Efficient Approach to Maximize Wireless Sensor Network Lifetime Using Genetic Algorithm

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***Abstract**-In wireless sensor network, the energy efficiency procedures are used to enhance the energy consumption of the network and maximize the lifetime. Efficient energy utilization is a prime designing issue in the deployment of Wireless Sensor Network, because the WSNs are mostly implemented in the harsh area where energy sources are difficult to recharge or replace. The task for new WSN proprieties is enhance the network lifetime while maintaining energy consumption. The sensor nodes are tiny parts of WSN and randomly deployed in the sensor field. The sensor nodes are arranged in a group for better communication and network performance it is known as clustering. This paper proposed an efficient approach to maximize the lifetime of wireless sensor network using genetic algorithm. This approach follows an energy-efficient scalable routing algorithm (EESRA). A comparison between EESRA and proposed algorithm made. In the proposed algorithm the cluster head selection is done by genetic algorithm. Various performance parameters are evaluated such as alive nodes, dead nodes and residual energy. The simulation results show that proposed algorithm outperforms the EESRA in terms of alive nodes and residual energy. The simulation result of the proposed approach is carried out in MATLAB.*

Key Words: Wireless Sensor Network, WSN, Node, Genetic algorithm. Cluster Head (CH), Base-Station (BS).

1. INTRODUCTION

Wireless sensor network mentions to a set of spatially spread and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. Wireless sensor networks measure environmental conditions like temperature, sound, pollution levels, wind, etc. [1] These sensors are small, with limited processing and computing resources, and they are inexpensive compared to traditional sensors. These sensor nodes can sense, measure, and gather information from the environment and, based on some local decision process, they can transmit the sensed data to the user.[2] For processing, important parameters collected from surrounding area forwarded by the sensing unit available in sensor nodes. To digitize the analog signals being generated from sensors, the Analog to Digital converter (ADC) is used. The processing unit is an important part of sensor node. The processor helps in executing the tasks and handling the functionality of other components.[3]

Wireless sensor networks are now being deployed in a variation of applications ranging from medical to military and from home to industry. It aims to provide a reference tool for the increasing number of scientists who depend upon reliable sensor networks. It helps the society in different application areas like, military application, structural health monitoring, environment monitoring, home applications and other commercial applications.[4]

As we know WSNs are deployed in the harsh and remote areas, it is quite difficult to deploy WSN there. Because during implementation and designing of Wireless sensor network some design issues and constraint are come across. These may be energy consumption, node deployment, scalability, security, fault tolerance and localization. But most of these issues energy consumption is the prime challenge for WSN. In this research work a genetic algorithm based clustering technique has been proposed to use the energy in efficient way to maximize the lifetime of wireless sensor network. Because most of the energy is utilized in the data communication and data aggregation by sensor nodes.

2. LITRATURE REVIEW

To make a network suitable and fruitful number of routing and clustering algorithms has been developed. Some of them are summarized below:

Deepti, Recent technological improvements have made the deployment of small, inexpensive, low power, distributed devices, which are capable of local processing and wireless communication, a reality. Such nodes are called as sensor nodes. Each sensor node is capable of only a limited amount of processing. But when coordinated with the information from a large number of other nodes, they have the ability to measure a given physical environment in great detail. Previously, sensor networks consisted of small number of sensor nodes that were wired to a central processing station. However, nowadays, the focus is more on wireless, distributed, sensing nodes. [5]

Nitika Garg, Sharad Saxena, Wireless sensor networks contains various sensor nodes. Every node has little assets as far as power, and bandwidth. In hierarchal clustering of sensors in wireless sensor networks, type-2 fuzzy logic with three parameters (remaining energy, distance, concentration) is used for cluster head selection. Various hierarchical based routing protocols are there to route the traffic from source to the goal. This sort of protocol divides the network into small clusters and builds a hierarchy of nodes. Therefore, a genetic algorithm is proposed by taking same parameters to improve lifetime of the network.[6]

Eyman Fathelrhman Ahmed Elsmany, the algorithm adopts a three-layer hierarchy to minimize the cluster heads' load and randomize the selection of cluster heads. Moreover, EESRA uses multi-hop transmissions for intra-cluster communications to implement a hybrid WSN MAC protocol. This paper compares EESRA against other WSN routing protocols in terms of network performance with respect to changes in the network size. The simulation results show that EESRA outperforms the benchmarked protocols in terms of load balancing and energy efficiency on large-scale WSNs.[7]

3. PROBLEM FORMULATION

In Wireless Sensor Network broadcast eats more energy than processing. Since, the nodes have partial energy resource it is important to accomplish and enable the energy through the network. To carry out the data transmission we need a correct path with nodes having adequate sum of energy. In this research work it is found that the central node in the network chosen as cluster head (CH) which is partially involved in the processing of the network and this single node also keeps the network causing wastage of energy leads to become a dead node. The CH has static behavior due to this both CH and route is fixed and cannot apply any change in CH and route in each round, only one route and CH maintain all the work. These problems disturb the energy and lifetime of the CH nodes in WSNs. The overall goal of this research work is to propose an algorithm which overcome the above problems and enhance the lifetime and reducing energy consumption of sensor network in WSN.

4. METHODOLOGY OF THE PROPOSED ALGORITHM

In the proposed work, we focus on the maximization of lifetime of WSN by utilizing the energy in better way. For efficient energy utilization we have to arrange the sensor node in an efficient manner. In it we construct an expression for the optimal cluster size for minimum energy dissipation on the basis of energy, centrality, and distance. On the basis of first model a threshold value of distance is calculated and energy consumption is also calculated. Generally, the sensor nodes are deployed randomly in a sensor field. The clusters are formed by using genetic algorithm. In cluster, cluster heads are located at center of the cluster and it is surrounded by the nodes lying within its range and these nodes act as cluster member. Energy is the main parameter which is used to determine the lifetime of network.

4.1. Overview of Genetic Algorithms

GA is based on survival of fittest theory. GA starts with a set of possible solutions called initial population which is generated randomly. Each individual solution is called chromosome. Length of each chromosome must be same. A fitness function calculates fitness value of each chromosome. Chromosome with high fitness value is closer to optimal solution. Two parent chromosomes are selected for crossover to produce two offspring. Mutation is applied to randomly selected chromosome to obtain a better solution. Crossover and mutation generate next population. Few best fitness value chromosomes of previous population are also selected in new generated population to ensure that the new generation is at least as fit as the previous.

- **Population:** Population consists of various individual solutions for the problem. Larger the size of population, higher is the accuracy of algorithm.
- **Fitness Function**: Survivability of an individual depends upon its fitness value. Fitness value of each individual is calculated according a fitness function.
- **Selection**: Selection is the process of choosing individuals from current population for new population. The purpose of the selection process in a genetic algorithm is to give more reproductive chances to those population members that are better fit.
- **Crossover**: The crossover operation takes place between two chromosomes with probability specified by crossover rate.
- **Mutation**: The mutation operator is applied to each bit of a chromosome with a probability of mutation rate.[8]

4.2. Performance Metrics

Rounds: Number of rounds are directly proportional to the lifetime of a network. As the rounds increases the lifetime of network also increases.

Alive Nodes: It is the number of nodes that sends data to the sink directly after aggregating the data.

Residual Energy: Any packet sent and received causes a node to lose a certain amount of energy. This is referred to as residual energy. To extend network lifetime, efficient power control mechanisms that reduce power consumption in sensor nodes are needed.

4.3. Algorithm Steps

Followings are the steps to be followed in implementation the proposed algorithm

Step 1: Deployment of nodes: Randomly deploy sensor nodes in the sensor field and also locate the base station at its position. All nodes are random and fixed. Initially all the nodes having same energy and they transmit and receive the data to base station.

Step 2: Distance calculation: Calculate the distance between all the nodes and distance between node and base station by using distance formula.

Ds(i,j)=sqrt((X(i)-X(j))^2+ Y(i)-Y(j))^2)

Step 3: Node degree calculation: Find the number of nodes that are with the range of 25m distance of a specific node.

Step 4: Cluster head selection: Cluster head selection is based on population size and fitness function.

Step 5: Fitness function: Maximize the fitness function which is function of distance, number of nodes, and energy parameters. If two or more nodes have same maximum value then select the node having lowest ID number as a cluster head and find its respective cluster member.

(inter_cluster_distance / inter_cluster_distance+ E+N)

Where

inter_cluster_distance= node to node distance

inter_cluster_distance=node to base station distance

E= energy

N= number of nodes

Step 6: Threshold calculation: Threshold value of distance (do) is calculated so as to calculate the energy consumption of the nodes.

Do= sqrt (Efs/Eamp)

Where Efs= Energy for free space

Emp= Energy for multipath

Step 7: Comparison with threshold value: the calculated threshold value is compared with calculated distance between the nodes and to the base station. If the threshold value is greater than the calculated distance then the distance parameter becomes 4 times and if the threshold value is less than the calculated value of the distance then the distance parameter becomes 2 times.

Step 8: Energy calculation: Energy is calculated using first model.

If d>do

Energy=n+1(*L*etx+L*emp*d^4) +n*L*erx+(n+1) *L*eda

Else

Energy=n+1(*L*etx+L*efs*d^2+n*L*erx+(n+1) *L*eda

Step 9: Live and dead nodes calculation: After the updating of energy, dead and live nodes are calculated by comparing the energy with zero. If the energy of the node is zero then it is considered as the dead node else is considered as live node.

If energy(node)<=0

Node is dead

Else Node is live

End

5. SIMULATION SETUP

Simulation setup holds parameters for the required field with area in which nodes are to be deployed, base station location, initial energy of each node and number of bits to be transmitted. In this research work we have taken different cases to analyse the network. In these cases, we changed the network parameters such as number of nodes, area, and base station location.

Primarily, we plot a network of 100 nodes deployed randomly in 100*100M^2 area with each node having initial energy 2J. The base station is located at (x=50m, y=100m). Graphs show the outputs of the research work.

Table-1: Simulation setup table

Parameters	Value
Number of nodes	100
Network area	100*100M^2
Base station setup	(50,100) M
Number of bits to be transmitted	4000bits/sec
Initial energy	2J
ETX/ERX	50nJ/bit/^{m2}
Efs	10pJ/bit/^{m2}
Emp	0.0013pJ/bit/^{m4}
EDA	5nJ/bit/signal

Table-2: Genetic learning parameters

Parameters	Values
Population size	20
Maximum Iterations	20
Crossover Probability	0.6
Mutation Probability	0.03

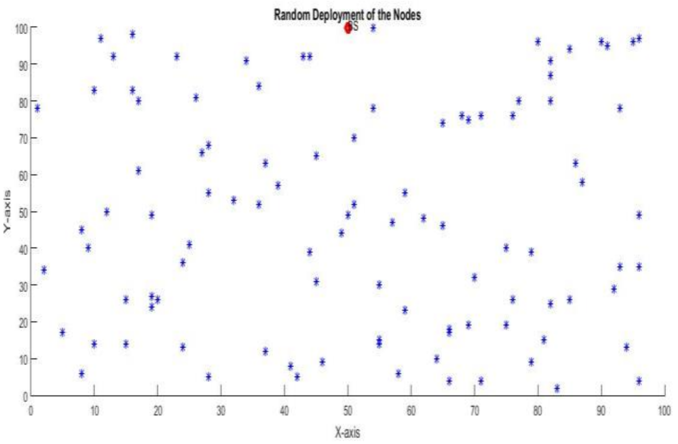

Fig.-1: Sensor node deployment

Fig. shows the 100 nodes deployment in the 100*100 m2 area. These nodes are randomly deployed in the area.

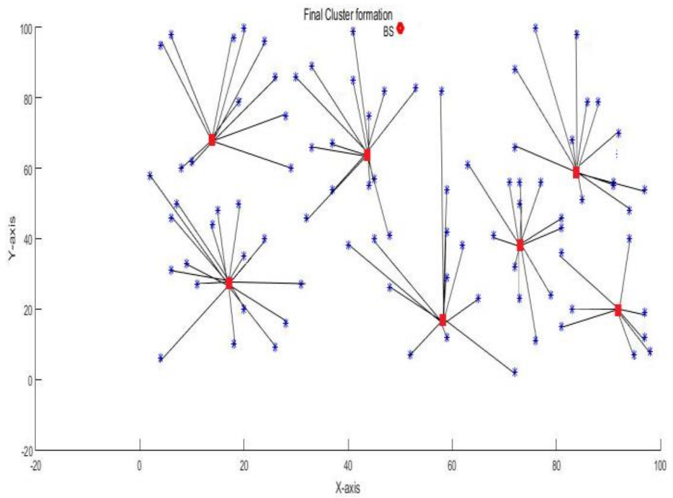

Fig.-2: Cluster formation

The above figure shows the cluster formation. Cluster is organized in the form of star topology with cluster head in the center and surrounded by cluster members. The node having extreme value is selected as cluster head and the residual nodes that are in range of cluster head (CH) and are not linked with other nodes are selected as cluster member. In this way the first cluster is organized. After formation of first cluster, we applied the first order radio model to determine the energy of each node. The distance between the nodes is compared with threshold distance value(do)i.e., 87.70m. If distance is greater than do then the multipath energy i.e., 0.0013pJ is used else free space energy i.e., 10pJ is used. The node having the maximum value is selected as CH for second cluster and also selects the particular cluster member. The cluster re-election procedure will be continued until all the nodes don't participate in cluster formation procedure and this complete procedure is called as round. If some nodes are connected with another cluster head than it will prefer first cluster. And if nodes are connected with other nodes at same time than it will prefer shorter path and create connection with the cluster head which id nearest to that node.

The next graphs show the alive nodes and residual energy vs no. of rounds in the network.

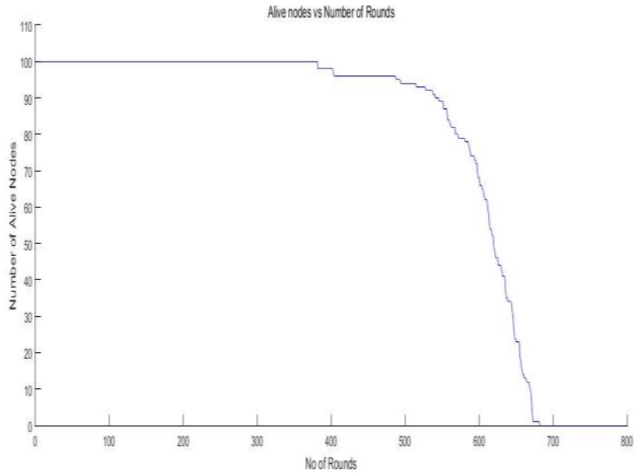

Fig.-3: Alive nodes vs number of rounds

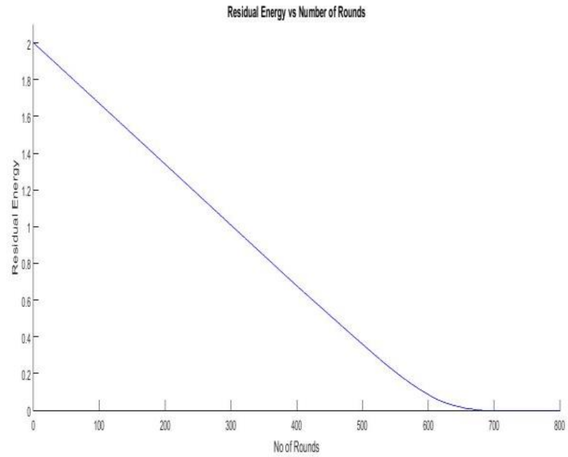

Fig.- 4: Graph of residual energy versus number of rounds

The maximum number of rounds are 700. After completion of first round, we calculate the sum of all the energies of 100 nodes and analyzed whether the sum of nodes is zero or not. If the sum of all energies is not equivalent to zero than the entire procedure continues till the energy of each node is not equivalent to zero. When energy of each node is equivalent to zero that time the system is totally dead. In my proposed technique, it takes 700 rounds for the system to totally dead, and the first node is died at 300 rounds.

6. RESULTS

We analyzed the energy consumption of the sensor field by changing it parameters such as number of nodes, BS location, and area. These parameters were evaluated in three different cases. The alive nodes and number of rounds for each case is calculated and is shown in the following table.

Table-3: Table of no. of nodes and rounds in different cases.

Variable entity	Rounds
BS (50,100), 100 nodes	300
BS (50,100), 100 nodes	550
BS (50,100), 100 nodes	620
BS (50,100), 100 nodes	700
BS (70,120), 200 nodes	475
BS (70,120), 200 nodes	700
BS (200,150), 300 nodes	342
BS (200,150), 300 nodes	600

7. COMPARISON

In the existing technique EESRA the algorithm uses a three-layer hierarchy to minimize the cluster heads' load and randomize the selection of cluster heads. Moreover, EESRA uses multi-hop transmissions for intra-cluster communications. Due to use of multi-hop communication, the energy consumes a lot. To overcome this phenomenon, we purposed a new technique using genetic algorithm that is EESRA-GA.

In the propose algorithm the cluster members directly transmit the data to cluster head. The cluster head is selected by fitness function and the node having maximum energy in the cluster.

We analyzed the proposed algorithm in different cases by changing its parameters such as no. of nodes, base-station location and area. We observed if the base station is located near the sensor field, it consumes less energy for the communication among nodes, else the base station is located farther from sensor field, the more energy utilized.

These following figures show the comparison of existing algorithm with proposed algorithm.

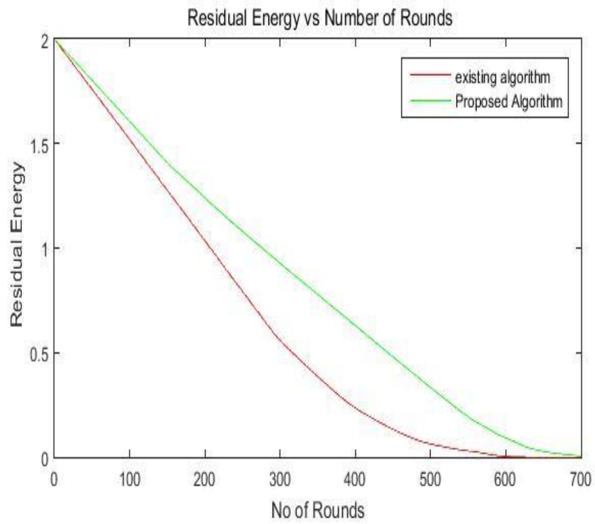

Fig.-5: Comparison of proposed algorithm and existing algorithm in terms of residual energy vs no. of rounds

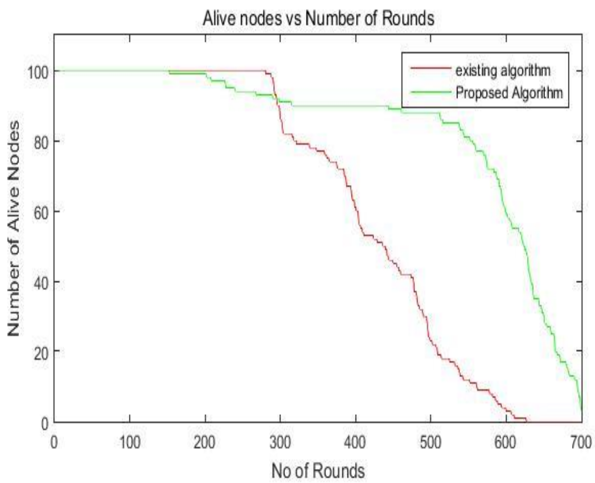

Fig.-6: Comparison of proposed algorithm and existing algorithm in terms of Alive nodes vs no. of rounds

The following table shows the proposed algorithm has large no. of live nodes as compared to existing algorithm (EESRA). In case of EESRA we have 5 live nodes after 600 rounds while in proposed algorithm we have 59 live nodes after 600 rounds. Hence it shows that our proposed algorithm provides better outputs as compared to existing one. On comparing the proposed algorithm with existing EESRA on the basis of residual energy we can conclude that our proposed algorithm provides better results as compared to existing technique because in case of EESRA the system dies at 610 rounds while in case of our proposed algorithm the system dies at 700 rounds. With the implementation of proposed algorithm, the network survives for a long period of time.

Table-4: Comparison of proposed technique with existing technique on the basis of live nodes

No. of Rounds	Live nodes (in)	
	Existing Algorithm	**Proposed Algorithm**
100	100	100
200	100	100
300	95	99
400	66	90
500	32	88
600	05	59

8. CONCLUSION

The proposed algorithm to maximize the lifetime of WSN as compare to EESRA is dynamic approach with efficient energy consumption. The proposed algorithm is more compatible to find better result in a smaller number of loops that are not possible in other techniques. The lifetime of the network only dependent on energy efficiency of nodes. For prolong lifetime of the network with reduction in energy consumption, the GA with EESRA algorithm is introduced. We analyzed the proposed technique in three cases with different number of nodes and area. In each case we achieved efficient energy with prolong lifetime.

9. REFERENCES

[1] Swetha. R 1, Santhosh Amarnath.V2 , Anitha Sofia.V.S3, “Wireless Sensor Network : A Survey”, International Journal of Advanced Research in Computer and Communication Engineering Vol. 7, Issue 11, November 2018.

[2] Jennifer Yick, Biswanath Mukherjee, Dipak Ghosal, “Wireless sensor network survey”ScienceDirect, 14 April 2008.

[3] Ajay khunteta and anurag bajpai, “genetic algorithm with leach protocol for cluster head selection in wireless sensor networks”, ictact journal on communication technology, june 2020.

[4] O.Deepa, Dr. A. Senthilkumar, “Wireless Sensor Networks: Application, Architecture, Design issues and Research Challenges”, National Conference on Advanced Networking and Applications, 27th March 2015.

[5] Deepti, “Applications, Challenges & Design Issues in Wireless Sensor Network”, COMPUSOFT, An international journal of advanced computer technology, 3 (11), November-2014.

[6] Nitika Garg, Sharad Saxena, “Cluster Head Selection Using Genetic Algorithm in Hierarchical Clustered Sensor Network” e Second International Conference on Intelligent Computing and Control Systems, IEEE Xplore (ICICCS 2018).

[7] Eyman Fathelrhman Ahmed Elsmany 1 , Mohd Adib Omar1 , Tat-Chee Wan 1,2, And Altahir Abdalla Altahir 3, “EESRA: Energy Efficient Scalable Routing Algorithm for Wireless Sensor Networks”, IEEE Xplore 2019.

[8] Vipin Pala,∗ , Yogitab, Girdhari Singhc , R P Yadavc, “Cluster Head Selection Optimization Based on Genetic Algorithm to Prolong Lifetime of Wireless Sensor Networks”, Third International Conference on Recent Trends in Computing (ICRTC 2015.