An Adaptive Routing Algorithm for Cluster Based WSN

Mr. Nirav Chittaliya[1], Mr. Jignesh Vania[2]

[1]Student, Information & Technology Department, LJIET (GTU), Gujarat, India.

[2]Asst. Prof., Information & Technology Department, LJIET (GTU), Gujarat, India.

ABSTRACT

WSN consist of sensor nodes of small size & having limited computational power & limited energy. Due to lower energy, sometimes it may happen that the data sensed by the nodes couldn't reach to the sink node and data loss occurs which is also a big problem. An algorithm named FNR provides around 90% of data loss recovery with the increase in energy which uses combination of Grade diffusion algorithm and Genetic Algorithm. But in WSN, clustering approach is very important for the increase of lifetime means decreasing energy consumption. Another algorithm, DFCA provides clustering, which is more important than other clustering techniques. By applying DFCA to FNR, we can have more energy efficient algorithm, which helps us in many approaches for the betterment of WSN and its lifetime.

Keyword:- *FNR, GA, GD, DFCA, SNR, Cluster Head.*

INTRODUCTION

WSN is a network is having thousands of tiny sensor nodes that collects the sensed data and transfers it to the base centre. These sensor nodes are having low battery power and when the energy is exhausted, WSN leaks will appear, and the failed nodes will not relay data to the other nodes during transmission processing. The FNR (Fault Node Recovery) was introduced to enhance the lifetime of a wireless sensor network and to reduce the data loss during the data transmission, which uses the Grade Diffusion (GD) algorithm and Genetic Algorithm (GA) for making the WSN energy efficient and for reducing the data loss. In FNR, the recovery of faulty nodes is replaced by the healthy nodes using the Genetic algorithm. And thus it will help in improving the battery lifetime as well as the reducing the data loss. But here the data sending is done using the single-hop or multi-hop transmission by sending the data to the neighbour and at last to the base station. But FNR algorithm transfers the data on the flat base network and doesn't use the clustering topology. Clustering is the most popular topology control method to reduce energy consumption and improve scalability of WSNs. In a cluster based WSNs the sensor nodes are grouped into different clusters with a leader, known as cluster head (CH). Sensor nodes send the sensed data to their respective CHs. CHs then aggregate the data and forward it to a remote base station (BS) using single hop (direct) or single-hop or multi-hop communication. For that we require a very important algorithm for the cluster formation. DFCA algorithm is a very important algorithm that addresses both issues formation of cluster on the basis of remaining energy and fault tolerance. In this paper we are applying the DFCA algorithm in the FNR algorithm and by combining them we will apply clustering to the FNR algorithm so that we can achieve more energy efficient algorithm. Fig 1 provides Cluster based WSN and data transmission within it.

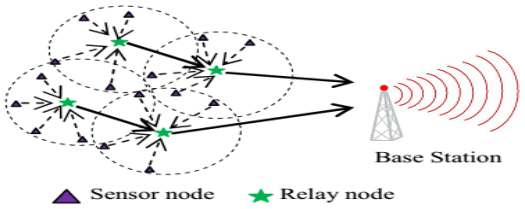

Fig 1 Cluster Based WSN. [1]

RELATED WORK

The WSN is having too many problems such as less energy, data loss, transmission loss etc. Though WSN is mission critical network, it requires more energy and less data loss, so that we can easily transmit data and communicate with the affected area. [5] For that we must have some protocols which help the networks in both securing data loss and enhancing the lifetime of network. An algorithm named, FNR (Fault Node Recovery) is very important algorithm which provides very less (around 90%) data loss and also provides energy efficiency but it does not use clustering approach. By using clustering techniques, we can enhance the lifetime of a sensor network. [1] DFCA (Distributed Fault tolerant Cluster based Algorithm) is very important clustering algorithm among some of others algorithms. [6] If we apply clustering to the FNR algorithm, we can enhance its lifetime and also data loss problems of clustering can be solved and also sensor node replacement cost can be decreased.

FNR algorithm

The FNR algorithm for WSN is based on the combination of Grade diffusion algorithm with Genetic algorithm. Grade diffusion provides grade values, routing table, set of neighbor nodes, payload value for each sensor nodes to the FNR and using Genetic algorithm it replaces faulty sensor nodes. The Flow chart of FNR is as per given below. [1]

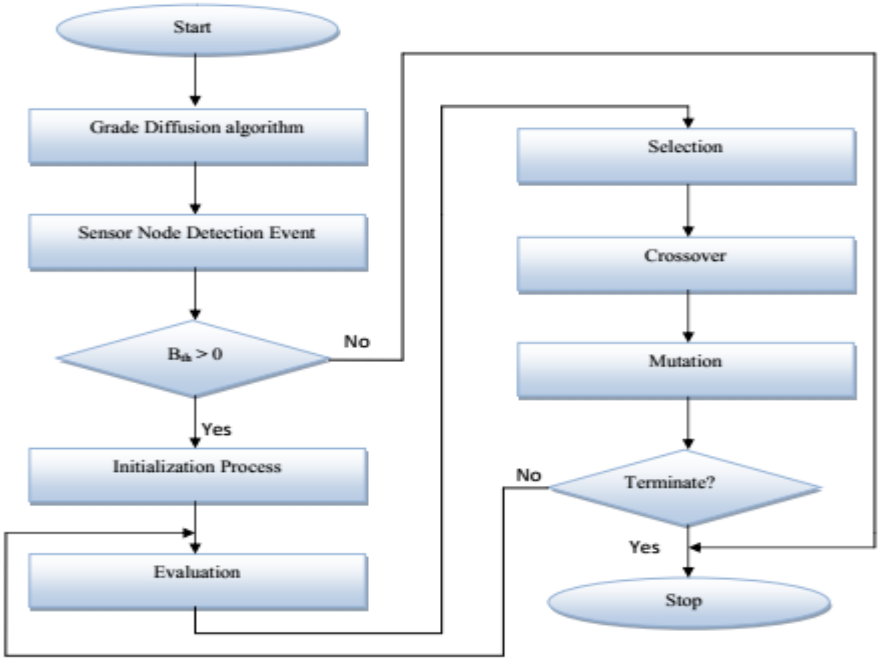

Fig 2 FNR algorithm flowchart [1]

Here in FNR, after applying GD and taking Grade values of the nodes of the network, Genetic Algorithm is applied. Here sensor nodes transfer data to the sink node according to the GD algorithm. Then B_{th} is calculated according to (1).

$$B_{\text{th}} = \sum_{i=1}^{\max\{\text{Grade}\}} T_i$$

$$T_i = \begin{cases} 1, & \frac{N_i^{\text{now}}}{N_i^{\text{original}}} < \beta \\ 0, & \text{otherwise.} \end{cases} \quad (1)$$

GA includes 5 steps: Initialization, Evaluation, Selection, Crossover, and Mutation. Description of the steps is given below.

A) Initialization

In this step it generates chromosomes, where each chromosome is an expected solution. Size of population determines the number of chromosome defined by the user. Fig 3 represents chromosome. Its length is 10 and gene is 0 or 1. This is chosen randomly in initialization step. 10 sensor nodes are not functioning.

9	7	10	81	23	57	34	46	66	70
0	0	1	0	1	1	0	1	1	0

Fig 3 Chromosome and its gene. [2]

B) Evaluation

Here, fitness value is calculated according to a fitness function, and the parameters of the fitness function are the chromosome's genes. In FNR the goal is to reuse the most routing paths and to replace the fewest sensor nodes.

C) Selection

This step will remove the chromosome with the lowest fitness values and retain the rest. Elitism strategy used here and half of chromosome with better fitness value is kept. This process is shown in Fig 4.

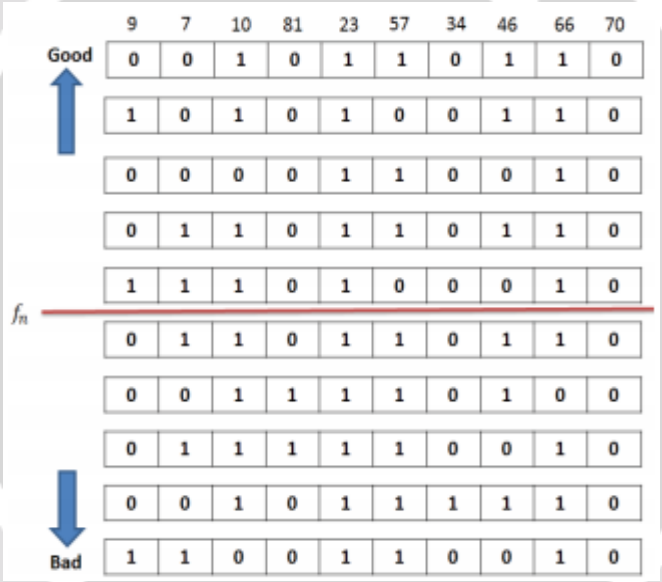

Fig 4 Selection step. [1]

D) Crossover

This step is used to change individual chromosome. One point cross over strategy is used to create new chromosome as shown in Fig 5.

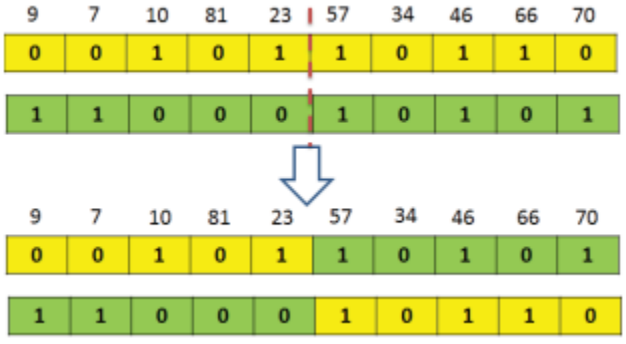

Fig 5 Crossover step [1]

E) Mutation

This step introduce traits not found in the original individuals and prevents the GA from converging too fast. In this algorithm, we simply flip a gene randomly in the chromosome, as shown in Fig. 7.

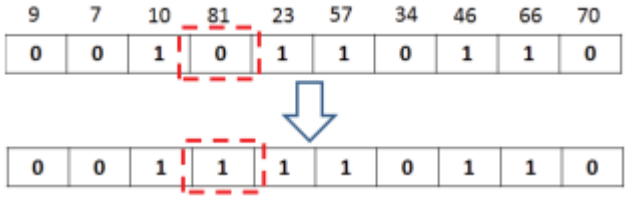

Fig 6 Mutation step [1]

Here FNR replaces faulty nodes with the healthier one and provides the reduction of data loss.

DFCA

DFCA is a distributed fault-tolerant clustering algorithm that addresses both issues, cluster formation based on remaining energy of the gateways and fault tolerance of the WSNs owing to death of some gateways. In DFCA, the nodes select proper Cluster Head by considering a cost function which consists of residual energy of the CH, The distance between sensor nodes to the CH and distance from the CH to the base station. In cluster formation, DFCA takes care about the sensor nodes that have no CH within their communication range. It also presents a distributed run time recovery of the faulty cluster members due to sudden failure of the CH. It avoids redundant deployment of the CHs or fully re-clustering approach to recover the faulty nodes to tolerate the failure. [6] The leach algorithm has the time complexity of O (mn^2), very high for a large scale WSN. Then the DFCA algorithm proposed with the time complexity O (n logn) time, which is an improvement over. Thus in the DFCA following terminologies are used:[6]

1 A set of sensor nodes denoted by $S=\{S_1,S_2,\ldots,S_n\}$

2 A set of gateways denoted by $G=\{G_1,G_2,\ldots,G_m\}$

3 Dist (S_i,S_j) denotes the distance between two nodes S_i and S_j.

4 $E_{residual}(S_i)$ denotes the remaining energy of S_i.

5 ComRangeCH(Si) is the set of all gateways, which are within the communication range(Rs) of nodes S_i. Therefore,

$$ComRangeCH(S_i) = \{G_j \mid Dist(S_i, G_j) \leq R_S \wedge G_j \in G\} \quad (2)$$

Here ComRangeCH(S_i) ={G2,G3,G5,G7} means sensor node S_i can be assigned to any one of the gateways G2, G3, G5 or G7.

6 Neighbor (Si) is the set of all sensor nodes, which are within the communication range of node Si.

Neighbor (S_i) = {S_j|Dist (Si, Sj) ≤ Rs ^ Sj€{S-Si}}

Depending on the communication range and connectivity between the sensor nodes and gateways, also in DFCA few kinds of nodes are defined in the systemas follows:

Covered Node and Covered Set: Covered nodes are having at least one Gateway within its communication range. And covered set is set of all covered nodes.[6]

Uncovered Node and Uncovered Set: Uncovered sensor has no gateway within its communication range. And uncovered set is collection of all uncovered nodes in WSN.

Backup nodes and backup set: Backup nodes for an uncovered sensor node Si are all the covered sensor nodes which are within communication range of Si. Backup set of an uncovered sensor node S_i is the set of all backup nodes of S_i. We refer this set as BackupSet (S_i).[6]

Alive and Inactive Sensor node: Alive sensor nodes are those sensor nodes, which have some residual energy and can send the sensed data to the CH directly or indirectly.

PROPOSED WORK

The primary goal of this proposed work is to improve the energy efficiency and the fault recovery of the sensor nodes by applying the DFCA in the FNR algorithm .The main idea behind our proposed algorithm is enhancing the features of FNR algorithm by applying DFCA. The overall goal behind this proposed work is to improve Energy efficiency of the cluster based WSN by applying the DFCA with Fault Node Recovery algorithm. In the combining of the DFCA with the FNR we have to take the following plan of action in the sight.

First, sensor nodes are taken as an input. Then by applying DFCA, clustering is applied & CH is chosen among the sensor nodes or Gateway is provided. After selection of the Gateway or declaration of the Cluster Head, Grade Diffusion (GD) is applied and using that grade value, routing table, payload values etc are decided.

In the next step, sensor node detection event is applied and using that the faulty nodes are identified. Then after calculation of Bth Genetic Algorithm is applied which contains 5 steps from Initialization to the Mutation as explained above. After the mutation process, the route is examined. It will improve the energy efficiency of the WSN and provide the recovery to the fault nodes.

Steps of Proposed Work

- Step 1: Take Given number of nodes as an input.
- Step 2: Apply DFCA algorithm and construct the clusters and assign CH according to that.
- Step 3: Apply GD algorithm to find the grade values, neighbor nodes etc.
- Step 4: Sensor node detection event takes place.
- Step 5: Calculate value of Bth.
- Step 6: Apply Genetic algorithm and if faulty node found then replace it with better one.

  Here in the sixth step, five steps of Genetic algorithms are considered where first chromosome and its genes are created using the Initialization step, after that the next step is evaluation in which fitness function is considered and according to the fitness value the faulty nodes are found. In the third step, selection process is being started according to which the faulty nodes' selection is done in which a point is decided according to which the chromosome having lower value than the given fitness function is selected for being replaced. After that next step is crossover in which the chromosomes' selected part is swapped with the other part of another one and using which we can make that nodes healthier. And the next and last step is mutation in which the selected chromosome's gene is changed and it can introduce traits not found in original individuals and prevents the GA from converging too fast. The Fig 7 shows flowchart for the proposed algorithm.

SIMULATION

Here simulation of proposed method was performed to verify the method. As same as FNR, the experiment was designed based on 3-D space, using 100×100×100 units, and the scale of the coordinate axis for each dimension was set at 0 to 100. The transmission ranges of the nodes were set to 15 units. In each of these simulations, the sensor nodes were distributed uniformly over the space. There are three sensor nodes randomly distributed in 10 × 10 × 10 space, and the Euclidean distance is at least 2 units between any two sensor nodes. Therefore, there are 3000 sensor nodes in the 3-D wireless sensor network simulator, and the centre node is the sink node. The data packages were exchanged between random source/destination pairs with 90,000 event data packages. Here, at initial stage energy of each sensor node was set to 3600Ws, the actual available energy. Here fig 8 provide us comparison of dead nodes after some rounds of transmission of data between the Original and proposed algorithms. It shows us that from 1000 to 2000 rounds the number of dead nodes is same but after that from 2000 to 7000 rounds the number of dead nodes decreases for the proposed method and are low compared to FNR algorithm so here we can have less data packet loss compared to original and thus we can easily improve our data transmission. But for around 8000 rounds no of nodes going to die are same so we can easily say that this method is better than the original one and improves data loss also.

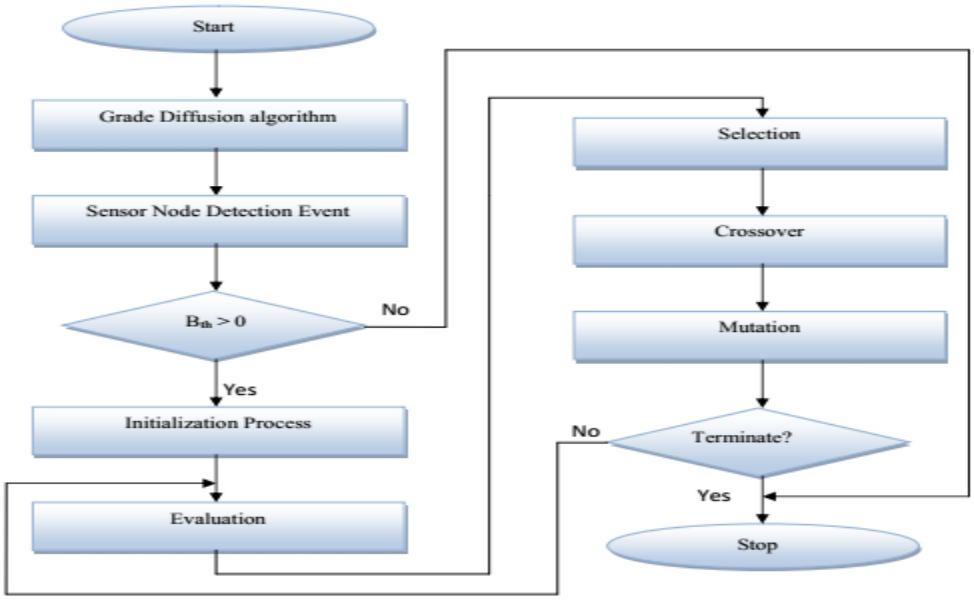

Fig 7 Adaptive Cluster based routing algorithm.

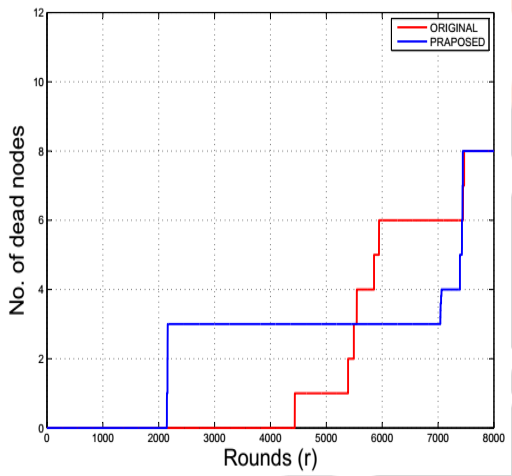

Fig 8 Number of dead nodes per round

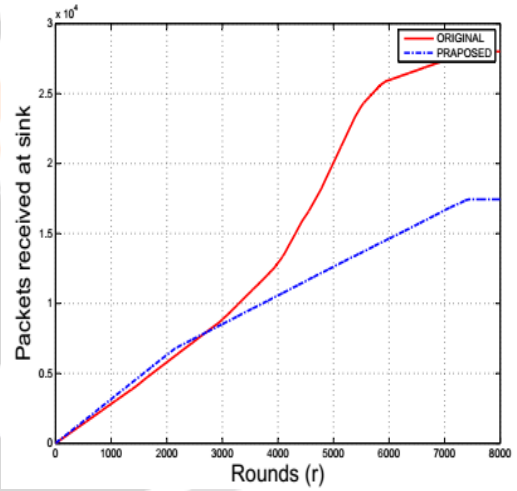

Fig 9 Packets received at sink per round

In the next fig 9 graph betweem packet recceived at sink node per rounds is compared between the original and proposed method, through which we can say that after the 3000 rounds, as per the graph, we can say that the original have more data received at the sink node than the proposed one but we can easily improve this by applying aggregation and make the proposed more data efficient.

In next two results we have the routing and energy efficiency information, through which we can exactly figureout the efficiency and betterment of our proposed system. In fig 10 path loss per round is shown. Here, the graph suggest us that as proposed method is combining the DFCA with FNR, means applying clustering, in starting path loss is more than the original one but after few round of transmission it becomes very less as it becomes stable and at htat time, proposed methods' graph is decreases continously and so the overall pathloss decreases when we apply the proposed method instead of the original one. Thus it improves the overall transmission of data and decreases overall routing path loss. The next graph shows us the residual energy after

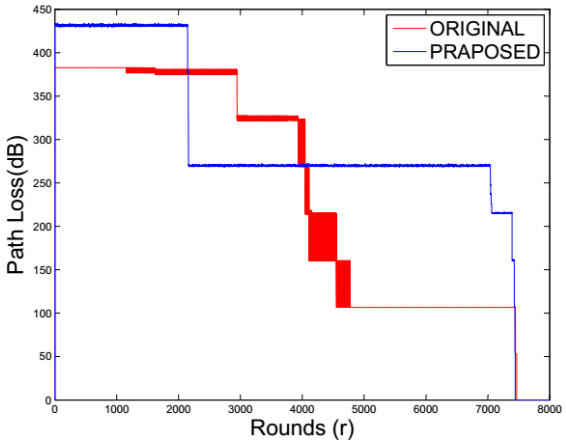

Fig 10 Packet loss per Round

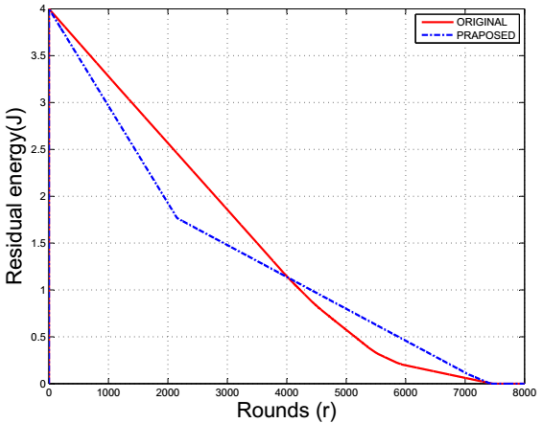

Fig 11 Residual Energy per round.

Completion of some rounds and it also shows us that at the starting of the transmission, the energy reduction of our proposed system is high as clustering and other stuffs are there but after a peak point, the reduction in the energy is very slow compared to original algorithm. So, we can say that for more transmission rounds the proposed algorithm is much better than the DFCA and FNR algorithm.

CONCLUSION

In WSN, sensor nodes are very resource constraints and they use battery power supplies and thus have limited energy resources. This paper proposes a combination of FNR algorithm and DFCA algorithm. The use of FNR provides us reduction in data loss, recovery of faulty nodes and also enhancement of life time of sensor network. But FNR uses flat base network, and cluster based networks provides more energy efficiency then the flat based networks. Here by applying DFCA to FNR we can enhance the lifetime of the network, can provide increase in active nodes up to 9.3 times then FNR, also overall number of active nodes is enhanced 4 times, also reduces overall rate of energy consumption more than FNR algorithm (up to 35%). Therefore, the proposed algorithm enhances the good quality of FNR algorithm by applying clustering to it. The proposed algorithm provides more energy efficiency, reduction of faulty nodes, and increases number of active nodes. But in this algorithm, clustering is provided so in starting rounds of transmissions the parameters compared are less efficient than the original algorithms so we can conclude that for small amount of sensor nodes the proposed algorithm is less efficient than FNR algorithm. And it is more useful if network is containing large number of sensor nodes. We can include this as our future work.

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