Deer Optimization Technique based on Clustering and Routing for Lifetime Enhancement in Wireless Sensor Networks

Dr. R. K. Krishna
Dept. of ECE
Rajiv Gandhi College of Engg.
Research and Technology, Chandrapur
rkrishna40@rediffmail.com

Dr. Amairullah Khan Lodhi
Director R&D and Professor, Dept. of ECE
Shadaan College of Engineering& Technology,
Peerancher, Hyderabad
lakresumes@gmail.com

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Abstract

Clustering is implemented using a new technique that is based on the social behavior of deer.As is known deer are highly social and always travel in groups or herds.The herds are generally segregated into male herds and female herds.In the male herds, the leader continuously changes whereas in the female herds there is stability with the dominant female continuing for a longer time as a leader. Based on the above behavior,clusters are formed and these clusters are divided into two groups analogous to male and female herds.In the male group, the cluster head changes after every round of communication whereas in the female group cluster heads continue until their energy is not drained.This results in improving the lifetime of networks resulting in a long time of the communication as the nodes remain alive for a longer amount of time and clusters also continue for a longer period of time.In comparison with the existing techniques,this method based on Deer optimization gives better results in terms of lifetime,energy consumption, and the number of alive nodes. Also, energy consumption reduces substantially resulting in an optimal network.

Keywords: Clustering, Deer Herds, Male andFemale Herds, HerdLeader, Network Lifetime, Live Nodes, Cluster Head, Deer Optimization, and Energy Conservation.

1. Introduction:

As is known wireless sensor networks consist of embedded devices called sensors, which are involved in the collection of data from the surrounding physical environment and transmit this data to the sink or base station. These nodes have limited capability and limited power. The batteries are prone to exhaust with time and since they cannot be recharged once distributed, they tend to die after some time. Therefore the only way to increase the lifetime of these networks so that they can send data for a long amount of time is to the conservation of energy in sensor nodes by optimum use of the nodes. There are many optimized ways to conserve energy but nowadays technologists have shifted theirfocus toward nature-inspired algorithms. This paper proposes to improve the network lifetime by reducing energy consumption. Integration of clustering and routing is a process that goes a long way in increasing the lifespan of a network. In this process, sensor nodes are assembled into small sets called clusters. From these clusters, the cluster heads are selected. Nodes with the highest energy are generally selected as Cluster heads. The data that is accumulated by all clusters is then transmitted to the cluster head which then transmits the data to the destination. The selection of a Clusterhead is an important task. The selection of a proper route that remains for a long amount of time is also significant. Hence these two tasks are proposed in this paper which aims to increase the lifespan of the network. Bio-inspired techniqueshave a limited set of rules and can provide solutions to complex problems. The ability to adapt to variations of the medium and withstand external factors is helping in making the system a robust one. Many novel Bio-inspired techniques have been proposed and implemented by technologists and have proved to have provided very efficient and accurate results.

2. RELATED WORK:

In paper 1, the authors propose a bio-inspired based routing technique that can be used to improve the efficiency of the routing technique. This has been done by minimizing delay as well as reducing energy consumption. This method is inspired by the behavior of paddlefish and this technique has been aptly called Saddle goatfish routing protocol. This technique proposes the field of hunting as the search area and there are two types of fish called chasers and blockers. Various cooperative behaviors are proposed in the natural hunting behavior that consists of different evolutionary activities and fitness is assumed to be one of the important parameters for the success of the behavior. The process involves five main stages, which are initialization, chasing, blocking, role exchange, and change of zone.End-to-End Delay (EED, Energy Consumption (EC), andPacket Delivery Ratio (PDR) are measured and compared in thistechnique. The authors have proposed to enhance the lifetime of wireless sensor networks by optimizing energy consumption.

According to the authors in paper 2 the process of clustering and Routing together is an efficient way to reduce energy consumption. This paper lies emphasis on the selection of a Cluster head and the methodology to select the cluster head uses a bio-inspired technique. For the selection of Clusterhead, the factors considered are residual energy, load balancing capacity, and distance to the sink. This paper proposes to integrate the PSO and GSA algorithms for the clustering and Routing process. The proposed algorithm uses the exploration capacity of GSA and the exploitation capability of PSO. The method when implemented shows that the energy consumption has been optimized, the premature convergence rate is avoided and a global optimum solution is obtained.

In paper 3, the authors' Zhang and Wang propose a novel algorithm based on PSO and propose an improved bio-inspired clustering scheme called PSO-WZ.In the proposed technique, the Clusterheads are first initially decided randomly, and then non-CHs are assigned based on the division rule. The division of the network is done based on two angles, one considering the non-CHs and secondly the network. The authors also propose a Gini coefficient to obtain the objective function. Here it selects as CH, the node with minimum consumption ratio, and non-CHs are assigned to the nearest CH so that the energy required for transmission shall be less. The proposed algorithm helps in keeping more nodes alive for a longer amount of time, and thus improves the lifetime of the network.

In paper 4, the energy consumption reduction technique is achieved by combining the clustering and Routing techniques but also uses a dual cluster head technique based on the Krill herd optimization technique Instead of choosing a random path, the method proposed chooses an optimized path by computing the path trust value krill herd maximization algorithm. The collection of data by the cluster heads results in large consumption of energy. To reduce this energy loss, the authors propose a method called thecentroids method. In this technique, the primary centroids or initial centroids aggregate the data and the secondary centroids provide details of the path trust value for each path. The accumulated data is then transmitted through the obtained optimized path.

In this method the initial clustering is done by the pillar k means algorithm resulting in the placement of centroids away from distribution resulting in efficient clustering.After clustering the initial centroids actas aggregators. These functions both as aggregators and routers initially. This helps in increasing the lifetime of the network.

In paper 5 the authors have carried out a detailed survey of existing optimized routing algorithms based onnatural science and metaheuristic algorithms and parameters related to energy efficiency as the main objective. The authors finally discuss the different limitations of the algorithms and methods to overcome these limitations. These algorithms include the ACO algorithm, GA algorithm, cuckoo search algorithm, and other methods.

In paper 6, the authors have proposed a hybrid algorithm by combining the GA and PSO algorithms.In this technique, the preliminary route is obtained by the GA technique, and optimization is obtained using the PSO algorithm. Finally, the proposed method has been compared with the existing techniques. In this method, a proficient cluster head is selected by utilizing the cluster head selection algorithm to pick the CH systematically. If some of the CHs are heavily loaded, their energy will be rapidly consumed. Hence it is necessary to balance the loadfor which a proper clustering and routing method must be implemented. Once clustering is implemented GA, PSO, and BFO techniques are used to find the optimum distance between the source and destination.

In paper 7, the authors have proposed a clustering and routing technique based on Energy efficient PEGASIS protocol and Dragonfly algorithm. In this technique, the nodes are distributed in an optimum manner using three different methods called the Random, the firefly, and the control methods. The nodes have the same energy with a unique ID. The base station and nodes are fixed after distribution and their location is known by the GPS technique. The data transmission used the PEG-DA algorithm wherein every sensor node chooses a typical path to communicate with the neighbor node.For reducing energy consumption, a protection technique is used to measure the remaining energy of its neighboring nodes. A stationary sink is used to collect the data from different regions. Pegasis protocol is used with the dragonfly algorithm to decrease data redundancy, the distance of neighbor nodes and delay transmission with long links and finally obtain the optimal chain.

In paper 8,the authors have presented a new clustering algorithm that is used to select the cluster heads for which the Grey wolf optimizer (GWO) is used.In this technique,the clusterheads are selected based on the predicted energy consumption and current residual energy of each node. The technique uses the same clustering in every subsequent round. This results in saving energy that may have been consumed due to reclustering. The clustering method divides the whole network into several clusters. To reduce the fast depletion of energy, a relay node is selected for each of the cluster heads. Only after 50% of energy is consumed in the cluster heads, the second clustering will take place with a new cluster head.Until then the process continues with the same old cluster heads and clusters. Thu energy saving takes place because of the running of clusters for a longer amount of time.

In paper9, PSO based load balancing clustering algorithm is proposed, where the cluster heads are placed in an optimum manner. Lifetime, fitness value, and convergence plots for different scenarios are envisaged.As is known, cluster heads are selected from the available sensor nodes and this result in the depletion of energy from the nodes as communication takes place resulting in the death of sensor nodes. To overcome this, it is proposed to use a DE-based clustering algorithm that acts as a bridge between the parameters.One of them is lifetime maximization and the other is load balancing. In this method, an additional node from outside called gateway which shall act as a cluster head is introduced.All the nodes already in the networks get attached to these cluster heads introduced. For load balancing the PSO technique is used.This leads to improvement in the lifetime of WSNs.

In paper 10, the authors have proposed to form clusters using Fuzzy logic and then select the cluster heads. The traditional Fuzzy logic has a limitation in that the rules and memberships have to be tuned manually.This results in more delay. Therefore the authors propose that GA as it is a more powerful tool for stochastic search techniques and it can be implemented as a multiobjective function and can be used to obtain alternative solutions.Therefore for recomposition and reclustering, the authors have proposed fuzzy based GA technique.For finding the shortest path, the authors use the ACO algorithm.All these techniques have helped the authors not only improve the lifetime of WSNs but also with the proper load balancing of the network.

Inpaper 11, the authors studied the problems of energy-efficient clustering and routing optimization techniques between clusterheads and sinks.The authors propose energy balanced clustering protocol using a binary salp swarm optimization technique for heterogeneous WSNs.In the paper, the authors have introduced a salp swarm optimization technique that has a strong global search capability. Key factors such as CHs energy, cluster quality, and network coverage are introduced into the SSA.For further optimizing the energy consumption, the authors have further proposed two-level gradient forwarding trees determined by the cost function.The method uses single-hop and multiple-hoptransmission for routing between CHs and sinks. In this work, the authors have used the binary SSA-inspired clustering protocol known as ECBS. This method optimizes the cluster head selection by considering the different parameters such as residual energy, energy dispersion of CHs, cluster density, and number of CHs.Also, a new technique for routing data is proposed where an intercluster forwarding tree is presented for data transmission of packets between CH and sink to reduce energy dissipation.

3. PROPOSED WORK:

3.1 Clustering and Routing:

The process of clustering and routing consists of two stages which are the cluster set-up stage and the data transmission stage. During the transmission process, the cluster heads aggregate data from the nodes in their respective clusters and then send it to the base station directly or through a relay node.

3.2 Cluster Head Selection:

The process can be formulated as an optimization problem and mathematically expressed as

$$Ft_{CH} = \alpha \times R_{energy}^{CH} \text{ --- (1)}$$

Where$R_{energy}^{CH}$is the ratio of the average energy of Cluster heads to the average energy of normal sensor nodes in the current round. By maximizing R_{energy}^{CH} nodes with higher energy levels are selected as Cluster heads.

3.3 Relay Node selection:

If the base station is at a distance more than the threshold, then it is necessary to select a relay node and transmit the data through the relay node. The relay node in the proposed method is chosen based on the following two criteria. The first criteria are that the node with the highest residual energy should be selected and the second criteria are that the node nearest to the base station is selected among the nodes with higher residual energies.
If there are 't' potential relay nodes RN1, RN2, RN3 ………… RNt, between the Cluster head and Base station, then the equation for selection of Relay node may be expressed as

$$Ft_{RN} = \beta \times R^{RN}_{energy} + (1-\beta) \times R^{RN}_{location} \ldots \text{------------------------- (2)}$$

WhereR^{RN}_{energy} is the ratio of average residual energy Relay nodes to average residual energy of Sensor nodes. Maximizing R^{RN}_{energy} results in the selection of a node with higher energy as a relay node.$R^{RN}_{location}$represents the location of the node which is nearest to the base station.

3.4 Energy Consumption Analysis:

Let us assume that there are 'n' clusters, and the number of nodes in every cluster is 'm'. The energy consumed by a sensor node for signal transmission and reception plus the occasional sleep phases can be computed as follows:

$$E_{sn} = (1-ps)[E_{tx}(l,d) + E_{rx}(l)] + p_s E_s \text{--------------------------(3)}$$

The data that is aggregated by the Cluster Head is then transmitted to the Cluster head nearer to the base station or directly to the base station. Depending on the distance between the cluster head and base station, the free space model or multipath model is selected.
Hence energy dissipated by the Cluster head is

$$E_{ch} = E_{tx}(l,d) + mE_{rx}(l) + ml(E_{da}) \text{-- (4)}$$

Where 'm' is the number of sensor nodes in a cluster. $'E_{da}'$ is the energy dissipated per bit due to data aggregation. Therefore, energy dissipation within a Cluster is given as

$$E_{Cluster} = E_{ch} + mE_{sn} \text{ --- (5)}$$

Therefore, the total Energy consumed is given as

$$E_{total} = E_{Cluster} \times n. \text{ ------------------------------------- (6)}$$

Where 'n' is the number of Clusters.

4. PROPOSED METHODOLOGY:

Deer are generally observed to be highly social and can be found to travel in groups which are known as herds.The herd in most cases isinevitably led by the dominant male, although in some cases these herds are segregated by sex.In some cases, it is found that males and females have separate herds or groups.Deer by nature are shy animals due to which an impression is created that there are only a few animals present eventhough the number may be more.They generally sense danger quickly and are always in alert mode and their response is also quick. Whenever they feel any inkling of threat they run in open fields or lie low to avoid the threats. Small separate male and female herds generally have three to five animals whereas combined herds generally have 8 to 10 animals.Female herds generally remain stable whereas male herds tend to change on regular basis.The strongest male at that time becomes the head of the herd.

Based on the above behavior of the deers, we propose an optimization technique for a wireless sensor network by making certain assumptions.We assume there are about 100 deers in an area and form about 20 groups each group consisting of 4 to 6 deers.Therefore initially about 100 nodes are randomly distributed in a fixed area of 300m×300m.Then clusters are formed with each about 4 to 6 nodes in each cluster.Every alternate cluster is assumed to be a female cluster. Numbering the clusters in such a way that all odd numbers of clusters shall be assumed as male clusters and every even number cluster shall be assumed as the female cluster. In the male clusters, the Rotation of cluster heads takes place in such a way that after every round of clustering the Clusterhead changes.That means if one node with the highest strength is the cluster head, and after one round of communication, the energy of that cluster head diminishes and then the node with the second highest energy becomes the cluster head.This process takes place continuously in all odd-numbered clusters.These clusters are considered analogous to male clusters. Similarly, in even-numbered clusters, the cluster head with the highest energy is the cluster head and when the energy of this cluster head reaches its threshold, the node with the second highest energy takes over.

In this way, the clusters work in two different ways.The base station is assumed to be at the center and the data collected by the nodes are sent to the cluster head of each cluster and then the data is transmitted to the base station.If the distance between the clusterhead of a particular cluster is more than a limit then an intermediate cluster head is selected and data is transmitted to the base station via this intermediate clusterhead.For this, the clusterhead that lies in the path of the source cluster head and the base station is generally selected as the intermediate cluster head.

The proposed technique willconsist of the following steps

All the 100 nodes are spread over a square area of the size of 300m×300m randomly. All the nodes are given random energies.

1) The base station is assumed to be at the center of the clusters.
2) Then around 20 clusters are formed with each cluster consisting of 4 to 6 nodes.
3) Each cluster is marked sequentially as 1 to 20.
4) The energies of all the nodes are computed.
5) In all the clusters let the nodes with the highest energy in each cluster be the Clusterhead.
6) The data is collected by the nodes and transmitted to the Clusterheads.The clusterheads transmit the data to the base station.
7) In case the distance between the cluster head and the base station is more than the threshold the clusterhead in between the source clusterhead and the base station is selected as an intermediate node for the transmission of data.
8) If there are more than two clusters in between, the clusterhead with higher energy shall be selected as the intermediate cluster head and data will be communicated to the base station through this clusterhead.

9) After the first communication is completed,the energies of the clusterheads come down and the energies maybe another node is more than the clusterheads.In all odd-numbered clusters the node with the second highest energies takes over as clusterheads analogous to male deers and the even-numbered clusters continue with the same clusterheads.
10) Again communications take place and after every round, the clusterhead changes in the odd-numberedclusters changes.
11) After a few rounds when the energy of the clusterhead of the even-numbered clusters gets exhausted that is it reaches its threshold, the node with the second highest energy takes over as clusterhead and the process continues.This is analogous to the female clusters.
12) In this way communication takes place and data is transmitted from source to destination for a longer amount of time.Two different energy conservation techniques used in the two clusters are a unique point in this type of communication.

5. RESULTS ANALYSIS:

Simulation of this scenario with the proposed technique is implemented in NS2. Two ray ground propagation models are considered. For traffic patterns, the constant bit rate (CBR) of the always-on type of pattern is considered. The threshold is 0.2 mJ for every node Number of alive nodes; energy consumption and network lifetime are recorded. For traffic patterns, the constant bit rate (CBR) of the always-on type of pattern is considered. The threshold is 0.2 mJ for every node.

Table1.Values of Simulation parameters

Sr. No.	Simulation Parameters	Values
1	Channel Type	Wireless
2	Simulation Area	300m ×300m
3	Number of nodes	100
4	Transmitting Power	2mw
5	Receiving Power	1mw
6	Packet Size	1000bits
7	Performance Parameters	Lifetime, energy consumption, and the number of alive nodes.

The figures below offer a graphical representation of performance comparisons of the proposed technique with the existing techniques in terms of various parameters.Fig.1 shows the comparison of the proposed technique with other comparable Bio-inspired techniques such as GA,PSO, and GWO techniques. It is observed that the proposed technique which runs for 595 rounds runs for the longest time when compared to the other existing techniques. Fig.2 shows the comparison of the proposed technique with some of the existing techniques in terms of the number of live nodes. Analysis shows that the nodes of all the compared techniques die earlier as compared to the proposed technique, which indicates that the proposed technique is better in terms of efficiency.Fig. 3 gives the energy consumption observations for the various techniques. Observation of the graph indicates that the proposed method consumes lesser energy as compared to the other techniques resulting in the proposed technique having a greater life span as compared to the other comparable techniques.

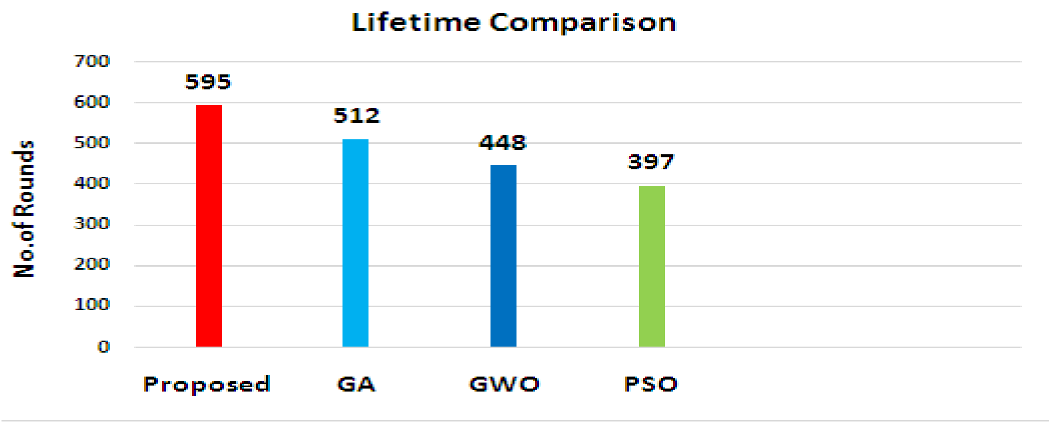

Fig.1:

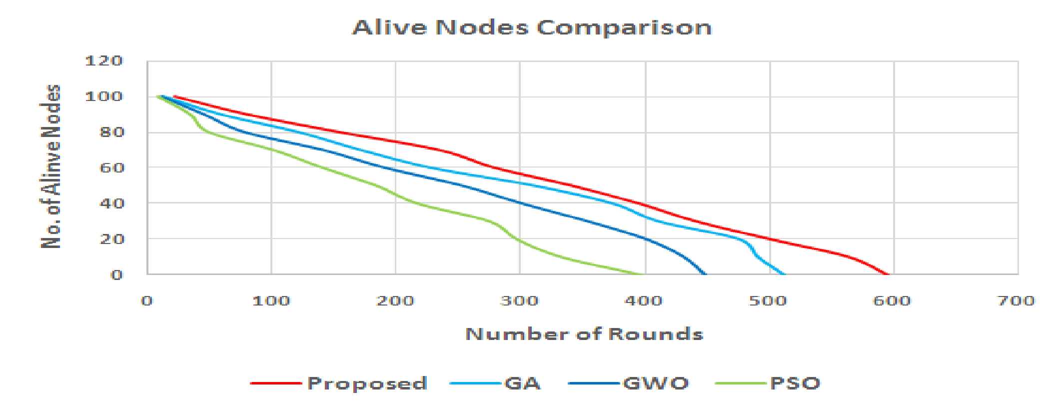

Fig.2:

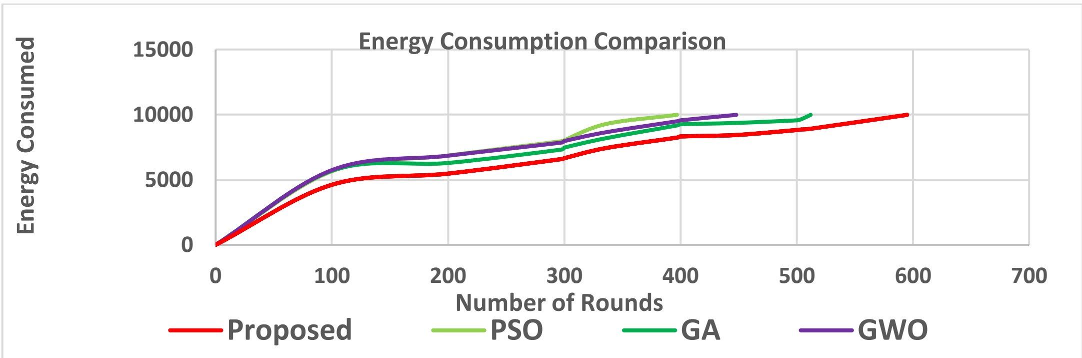

Fig.3:

6. Conclusions:

This paper has proposed a clustering and routing technique that is based on the herd behavior of deer.Here the clusters have been divided into two groups analogous to male and female groups in the deer herd in one group the Cluster head changes after every round analogous to the male deer group and in another cluster analogous to the female group the Cluster head continues until its energy is not drained.The data is aggregated by the Cluster heads and is transmitted to the base station directly or if the distance is more than through an intermediate relay node. In comparison with the existing techniques, it is seen that the proposed techniques give a higher lifetime, and also energy consumed by the above technique is lesser as compared to the existing techniques.Also, the number of nodes is alive for a longer amount of time in the proposed technique as compared to the other comparable techniques such as PSO, GA, and GWO. Therefore it can be concluded that the proposed technique is more efficient than some of the existing comparable techniques.

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