Elephant-Based Crow Optimization For Enabling The Energy Aware Multihop Routing In Clustered Wireless Sensor Networks

Mahesh N, Vijayachitra S

Abstract : The multi-hop routing in WSNs are important in the improvement of the robustness and network lifetime by neglecting the unwanted nodes that connects the communication between the source and the sink node. The multi-hop routing protocols always intensify the energy-aware routing in the WSN to satisfy the concept energy in WSNs. In addition, the selection of the node optimally is very important to satisfy the concept of minimum node energy conservation and maximum throughput. In order to satisfy the above requirements, this chapter uses an algorithm for cluster head selection called Dolphin Echolocation-based Crow Search Algorithm (DECSA) that is the integration of Dolphin Echolocation (DE) and Crow Search Algorithm (CSA). The proposed Elephant Crow Search Algorithm (ECSA) is used to optimally select the hops with the capability of satisfying the multi-objective constraints, namely delay, energy, intra-cluster distance, mobility, inter-cluster distance, trust, and link lifetime. The proposed Elephant-based Crow optimization (ECSA) algorithm is obtained from the integration of the Elephant Herd Optimization (EHO) and the Crow Search Algorithm (CSA). The results shows significant improvement in performance parameters when compared to that of conventional algorithms.

Index Terms: Sensor Networks, evolution algorithms, Multihop routing, LEACH, inter-cluster distance, fitness estimation, normalized energy

1. INTRODUCTION

Wireless Sensor Networks (WSNs) comprises number of nodes that transfers the data to the sink nodes through the cluster heads (CHs). Each node acts as a sensor and the data is transferred using a particular cluster termed as CH. The data is transferred to the sink node only when the sink node is present within the transmission range, but in case if the sink is present in a long distance from the source, then the routing process takes place with the neighboring nodes or clusters that are directly connected to the sink or with the selection of any one of the cluster (CH) to transmit the data. This process is carried out until the data is received by the sink node.

- The multi-hop LEACH combined the concept of multi-hop communication and clustering adaptively, and thus the CHs that are present around the sink node experiences increased relay traffic and affect the network lifetime as the node die soon. In addition, there exist some solutions to reduce the rate of consumption of energy in the network, but these max-min lifetime routing protocols do not save energy in entire network scale basis [1].
- The link that is present among the neighbour node and the forwarding node may be asymmetrical in the maximum distance greedy forwarding strategy due to radio irregularity. Thus, no Acknowledgment is forwarded to the forwarding node from the neighbour node even if there is need for the retransmission of the node. The forwarding node has no way to know about the node that reached the destination, and the retransmission is carried out and the asymmetrical links wastes the energy. This leads to the reduction in PDR and the increase in end-to-end delay when the links present are unreliable [2].
- The Geographical adaptive fidelity (GAF) identifies the equivalence among the sensors with the use of the geographic location information as it is an energy-aware topology management multihop location-based routing protocol. This protocol keeps only the required sensors in the active state and all the other sensors in the sleep state to increase the network lifetime with the maintenance of the network fidelity. However, this protocol cannot be used in the achievement of the optimum usage of the resources that are available due to the absence of load balancing between the sensor nodes in the routing of data [3].
- The projection nodes are selected in random in case of the compressive data gathering method with the random projection. As the nodes are selected in random manner, the selected projection does not produce any advantage. The projection node distribution is not ideal as the node is present away from the sink node and the remaining energy of the node is depleted very quickly [4].
- Cluster head selection protocol by improving the leach protocol for WSNs make use of the fuzzy logic with the energy of node, and the network density for the selection of cluster head. In this method, the fuzzy logic selects the optimal cluster head with respect to the cost of communication and the energy of node. However, as the cluster head selection algorithm runs at the Master Station (MS), each of the node need to send its current location and the level of energy to the MS in each of the round, which is not possible in the real world sensor network due to the lack of energy in the node [5].

2 PROPOSED MULTIHOP ROUTING USING ELEPHANT CROW SEARCH ALGORITHM

WSN environment consists of a number of nodes from which a single node is selected to perform the action of data transfer to

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the destination. The selected node is termed as the cluster head and is optimally selected using an algorithm called DECSA that is obtained with the integration of the DE [7] algorithm and the CSA [6]. The block diagram of the proposed multi hop routing using ECSA is shown Fig.1.

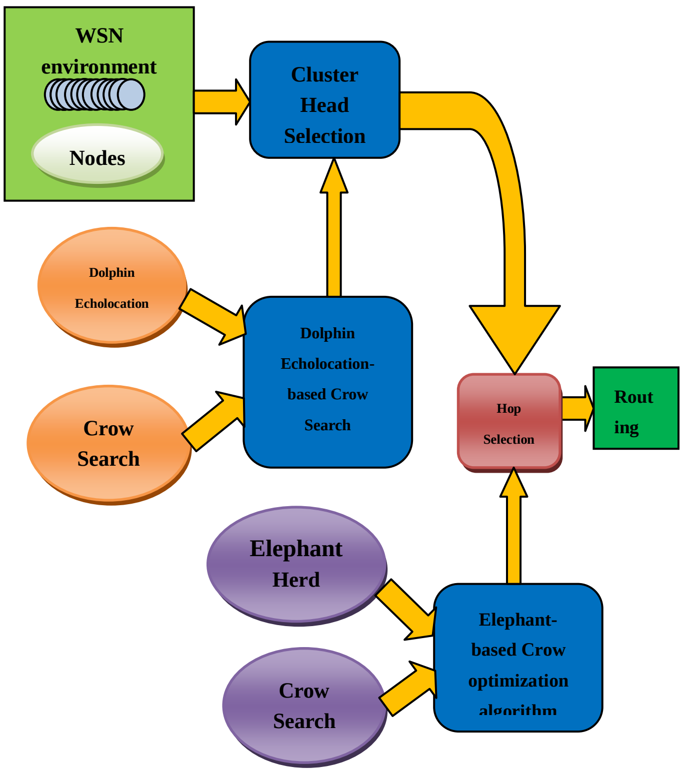

Fig.1. *Block diagram of proposed Multi hop routing using ECSA*

The selection of hop from the cluster head is termed as the multihop routing, which is performed with the proposed ECSA algorithm that is obtained from the integration of EHO [8] and CSA algorithms. Figure1 depicts the block diagram of the proposed multi hop routing using ECSA.

2.1 Multi-Objective fitness estimation

The fitness is estimated in terms of energy, intra-cluster distance, mobility, link lifetime, inter-cluster distance, and the delay of the nodes. The fitness factor related to the energy parameter is based on the addition of the energies from each of the nodes that are present in the cluster and the addition of the energies of the cluster heads. The measure of fitness depends on the inter-cluster distance. The value of inter-cluster distance is always less and is termed as the measure of distance between the nodes and the CHs. The measure of fitness based on the intra-cluster distance is obtained from the distance between the clusters, and the value of intra-cluster distance must be maximum. The fitness based on mobility is the obtained from a particular cluster in its current and previous iterations, and the link-lifetime based fitness is the calculated from the direction, location, and the mobility of the nodes. The mobility of the node depends on the direction of the node motion and in general, the link-lifetime must always be maximal. The measure of fitness depending on delay is obtained from the count of nodes that are present in a particular CH.

2.2 Cluster head Selection with the DECSA algorithm

All The optimal CH is obtained using the fitness evaluated to provide efficient communication of data with the use of the hybrid optimization algorithm. The DECSA acts as the hybrid optimization algorithm that is obtained with the integration of the DE algorithm and CSA and it implements the advantages of both of the algorithms. In general, the DE algorithm works on the basis of echolocation of the dolphin that provides improved convergence to global optimum solution and are computationally efficient. The DE algorithm is capable for multiple constraints, but suffers from the problem of dimensionality. The CSA is integrated with the DE algorithm to provide improved diversity and memory capacity. The optimal CH is selected using the hybrid optimization algorithm and the communication is carried out in the energy-aware network.

2.3 Algorithmic steps of proposed ECSA algorithm

The main aim of the proposed ECSA algorithm is to select the optimal hops to perform the multi-hop routing in WSN in an effective way. Crows acts as the most brilliant birds and the brain size of the crow is little less than that of human brain and the proof to prove the ability of the crows are unlimited. The crows contain self awareness and tool-making capability and are capable of remembering the faces and warn other crows if any unfavourable incident arises. The crows use the tools and communicate with each other in a matured way and can recall the location of their hiding food even after several months [9]. Crows watch other birds to know the hiding place of their food, and then steals the food if the other bird is not present in its place. If a crow steals the foods of the other birds, it moves to a hiding place to avoid being caught by the other birds. The crows make in use of their own experience to find the safest place after stealing the food in order to safeguard the food [10]. On considering a crow flock, most of the behaviour of the crow matches with the optimization process. Based on this behaviour, the crows search for a hiding place to hide the excess food, and then makes use of it whenever necessary. The crows behave selfish as they follow each other in order to know about the better source of food. It is a difficult task for a crow to find the hidden food source of another crow, if some other crow follows it. If it happens, then the crow fools the other crow by moving its position to other location. In terms of optimization, the crows acts as the searchers, the environment acts as the search space, and each of the position of the environment corresponds to a feasible solution. The food source quality is considered as the objective function and the best source of food that is present in the environment is the global solution of the problem. Depending on the similar factors, the CSA tries to use the brilliant behaviour of the crows to obtain the best solution to the problem. The standard equation of the CSA is given as,

$$C^{s+1}_{m,n} = C^{s}_{m,n} + p_m \times F^{s}_{m,n} \times \left(d^{s}_{v} - C^{s}_{m,n}\right) \tag{1}$$

where, $C^{s+1}_{m,n}$ is the position of the m^{th} crow in n^{th} dimension at $(s+1)^{th}$ iteration, $C^{s}_{m,n}$ is the position of the m^{th} crow in n^{th} dimension at s^{th} iteration, p_m is the random number between '0' and '1', d^{s}_{v} is the memory of v^{th} crow in

s^{th} dimension, and $F^{s}_{m,n}$ is the flight length of m^{th} crow at s^{th} iteration. The Pseudocode of the proposed ECSA algorithm is depicted below

Proposed ECSA algorithm for multi-hop routing	
1	Input: Solution vector $\rightarrow C^{m,n}_{s+1}$
2	Output: Best solution $\rightarrow C_{m,n}$
3	Start
4	Parameter initialization
5	r : Maximum crows $\rightarrow$ total crows
6	decision variables $\rightarrow n$
7	size of flock $\rightarrow R_s$
8	flight length $\rightarrow F_{m,n}$
9	Awareness probability $\rightarrow P_A$
10	maximum number of iterations $\rightarrow I_{\max}$
11	$rand \rightarrow$ random number
12	Estimate the position of each of the crows
13	Initialize the memory of each of the crow in the flock R
14	For $m = 1 : r$
15	Choose crow m to follow crow l in random
16	If
17	$rand$ of v^{th} crow $\geq P_A$
18	Calculate the position of crow using equation (1)
19	Else
20	Calculate a random position
21	End if
22	End for
23	Perform feasibility check
24	Estimate new position of crow
25	Update crow memory

3 I… GORITHM

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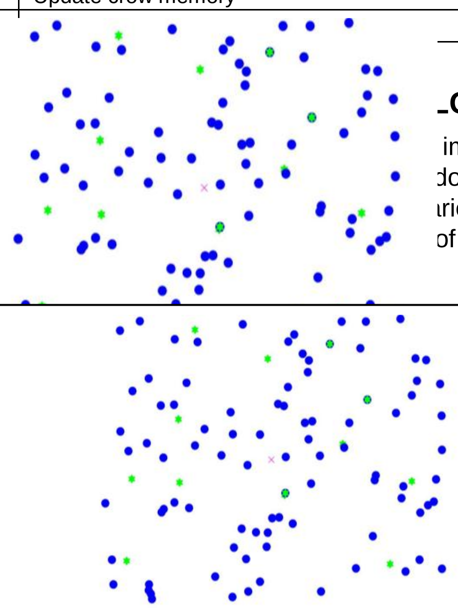

Fig 2 Sample results of the experiment using proposed algorithm

The simulation was carried out with 500, 1000, 1500 and 2000 rounds.

4 COMPARATIVE ANALYSIS

Figure 3 shows the comparative analysis using 50 nodes, based on alive nodes. Initially, the count of alive nodes is 50, for all the methods and as the round increases, the count of alive nodes increases and at round 2000, the count of alive nodes is 6, 5, 5, 9, and 11, for the methods, ABC, PSO, GA, DEMFO, and proposed ECSA algorithm, respectively.

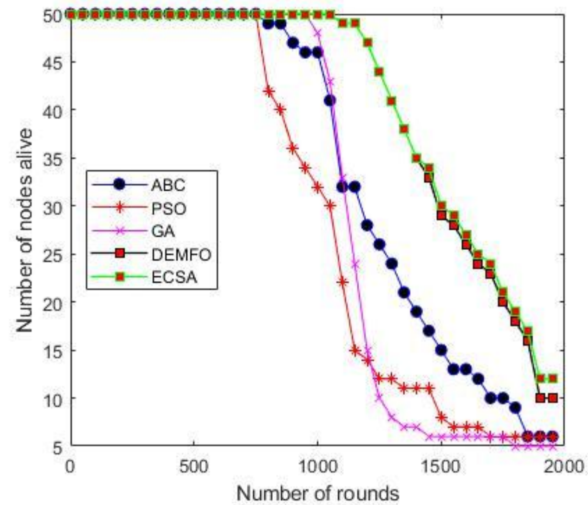

***Fig 3 Comparative** analysis based on the alive nodes*

Figure 4 shows the comparative analysis using 50 nodes based on normalized energy. Initially, the normalized energy is maximum, and the normalized energy decreases with the increasing number of rounds. The normalized energy for the methods, ABC, PSO, GA, DEMFO, and the proposed ECSA is 0.0287, 0.0407, 0.0366, 0.0469, and 0.0574, respectively, at round 2000.

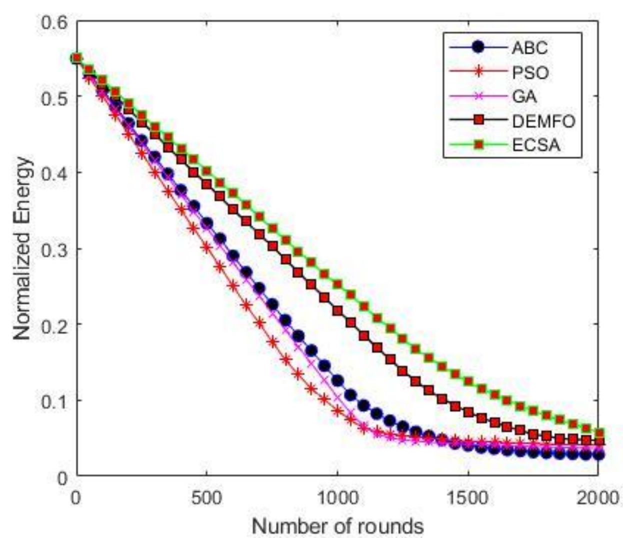

***Fig 4** Comparative analysis depending on normalized energy*

Figure 5 shows the comparative description using 50 nodes based on throughput.

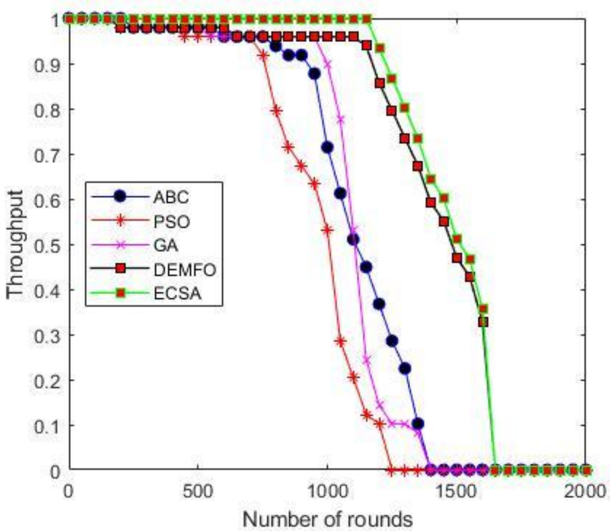

Fig 5 *Comparative analysis depending on Throughput*

Initially, the throughput is maximum at 1 and as the round increases; the throughput decreases and reaches 0 at 2000th round.

5 CONCLUSION

In this paper, the multihop routing is carried out in the WSN environment comprising of a large number of nodes. A single node is selected from the nodes present in the WSN network to transfer the information to the destination. The selected node is known as the cluster head and is selected optimally with the use of the DECSA algorithm that is obtained with the integration of the DE algorithm and the CSA. The selection of hop from the cluster head is known as the multihop routing that is carried out using the proposed ECSA algorithm, which is obtained with the integration of EHO and the CSA. From the comparative analysis it is clear that the count of alive nodes remains in the network is high for the proposed method. At the same time, the normalized energy of the alive nodes and the throughput is maximum for the maximal number of rounds, for the proposed method as compared to the other methods. The number of alive nodes is 31, the normalized energy is 0.0689, and the average throughput is 0.7539 for the proposed method and thus, proved the effective performance of the proposed method.

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