic change by determining the amount of disaster occurred in a particular location. Based on the physical parameters measured by the sensors, appropriate remedial actions can be taken. **Methods/ Statistical Analysis:** In this paper, the utilization of the Heterogeneous Sensor Networks for Disaster Management (DM) is analyzed. Also, this paper reviews the types of disasters and the different sensors utilized for measuring their intensity. Heterogeneous clustering protocol is suggested for disaster management using wireless sensor networks. Moreover, utilizing heterogeneous clustering protocol increases the life time of the power constrained sensor node. Different types of Heterogeneous clustering protocols viz. SEP, DEEC, EDEEC, BEENISH are analyzed. **Findings:** Among these protocols, EDEEC and BEENISH protocols show better results when the number of parameters are increased. EDEEC protocol can be applied in the analysis of earthquake, storm and volcano and BEENISH protocol can be applied in the analysis of Tsunami. **Application/Improvements:** For disaster prone regions, these types of clustering protocols can be utilized efficiently in order to avoid huge loss for the society as well as for the human beings.

Keywords: Clustering, Deployment, Disaster Management, Lifetime, Sensor Node

1. Introduction

A Wireless Sensor Network (WSN) of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature sound, pressure etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on[4,15,17].

Two types of Sensor Networks are available. Based on the types of sensors utilized in the network, the wireless sensor network may be homogeneous wireless sensor network and heterogeneous wireless sensor network. The purpose of utilizing heterogeneous wireless sensor network in the disaster prone zone is to sense more than one parameter which helps in preventing the disaster.

The rest of the paper is described as follows. Section 2 describes the types of disasters, section 3 describes Sensors for measuring disasters, section 4 describes homogeneous and heterogeneous sensor network, Section 5 explains clustering protocols, section 6 gives the conclusion.

2. Types of Disasters

2.1 Volcanic Eruption

A volcano erupts when hot molten rock from deep inside

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the earth bursts out of the ground. Magma is accompanied by rocks, ash, dust, steam and hot gases. Once the magma comes out, it is called lava, which flow down from the upper portion of the volcano; the temperature of the lava that comes from the volcano is very high, it burns the trees, buildings and anything else that are present in their paths. Ash, mud and poisonous gases come out when the volcano explodes. Volcanoes are named after "Vulcan", the roman god of fire and metal work who was said to have had his workshop under Mount volcano, an island off the north coast of Sicily.

Beneath an active volcano lies a chamber of hot molten rock called magma. The density of the magma is less when compared to the solid rock around it, so raise to the surface through cracks or fissures and a main outlet called a vent. Magma contains a lot of dissolved gas will explode at the surface throwing ash and rocks known as bombs into the air. Sometimes burning gas and ash known as pyroclastic flow pour down the sides. The lava cools and becomes hard rock. Accumulation of the lava creates a mountain with a creator on top. Five types of volcano are available. They are cinder cone, shield volcano, strato-volcano, super volcano and submarine volcano. 90 percent of volcanoes that lay along the ring of fire a circle of volcanic activity around the edge of the Pacific Ocean at the boundaries of earth's plates. Some volcanoes are on land, but there are also many that form under Water Mountains. The floor of the Pacific Ocean has large number of volcanoes.

2.2 Weather-Disaster

The earth's atmosphere and the sun's heat cause the weather. Some parts of the earth are warmed ore than others, because the earth is tilted on its axis. This causes variation in temperature across the earth's surface, which causes the wind and other weather conditions.

2.3 Storm

A storm happens when cold air and warm air runs into each other. Moving cold air is called a cold front, and moving warm air is called a warm front. When these fronts clash, storm clouds form. The cloud produce lightning, thunder, heavy rain and sometimes even balls of ice called hail.

2.4 Tornadoes

Tornadoes or whirlwinds are the most violent storms. They occur when a rising column of twisted air develops beneath a thunder cloud. Extreme weather conditions such as hurricanes and tornadoes can cause a great deal of damage and destruction. Tornadoes appear as funnel shaped clouds with winds that can reach speeds of about 480 km/hr.

Tornadoes are so strong that they can flatten homes and uproot trees. The rotation of the earth causes the wind to move to the right in the northern hemisphere and to the left in the southern hemisphere. This feature is known as the Coriolis Effect that affects the weather patterns, causing thunderstorms and hurricanes. The pressure at the poles is higher than at the equator. This causes air from the poles to move towards the equator. Since the pressure changes quickly, the air flows at high speeds forming strong winds known as jet streams. These winds can reach speeds of more than 320 km/hr.

2.5 Hurricane

Hurricanes are tropical storms that are formed in places lying near the equator. These tropical storms are accompanied by heavy rains and winds that travel at speeds of more than 117 km/hr. hurricane are born when hot air above the sea rises up and cooler air takes it place, creating a low pressure area. The earth's rotation causes air to twist forming a cylinder. As the warm air cools down it creates huge clouds around the cylinder. Meteorologists study different types of clouds, measure wind speeds, and use weather balloons to determine the temperature and humidity in the atmosphere. They also make use of satellite pictures to see whether there are any approaching storms. All this information is fed into highly advanced computers that help to forecast the weather.

2.6 Earth Quake

The surface of the earth is like a massive jigsaw puzzle made up of huge rocky pieces called tectonic plates. These plates are constantly moving about very slowly but with immense force.

Earth quake like volcanoes are caused by the movement of the tectonic plates. When these plates slide past each other or a part is broken suddenly, the earth trem-

bles. This is an earth quake. Sometimes the earth trembles very hard which causes buildings to collapse. Tectonic plates meet along lines called fault lines. The plates on either side of the fault press against each other with a great deal of force, when a plate moves suddenly, it causes shock waves to travel through the ground. As a result the ground shakes. The place on the fault line where the plates move is called the focus of the earth quake. The place on the ground that lies directly above the focus is called the epicenter. The intensity of the earth quake is strongest near the epi-center.

Scientists measure earth quakes in two different ways- by its magnitude or by its intensity. Magnitude means the power of the shock waves and it is usually measured on Richter scale. The effects of an earth quake are measured by Mercalli intensity scale. Geologists use an instrument called a seismograph to measure the intensity of an earth quake. The scale uses a number to indicate earth quake's intensity.

2.7 Tsunami

Most Tsunamis are caused by the undersea earth quake. The sudden intense movement of a plate along the fault line deep beneath the ocean sends a shock wave through the water. This sets off a powerful series of waves that spread out across the ocean. These massive waves are called Tsunamis. Tsunamis can cause devastating damage to life and property. As they reach shallow water near land, the waves begin to tower higher and higher.

A Tsunami wave can be 100 km to 200 km long and can reach speeds of 800 km/hr. it has a destructive force that equals millions of tones. Tsunamis are capable of completely destroying life and property on land. The worst Tsunami disaster in history occurred on 26th December 2004. An underwater earthquake measuring 9.0 on the Richter scale, centered in the Indian Ocean caused a massive Tsunami. It struck the costs of 14 countries from South East Asia to Northeastern Africa. More than 250,000 lost their lives. The purpose of deploying sensor nodes is to monitor some important parameters in that area. SN consists of a sensing element for sensing, signal conditioning element for processing the sensed parameters, transmission element for conveying the processed information either to CH or to the BS, Power supply unit for the operation of the sensor node[16].

3. Sensors for Measuring the Disasters

The motion of the ground can be measured with the help of seismometers. During the earthquakes or in volcanic eruptions or in Tsunami periods, plates that are present beneath the earth moves slightly or severely. Seismology is the study of earthquake. Seismograph is the recorded form of earthquake measurement. Two types of seismometers are available. They are Tele-seismometer and strong motion seismometers. The severity of the earthquake has been measured by using strong-motion seismometer.

It is possible to predict the symptoms of volcanic eruption. For the prediction of volcanic eruption continuous monitoring of the volcano is needed. The volcano may be in sleep state or in awake state. During the sleep state, the volcano will not erupt. But during the awake or alert state, the volcano may erupt. Seismic waves have been generated during the volcanic eruption period. Two types of these seismic waves have been sensed. They are "A waves" and "B" waves. "A" waves have been generated during short period of earthquake. "B" waves have been generated during the long period of earthquake. The volcanic eruption has been measured by analyzing thermal monitoring, hydrology or by remote sensing.

The Tsunami waves have been measured by deploying Deep-ocean Tsunami detection buoys. Two components are being attached in this detection buoys. They are surface buoy and the pressure sensor. The pressure sensors have been deployed in the Tsunami prone area. These sensors sense the changes of the water column height by analyzing the pressure created by the water. Then this pressure change has been conveyed to the surface buoy.

The storm has been determined by using Dripstones. Dripstones comprises of Sensors that are used to sense the speed of the wind, direction of the wind, temperature as well as humidity of the wind.

3.1 Homogeneous Wireless Sensor Network

In Homogeneous sensor network, the SNs have identical characteristics. i.e. SNs have identical characteristics and they measures same type of parameters. For example in an area if SNs nodes are deployed and they measure same type of parameter (example temperature) then, the SNs are said to be homogeneous SNs and the network is

said to be homogeneous sensor network. The hardware complexity, battery power, energy level are same for all for homogeneous SNs[2,3,7,8]. Low Energy Adaptive Clustering Hierarchy (LEACH). Power Efficient Gathering in Sensor Information Systems (PEGASIS) and Hybrid Energy-Efficient Distributed Clustering (HEED) are examples of cluster based protocols which are designed for homogenous WSNs[10].

3.2 Heterogenous Wireless Sensor Network

In heterogeneous sensor network, the characteristics of the SNs differ from the other SN, because the SNs have to measure different parameters. So characteristics of the SNs depend on the parameters they are going to measure.

The memory capacity of the heterogeneous SN is more when compared to the Homogeneous SN. The processor Present in the Heterogeneous sensor node is more complex in nature. Because of these characteristics it is possible for the heterogeneous SN to perform well when compared to the other types of SN. The bandwidth available in the heterogeneous SN is also larger than other SNs[1].

Sensor nodes take self-decisions to accomplish sensing tasks, constructing network topology and routing policy. Therefore, it becomes important to design energy efficient algorithm for enhancing robustness against node failures and extending lifetime of WSNs. Efficiently Grouping Sensor Nodes in form of clusters is beneficial in minimizing the energy utilization[14].

Numerous energy efficient protocols are made based on clustering structure. In clustering, nodes assemble themselves in form of clusters with one node acting as the Cluster Head (CH). All cluster member nodes transmit sensed data to their CH, while the CH aggregate data received and forward it to the remote BS.

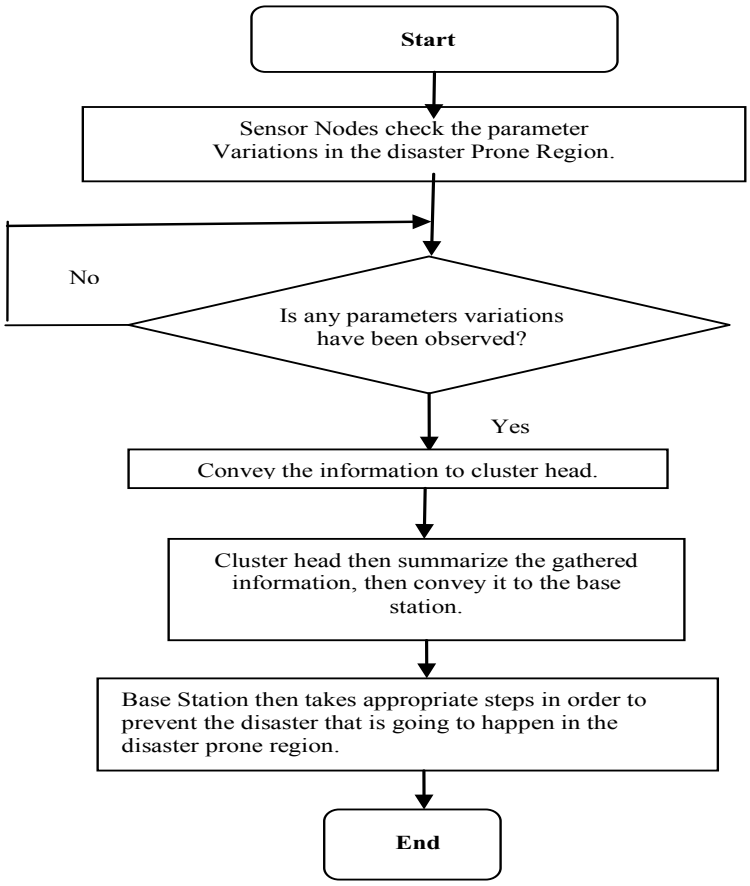

Figure 1. Flow chart representing the use of sensor Network in Disaster Prone Region.

3.3 Heterogeneous Clustering Protocols

For implementing this heterogeneous wireless sensor network in disaster management, heterogeneous clustering protocols are efficiently utilized[9]. The reasons for utilizing heterogeneous clustering protocols are to measure more than one parameters to be measured in the disaster prone area[5].

Protocols like Stable Election Protocol (SEP), Distributed Energy Efficient Clustering protocols (DEEC), Enhanced Energy Efficient Clustering Protocols (EDEEC)[6], Balanced Energy Efficient Network Integrated Super Heterogeneous Protocols (BEENISH) may be utilized. In these protocols the energy level of the sensor nodes may vary. In SEP normal nodes and advanced nodes are used. The advanced nodes are acting as cluster head for communicating the gathered information to the base station.

In DEEC and EDEEC three types of nodes are available. They are normal nodes, advanced nodes and super nodes. Super nodes act as cluster head for collecting the information from the other nodes and convey the gathered information to the based station. In BEENISH protocol, four types of nodes are available. They are normal nodes, advanced nodes, super nodes, and ultra-super nodes. The ultra super nodes act as cluster head for gathering the information send by other nodes. The cluster head then convey the gathered information to the base station[11-13]. Figure 1 shows the flow chart representing the use of sensor network in disaster prone region. Table 1 shows the summary of Disaster Management.

4. Conclusion

By implementing heterogeneous Wireless Sensor Network in disaster prone areas, appropriate actions have been taken based on the information given by these clustering protocols. Heterogeneous clustering protocols have been selected because; more than one parameters have to be analyzed in order to predict the nature of the disaster that is going to happen. The types of disaster management that

Table 1. Summary of disaster management

Parameters	Types of Disasters			
	Earthquake	**Volcano**	**Storm**	**Tsunami**
Nature of waves generated	Seismic waves have been generated	"A" waves or " B" waves have been generated	Cone shape waves have been generated	Harbor waves have been generated
Types of parameters to be measured	Movement of Tectonic plates, pressure below the earth's surface	Movement of Tectonic plates, Temperature below the earth's surface, pressure below the earth's surface	Speed of the wind, direction of the wind, Humidity of the wind, Temperature of the wind	Movement of Tectonic plates, undersea pressure, height of the tides, water level height.
Instruments to be used for measuring the disaster	Seismometer	Thermal monitoring, Hydrology monitoring, cloud sensing, gas sensing,	Weather radar	Deep ocean Tsunami Buoys
Types of Heterogeneous clustering protocols to be utilized	Enhanced Distributed Energy Efficient Clustering Protocol (EDEEC) protocol	Enhanced Distributed Energy Efficient Clustering Protocol (EDEEC) protocol	Enhanced Distributed Energy Efficient Clustering Protocol (EDEEC) protocol	Balanced energy efficient Network Integrated Super Heterogeneous (BEENISH) Protocol

has been adopted with the help of sensor networks are also called as Proactive Disaster Management. In general the EDEEC protocol, BEENISH protocol can be utilized for obtaining best results.

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