An Approach for Faulty node Replacement in Wireless Sensor Network

Mihir Narayan Mohanty
Department of Electronics & Communication Engineering
ITER, Siksha 'O' Anusandhan University,
Bhubaneswar, Odisha, India

Bibhuprasad Mohanty
Deprtment of Electronics & Communication Engineering
ITER, Siksha 'O' Anusandhan University,
Bhubaneswar, Odisha, India.

ABSTRACT
Sensor network has occupied an important space in current research. Small size of the sensor nodes put constraint on the hardware capabilities and battery supported on it. In this paper we have discussed threshold policy for selecting a particular state of sensor node with fixed threshold policy. Threshold policies are needed whenever to choose the better one between two or many possibilities. We investigate the dynamics on random geometric networks. Fixed threshold policy is considered that enables the sensor node to vary and continue its service so that data loss can be minimized.

Work has been carried out for faulty node among intermediate nodes. The rectification is done by replacing the faulty node and to continue the network data transfer. For fault location, the method of thresholding is applied as the energy measure. Once the node is located, it can be replaced by a redundant node. Fifty nodes have been considered in this network.

Keywords
Sensor Network, NS-2, NAM, Energy of Node,

1. INTRODUCTION
A sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, humidity, motion or pollutants and to cooperatively pass their data through the network to a main location. The sensor network includes both wired sensor network and wireless sensor network. A sensor network is comprised of a large number of sensor nodes which monitor, sense, and collect data from a target domain and then process and transmit the information to the specific sites (e.g., headquarters, disaster control canters). There are many potential applications of sensor networks including military, environment and health areas.

Sensor nodes have limited battery power without recharging capabilities. Nodes running out of power may cause topology changes in sensor networks even without mobility. New sensors with fresh batteries may be injected to a sensor network, already in use, to enhance and ensure its correct operation. They are battery operated and thus their performance tends to deteriorate as power is exhausted.

Wireless sensor networks often tend to operate in an autonomous mode without human intervention. However, sensor nodes are prone to failure due to battery depletion, accidental damage, or environmental interference. Sensor failure may cause network topology changes and in extreme cases, network partitioning and the network may fail to deliver its functionalities required by applications. For accurate sensing, this faulty sensor node should be replaced immediately. One of the simple solutions for this problem is to have redundant deployment and to maintain a set of backup nodes. When a sensor node fails, backup node is used to replace it. Mobile sensor is a potential solution for fault repair problems, and for increasing the coverage of existing sensor network deployment. We consider a hybrid sensor network where a subset of the nodes has movement capability, possibly at high energy expense. A static sensor node can check its energy status and seek for replacement when its current energy falls below a certain threshold. If a redundant static sensor is located close to a dying sensor and can fulfill the coverage requirement, it can be used for substitution. However, if the redundant sensor is a mobile node and is located far away from the dying sensor, a protocol should be in place to locate redundant mobile sensor and to schedule the move ment of mobile sensor for replacement purposes.

Section-2 describes the previous related work. Section-3 gives the experimental setup. Section-4 explains the methodology. Section-5 shows the results obtained. Section-6 concludes the work.

2. RELATED LITERATURE
In this section, some literature has been reported in the area of fault detection and recovery in wireless sensor networks (WSNs). Some techniques have been proposed by authors for fault detection, fault tolerance and repair in sensor networks [1-3]. A survey on fault detection through fault tree analysis and conversion of fault tree to Bayesian network and fault detection can be also found by detecting the faulty node by cutest generation method [4-7]. Fault detection has been done by End-to-End Measurements and Sequential Testing in WSN is done in [8]. To improve network connectivity additional relay nodes have been placed in wireless sensor networks [9]. Implementation of routing protocol and simulation in WSN by NS-2 software has been analyzed in [10]. Energy efficiency and maximum lifetime routing for extending the life time is described in[11-13]. Fault tolerance in Internet such as network availability and performance has been discussed by authors. Also, Hierarchical and cluster-based approaches for fault detection and repair have been proposed by researchers in [13]. In this work, simulation is performed to detect and replace the faulty nodes. It is approached by determining the nodes with lower energies than the threshold energy. We extract the relevant data from the trace file. This data is then provided to the simulation for a fault free network.

3. Experimental Setup
A wireless sensror network is established within a boundary of 1500x1500 m2. It has Two-Ray-Ground propagation, droptail queue, omni antenna, AODV routing protocol and the simulation runs for 100s. The initial energy is provided as 100 Joules. The nodes have been assigned transmitting power of 0.275W and receiving power of 0.275W. This is done by using the energy model. All the mobile nodes have their initial node position assigned to them. A total of 5 redundant nodes have been placed. All the nodes are attached to the agents determining the source and destination nodes. The source and sink nodes are then

attached for the data flow. There after the traffic is attached to the agent and is provided with start and stop time. Then, finally the simulation is run in ns2.

4. Methodology

Threshold policies are used for selecting a particular data rate at wireless switch or router in order to increase the throughput [14-15].

Single threshold policy: For a finite sized buffer with particular amount of energy (battery), a threshold value is set such that whenever the number of packets in the buffer is more than the threshold K, server switches to the high service rate consuming more power. On the other hand if the number of packets in the buffer are less than or equal to the threshold K, server continues in the low power state consuming less power and working with low service rate. It reduces the idle period and power consumption but increases the possibility of data loss due to buffer overflow.

Dual threshold policy: Single threshold policy is suitable when the traffic arrival rate does not change abruptly and very frequently because for such traffic arrivals we may need to switch the service rates in consecutive time slots. Switching the state consume extra time and extra power which may over weigh the power saved by working with lower service rates. It is better to have some margin before switching to another state. In dual threshold policy two thresholds K1 and K2 have been defined such that K2 > K1. At the start of a new slot if number of packets in the buffer is more than K1 and less than K2 then server will continue with the service rate as in the previous slot. Service rate will change only when buffer occupancy is outside the margin.

Threshold-based model considers the dynamics *on* a network of interacting agents (wireless sensors in the present context), each of which must decide between two alternative actions and whose decisions depend explicitly on the actions of their neighbors according to a simple threshold rule.

Each agent can be in one of two states: state 0 or state 1, corresponding to the agent being inactive or active, respectively. Upon observing the states of its neighbours, an agent turns its state from 0 to 1 only if the fraction of its active neighbours is equal to or larger than a specific threshold '. For simplicity all agent have the same threshold. Initially the agents are all off (in state 0). The network is perturbed at time t = 0 by a small fraction of nodes that are switched on (switched to state 1). The number of active nodes then evolves at successive time steps with all nodes updating their states simultaneously (synchronous updating) or in random, asynchronous order (asynchronous updating) according to the threshold rule above. Once a node has switched on, it remains on (active) for the duration of the experiment.

We define the energy consumption during a successful global cascade. The total energy consumption in a wireless sensor network is, in most part, due to communication between nodes, computing, and storage (neglecting some smaller miscellaneous costs). The communication is the main part of energy consumption, and is directly related the network structure and dynamics, while energy used for computing can be regarded as a constant, so it can be easily evaluated. Consequently, in the following, we only consider the energy consumption in communications between sensor nodes.

According to the nature of sensor nodes, the wireless broadcast is the most commonly used method for local communication. Thus, the energy cost for local broadcast is proportional to the square of radio range R, El = cR2, where c is a coefficient that we scaled to 1. Here we proposed algorithm with threshold techniques:

(i) Assign 50 units to each sensor node with some additional redundant nodes.

(ii) Assign no. of packets to transfer and the corresponding power is Pmax

(iii) Enter the threshold value (Thvalue).

(iv) Node senses the packet.

(v) If power<= Thvalue then transfer the packet to next most probabilistic node by searching another nearest redundant node.

(vi) If search==true then transfer the packet to that replaced node.

(vii) Else transfer the packet to any node available in neighboring list.

The trace file contains all the information of the events happening within the simulation. So we extract the energy information from the trace file. If the energy is less than the threshold,then the node is considered as faulty node. The coordinate and time of the faulty nodes is obtainted using the following algorithm:

```
BEGIN {
    n = 0;}
{
for (j=0;j<=nn;j++)
{
if($9==j)
  {
energy = $17;
if (energy < 15)
{
x=$11
y=$13
    time=$3;
    n++}}}
    }

    END {
    for ( i = 0; i < n; i++ ) {printf("%f %d%d
\n",time,x,y)>>result.txt";}}
```

The data extracted is then provided to the simulation for a fault free wireless sensor network communication.

5. Result

With various time instant the results have been noted. Initial stage represents the WSN communication in fig.1. After some time fig.2 represents the gradual reduction of energy that will be the faulty node and is considered the YELLOW color node. It seems to be less than the threshold value. In fig.3 the same node has no energy for data transfer and is represented by RED color. Next to it in fig.4 the replacement has been occurred. Finally in fig.5 the graph is shown for energy reduction with respect to time. The work is simulated with NS-2 environment and the figures have been represented as the network animator output.

NETWORK ANIMATOR(NAM) OUTPUT:

At 1.0s:

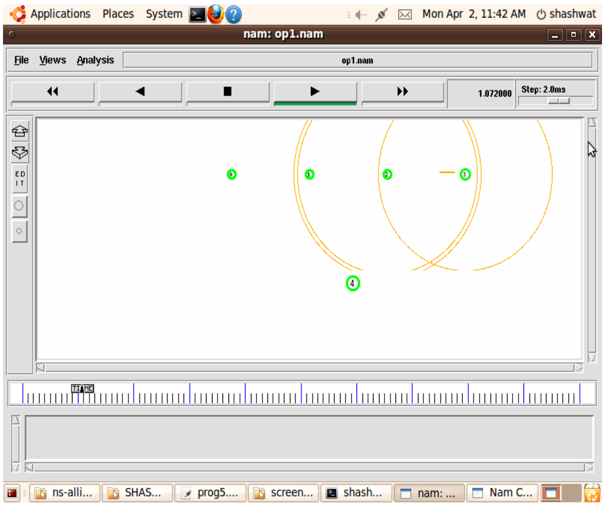

Fig. 1 Initial Stage

At Time 5.1s:

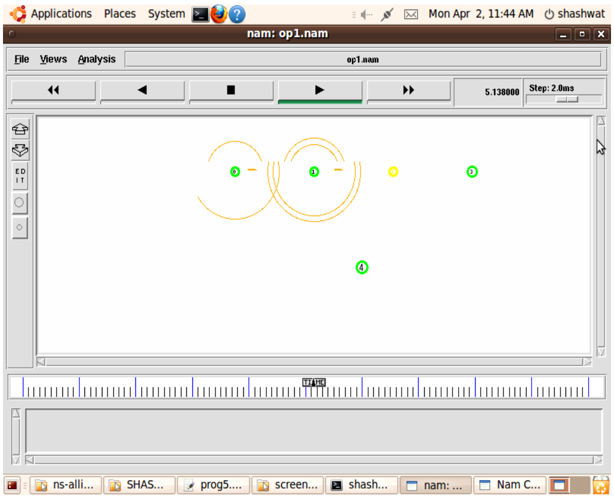

Fig. 2 Energy of faulty node less than threshold

AtTime5.95s:

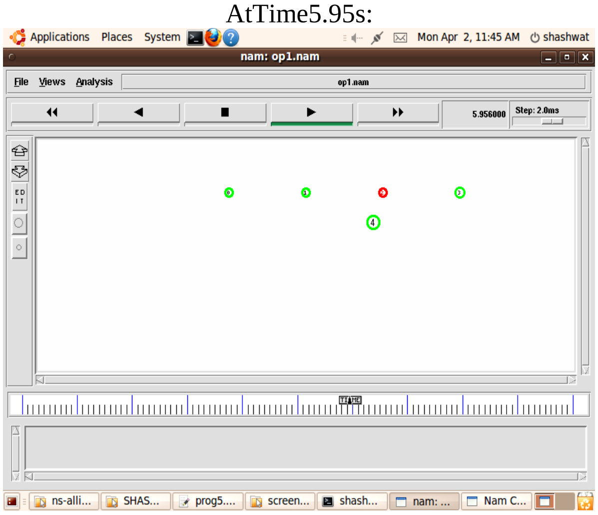

Fig. 3 Communication failure

At Time 7.0 s

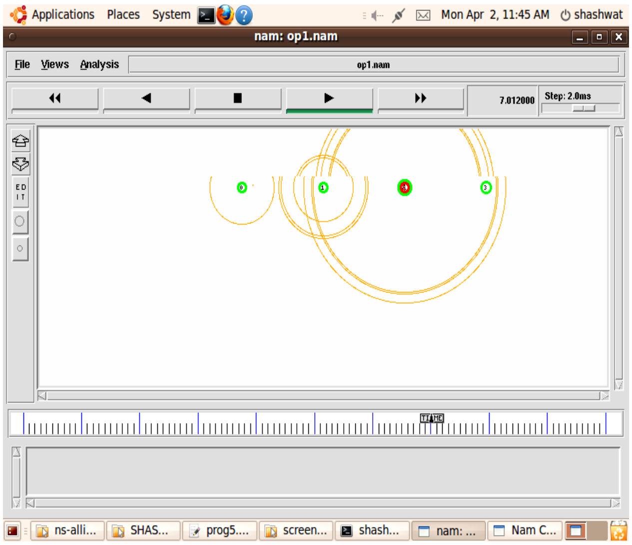

Fig. 4. Replacement of the faulty node

Plot for (ENERGY ~ TIME)

For node n2 (faulty node):

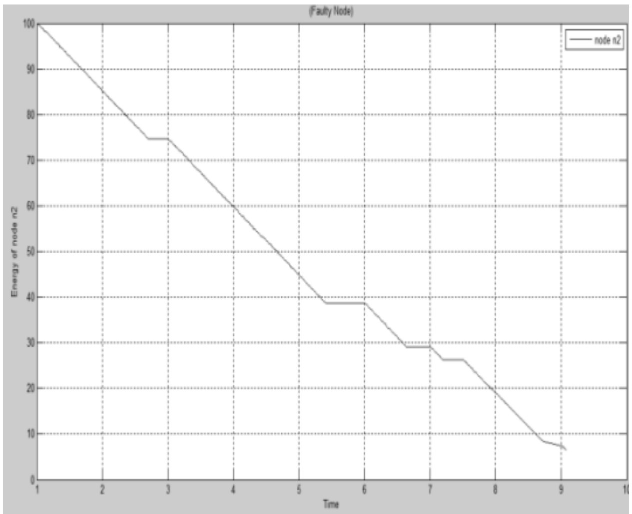

Fig. 5. Faulty node energy reduction

5. CONCLUSION

Efficient power consumption is a challenging problem in a battery-powered wireless sensor networks. The fact that each node has a limited battery power and it is impossible or infeasible to recharge the batteries. Therefore, it further reduces power consumption and increase the network lifetime. The network lifetime is directly proportional to the efficient power consumption, thus dysfunctional of any node causes serious damage to the network service considering nodes dual role of data originator and data router. Simulation results show that the lifetime of a sensor node capable of working continuously by using threshold policy. It also reduces idle time period and power loss during idle period. If number of service rates offered by a node are more than two then instead of using single adaptive threshold policy, multiple fixed thresholds are needed to select required service rate. A sensor node with multiple service rates is much complex than that with two service rates and also switching power and switching time overheads increases. So it is a better option to achieve the long lived wireless sensor networks having sensor nodes offering service.

REFERENCES

[1] Tuan Le, Nadeem Ahmed, Nandan Parameswaran, Sanjay Jha, “Fault Repair Framework for Mobile Sensor Networks”, IEEE Conf.. 1/06/2006, 0-7803-9575, 2006.

[2] Abolfazl Akbari, Neda Beikmahdavi, Ali khosrozadeh, Omid Panah, Mehdi Yadollahi and Seyed Vahid Jalali, “A Survey Cluster-Based and Cellular Approach to Fault Detection and Recovery in Wireless Sensor Networks”, World Applied Sciences Journal 8 (1)., pp.76-85, 2010.

[3] Tuan Le, Nadeem Ahmed, Sanjay Jha, “Location-free fault repair in hybrid sensor networks”, First International Conference on Integrated Internet Ad hoc and Sensor Networks. May 30-May 31 2006.

[4] Rongxing DUAN, Jiliang TU, Decun DONG, “A Novel Hybrid Approach of Fault Tree and Bayesian Networks for Fault Diagnosis”, Journal of Computational Information Systems 6:11, pp. 3605-3612, 2010.

[5] Rongxing DUAN, Dongxiu OU, Decun DONG, Huilin ZHOU, “Optimal Sensor Placement for Fault Diagnosis Based on Diagnosis Cost Specifications”, Journal of Computational Information Systems 7: 9, pp. 3253-3260, 2011.

[6] Bing Wang, Member, Wei Wei, Member, Hieu Dinh, Wei Zeng, and Krishna R. Pattipati, “Fault Localization Using Passive End-to-End Measurements and Sequential Testing for Wireless Sensor Networks”, IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 11, NO. 3. MARCH 2012.

[7] K. Lu G. Liu R. Mao Y. Feng, “Relay node placement based on balancing power consumption in wireless sensor networks”, IET Wirel. Sens. Syst. Vol. 1, Iss. 1, doi: 10.1049/iet-wss.2010.0004. 2011, pp. 1–6.

[8] Kristoffer Clyde Magsino, H. Srikanth Kamath, “Simulations of Routing Protocols of Wireless Sensor Networks”, World Academy of Science, Engineering and Technology, pp-50, 2009.

[9] Abolfazl Akbari, Neda Beikmahdavi and Meysam Mohammadi, “A New Algorithm Fault Management by Clustered in Wireless Sensor Network”, World Applied Sciences Journal 12 (10), pp.1784-1790, 2011.

[10] Jae-Hwan Chang and Leandros Tassiulas, “Maximum Lifetime Routing in Wireless Sensor Networks”, IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 12, NO. 4, AUGUST 2004.

[11] Giuseppe Anastasi, Member, Marco Conti, and Mario Di Francesco, “Extending the Lifetime of Wireless Sensor Networks Through Adaptive Sleep”, IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 5, NO. 3. AUGUST 2009.

[12] Xiaofeng Han, Xiang Cao, Errol L. Lloyd, and Chien-Chung Shen, “Fault-Tolerant Relay Node Placement in Heterogeneous Wireless Sensor Networks”, IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 9, NO. 5, MAY 2010.

[13] Hsien-Chou Liao, Yi-Wei Ting, Shih-Hsuan Yen, and Chou-Chen Yang, “Ant Mobility Model Platform for Network Simulator”, Proceedings of the International Conference on Information Technology: Coding and Computing (ITCC’04) 0-7695-2108-8/04, IEEE 2004.

[14] Christian Callegari, Rosario G. Garroppo, Stefano Giordano, Gianfranco Nencioni, “A New Markov Model for Evaluating the ALR Dual-Threshold Policy”, 2nd International Workshop on Green Communications (GreenComm2) 2009, Honolulu, Hawaii, USA; pp. 1-5, 2009.

[15] Gunaratne, C., Christensen, K., Suen, S.W., “Ethernet Adaptive Link Rate (ALR): Analysis of a Buffer Threshold Policy”, IEEE GLOBECOM 2006, San Francisco, CA , November 2006.