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# Evolution of Perimeter Routing Through Genetic Optimization in Wireless Networks

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***Abstract:*** The continuously advancements in WSN demands its more usage in a variety of applications. We proposed a genetic optimization of non-linear type to give better response in the area of energy consumption and network lifetime. The scenario which is shown in this paper have try on exhaustive improvement in the different working stages of a network such as node positioning, coverage area, clustered data and aggregation output among regions. Our aim is to apply genetic approach under perimeter routing on network simulator environment, to get a specified fitness function, optimized and to personalise the network at all working scenario. Our focus is also to built the updated routing schedule with consideration of energy saving and to balance the energy factor in the whole network. The aim is fulfilled by using the innovative technique of crossover and mutation operators. So, we analyze that by introducing the genetic approach to WSN network quality improves in terms of functional parameters of the network. This proposed dynamic genetic optimization approach enhances the flexibility criteria and improvement under sudden changing conditions in the environment. It will also help to minimize the ratio of dead nodes in a frequent manner.

***Keywords:*** wireless sensor networks, perimeter routing, optimization technique, genetic approach, energy consumption.

## I. INTRODUCTION

Wireless sensor networks are configured with tiny mobile energy sources with their battery charging capability. The limitation of using batteries among sensor nodes is the very short span of time of energy supply [1]. So, the efficient usage of energy is having the utmost importance among sensor networks. There is a need for continued passage of data from transmitter to the base station, so the permanent solution of effective battery utilization is its main necessity.

Fig. 1 shows the working stages of WSNs. The positioning of nodes is distributed as grid-type, random deployment and regular structure as shown in fig.2.1-fig.2.3. In grid-type structure the distance between the nodes can be calculated dimensionally and the gap is fixed among nodes. The random deployment is used basically for applications such as under-water sensors and military requirements. The regular-structure is adopted for urban areas mainly. The regular deployment consists of patterns such as square, hexagon as shown in fig. 2.3. This is used for higher connectivity between nodes and maximum coverage in the network.

The final selection of type of positioning of nodes depends upon the corresponding application among networks.

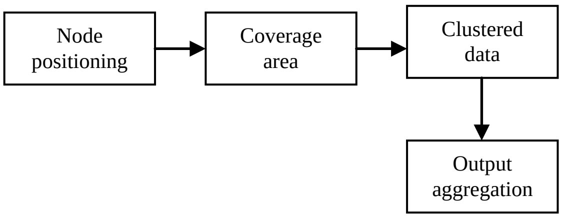


**Fig.1 Working stages of WSNs**

Clustering is the backbone feature of WSN optimization. Under which the cluster-head is connected to the sink via internet connection. By proper clustering technique, there is a chance to save maximum energy and to improve the scalability of the network [2].

Fig.5 shows the coverage area phenomenon under WSNs. In which the each sensor field is composed of CH i.e. cluster head. The main task of cluster head is to collect the header information. The header contains the node identification, route adopted and traffic overload information. One sensor field is connected to other with the help of cluster heads respectively.

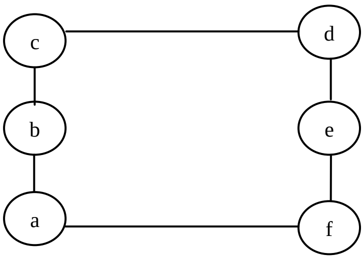


**Fig. 2.1 Grid type**

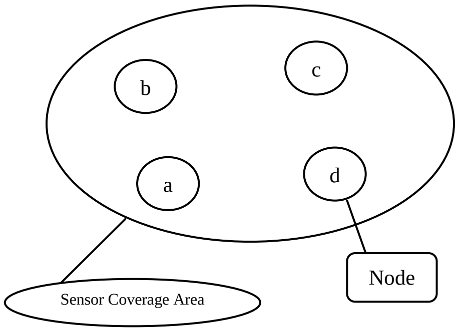


**Fig. 2.2 Random-deployment**

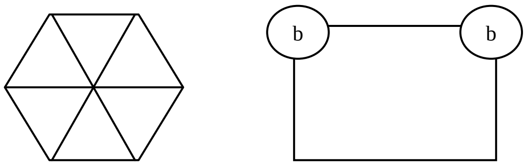


**Fig. 2.3 Regular structure: Hexagon and Square**

From fig.3, the highest energy consumption is spent during radio propagation communication. Under optimization category neural networks, fuzzy logic can be used, but the selection of optimization technique adopted is highly based on current applications scenario and on best results [3]. The energy is consumed in node deployment, CPU, signal transmission and reception, radio communication.

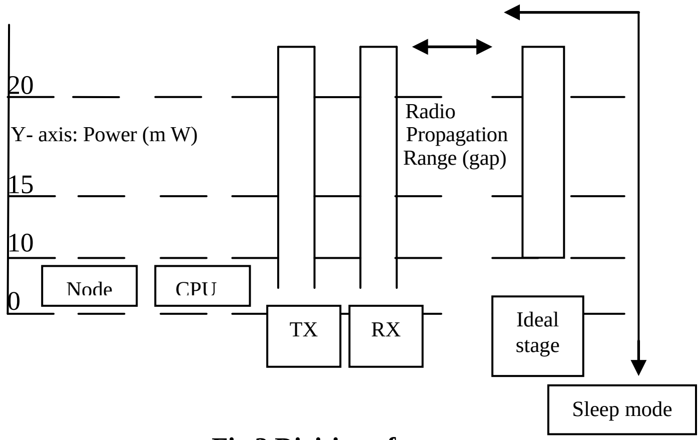


**Fig.3 Division of energy**

Basically, optimization approaches are used in WSNs at different working levels as shown in table1.

**Table1. WSNs working levels**

| Working - level | Optimization approaches |
|---|---|
| Operating system environment | Dynamic power source, Delay tolerance, Event-driven approach |
| Network-level-phenomenon | Aggregation, Real-time systems, Topology, Adaptation, Dynamic platform, Query event |
| Component-deployment | Scaling, Frequency consideration |
| Architecture-Layer | Sensor approach, Bridge destination, Tunneling cause |
| Data Link level | Energy, Through put ratio, Load balance consideration |

## II. GENETIC APPROACH

Genetic approach (G.A.) deals with the generation of different individuals under global algorithm to get the optimal solution of the given problem [4]. The main backbone of G.A. is to find out the fitness function. The fig. 4 shows the flow adaptation under working of G.A.

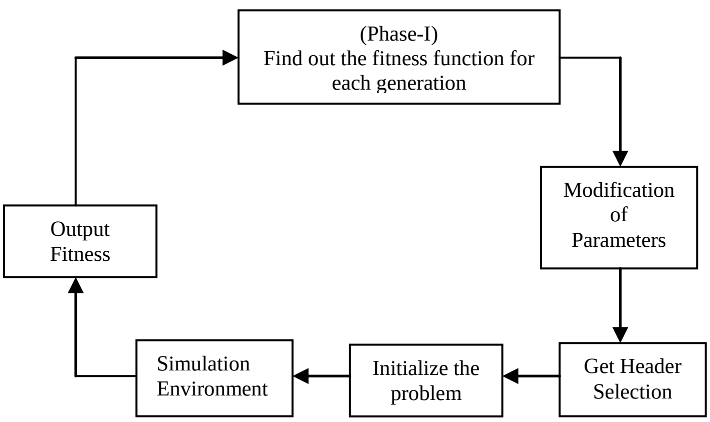


**Fig.4 Genetic flow diagram**

After getting the fitness function in one round, next aim is to analyze the best fitness response. To do this, from fig.5 we evaluate whether the fitness generation is required or not. And then again formation of generation exists to start the genetic approach.

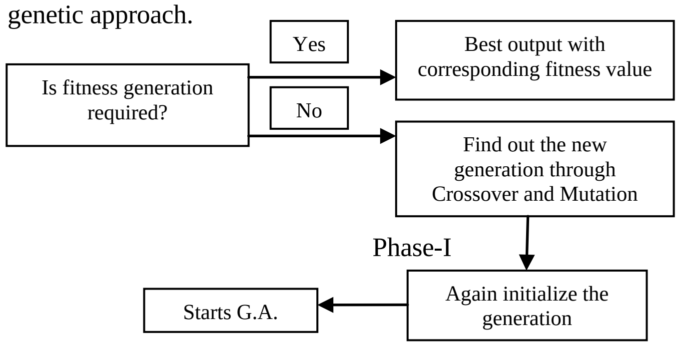


**Fig.5 Fitness evaluation**

### *A. Initialization*

It consists of data sequence with 0s and 1s. Through crossover and operators, algorithm is used to get the optimum solution. Two strategies are used as: 1. Steady state 2. Generation based. In the first strategy, only one or two value data is replaced and the second strategy replaces all the individuals of a generated population.

### *B. Fitness*

In this, each chromosome is scored according to its qualification. The flow to the next generation is based on the fitness scoring capability.

### *C. Header Selection*

The best selection is basically depends upon the highest score among solution. The probability of selection is considered as:-

$$p_s = \frac{f_n}{\sum_{k=1}^{I} f_n} \qquad 0 < p_s < 1$$

Where '$f_n$' and 'I' are the chromosome fitness value and population size respectively.

### *D. Crossover*

This is used for reproduction towards major production. It includes the study of characteristics of one generation to another. Fig.6 shows the crossover method to evaluate the data. Children are generated from a set of corresponding parents. The offspring bit sequence follows the duplication of parents bit data till the crossover point.

Parents
010010 ↑ 10010010 ⟶ 100001↑01111000

**Fig.6 Crossover technique**

### *E. Energy-fitness parameter*

It is used to find out the chromosome's fitness to the level at which the energy consumption is minimized and opted maximum coverage area in the sensor networks. Some parameters under this energy fitness as follows:-

1. Gap to base station (GBS):

It is the sum of all distances between the respective sensor nodes and is represented by:-

$$\text{GBS} = \sum_{n=1}^{i} D_n$$

In this, 'i' is the number of nodes in the network. It is mainly applicable for small-scaled networks.

2. Cluster-distance (CD):

The summation of base station distance and total of cluster heads between individual nodes.

$$\text{C.D.} = \left(\sum_{q=1}^{v}\left(\sum_{i=1}^{l} d_{qi}\right) + D_{qb}\right)$$

In the above equation, 'v' and 'i' indicates the number of cluster-groups and present total members. Here, '$d_{qi}$' represents distance between cluster head and corresponding nodes and '$D_{qb}$' represents the distance cluster head and base station. Higher energy consumption is used for higher cluster distances between the nodes. Density of network depends upon the presence of total number of nodes in the network.

3. Distance of cluster based network (DCB):

It measures the changes of distances among clusters. The placement of nodes under DCB technique is random or deterministic. In random manner, different size of cluster-variation is acceptable at the particular extent. Uniform distribution of clusters is placed under deterministic manner. The change in clusters is minimized under this manner. Deterministic changes leads to the poor quality of the network. This is the main difference in between random and deterministic placement of clusters.

Average cluster distance is used as:-

$$\Phi = \frac{\sum_{i=1}^{p} D_q}{p}$$

4. Energy transfer parameter:

This energy is used to transfer all data to the base-station.

$$\text{E} = \sum_{q=1}^{g}\left(\sum_{v=1}^{h} e_{vh} + \text{h} * E_R + e_q\right)$$

The above equation consists of the following variables as:-

'h': Number of nodes in the cluster.

'e': Energy needed to transfer the data from corresponding node to cluster head.

'q': Energy needed to transfer aggregated data to cluster head.

'$E_R$': Energy needed to transfer data from cluster head to the base station.

5. Transmission parameter:

The base station stores the information regarding total number of transmissions at each instant. At maximum energy level, superior solution is obtained and at the minimum energy level, deteriorate solution is obtained. The performance of G.A. basically depends upon the previously obtained G.A. solutions under population.

## III. PERIMETER ROUTING WITH G.A.

The utmost feature of robustness in G.A., leads it to get efficient energy results under perimeter routing in WSN [5], [6]. To get the good data communication directly among all nodes, route selection through perimeter under greedy approach is the most finest and beneficial criteria among routing protocols. Whenever there are chances of large communication gap among nodes, then chances of higher energy wastage are probably there. So we need to compensate the much wastage of energy during passage of data between transmitter and receiver sides. It can do the high node-die ratio, which may affect the quality of network under considerations. Thus here is a need to apply genetic algorithm on far-away nodes formation [7]. To fulfill the need of strengthen the network's life; the genetic algorithm is applied in three modes of configuration. 1. To divide the environmental platform into clusters. 2. Choose the appropriate cluster head (CH) based on distance. 3. To select efficient waypoint of CH.

### *A. Cluster formation:*

Its main goal is to reduce the data quantity. So it will make the network more redundant and with less congestion. The formation of coding under this is adopted through G.A. in the form of {0, 1}.

Where '0': CN → Client node

And '1': CH → Cluster head

The number of nodes in a particular cluster depends upon the distance among node's balancing. To get in the behavior of sensor network, 'n' denotes the string length of total number of nodes present as shown in figure 6 and figure 7.

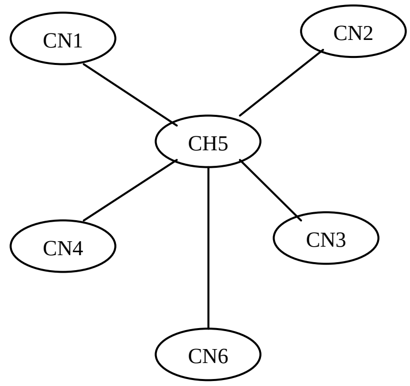


**Fig.6 Coding sketch**

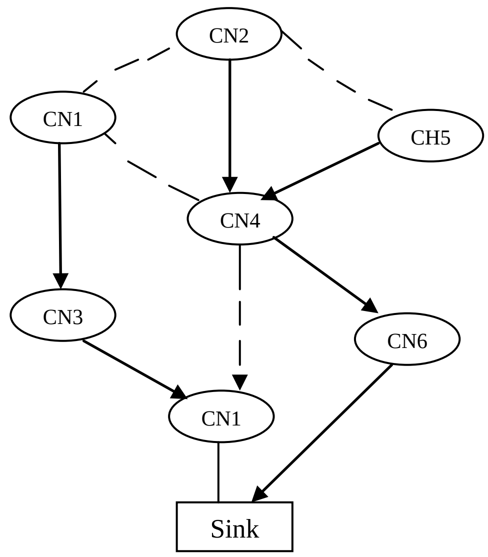


**Fig.7 Network sketch formation**

### *B. Choosing efficient way-point:*

In this technique, we choose the cluster-heads near to sink and to transmit the data via CH-coding by using real numbers. The limitation under this is that the two or more CHs should be in their reachable perimeter. Figure 7 shows the way-point method in which the real line connections show the chosen nodes and address list is updated after each route under this perimeter routing technique.

 

This work proposal is based on 150*150 areas in random grid construction. The minimum coordinators of node chosen is {0, 0} up to the maximum limit of {150, 150} without repeated nodes formation. It is applied on random grid-based platform with fixed distance values between them.

The energy related functions used in this are:

$e_t$ = B * $e_\varphi$ + B * $\varphi_1$ * $D^4$ ------------------------------- (1)

$e_t$ = B * $e_\varphi$ + B * $\varphi_s$ * $D^2$ ------------------------------- (2)

In the above equations,

$e_t$ : Wastage of energy during transmission of data

B: Bit quantity used in the transmission of data

$\varphi_1$: Long distance assumption

$\varphi_s$ : Short distance communication

When distance 'D' > 89.7 then equation (1) is used.

And at 'D' < 89.7 equation (2) is used.

The values taken are as:

$\varphi_1$ = .0013 p J/bit/$m^4$

$\varphi_s$ = 10 p J/bit/$m^2$

$e_\varphi$ = 50 n J/bit

During simulation, the maximum energy limit used is 1 joule and the node's quantity should be less than 40 for algorithm to be performed.

## IV. RESULTS AND COMPARISON ANALYSIS

The performance of perimeter routing is analyzed with genetic algorithm is known as 'PGA' and perimeter routing without genetic algorithm is known as 'WPGA' on NS-3.

The PGA is a code selection with 200 bytes and carries 600 byte data. The node's region randomly distributed is 40, 70, 90, 130, 160, 200 and 260 on 150 * 150 m region. The target destinations are equal to 10. The initial energy is set at 1J. The radius between nodes under communication is 20m. The crossover probability $P_C$ and mutation $P_M$ selects at 0.8 and 0.08 and the maximum value of evolution is generated at 120. Final results are experimented under 10 trials.

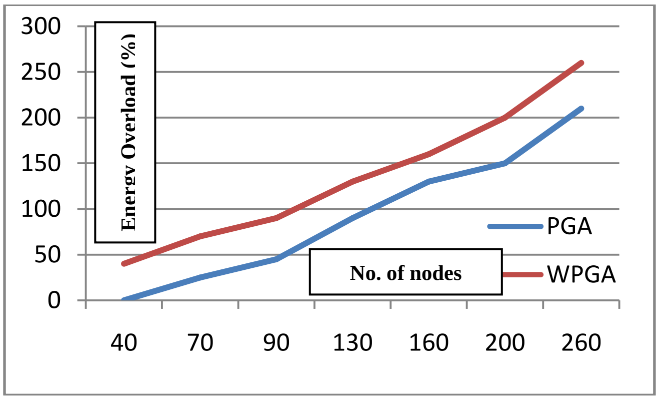


**Fig.8 PGA VS WPGA (energy consumption)**

Fig.8 shows the graph of comparison between PGA and WPGA. The result here indicates that the performance of WPGA is worst than PGA. In WPGA the energy overhead increases with the increasing number of nodes. Because by using the selection of improved crossover operator, we can make the perimeter routing much efficient. Furthermore, greedy approach is added to the mutation operator to get the best generation among population.

Optimization is also used to decrease the frequency of dead nodes. As the relation among energy consumption and distance is negative. So to get the dead nodes at much lower rate, we chose the way to decrease the distance between CH and member nodes. By introducing increased number of clusters, there can be the chances to avoid long distances. The ratio of overall energy in usage to the distance travelled was formulated.

Where {($E_j$ * t) * $E_i$ * t} is overall energy consumption and {($d_b$ * no. of nodes) * (CHs * $d_b$ )} is the total distance between CHs. A (i) shows the maximum ratio of achieved value.

$$A\ (i) = \left(\frac{E_j * t}{d_b * no.of\ nodes}\right) * \left(\frac{E_j * t}{d_b * CHs}\right)$$

To get the optimum response, the optimum number of chromosome choice is done from passing generation.

Here we compare the WPGA & PGA to show the repair of dead nodes by using G.A. Fig.9 shows that as the simulation round increases with the gap of 5ms at each interval, we get the good energy consumption response as the dead nodes decreases with strong fittest function. The death time of nodes will be delayed in PGA as in compared with the WPGA. In addition to this, we found that network is able to run with their lesser number of active nodes. By using perimeter routing algorithm, function takes three steps of status of energy as Low, Medium and High. This type of feature contributes a great emphasis on network's lifetime.

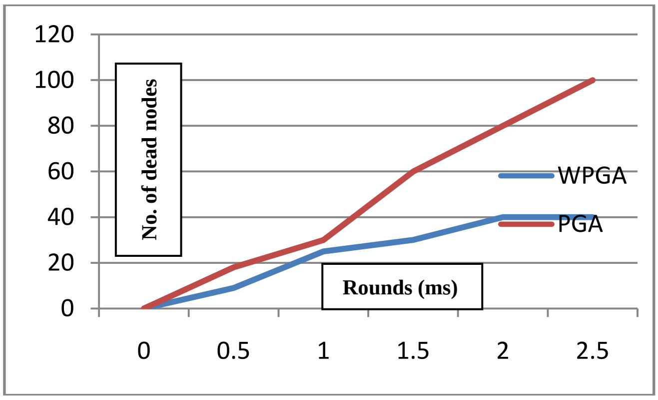


**Fig.9 WPGA VS PGA (dead nodes evaluation)**

## V. CONCLUSION

Finally, by using G.A. (genetic algorithm), optimum fitness function is obtained and the protocol is well optimized. Our work concentrates mainly on the parameters related to saving of energy through decrement in dead nodes ratio. It also helps in to reduce the transfer overhead and protocol becomes much energy efficient as compared to traditional perimeter routing approach. The algorithm has been strengthening successfully in making suitable selection of crossover, mutation and fitness function. At present, we try to work on the energy efficiency of WSN through G.A. with the combination of scalability and clustering.

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