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Disaster Management through Wireless Sensor Networks

(WSN for hazardous and scarce areas for easy and timely deployment of the network)

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Abstract: We are living in the world where almost everything is dependent on right information. Nowadays many kinds of disasters are happening around the world like: earthquake, hurricane, terrorist attacks, explosions or biological warfare etc. are few of them. Therefore steps are required to be taken to prevent from these kinds of threats and for the rescue measures or disaster management operations quick and correct information is required. Wireless communication plays an important role in helping these kinds of situations. Among all Wireless Communication, Wireless Sensor Network (WSN) is able to cause immediate alert for disaster management operations to begin.

In this paper we will focus on the disaster detection and disaster managing operations through WSN. First we need to understand the basic architecture of WSN and then how it can be helpful for disaster management. We will see the world's scenario and incidents for examples.

Keywords: Wireless Sensor Network, Mobility, Flooding, Gossiping, Disaster.

I. Introduction

WSN is a significant technology which is low cost, low power, and small in size. Nodes in Wireless Sensor Network work together to sense environmental activities. WSN is attracting many researchers because it is capable to enable early warnings and to learn about the phenomena of natural disasters.

Disasters are increasing worldwide due to global warming, climate change and increasing terrorist's activities. The losses due to such disasters are increasing in alarming rate. Therefore it is needed to take steps by using such technology which can alert prior or exchanges quick information that can be responsive to crisis or disaster so the population can be evacuated soon and disaster recovery steps can taken as soon as possible to save people's life and to save or reduce big monetary losses. However risks and disasters are unpredictable and not always happen but if the steps are not taken then it can leads to give a big challenge to country's economy or human life. However WSN has its own limitation such as low battery, low memory, low computation capacity but has a big advantage over other wireless networks that it can be deployed in scarce or hostile environment with minimum maintenance and it can be deployed in no time when other network fails due to the infrastructure failure. This feature fulfills an important need for real time monitoring in calamity or disastrous scenarios.

II. Existing System and Proposed System

Most WSN applications are based on GPS which is based on satellite and it is very expensive to deploy and it delays in responding. WSN is low cost, low power and small in size, therefore we need to develop a WSN system which is made up according to its limitations and characteristics of WSN, here we are focusing on non GPS based WSN system which can be deployed in very less time especially in hazardous situations.

III. Scenario of disaster and system failure (need of WSN)

In United States there are 78,000 local government, local fire departments, and local police departments, 18,000 local police departments, 15,000 schools districts and 3,400 country governments (Pelfrey 2005). [1]. There were so many organizations worked together to respond to the major disaster. In 9/11 terrorist attack in New York city, there were almost 1,607 government and non government organizations were involved (Kapuca 2004). But there was a communication bottleneck was created due to Radio System failure. Police and other emergency departments were not able to communicate on Radio frequency.

By analyzing this scenario we can understand that there is a requirement of that kind of network or architecture which can sustain or can be implemented in these kinds of situations, therefore WSN is a good idea for that. Disaster Risk management can be categorize into four parts.

- Prevention or Avoidance
- Prepare with the arrangements
- Response Address the situation when it occurs
- Recovery or Rescue operations after it happens

The first 2 parts are before the disaster and next two parts are implemented after the disaster.

To Implement WSN for hazardous scenarios we need to understand some issues related to WSN:

1) **Implementation :** Implementation can be further divided into 2 categories:

(i) Nondeterministic: Where the location of the disaster cannot be determined prior to deploy the network. Example: Terrorist activities etc.

(ii) Pre- Deterministic: In this scenario the location of the disaster is predictable like floods (near sea, river etc.) therefore for this kind of area WSN network can be prepared in advance to deploy it when disaster occurs.

2) **Protocols:** Protocols of WSN are divided into two major categories

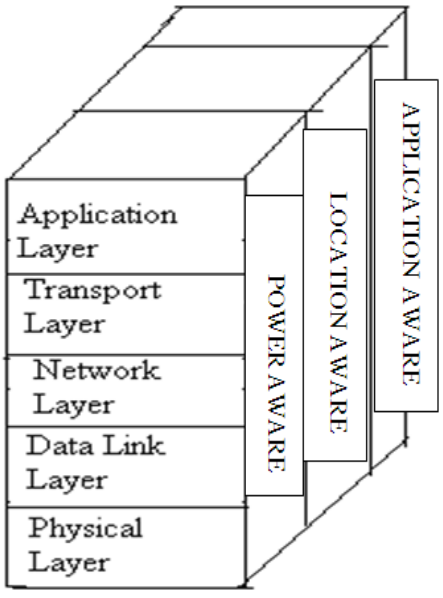

Fig. 1: Layered Architecture of WSN

(i) **Data Centric protocols:**

Data Centric protocols are used to control the redundancy of data, it happens because sensor node does not have unique/ global identification number (UID or GID) which make them unique in the network, so data is transmitted to each node with significant redundancy. Data centric protocol works where the sink requests for data by sending the query to send its data to the nearest sensor. The property of data is specified by attribute based naming. In Data Centric protocols again further categories:

Flooding: Each Sensor in the network receives a data packet and broadcasts it to all its neighbor and process continues until the destination node receives the packet or the maximum number of hop count is reached for the packet.

Gossiping: Here the receiving node sends the packet only to a randomly selected neighbor, which picks another random neighbor to forward the packet to and so on.

(ii) SPIN Protocol (Sensor Protocol for information via negotiation) :

SPIN is operated to use the energy to conserve energy. Flooding and Gossiping waste valuable communication energy by sending redundant information throughout the network.

SPIN keeps track of current energy level; it also distributes data in faster rate the flooding and gossiping which is beneficial for **Disaster management.** SPIN has 3 steps of message:

a) ADV (Advertisement): Sensor broadcast and ADV message containing a descriptor.
b) REQ (Request): If a neighbor is interested in data it sends a REQ memo for the Data.
c) **DATA (data):** Then Data is sent to the interested sender.

3) Mobility: Some WSN nodes are **freely moving,** they move with air or environmental changes and other category of WSN nodes are **controlled,** they move as and when the moving subject occurs and this is because they are energy effective and useful for Disaster management applications.

IV. Requirements while designing Algorithms for Disaster Management using WSN:

The criteria to be analyzed while designing the algorithms are: [2]

i. The total area of deployment.
ii. Maximum and Minimum transmission range.
iii. Maximum number of required sensor nodes to create a network for Disaster Management.

iv. Maximum number of available sensor nodes to create a network for Disaster Management.
v. Required amount of power in the batteries used.
vi. Required memory for each node of network.
vii. Availability of the constant power source
viii. Maximum bandwidth available.
ix. Frequency of transmission on a specific application.
x. Suitable Data Aggregation Methods.

These above criteria is required to set up the network to design network topology to design collection algorithm, to design data aggregation algorithms, to design energy efficient network which has maximum life time, also to design localization techniques and last but not the least which can be deployed in no time. If these above mentioned criteria is identified well in advance then the robust system can be made for Disaster Management using good algorithms like SPIN.

WSN networks may be prepared in advanced and can be deployed later when the situation arises. Rough estimate of topology, network, and other things can be managed; this comes under the category of Risk management. In Risk management also the plan and strategies are made well in advance to deal with the threats and uncertainties.

WSN architecture:

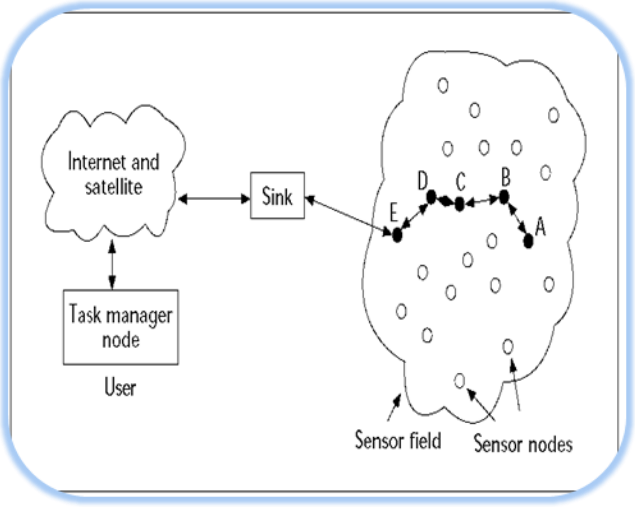

Fig.2: General Architecture of WSN

Deployment of WSN is dependent on many factors it can be decided after considering vulnerability Index Approach.

Since the geological and other conditions are different in every disaster so with respect to the different properties the area is to be divided into regions or parts. For Disaster recovery System we need a real-time data or data in no-time (least time). When data collection and Data Aggregation methods are combined with newly designed state transition algorithm it works efficiently in energy consumption and therefore it increases life of the network. We can take few examples of Disasters to understand it better:

For Earth Quake:

We have GEAR (Geographical and Energy Aware Routing) for this situation. Instead of broadcasting to all nodes in the network, a more common situation is to wish to reach all nodes in a certain geographic region. GEAR efficiently route a message to a geographic region at the same time it perform load balancing and therefore avoid energy depletion.

GEAR operates in two phases:

- Deliver the packet to a destination node of desired region.
- Deliver the packet within the region. Here we need frequency based detector and indicate when receives higher signal level.

For Forest-Fire detection:

Here we need sensors in large numbers which are densely deployed in the forest; each cluster has a cluster head to transfer the signal from one cluster to another. Sensor nodes can measure humidity, heat, smoke, temperature etc. And with the help of GPS they transfer the information about and location to the corresponding cluster head. When the level goes beyond the danger rate the disaster recovery steps can be taken. [3]

V. Conclusion

WSN is commonly used to monitor and to detect disaster prone areas. WSN can be proved a very good technology where other technology or applications fails due to disaster impact. WSN can be used to locate the victim and it may help the rescue agents to assess the victims and to make effective plans. WSN is not only helping to make disaster recovery plans but also disaster prevention methods.

In our paper we have highlighted the WSN architecture, its characteristics, kind of disasters and how we can address them by using WSN. This paper will be helpful for Indian scenario because India somehow lacks in infrastructure and impacted from disasters due to its old and under developed infrastructure, changing climate and high population is also a strong reason, also it is prone to adversary attacks from different countries. This paper may also be useful for developed countries like: USA, UK, Germany, France etc.

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