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Performance Analysis of Disaster Management using WSN technology

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Abstract

In this research paper we propose a model of Wireless Sensor Networksused for pre-detection of disasters. Here we have discussed the basic architecture of WSNs and how these can be used in disaster management. The major reasons for mass destruction are Earthquake and Tsunami. Millions of lives are lost owing to these. Disaster, be it natural or man-made has a catastrophic impact on lives, money and infrastructure. We do not have a sensitive system yet which provides pre detection of these calamities. Therefore we need to take serious measures to ensure our safety from these disasters. WSNs are a new technology which can be helpful in these situations. The paper also throws light on the future scope of the topic. The information derived can be stored and used for future reference to predict climate of the area at a particular time period.

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Keywords: Wireless Sensor Networks, Mobile Operator, Mobile Switching Center, IPv4, Base Station.

1. Introduction

The climate around the globe is changing at an alarming rate. The cause is mostly man-made. It affects the life of people severely. For instance Gujarat had an earthquake which killed nearly 20,000 people, injuring 167,000 and destroyed around 400,000 homes [1]. It was a notable disastrous incident which occurred in 2001. These types of events seldom occur around the world, which is a matter of great concern. Rehabilitation sometime takes months and even then the condition don't go back to normal in years. Hence we thought to devise a mechanism to detect the

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calamity in advance so that we can prepare for the worst case scenario. It will be a boon for many lives across the globe since their home, capital and everything is lost. Wireless Sensor Networks can pre-detect the disasters in certain landmasses, making it possible for humans to prepare for them. It is a network [8] of sensors, very small in size, which can communicate with base station, which in turn communicates with other elements of the wireless communication network, using GSM technology [2]. WSNs are used since these can detect even slight variation in temperature, pressure, sound, etc.

WSN has the following parts as follows-

The network is simple. The sensors sense the environment surrounding it (in terms of temperature, pressure, height, frequency) and generate a signal accordingly. It is then compared with a threshold value of the signal (in terms of voltage). If it is above the threshold level, it is transmitted to the nearest Base Station via a wireless link. For further transmission, it is sent to Mobile Switching Centre of the corresponding Base Station, from where the message is transferred to appropriate authority, like Police, Emergency, WHO (World Health Organization), through SMS, etc. (Process involved is transmission from one MSC to another MSC (if person, etc. falls in different circle (mobile circle)), then to Base Station where the mobile, etc. is present, and finally to the mobile station). Satellite can be used to transmit message from Ambulance to Hospital, since they will always be at high priority [3].

In case of Tsunami, Earthquake, etc. the message will reach to every person in that area via SMS, thus ensuring that that area is evacuated before time. In this case many sensors will be denoting the same characteristics in the same area, hence it will be known that it is the case of calamity. With regard to future research work and development, a disaster relief system can be a key factor which will be based on the results given by the WSN, and will be helpful for rehabilitation of the mass.

2. Proposed Network Architecture

2.1. Architecture

The diagram representing the new architecture for the phenomenon is shown in Fig. 1(a).

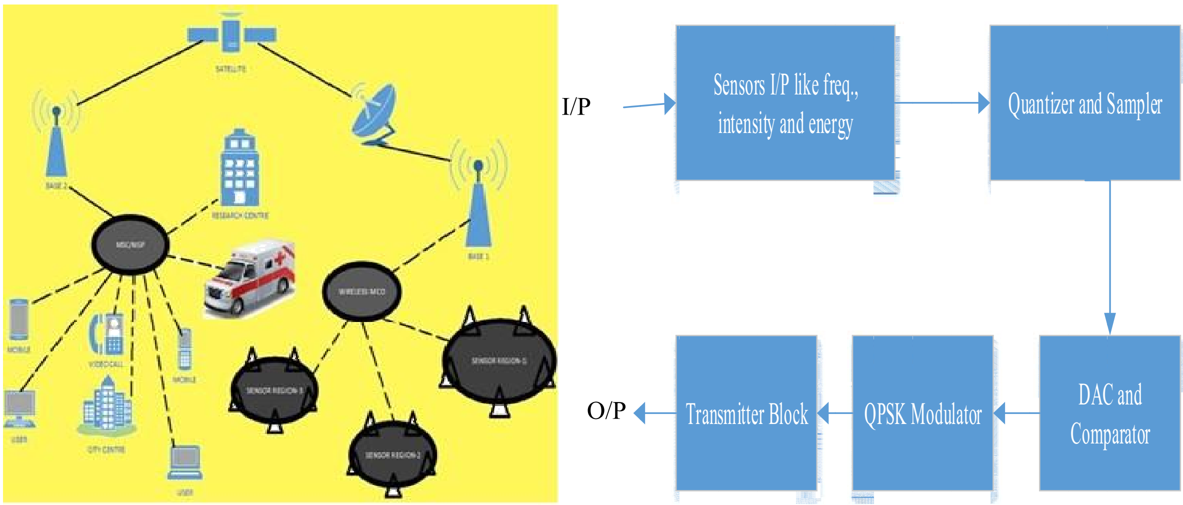

Fig. 1. (a) Proposed Network; (b) Working of Earthquake Sensor

2.2. Working Description

The working description of the device has been broken down briefly into the five points as mentioned below.

Step 1. All the sensors follows AODV routing protocol and 802.15.4 network protocol. They send the bit information after encoding and sampling process of analog information like pressure, frequency, temperature and levels to the nearest sensor head node, which is also communicated wirelessly.

Step 2. After receiving this information this head sensor compares the data bit to the self data bit and sends all information to the nearest base station by constant bit rate (CBR) link.

Step 3. As many of the sensor head node take the bit value to nearest source sensor, then these sink node also give the information regarding environment values to the BTS. Then BTS again encodes this information, and compares this information with threshold value manually at the embedded setup.
Step 4. If these value exceed the threshold information, then BTS encodes a message of alert and sends the information to nearest BTS, that have been connected to GSM network, nearest Base Station also communicates to the BTS, and all the information will send to all the mobile users, research centre, and defence headquarters.
Step 5. Then finally all the people who live in this area and also who live near this area, leave the place.

3. WSN Architectures for Disaster Management and their Properties

The description of each type of architectures are as described below.

3.1. Wireless Sensor Networks for Earthquake Pre-detection

Due to earthquakes many lives are affected and country faces a huge economical and manpower loss. The most disastrous and high numbered (on Richter scale) earthquake happened in India on 26th January, 2001 that rattled not only India, but other neighbouring countries also. Even in Himalayas region, in a day approximately 50 to 60 and in non-mountain area also, earthquakes are always detected. Due to this, mass destruction of human lives and loss of propertyis a serious consequence. Although these destructions cannot be ruled out completely, we can still save many lives by pre-detection and exact timing. In our network architecture in the figure, we have shownthat each sensor senses the earthquake based on the earthquake seismic frequency spectrum or low frequency below to 20Hz at every time in different earthquakes sensitive small zones. To handle the dynamics of earthquakes such as high magnitude of earthquake measurement unit and variable sensor location each sensors are distributed in separated statistical model of frequency spectrum for different units of seismic signal energy received by sensors. These sensors give the information in voltage to the nearest sensors and compares the output of the sensors to the pre-detected values. If the values of compared voltages or data are approximately same and more than the threshold values that has been saved in the sensors then the information is sent to the nearest Base Station that has been located in the nearby area or regions. At Base Station, these values are fed as input to a data processing centre located there, anda processor or a virtual plate-form like software that has already been installed at data processing centre fetches the information about the intensity of earthquakes, location of sensors etc. from the Base Station. The local base stations are powerful enough to communicate with one another directly using wireless communication. Thereby the Base Station sends the same information to the nearest Base Station that has been located at the nearestkilometre to the sensitive zones or the zones where earthquake has been detected and also sends the information to earthquake research Centre and network Service Provider Centre. They send SMS to the mobile users of that zone as an alert message and also to the police headquarters and ambulance stations. Various research results that frequency-based detector has better detection performance when the sensor receives higher signal energy [1]. Therefore, the base station first processes the subset data of informative sensors based on the signal frequency and energies received by sensors while satisfyingsystem sensing quality requirements. The sensors then compute seismic frequency spectrum using different technologies and make local detection decisions which are then transmitted to the base station for further processing. To localize earthquake source we have to provide addresses to different sensors. Here we are using wireless sensors with inbuilt GSM module therefore they will have their own SIM number. [6] In this approach, the base station first identifies an individual earthquake and estimates an onset time and area affected. Fig. 1(b) represents the diagram of the working of the Earthquake Sensor (Block Diagram).

3.2.Wireless Sensor Networks for Flood Pre-detection

Flood causes a havoc at the impact area. In September, 2014, Jammu and Kashmir witnessed flood in which entire houses were submerged, people left the area to save themselves. Each year in many parts of the globe flood is a serious problem which comes with huge loss of money, livelihood and life. Though these calamities cannot be ruled out completely, but we can do something to minimize their loss. Prevention can be taken which will be much better than the catastrophe itself. The sensors are spread in the water body such as a river, which will constantly monitor the level and will compare it with the threshold level already set before. This information is then passed to the Base Station. If it the case then SMS is sent to every person in the area displaying the “WARNING” that water level is above the danger level. This information will be very important in all cases. Since some amount of time will be available for people to save themselves and their belongings.

3.3. Wireless Sensor Networks for Tsunami Pre-detection

The methodology of Earthquake Pre-detection can be used for Tsunami too, since in broad terms Tsunami is a form of earthquake and landslides in oceans, etc. Tsunami causes a great havoc in coastal and nearby areas. The 2004 India Ocean Tsunami killed 230,000 people across fourteen countries. As it seems, it is very powerful and the loss is unspeakable. We propose use of water-proof sensors [5], just like that used in Earthquakes and place them deep in the seas and oceans. They detect vibrations of frequencies matching the seismic pattern and respond accordingly if the vibration is abnormal. If many of such sensors give similar data, we will know that Tsunami is going to hit the shores pretty soon so that we can take suitable measures to minimize its effects on lives and property.

4. Equations

The description and derivation used regarding different coding schemes are as mentioned.

4.1. Amplitude Phase Shift Keying

This modulation scheme is similar to Amplitude Modulation. When carrier signal is 1 it allows the message to modulate and pass and we get a modulated signal.

We define two signals s1(t) and s2(t), which get modulated through correlation. If γ is the Signal to Noise Ratio (SNR)

$$\gamma = \frac{2}{N_O}\int_0^\infty P^2(t)\,dt$$

$$= \frac{2}{N_O}\int_0^\infty [s_1(t) - s_2(t)]^2\,dt$$

Substituting $s_1(t) = A\cos 2\pi f_c t$ and $s_2(t)$

$$\gamma^2 = \frac{A^2T}{N_O}$$

4.2. Binary Phase Shift Keying

In case of BPSK, we take two phases 180° apart. Taking γ is SNR,

$$\gamma^2 = \frac{2}{N_O}\int_0^T P^2(t)dt$$

Substituting $P(T) = s_1(t) - s_2(t) = 2A\cos 2\pi f_c t$

$$= \frac{4A^2T}{N_0}$$

4.3. Offset Quadrature Phase Shift Keying

In this type of modulation scheme we transmit using four different values of the phase.

The SNR comes out to be

$$\gamma = \frac{1}{2}\, erfC\left[\frac{A^2T}{2N_O}\right]^{\frac{1}{2}}$$

Now, the table representing the differences among the three technologies is as shown below.

Table 1. Table representing difference in three modulation schemes

Parameter	ASK	BPSK	OQPSK
Probability of error	$\frac{1}{2}\, erfC\left[\frac{E_b}{2N_O}\right]^2$	$\frac{1}{2}\, erfC\left[\frac{E_b}{N_O}\right]^2$	$\frac{1}{2}\, erfC\left[\frac{2E_b}{N_O}\right]^2$

Signal to Noise Ratio	$\frac{1}{2}\, erfC\left[\frac{A^2T}{8N_O}\right]^{\frac{1}{2}}$	$\frac{1}{2}\, erfC\left[\frac{A^2T}{4N_O}\right]^{\frac{1}{2}}$	$\frac{1}{2}\, erfC\left[\frac{A^2T}{2N_O}\right]^{\frac{1}{2}}$
Bandwidth	f_c	$2f_c$	$4f_c$

5. Qualnet Platform Network Design

Qualnet is used to design the networking model which is given below. The wireless sensor module uses IPv4 Network Protocol, AODV Routing protocol IPv4 and Enable IP lookup for better addressing. The network diameter of this sensor we use here are 35 hops. GSM Base Station then transfers the data to the GSM Mobile Switching Centre, which forwards the call to mobile station.
The screenshot of this network [7] architecture in QUALNET are suited below. The diagrams representing the whole network is shown in Fig. 2-4.

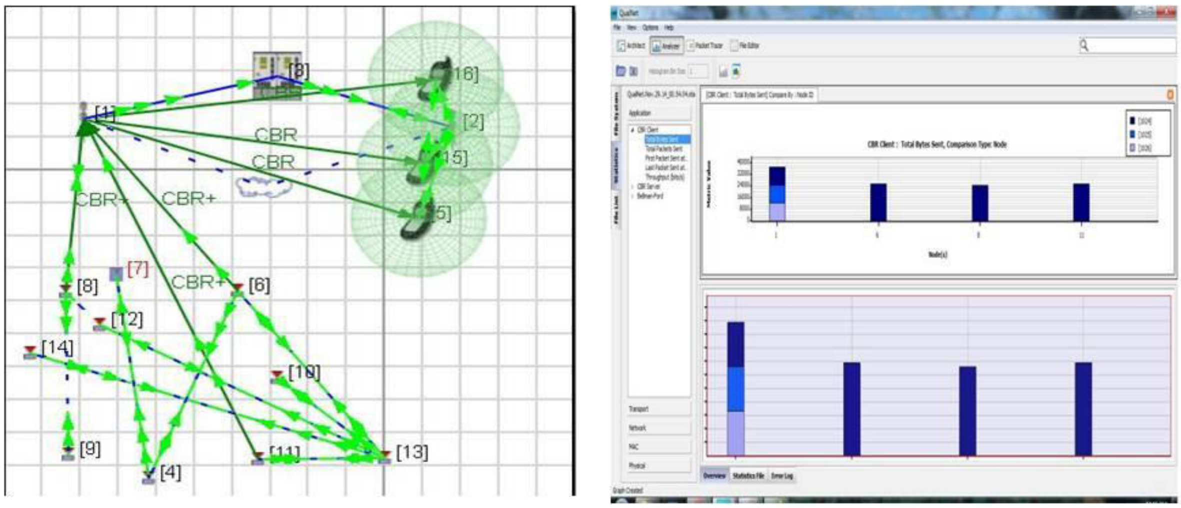

Fig. 2. (a) Architecture Design; (b) Total Byte sent in terms of Packets

Other simulation results are shown in the figures below, with their title written in caption.

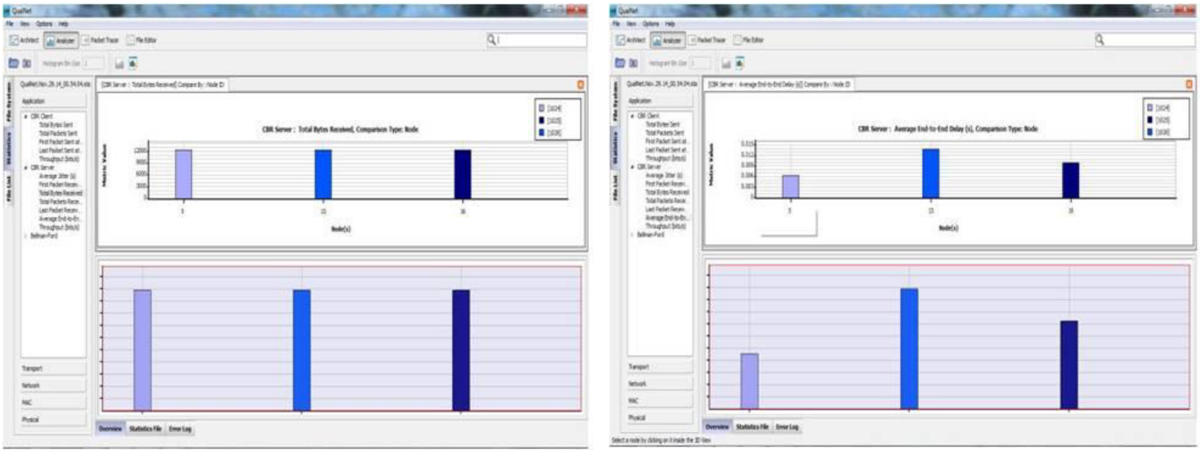

Fig. 3. (a)Total Byte sent in term of Nodes; (b)Average End to End Delay in Data Bytes.

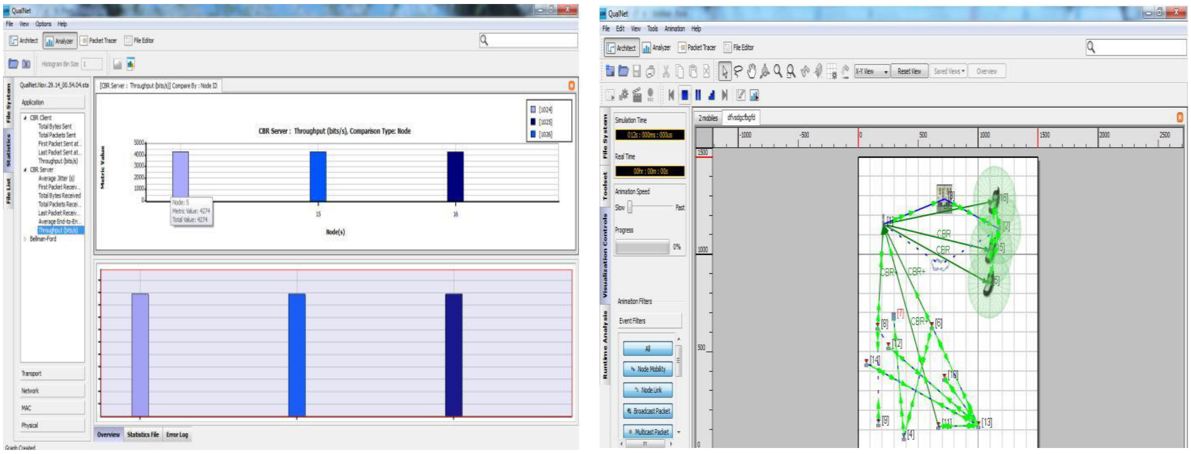

Fig. 4. (a) Throughput Data; (b) Design in Qualnet

6. Sensors and their Description

The description of each sensor that will be used are mentioned in this section.

6.1 Earthquake Sensor

This sensor [5] is an accelerometer. It monitors the activity in form of frequency (range- 0 to 20Hz).This low power sensor is able to detect even the slight mechanical or electrical shake and it converts it to pulse of voltage (user adjustable range). This sensor has linear characteristics, less than 1000μg/g^2.The sensor has two modules, one to sense vertically, and other to sense horizontally and another is used as a comparator to compare it with pre-decided value of the vibrating waves of the quake. The image showing the diagram of Earthquake sensor is shown in Fig.11

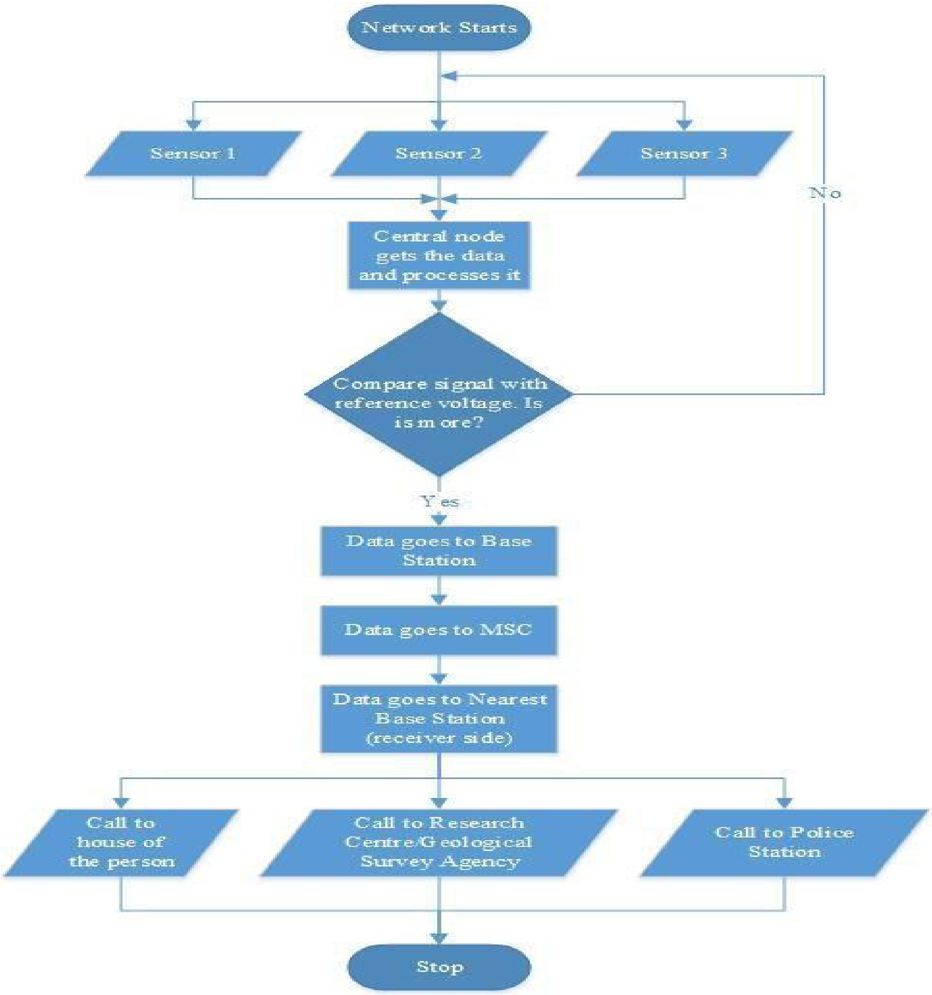

Fig. 5. Flow Process

Fig. 6. (a) Earthquake Sensor; (b) Flood Sensor

6.2 Flood Sensor

The shown device is the Flood Sensor used to transmit the level analysis of Flood to the Receiver. The device is enhanced with multiple modules embed inside it so that an advance integration of technicality can be achieved with high efficiency. The Fig. 6(b) shows the image of the device.

7. Conclusion

The natural calamities are a cause of millions of deaths all over the year. The causalities are very large in number, depending on the zone of calamities. This research paper discusses to install earthquake sensors so that it can read signal from outside atmosphere, display, using WSN. It gave sufficient data to prove that these disasters are an important factor to keep in mind. The Qualnet result is shown above, which clearly demonstrates that the information which is sensed by the sensor is properly received at the mobile station, etc. The techniques shown to sense vibrations from outside are discussed, along with the network with simulation result. Also the delay which has been observed in our network while the data has been dispatched as well as received is of the interval.003;.006;.009 seconds following the same pattern and hence reducing the time rate and increasing the efficiency rate.

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