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# FAULT TOLERANT SENSOR NETWORK PROTOCOL FOR DISASTER MANAGEMENT

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Abstract-Wireless sensor network is playing a vital role in Wireless data transmission infrastructure. Due to its compressed size and energy efficient structure of senor nodes can be effectively deployed in a Wireless error prone environment where these nodes can efficiently transmit the disaster related sensed data to sink nodes. In this research study we are going to propose a model to improve the performance of the disaster management protocol. The emphasis of the research focuses on landslide based disasters. The proposed model can also be successfully integrated with other disaster management systems such as military surveillance and emergency response. In a critical application such as landslide prediction, Fault Tolerant approaches have to be followed, to ensure the availability of Sensor data, at the analysis station. In this circumstance, the proper selection of clustering architecture and ARS enabled Fault Tolerant scheme is required to improve energy efficiency of Wireless Sensor Networks.

Keywords: Sensor network, Disaster management, ARS, lifetime, fault tolerant, clustering

## INTRODUCTION

Wireless sensor Networks make easy monitoring and controlling of physical environments from remote locations .Figure 1 shows a general architectural diagram of the Sensor network. WSN have applications in a variety of fields such as environmental monitoring, climate control, military surveillance, structural health monitoring, medical diagnostics, disaster management, emergency response, air pollution monitoring and gathering sensing information in error prone environments. Sensor nodes have various energy and computational constraints because of the deployment of Sensor Node in hostile environments. Considerable research has been focused on overcoming these deficiencies through more energy efficient mechanism. [21, 22, 23]

Wireless Sensor Networks typically consist of a large number of Sensor nodes distributed over a certain region. In many situations, the Wireless nodes must operate without battery replacement for a long time. As a result, minimizing the Energy consumption is a very important design consideration, and Energy efficient transmission schemes must be used for the data transfer in Sensor Networks

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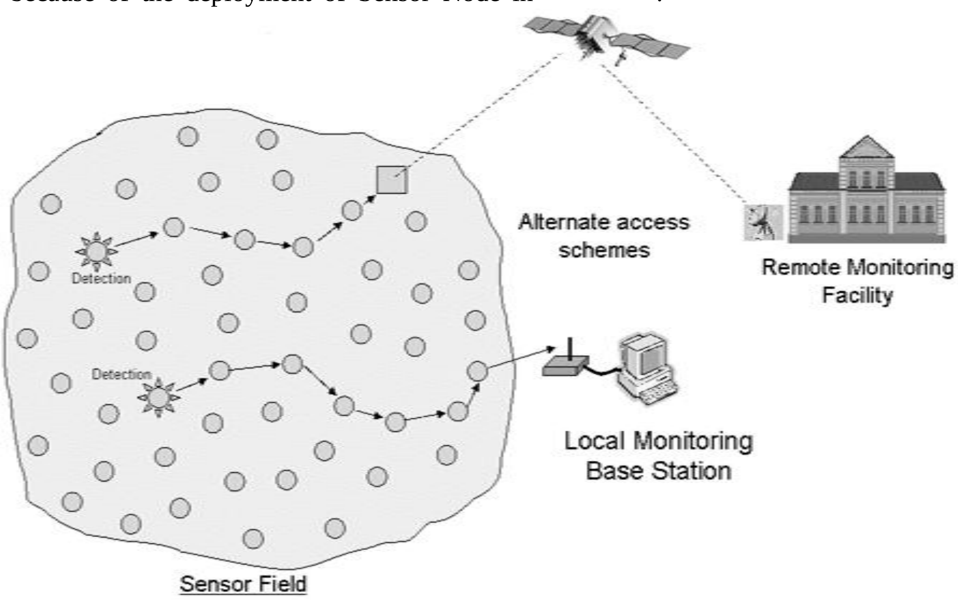


**Figure 1-Wireless Sensor Network**

 

Landslides are a severe environmental danger caused when masses of rock, earth, and debris flow down a sudden slant during periods of severe rainwater .The earth's population has greater than before very stridently, causes human need more land to be alive As an outcome, settlements occupy steep areas, which previously resulted in movement of land every year in all corners of the world. Losses suffered from movement of landslides for one year is more than that of damage caused by the disasters like earthquake. The landslide is a critical environmental process. Such process always happens every year and makes losses of lives and properties. So study is needed to propose a system that can help to prevent the calamitous environmental process.

**EXISTING WORK**

**2.1 Sensor Network for Landslide Prediction and Monitoring**

Many researchers working on disaster management protocols. They have given various types of protocols for different disaster situation. Especially landslide prediction and monitoring protocols were developed with the use of Energy efficient Sensor Networks. In the rainfall induced landslide scenario explained in earlier research. [1]. The Sensor nodes are distributed in different locations which are categorized into hierarchical zones. In the hierarchical architecture, the geological data that are measured for the particular application are pore water pressure, ground vibration, soil moisture, tilts or acceleration and strain on the particular Sensor column into which these analog sensors are placed and buried under the ground. The Sensor nodes periodically sample the environmental data and transmit the data at constant time intervals to the aggregating node.

Rehana Raj T et al also described their research in Fault Tolerant Energy saving clustering scheme in WSN (Wireless Sensor Network) for Landslide Area Monitoring to reduce Communication and processing overhead. The proposed approach, which organizes the whole network into smaller Cluster and sub Cluster groups enabling a considerable reduction of Communication and processing overhead. Sub clusters formation also gives the possibility to deal skillfully with Sensor nodes, node leader, and Cluster head failures. On this approach failed data prediction is being achieved by a fuzzy control system [1]. Dominating Set based algorithm used for fixing Cluster heads to improve the Energy efficiency of the network

A new distributed clustering multihop protocol, CAMP is proposed for landslide prediction. The cluster heads are selected with sufficient amount of energy, heads are dynamically changed. The authors furthermore compared their proposed approach with traditional LEACH protocol to improve the energy consumption of sensor nodes. [7].

Fault Tolerance Aspects in Routing Protocols for WSN is evaluated by Daniel et.al.In this article authors considered the main reason of silent failures in WSNs, and assess the performance of routing protocols based on this characterization. Fault tolerance is improved by the design of failure assessment mechanisms based on current and past operational history of nodes. The paper furthermore proves how routing protocols save energy by temporarily disconnected nodes. [8]

Alberto Rosi et al. Proposing their research in “Landslide Monitoring with Sensor network”. This paper report on the implementation and deployment of a system for Landslide Monitoring in the Northern Italy Apennines and analyze the results . Here efficient ‘data collection algorithm’ is used to receive the data correctly when disaster is occurring. [10].

The researchers explained the use of various distributed algorithms for landslide prediction using WSN. The distributed vector based detection with independent Cluster (DVBD-IC) algorithm stated that each CH (Cluster Head) sends the calculated likelihood ratio ( LR) to the Base station through multihop. They assumed that the data from the nodes within the Cluster correlated but the data from different clusters are independent. The result of this paper shows that high Energy consumption of WSN protocol. [11] Siti Khairunniza-Bejo et al, Analyzed the Land Movement in Landslide Area Using an image processing approach. An elastic image registration and change-unchanged conditional statements procedure appropriate for historical analysis of the land movement in a landslide area presented herein. Landslide areas detected using the number of pixel movements during the registration process. It shows that the size of pixel movement used to detect changes in landslide areas. The additional sequences of altered images were used, and the more information about the history of the area can be gathered [12].

G. P. Ganapathy et al reported their recent research in need for Urgency on Landslide Risk in hilly areas. The landslide is one of the major natural hazards that are commonly experienced in hilly terrains all over the world. In this, paper Landslide Vulnerability Index Risk analysis is performed by the authors. This process involves assessing the threat and these affected the people and property. It besides, provided an overview of risk management processes on Landslide Monitoring and relief operation. [13].

Kohei Arai et.al analyzed their present research in “Sensor Network for Landslide Monitoring with Laser Ranging System, Avoiding Rainfall Influence on Laser Ranging by Means of Time Diversity and Satellite Imagery Data Based Landslide disaster relief”. Sensor Networks for Landslide Monitoring with a laser ranging system developed together with landslide disaster relief and remote sensing satellite imagery data. Experimental results show that the proposed protocol does work for the situation like rainfall influence and for landslide disaster relief [14].

Energy efficient Sensor network protocol for landslide area monitoring proposed by sheik Dawood et.al. The work furthers explained the Energy efficient modulation with two tier clustering architecture for the Fault Tolerant Sensor network. The improved lifetime of this protocol can be useful for the disastrous condition like Landslide Monitoring and management. [15].Sheikdawood et.al also reviewd disaster management protocols for WSNs.The work furthermore classify the disaster managenet protocols based on their application .[16]

A new Landslide Monitoring mechanism especially used at initial stages of landslide is proposed by Wu Chuan et.al.The system designed to monitors internal displacement, internal Geotechnical pressure and pore water pressure for landslide detection. It furthermore worked on data collected by sensors are firstly stored in the SD card, and the user will be able to read the monitoring data at regular intervals. It is an economical Landslide Monitoring system compared with other monitoring designs. [4]

## 3. PROPOSED WORK

We propose an ARS based Fault Tolerant and Energy efficient clustering approach which organizes the whole network into smaller Cluster to reduce the Communication and processing overhead. The subcluster formation of the clustering technique provides the improved responsiveness regarding CH failures .ARS scheme is implemented in the existing zone based clustering architecture to improve the Fault tolerance of the Sensor nodes .The performance of the ARS scheme overcomes the drawbacks of the matrix based error approximation method proposed in earlier research [1].

### 3.1. Cluster Formation

In this work zone based clustering method [1] is considered. In this clustering mechanism Base station initiates the CH to from their groups by sending a broadcast packet at its maximum transmission range. All Sensor nodes in the Cluster that listen to the broadcast message and generates a node database includes Node ID, Energy Level of the node and neighbor Node list, Received Signal Strength Indication and Number of other CH sharing the same Node. All sensor nodes hearing the broadcast from the CH will send an acknowledgement message tagged with the Node database. CH decide the members of the group on receipt of the acknowledgement messages. After Cluster groups are formed, the time synchronization signals will be broadcasted from the BN (Broadcast Node) to the Cluster members through its respective CH. The Cluster members start sampling at the same instant. Individual CH Node decides its information frame and time slot size concurrence to the number of nodes connected to it. This process helps to adapt the dynamic change of frame and slot size, which is used to reduce a redundant delay .TDMA scheme, each Sensor Node will send the corresponding Node details to the CH from which the Cluster head can find out the SN in the overlapping zone between the Cluster head. The Cluster formation schematic of a Landslide Monitoring area is as shown in figure2.

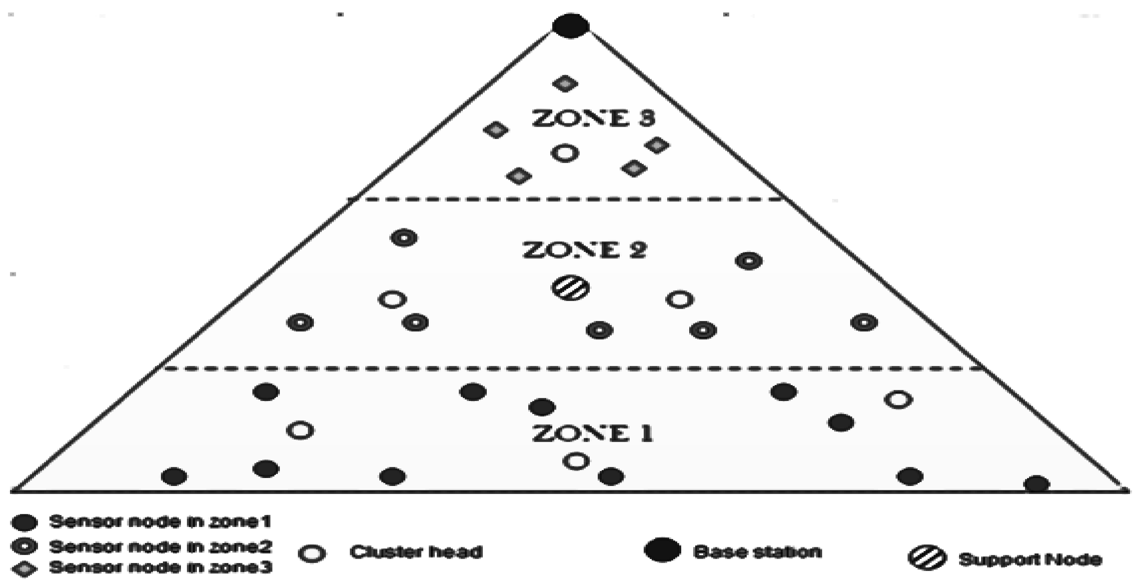


**Figure 2-Zone Based Clustering Architecture**

 

### 3.2 Sub Clustering

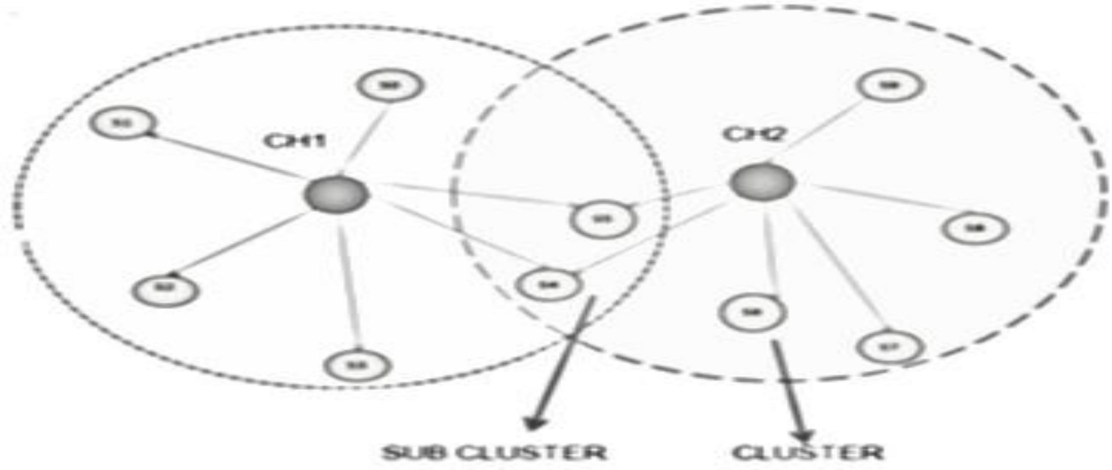


Figure 3- Sub cluster formation of Zone based Sensor architecture

The Sensor Node at the intersection of two or more Cluster groups will form a subcluster of the respective clusters. The intersection sub clusters are recognized from Node database. Sensor nodes lying in the range of more than one or more CHs in the same range, falls within the intersection zone as shown in Figure 3. The single CH failure is shown in Figure 4.

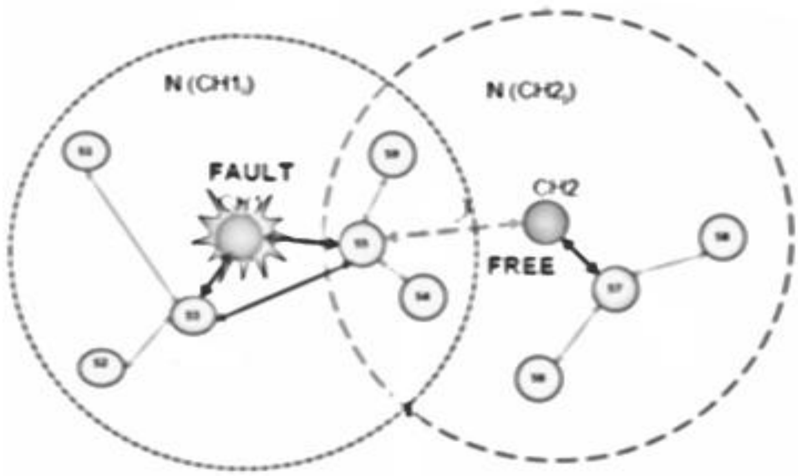


Figure 4- Single CH failure

## ENERGY EFFICIENT SENSOR NETWORK ARCHITECTURE WITH ARS SCHEME

### 4.1 Fault Tolerant Mechanism not Including ARS

Fault tolerant routing protocols [2], such as local rerouting or multipath routing, used for finding the faulty links. The traditional Wireless Networks depend on indirect route paths and retransmission mechanism. This mechanism leaves resource scarcity in the network .Its further require an energy efficient energy efficient Sensor network architecture with effective Fault Tolerant mechanism.

### 4.2 Fault Tolerant Mechanism including ARS

To overcome the restrictions, in the Sensor Networks the combination of an ARS and energy efficient clustering algorithms is deployed. This combination allows the network to autonomously reconfigure for Fault detection with energy efficient Cluster based routing. ARS are set with a reconfiguration planning algorithm that identifies local configuration changes and route failures of network settings. For a while, ARS first searches for realistic local configuration changes available around an inactive area, based on current channel and radio links.

Then, by imposing current network settings as constraints, ARS identifies reconfiguration plans that require the Minimum number of changes to the network settings. Furthermore its also include a monitoring protocol that enables a WSN to perform realtime failure recovery in conjunction with the clustering algorithm. The Node link-quality information from the monitoring protocol is used to identify network changes with Quality of service demands to avoid failures to neighboring links. The monitoring protocol is used to measure Wireless link environment from side to side by a hybrid link-quality measurement techniques. Support on the information measured , ARS sense link failures and generates quality of service aware network reconfiguration plans to detect a link failure.

### 4.3 Algorithm for ARS

Algorithm describes the operation of ARS[5]. First, ARS in every Sensor Node monitors the quality of its outgoing Wireless links at every sensing and report the results to a gateway via a management message. Second, once it detects a link failure(s), ARS triggers the formation of a group among the nodes, and one of the group members is elected as a leader for coordinating the reconfiguration. Third, the leader Node sends a planning request message to a gateway. Then, the gateway synchronizes the planning requests—if there are multiple requests—and generates a reconfiguration plan for the request. Fourth, the gateway sends a reconfiguration plan to the leader Node and the group members. Finally, all nodes in the group execute the corresponding configuration changes, if any, and resolve the group. We assume that during the formation and reconfiguration, all messages are reliably delivered via a routing protocol and per-hop retransmission timer.

Algorithm : ARS Operation at node i
(1) Monitoring period (tm)
1: for every link j do
2: measure link-quality(lq) using passive monitoring;
3: end for
4: send monitoring results to a gateway g;
(2) Failure detection and group formation period (tf)
5: if link l violates link requirements r then
6: request a group formation on channel c of linkl;
7: end if
8: participate in a leader election if a request is r received;
(3)Planning period ( M,tp)
9: if node i is elected as a leader then
10: send a planning request message ( c, M ) to a gateway;
11: else if node i is a gateway then
12: synchronize requests from reconfiguration groups Mn
13: generate a reconfiguration plan p for Mi;
14: send a reconfiguration plan p to a leader of Mi;
15: end if
(4) Reconfiguration period (p,tr )
16: if p includes changes of node i then
17: apply the changes to links at t;
18: end if
19: relay p to neighboring members, if any

### 4.4 Calculation of Node Lifetime with the Existence and Absence ARS

The radio model used in this work shown in Figure 5 has been widely adopted in several studies [8,23-26]. Here the energy spent by the transmitter is only considered for calculating node lifetime.

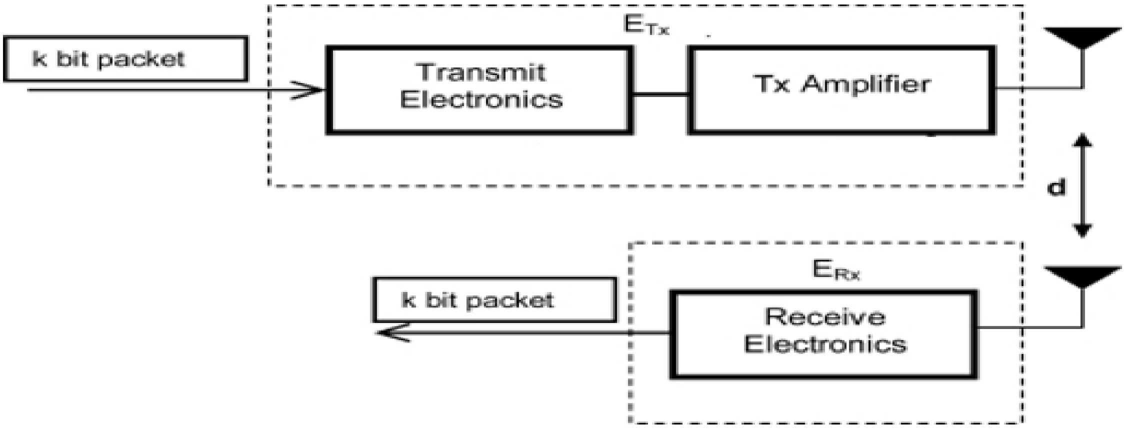


**Figure 5-Sensor Radio Model**

Here log-distance path loss model [3], has taken for calculating the required energy per transmitted bit in the i[th] Sensor Node may be written as:

$$e_{Tx}(i) = K_{Tx}.E_b.\left(\frac{4\pi d_{e(i),i}}{\lambda\omega}\right)^{\beta_{e(i),i}} \ldots\ldots\ldots\ldots\ldots..(1)$$

KTx is a constant coefficient, it is a value based on the antenna gain and the output amplifier efficiency of the

Sensor Node and the receiver Noise Figure of CH.Eb is the needed energy per bit of the receiver for a desired maximum bit error rate (BER) . de(i),i and βe(i),i denote the distance and the path loss exponent between Sensor i and it assigned CH Node e(i), respectively. βe(i),i depend on the environment and is typically between two and five, whereas $\lambda_w$ denotes the signal wavelength.

The required energy per transmitted bit is calculated using equation (1) with the following conditions .The Modulation technique used in transmitter is Minimum shift keying (MSK) with the additive white Gaussian channel condition. Lifetime of Sensor Node is calculated based on this transmission energy per bit and energy efficient clustering technique with the existence and deficiency of a Fault Tolerant technique .

In this section, we study the average lifetime of WSNs is calculated for an existing zone based architecture and proposed system (i.e. Zone based structure with Automatic .

## 5. SIMULATION MODEL

The NS2 (Network Simulator) is used for the simulation of WSN. In these settings, energy efficient clustering protocol with ARS is implemented. It periodically collects channel information about media access control and requests link-association changes based on its decision. At the same time, it informs the routing protocol of network failures and routing table update.

There are quite a few steps to emulate realtime network activities. First, to generate users' traffic, multiple UDP flows between a gateway and randomly chosen nodes are introduced. Each flow runs at 500 kB/s with a packet size of 1000 bytes. Second, to create networking failures, uniformly distributed channel faults are injected at a random time point. Random bit error is used to emulate channel-related link failures and lasts for a given failure period.

reconfiguration Fault Tolerant mechanism). According to the channel and the energy consumption model given in Figure 5 , the lifetime of a Sensor network is calculated by general Sensor network lifetime formula proposed by Yunxia Chen .Et. al[9] for a WSN with total initial energy $E_0$, the average network lifetime E [L], measured, is given by the equation 2

$$E[\iota]=\frac{S\varepsilon_0 - E[E_\omega]}{E[E_r]}\text{..............................}(2)$$

Where, S is the total number of sensors, $E_0$ is the initial energy, E [Ew] is the expected wasted energy, E [Er] is the expected reporting energy consumed by all sensors [9]. Lifetime is calculated based on the equation 1 and 2. The nodes average remaining energy is calculated after 500 days. The following consideration is made for calculating lifetime of Sensor Node .The results are shown in table 2&3.

## 6. ENERGY EFFICIENCY AND LIFETIME IMPROVEMENT.

Here we compared the performance of ARS based Fault Tolerant clustering technique with that of existing Fault Tolerant architecture [1]. In the simulation we set 15J of initial energy and observed the energy utilization for certain time.

From Figure 10, for 20 seconds the ARS consumed only 6.4J while the counterpart consumed 8J.The results shows that by using the ARS technique, the energy efficiency is improved by 35% compared to the Fault Tolerant clustering without ARS. Thus the lifetime of the WSN is improved by the inclusion of ARS technique. The Figure 10 shows the remaining energy in joules at various instants, Table1 shows a comparison of Fault Tolerant techniques.

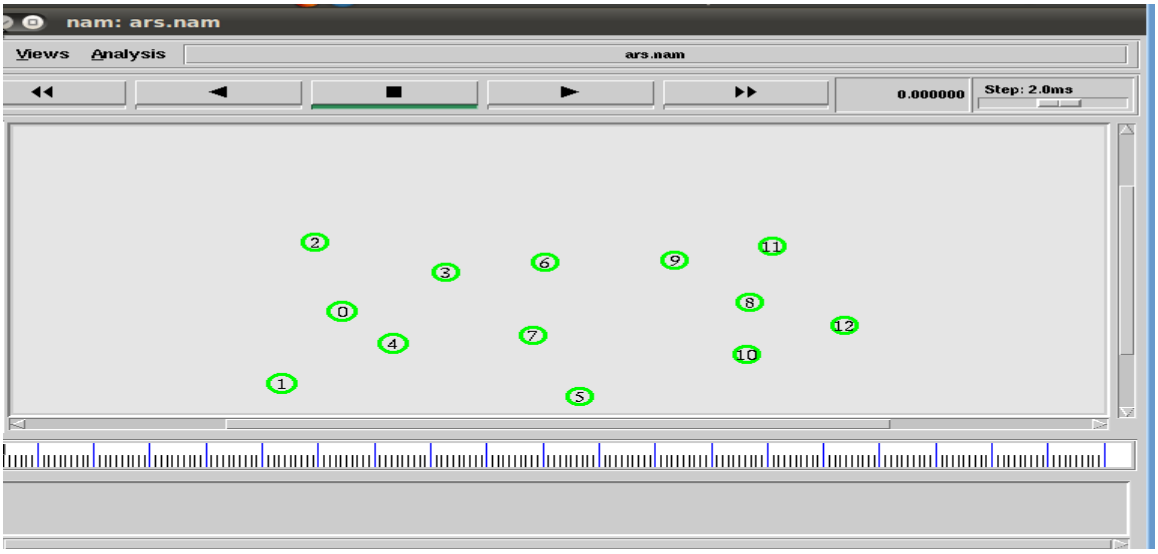


**Figure 6-Cluster Formation**

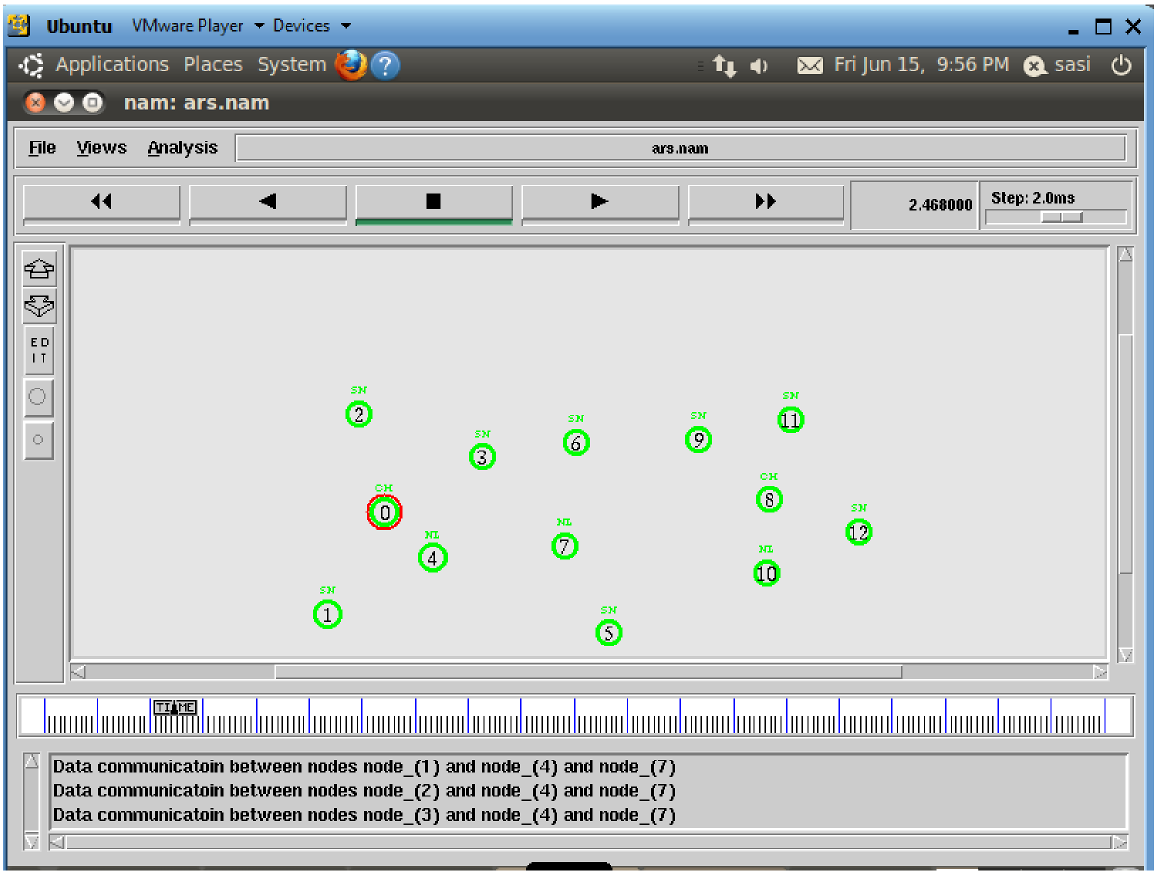


**Figure 7-Failure of CH**

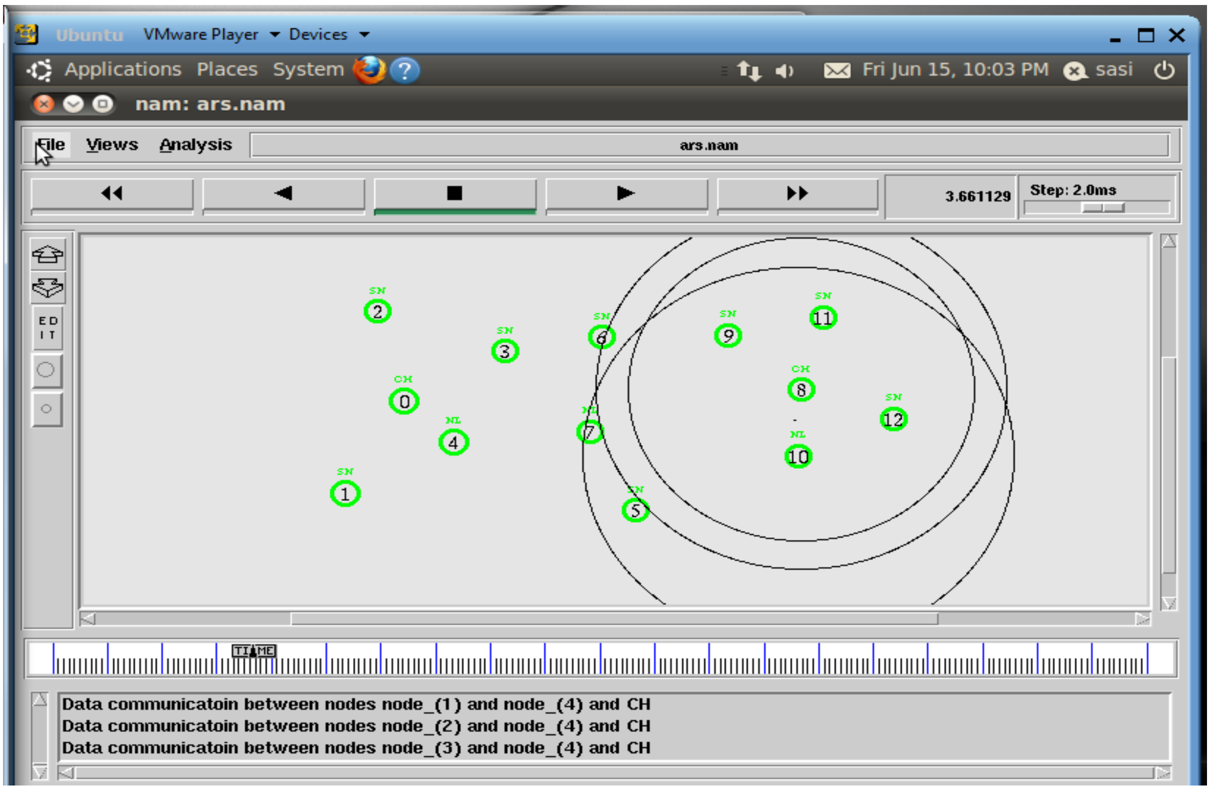


**Figure 8-Reconfigured cluster using ARS**

The faulty network is reconfigured by using the ARS algorithm as shown in figure

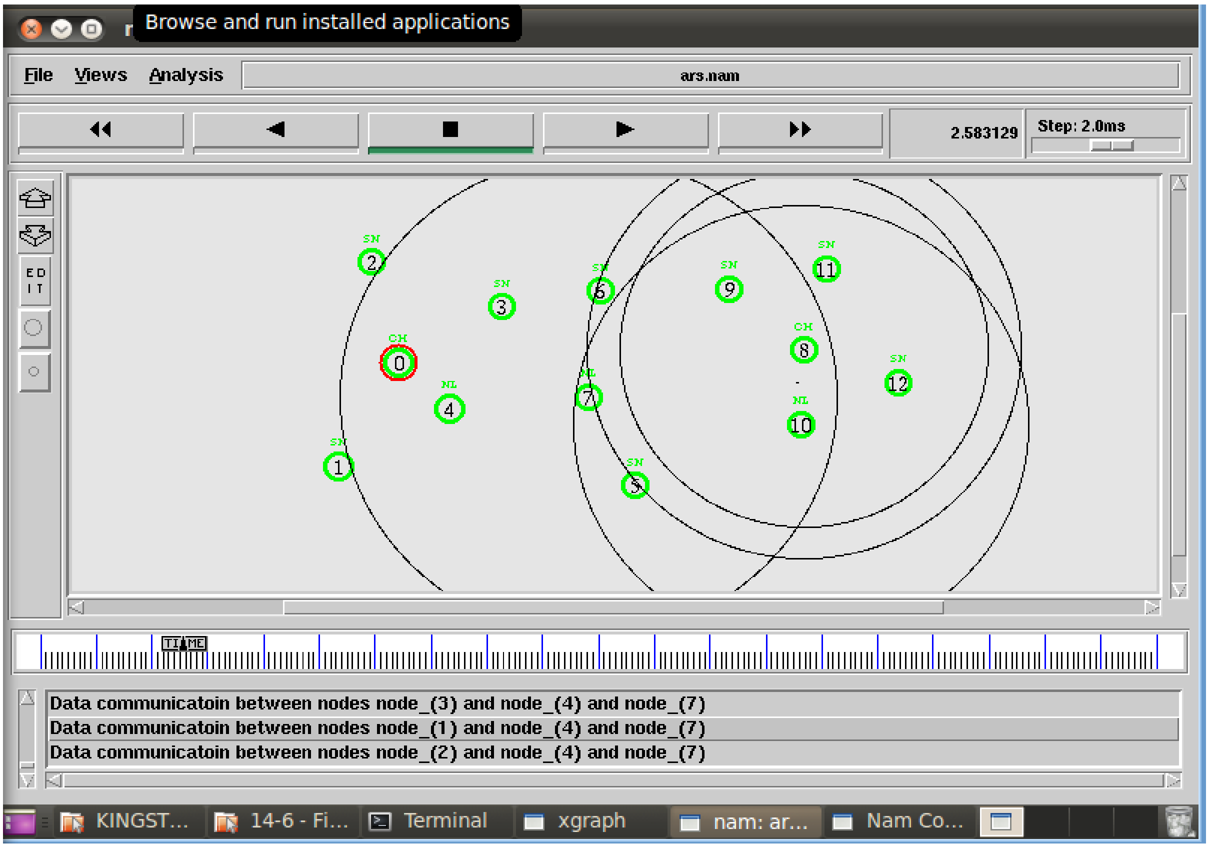


Figure 9-Reconfigured WSN using ARS

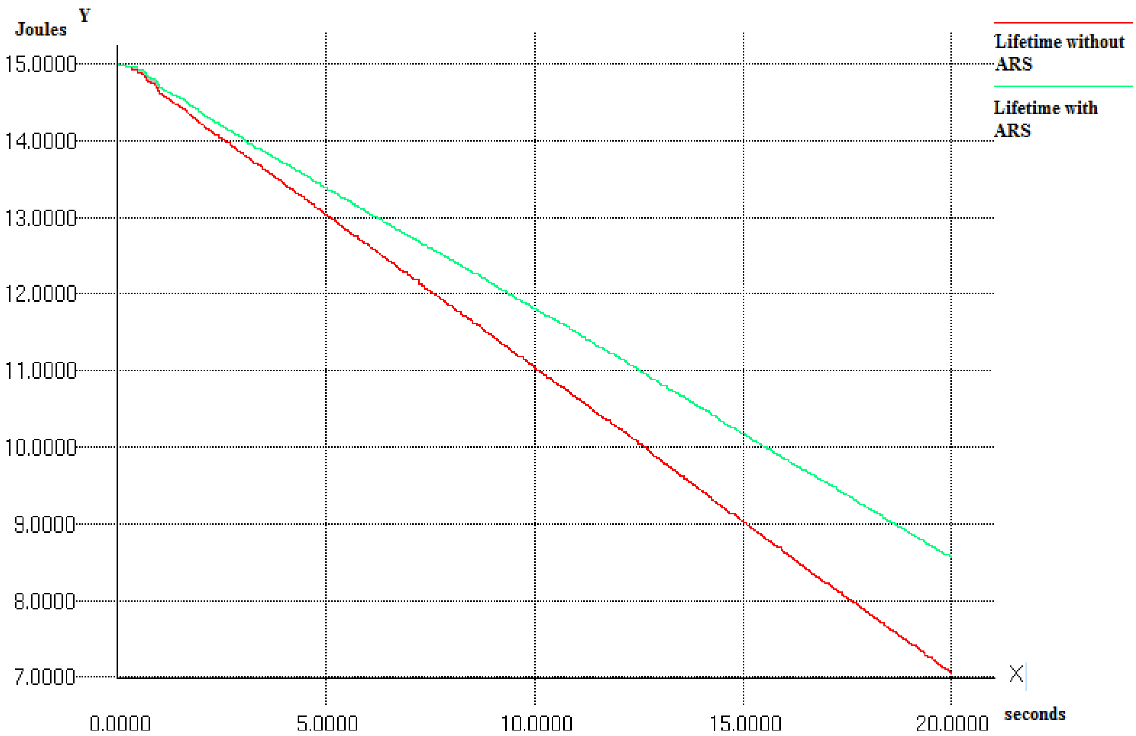


Figure 9-Energy Consumption Graph

**Table 1- performance Comparison of Fault tolerance techniques by and not including ARS Scheme**

| | Fault tolerance not including ARS | Including ARS |
|---|---|---|
| Initial energy | 15 J | 15 J |
| Remaining Energy after 20s | 7J | 8.6 J |
| Energy utilized for 20s | 8J | 6.4J |
| Network Lifetime | Low | 35% more |
| Fault Tolerance | High | Very high |
| CH overhead | High | Low |

**Table 2- Calculation of node lifetime not including ARS technique**

| | Not including ARS scheme on Zone based clustering architecture |
|---|---|
| Average remaining energy over the initial energy after 500 days | 59.6% |
| Lifetime | 298 days |

**Table 3- Calculation of node lifetime including ARS technique**

| | Implementing ARS scheme on Zone based clustering architecture |
|---|---|
| Average remaining energy over the initial energy after 500 days | 94.6% |
| Lifetime | 473 days |

## 7. CONCLUSION AND FUTURE WORKS.

This paper presented an energy saving clustering technique with a Fault tolerance scheme to compute the data gathered from Sensor nodes in the zone based Cluster group areas. The proposed ARS with zone based clustering architecture enables a WSN to autonomously recover from Wireless link failures. ARS generates an effective reconfiguration plan that requires only local network configuration changes by effectively identifying reconfiguration plans that improves energy efficiency and lifetime of WSN. The experimental evaluation and simulation shows the effectiveness of ARS compared to an existing Fault Tolerant scheme in satisfying application such as land slide area monitoring. In future work ARS scheme will be implemented with different clustering architectures with energy efficient transmission schemes to improve Sensor network lifetime.

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