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Abstract: Energy efficiency of sensor nodes has always been the prominent area of research for the researchers to enhance network longevity. Many routing protocols have been reported so far working towards the same direction. However, acquiring the optimal performance of the routing protocol is NP-Hard (Non-Polynomial Hard) problem. Therefore, in this paper, to acquire the optimized routing, Genetic Algorithm has been used that helps in constructing the optimized Cluster Head (CH) selection. The proposed strategy is termed as Genetic Algorithm based Energy Efficient Routing protocol (GAEER). The CH selection in this work, incorporates node’s residual energy, distance, node density and also the network’s remaining energy. The factor network remaining energy is incorporated to take a control on the number of CHs with respect to the remaining alive nodes in the network. The simulation for the GAEER is done in MATLAB and performance validation of the GAEER is done against the other GA based existing techniques. It is observed from the simulation that GAEER outperforms the competitive protocols for different performance metrics.

Index Terms: GAEER, GAOC, Genetic Algorithm, Cluster Head (CH), energy efficient routing, GADA-LEACH

1. INTRODUCTION

The advancement in MEMS (micro electro-mechanical systems) has led to the development of small sized sensing devices that not only possess the capabilities to communicate but also, they are computationally efficient [1]. These nodes are sensitive to the hardware damage however they are deployed in a robust structure that they stop functioning only when their battery is exhausted. A WSN consists of a large number of nodes deployed over a specific area where the environment or the surrounding has to be monitored. A sensor node generally comprises of sensors, actuators, memory, a processor and communicating transceiver [2]. As we know, the prominent concern of the WSN is the battery consumption as the batteries of the sensor nodes cannot be replaced once they are completely exhausted [3]. Therefore, the communication among the sensor nodes have to be made efficient enough so as the data packets among sensor nodes can be routed efficiently. The routing techniques have three genres; flat routing; hierarchical and location-based routing [4]. In this paper, the hierarchical routing is taken into consideration. Such routing deals with the clustering among sensor nodes. It is observed that hierarchical routing is more balanced than any other routing schemes. The power consumption in the such routing is very less as compared to the any other technique. Clustering is followed in hierarchical routing which helps in making clusters of different sizes where on node is selected as CH and other nodes act as Cluster members [3].

1.1. Major Contributions

It is important to enhance the routing strategy in WSN to elongate the network lifetime. To address this concern, the major contributions in this paper are stated as follow:

a) In this paper, GAEER (Genetic Algorithm based Energy Efficient Routing protocol) is proposed that selects CH based on the novel combination of parameters; residual energy, distance factor, network’s residual energy, and node density.

b) The performance of the GAEER is validated against the GADA-LEACH (Genetic Algorithm and distance based Low energy adaptive clustering hierarchy) [5] and GAOC (Genetic Algorithm based Optimized Clustering) [6] protocols.

The paper is organized as follows. Section 2 represents the literature work, Section 3 presents the proposed routing strategy, results and discussions are given in Section 4, finally the work is concluded in Section 5.

2. LITERATURE STUDY

Recent advancements in the technology has led to the development of small sized sensor nodes that can be used to monitor any surrounding [7]. Whenever the signal is transmitted and received, it consumes a lot of energy, so inherent limited battery power is an important issue within network sensor nodes. Therefore, battery power is essential factor in the design of algorithm to increase lifespan of nodes in the network. Distribution of Energy Dissipation throughout the WSN is also really significant. The optimization of routing among sensor nodes could be...
achieved in the various routing technologies [8]. Yuan et.al. in paper [9] proposed an unequal clustering algorithm UCA for prolonging the lifetime of network and mitigating hotspot problem. Here clusters near to the base station are of smaller size than farther clusters. In this algorithm there is rotation of cluster head and choosing CH with more residual energy same as EEUC. Gong et.al. in paper [10] proposed a new energy aware clustering routing protocol MRPUC for saving and balancing the energy consumption among all nodes. Here nodes of maximum residual energy become the cluster-head. Clusters close to base station have smaller cluster size than the distant cluster to preserve energy for inter cluster communication. In this algorithm each node collects data from its neighboring nodes and give it to the CH and CH relay it to the other CH. Barekatain et.al. in paper [11] proposed an algorithm i.e. GA-Based Clustering on the basis of residual energy. In this paper, the Clustering is done according to GA as it decreases the number of chromosomes by considering nodes with residual energy greater than the average energy of network. After the cluster determination by GA, the selected points are considered as initial points for K-Means Algorithm which fastens the speed of the convergence. The proposed algorithm does not consider the node density factor while selecting the CH in its fitness function which tend to select nodes with less proximity as CH. Elhoseny et.al. in paper [12] proposed Dynamic Cluster Head Selection Method Based on GA (DCH-GA). The Cluster Head is selected on the basis of remaining energy, the consumed energy, the number of nearby neighbors i.e., energy aware distance (EAD), the node vulnerability, and the degree of mobility. DCH-GA assigns each factor a degree of priority Proposed model works for both single hop and multi hop network. Network Life Time is increased with this as compare to TSEP and other protocols DCH-GA suffers from Hot-Spot problem in the multi hop model, as the nodes lying near to the Base Station drains their energy much faster than the other nodes. Eventually, the CH nodes are dead which are nearby to the Base Station. Verma et al. in proposed an architecture that made use of the four gateway nodes in the network to eradicate the hot spot problem [13]. Further, the architecture was proposed for single sink as well as multiple data sink [2]. Gupta et.al. in paper [14] proposed GA-Based Cluster Head selection as well as GA-Based Routing. In this paper, the clustering is based on residual energy of the nodes and distance from sensor nodes to their corresponding cluster head. This routing is also based on the residual energy of the gateways (CHs) along with a tradeoff between transmission distance and number of forwards. The proposed algorithm does not consider the node density factor while selecting the CH in its fitness function which tend to select nodes with less proximity as CH. It will lead to higher energy consumption as the intra-cluster communication distance will be enhanced. Verma et al. proposed zone based clustering which selected CH on the two levels [15]. Yuan et.al. in paper [16] proposed GASONeC in which six parameters were taken into consideration that basically included; energy distance, node density and network structure. The surrogated node is selected as CH. After the cluster determination by GA, the selected points are considered as initial points for K-Means Algorithm which fastens the speed of the convergence. The proposed algorithm does not compare its performance with the state-of-art algorithms. The performance comparison is done with the old algorithms. Verma et al. [6] proposed an algorithm based on GA to improve the network performance by involving the three CH selection parameters namely, residual energy, distance and node density. However, it is observed that the involvement of these parameters are still not efficient enough to acquire the network performance.

### 2.1. Inferences drawn from the literature study

It is being observed from the literature survey that there have been various techniques contributing towards energy efficient CH selection. Furthermore, it has been observed that energy resources have been the most concerning issues in dealing with the WSNs. Some of the inferences drawn from the study of related work are discussed as following.

a) The fundamental fact behind the energy drainage has been the communication among the sensor nodes and i.e. rendered by the routing strategies in the WSN.

b) There have been various optimization techniques aiming to acquire enhanced network lifetime and stability period. However, there is still scope of improvement for improving the fitness function involved towards integration of different fitness parameters.

c) The protocol DCH-GA has incorporated various parameters for CH selection, however, the multi hop communication is not energy efficient as it leads to hot spot problem.

d) The protocol GASONeC improved network lifetime tremendously, however the performance evaluation was done with the traditional protocols.

e) Therefore, there is need to design energy efficient routing protocol based on GA that selects CH efficiently and also evaluates its performance with the state of art protocols.

f) The one of the algorithms proposed by Barekatain et al. in [11] improves the network performance by selecting CH by using GA and performing routing operation by using K-Means algorithm. However, the CH selection is done only on the basis of energy.

g) The protocol GAOC considers only three parameters; residual energy, distance and node density. However, the involvement of other factors will enhance the network performance of GAOC.

### 2.2. Problem Definition

The inferences drawn from the literature highlights the research gap in the state-of-art protocols. It is observed that GAOC adopts the CH selection using solely three factors namely, residual energy, distance and node density of the nodes. The problem for the proposed work can be defined as follows.

a) In consideration to the research work utilizing GA for CH selection and utilizing many factors, the GAOC proves to be inefficient leaving much scope behind for further improvement.

b) The factors other than the aforesaid parameters can be taken into consideration for improving protocol GAOC. The factor of node density helps in reducing the intra-cluster distance among the selected CH node and cluster member nodes. The distance factor i.e.,...
distance of a node to be selected as CH, to the Base Station can be encountered for the selection of CH. Most importantly, the network’s remaining energy can be taken into consideration for keeping a control over the number of CHs.

c) While considering the GA, these parameters can be integrated to construct a fitness function which is iterated in GA operation.

The CH selection for the protocol GAOC is improved by incorporating the additional parameters namely, residual energy, distance to the base station or sink, and node density. It is to be noted that each of these parameters have significant role to play in reducing the energy consumption of the network. The objectives to perform the aforementioned proposed work can be states as follow.

2.3. Introduction to Genetic Algorithm

The genetic algorithm [17] based unequal clustering multi-hop routing protocol is an optimized technique which follows the procedures of this heuristic algorithm. Genetic Algorithm is an optimization technique based on the phenomenon of Survival of the fittest. Genetic Algorithm works with some individual that represent solutions, that helps in taking measures for the given solution as compared to the proposed solution. The best suited individuals create the next generation.

2.3.1 Initialization

The initial population includes the randomly chosen chromosomes that consist of genes with a sequence of 0 s and 1s. There are two methods viz., steady state GA and generational GA that are used to produce new population. In the steady state GA one or two members of population are replaced that means the new generation may contain the previous generation members while the generational GA replaces all of the produced individuals at each generation which means the new generation does not contain the previous generation chromosomes.

2.3.2 Fitness Function

The fitness function is defined as the ability to survive and reproduce again, the more is the fitness value more are the chances of survival. It defines the particular problem. In the proposed work it is defined by the distance and energy as the parameters.

2.3.3 Selection

The selection process is used to select the chromosomes from the population based on fitness function. In order to create new chromosomes, the crossover operation is performed and the new made population become the base of the next selection process. There are various types of selection methods, Tournament selection is one of them and chosen for the proposed protocol. In tournament selection method, random selection for the two chromosomes is done and the chromosome with higher fitness value is selected for further operation.

2.3.4 Crossover

Crossover is a binary genetic operator which selects a pair of individuals as parents to generate an offspring. In this process the inheritance characteristics are naturally transferred into the new population. There are various crossover operations that have been developed, one of the simplest is single point crossover in which a random point is chosen to divide the contribution of two parents. Fig. 2 represents an example of single point crossover, in which randomly a point is selected and thereafter, the information transfer takes place after the selected point [11]

![Fig. 2 Single point crossover](image1)

<table>
<thead>
<tr>
<th>First</th>
<th>Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent</td>
<td>Offspring</td>
</tr>
<tr>
<td>1 0 0 0 0 1 0 1</td>
<td>0 0 1 1 0 1 1 0 0</td>
</tr>
</tbody>
</table>

2.3.5 Mutation

Crossover introduced a new generation whereas this causes problem when there is absence of any new genetic material in the offspring. Mutation permits the new genetic patterns into chromosomes. Fig. 3 shows an example of mutation process.

![Fig. 3 An example of mutation](image2)

<table>
<thead>
<tr>
<th>Original</th>
<th>Offspring1</th>
<th>Offspring2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1 0 0 1 0 1 1 1</td>
<td>0 0 1 1 1 0 1 1 1</td>
<td>0 0 1 1 1 0 1 1 1</td>
</tr>
</tbody>
</table>

3. PROPOSED ROUTING STRATEGY

The GAEER operates like any other cluster-based routing techniques. The network model assumptions for the GAEER are given below.

3.1. Network assumptions for GAEER

Network assumptions for the proposed work are listed as follow.

a) The network is energy heterogeneous and the three-level energy heterogeneity is considered normal and advanced nodes. Wherein advanced nodes have more energy as compared to normal nodes [19].

b) The deployment of the nodes is random but uniform. These nodes are location unaware.

c) The communication link of the nodes is symmetrical.

d) The base station is placed outside the network which is taken in a rectangular shaped.

e) Base station is assumed to be energy unlimited.

f) There is no recharging source for the sensor nodes once they are dead.

g) The security consideration for the proposed protocol is out of the scope of this work.

3.2. Operation for the GAEER

The network model for the proposed work GAEER is given as follow. In this network model, the heterogeneity among the sensor network is introduced as shown in the figure 2. There are heterogeneous nodes forming a cluster in different zones that are formed in the network.

3.2.1 Set-up phase

The heterogeneous nodes; normal and advanced nodes are uniformly but randomly deployed in the network. The network can be attended or unattended depending upon the application. The set-up phase involves the selection of both CHs and the sink placement. The process of CH
selection is initiated by the Hello message from the sink to the network and in return the unique ids are shared from each node with the sink. As soon as the sink receive these ids, it broadcast all of them in the network. Thereafter through the distributed approach, the CH selection takes place in each cluster through the following process.

The GA technique is followed for the CH selection. The selection parameters for the CH are listed as follow.

a) Residual energy: It is the current energy of the node in each round which is monitored.

b) Distance to the sink: The distance of the node from the sink is checked so that energy consumption is reduced.

c) Node density: The number of neighboring nodes around the node can also be termed as node proximity is also considered.

d) Network’s remaining energy: The remaining energy of the network is considered for the CH selection to exert a limit on the number of CHs in the network. As the data transmission proceeds, the number of nodes die gradually, that requires the number of CHs in the proportion numbers.

3.3 The system framework of GAEER

In this description of system framework, the heterogeneous model of GAEER and its operation involving different functioning steps of GA are discussed.

3.3.1 Heterogeneous Model of GAEER

The heterogeneous nodes are deployed in the network. The nodes are of different energy proportions as they are incorporated with three levels of heterogeneity [6]. The number of normal, advanced and super nodes used in the network are represented as N\text{NORM}, N\text{ADVN} and N\text{SUP} as given eq. (1-9). The quantity of these high-energy nodes i.e., advanced and super nodes are represented by α1 and β1, respectively.

\begin{align}
\alpha_1 &= n \times \lambda \\
\beta_1 &= n \times \mu \\
N_p &= n \times (1 - \lambda - \mu) 
\end{align}

The advanced and super nodes are λ and μ times more in energy as compared to normal nodes. The computation of total energy of the network represented by E_T is done through the set of eq. (4-9). E\text{SUP}, E\text{ADVN}, and E\text{NORM} represent the energy of super, advanced, and normal nodes, respectively.

\begin{align}
E\text{SUP} &= E_0 \times (1 + \lambda) \times n \times \lambda  \\
E\text{ADVN} &= E_0 \times (1 + \mu) \times n \times \mu  \\
E\text{NORM} &= E_0 \times (1 - \lambda - \mu) \times n 
\end{align}

The total energy computed above is used further in the process of CH selection while integrating fitness function in the following Subsection.

3.3.2 Working of GAEER

The protocol GAEER starts working with the validation process where the nodes are represented as the set of particles, which are further evaluated in the form of bit streams. The status of node as a CH is indicated when the bit is ‘1’ otherwise, the node is declared as member node when the bit value is ‘0’. This process of validation helps in the initialization process in a way that the eligible nodes are taken into consideration for the further steps of optimization.

A. Initialization

After performing validation, the process of initialization is brought into operation. The certain particles are initialized based on their desirable characteristics. It is analogous to the network parameters comprising network area, number of nodes, sink position in the network and the value of transmitting and receiving energy encountered while data transmission. After performing initialization process, the fitness function is computed

B. Fitness Function

Fitness function is integration of different performance parameters combined together to frame an expression that is to be either maximized or minimized. Fitness function deals with various fitness parameters that decide for the fitness of current individual. The fitness parameters employed in the fitness function as discussed as follows.

C. Fitness Parameters (FPs)

The FP is computed for its current value depending upon various factors. It is to be noted that more significant the parameter is, more optimized value will be acquired. Here the fitness parameters aim to reduce the energy consumption and rendering the network longevity to the network. The following parameters are taken into consideration while developing fitness function. These parameters are considered for the selection of CH in the network and are discussed as follow.

i. The residual energy of a node

It is the fitness parameter that considers the residual energy of the sensor node to be selected as CH. In every round, the energy dissipates of the sensor nodes, therefore, it is necessary to monitor residual energy of the sensor nodes in every round for its selection as CH. FP_{1st} (First Fitness Parameter) introduces the fitness factor in the following way.

\begin{equation}
FP_{1st} = \frac{1}{E_{res(i)}} 
\end{equation}

In eq. (10), the residual energy of the ith sensor node is mentioned in the denominator term as it is targeted to minimize the fitness parameter and eventually selecting the node with higher residual energy.

ii. Distance between node and sink

Once the nodes are deployed randomly in the network, the distance of the nodes from the sink varies correspondingly. The lesser the distance between the sensor nodes and sink, the lesser will be energy consumption. Therefore, it is one of the crucial factor for the selection of CH. It should be minimum between the cluster nodes and also in between the CH nodes and the sink to reduce energy consumption. It is computed with the help of Euclidean distance formula that deals with the coordinates of the two entities.
The second Fitness Parameter ($FP_{2nd}$) for designing the fitness function for the CH selection pact with distance factor and is given by eq. (12).

$$FP_{2nd} = \sum_{i=1}^{N} \left( \frac{D_{N(i)-Sink}}{D_{AVG(N(i)-Sink)}} \right)$$  

(11)

$FP_{2nd}$ calculates the summation of distance cost incurred for each $i$th node where $i$ ranges from 1 to $N$ (total number of nodes in the network). In eq. (12), $D_{N(i)-Sink}$ represents the Euclidean distance of a $i$th node from the sink whereas, $D_{AVG(N(i)-Sink)}$ represents the average distance between $i$th node and the sink. It is observed that lesser the value of $FP_{2nd}$ more it will favor the selection of a node as a CH.

**iii. Node Density**

It is crucial to reduce the distance of the cluster nodes from the CH, therefore, the selection of CH is done based on the number of neighboring nodes. It is determined by identifying the nodes with least distance from all other nodes. The third fitness Parameter ($FP_{3rd}$) deals with number of neighboring nodes and is defined by the following eq. (12).

$$FP_{3rd} = \left( \sum_{i=1}^{N} \frac{D_{N(i)-N(j)}}{N_{clus}} \right)$$  

(12)

In above eq. (13), $D_{N(i)-N(j)}$ represents the distance between $i$th node and $j$th node of the cluster. $N_{clus}$ denotes the number of nodes in the cluster. In such a way, $FP_{3rd}$ must be minimized to make it an energy efficient CH selection.

**iv. Network’s remaining energy to control number of CH**

In this, the network’s remaining energy is taken into consideration for deciding upon the fact that if the number of dead nodes increases with the data transmission in process, the number of CHs should be controlled accordingly. Therefore, this parameter is considered to bring load balancing in the network. The fourth fitness parameter $FP_{4th}$ is given in the following eq. (13).

$$FP_{4th} = \frac{\sum_{i=1}^{N} E_{(i)}}{D_{nodes}}$$  

(13)

In above eq. (13), the numerator term $\sum_{i=1}^{N} E_{(i)}$, is the sum total of the residual energies of the all nodes and the denominator term $D_{nodes}$ represents the number of dead nodes in the network. Lesser the value for $FP_{4th}$, lesser it will make the probability of a node to be selected as CH, hence controlling the number of CHs.

**D. Fitness Function for the network:**

As discussed above, the fitness function of the network is the combination of different fitness parameters framed in a single expression given as follows in eq. (14).

$$F = \frac{\alpha \times FP_{1st} + \beta \times FP_{2nd} + \gamma \times FP_{3rd} + \delta \times FP_{4th}}{\sum_{i=1}^{I} F_i}$$  

(14)

The fitness function represented by $F$ in eq. (14) should be minimized to bring the network performance to the optimum value. In eq. (15), $\alpha$, $\beta$, $\gamma$, $\Omega$ are the weight coefficients multiplied with fitness parameters. These factors are evenly weighted such that it follows eq. (15).

$$\alpha + \beta + \gamma + \Omega = 1$$  

(15)

<table>
<thead>
<tr>
<th><strong>Table 1 Simulation Parameters</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Network coverage</td>
</tr>
<tr>
<td>Data packet size</td>
</tr>
<tr>
<td>Initial energy (Quantity)</td>
</tr>
<tr>
<td>Node Number</td>
</tr>
<tr>
<td>advance fraction (a)</td>
</tr>
<tr>
<td>Number fraction of advanced nodes (m)</td>
</tr>
</tbody>
</table>

**E. Steady State Phase**

As soon as the CH is selected based on GA, the nodes undergo cross crossover and mutation process as explained in the previous section. Afterwards, the data transmission is proceeded in the steady state phase. The nodes send data to the CH node and eventually the CH node sends data to the sink after implying data aggregation on it.

**F. Radio Energy Consumption Model**

The same energy model is used as used by various cluster-based routing [18]. As soon as the steady state phase is initiated, the nodes consumes energy according to this model.

![Flow chart of working operation of GAEER](https://www.ijstr.org)

**Fig. 4 Flow chart of working operation of GAEER**
RESULTS AND DISCUSSIONS

The results and discussions of GAOC are discussed as follow and different simulation parameters are given in Table 1. When simulations are performed in MATLAB, the proposed routing scheme, GAEER is evaluated on different performance metrics. The evaluation is done with respect to different number of rounds acquired by these metrics. A round is defined as the one iteration in which the data is collected from all the nodes by the sink for one time. The metrics involved are discussed as below.

a) Stability Period

The number of rounds that are successfully completed before the first node is dead is termed as stability period. It is one of the essential parameters that ensures about the stability and reliability of any routing scheme. As shown in Fig. 5, the stability period of GAEER is higher than the other protocols. It can be seen from the Table 4, the stability period of GAEER is 7380 rounds where as it is just 5825 and 4400 rounds in case of GAOC and GADA-LEACH protocols, respectively. The reason behind such enhancement is the use of ‘network’s remaining energy’ and network density in the CH selection along with the energy and distance parameters. Furthermore, the enhancement is acquired due to the load balancing approach adopted due to energy efficient CH selection. The graph of alive vs round is shown in Fig. 6 which gives the status of alive nodes with the passage of rounds.

b) Network Lifetime

The number of rounds completed before to the moment when all nodes are dead, it is termed as network lifetime. The status of dead nodes vs round in shown in Fig. 6. The first dead node of GAEER is 7380 rounds, the half dead nodes is 15124 rounds. It can be observed that the network lifetime of GAEER is very high as compared to the other protocols. The reason behind such improvement is the distribution of the load for the updated number of CHs in each round. The control on the number of CHs reduces the energy consumption incurred by the unnecessary selected number of CHs. That makes them functioning for longer period of time.

c) Networks remaining energy

The proposed scheme helps in the enhancement of network remaining energy with respect to the number of rounds. The status of network’s remaining energy is acquired during the simulation analysis when the continuous value of energy of whole network is updated and the graph given in Fig. 7 is obtained. Due to the energy
efficient CH selection, the network preserves more energy than the other protocols as shown in Fig. 7. The percentage improvement by the GAEER is shown in Table 3.

**TABLE 3** **PERCENTAGE IMPROVEMENT OF GAEER AS COMPARED TO OTHERS**

<table>
<thead>
<tr>
<th>Metrics</th>
<th>GADA-LEACH</th>
<th>GAOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability Period</td>
<td>67.7%</td>
<td>26.6%</td>
</tr>
<tr>
<td>Half Node Dead</td>
<td>41.6%</td>
<td>20.4%</td>
</tr>
<tr>
<td>Network Lifetime</td>
<td>173.6%</td>
<td>76.8%</td>
</tr>
</tbody>
</table>

It is evident from the Table 3, that the protocol GAEER improves the stability period by 26.6% in comparison to the GAOC and 67.7% in comparison to the GADA-LEACH protocols. Furthermore, the network lifetime is enhanced by 76.8% and 173.6% in comparison to the GAOC and GADA-LEACH protocols, respectively. The reason for the respective improvement is discussed in the aforementioned metrics.

5. **CONCLUSION AND FUTURE SCOPE**

The battery consumption of the sensor nodes is a dominant concern that must be addressed for the network lifetime enhancement. There are many algorithms that are presented by various researchers that optimizes the CH selection. After addressing the research gap, we have presented a novel GAEER protocol that exploits GA to select CH based on residual energy, distance, node density and network’s remaining energy. It is the first ever attempt that proposes CH selection based on aforesaid parameters. Through simulation, it is observed that GAEER outperforms the GADA-LEACH, and GAOC. The incorporation of network’s remaining energy ensures about the updated number of CH selection. As the nodes die in the network, the number of CH needs to be reduced, therefore the network’s remaining energy is monitored continuously. It is learnt that through the simulation analysis, the GAEER improves stability period, network lifetime by 26.6% and 67.7% and 76.8% and 173.6% as compared to GADA-LEACH, and GAOC, respectively.

**REFERENCES**