Artificial hummingbird algorithm for cluster head selection in WSNs

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Abstract-Wireless sensor network is composed of hundreds to thousands of nodes called sensors. WSNs are successfully applied to real world problems ranging from defence to civil applications. In this paper, we compared various WSN techniques namely LEACH, ABC and PSO with proposed algorithm called Artificial hummingbird algorithm (AHA). Results show that AHA performed better than all other algorithms in terms of energy efficiency, alive nodes and Cluster head (CH) count.

Index Terms- Artificial hummingbird Algorithm (AHA), Cluster Head (CH), Base station (BS)

I. INTRODUCTION

Wireless sensors have microsensors embedded in them. WSNs is integrated into Internet of Things (IOT) through sensors via Internet [1]. Currently, a lot of research is being going on in Underwater WSNs. The standard used for WiFi is IEEE 802.11 and for Bluetooth is 802.15.1 [2]. Different areas of WSNs include routing, clustering, Security, and topology control. The architecture of WSNs constitute sensors along with routing nodes [3].

The important components of WSNs are [4] Sensors, network protocol and Application,. Sensors are devices that take input from the environment. Sensor usually contains five key components, these include sensing hardware, memory, battery, embedded process and trans-receiver. Network Protocol is the Path that is established between sensors. The sensors report to Base Station [BS] via Cluster Heads [CH]. The Application/Observer consists of queries from observer.

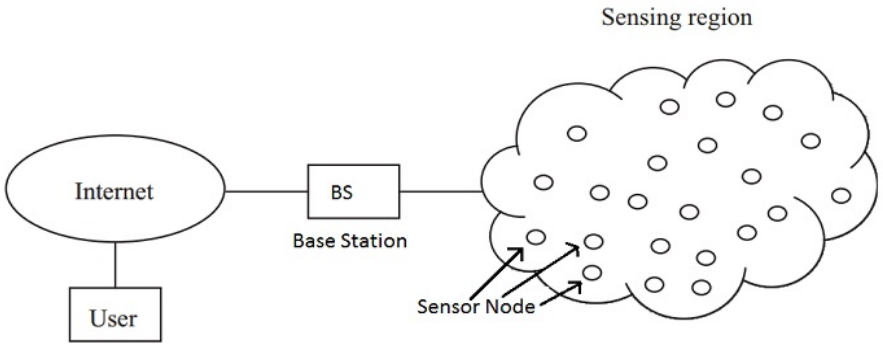

Fig. 1: Architecture of WSNs

WSNs has diverse range of applications. The applications are numerous with majority finds in environment, military, health, home applications etcetera [5]. WSNs plays a key and central role in IOT [5]. In

Environmental applications, WSNs are used in forest fire detection, flood detection and automated agriculture. In military applications WSNs helps to monitor equipment and enemy forces. Also, it helps in Nuclear, biological and chemical attack detection. In Health applications WSNs helps in monitoring of physiological attributes and in disease prevention.

Clustering and Routing are the two main aspects of WSNs. Clustering is done on the basis of control, cluster formation strategy and cluster structure. On basis of control clustering can be classified into Centralized Clustering and distributed clustering. In Centralized Clustering the BS elects CHs. Example of this type of clustering is LEACH-C while in distributed Clustering the nodes decides among themselves that who will be CH. Example of this type of clustering is hybrid energy efficient protocol (HEED). On basis of cluster formation strategy, clustering can be single- hop clustering or multi-hop clustering. In single-hop there is direct communication between nodes and BS. For instance, in LEACH there is direct communication. In multi-hop there can be two or three way communication between the nodes and BS. On basis of cluster structure, clustering is classified into flat and hierarchical clustering. In flat clustering, all cluster have similar size and hierarchy whereas in hierarchical clustering, the Clusters are organized into levels. Example of this type of clustering is Hybrid- Threshold sensitive Energy Efficient sensor Network protocol (H-TEEN).

There are various soft computing techniques used in WSNs. Artificial Bee Colony(ABC) uses roulette wheel method to choose better solutions. ACO successfully solves vehicular routing problem [7]. Other soft computing techniques are Ant Colony Optimization (ACO), particle swarm optimization(PSO), Artificial hummingbird Algorithm (AHA) etcetera.

II. LITERATURE REVIEW

In paper [8], author proposed low-energy adaptive clustering hierarchy (LEACH) protocol which contains clusters. Within a cluster there is a cluster head and rest of nodes act as cluster members. LEACH is an energy-efficient approach because the Cluster head (CH) which consumes most of the energy is not fixed. However, CH are chosen randomly. If CH were fixed then as soon as CH loses its energy, then communication between nodes and CH wouldn't takes place. In LEACH-Centralized (LEACH-C), CH are chosen in such a way that load of becoming CH is evenly distributed among nodes. For this to happen, the number of times all nodes become CH is equal to N/K, where N is number of nodes and K is CH. LEACH-C is location aware protocol. It is centralized because base station tells which nodes should become CH.

Table 1: Solution offered by WSNs to key challenges.

Challenges	Solution
WSNs have limited energy [6].	Energy efficient algorithms are used so that no node become energy deficient.
Deployment of sensors in harsh and uneven terrain.	WSNs are scalable(extended to hundreds or thousands of sensors) and fault tolerant.
WSNs have limited lifetime.[8]	WSNs are designed in such a way that the network lifetime is prolonged. Threshold sensitive Energy Efficient sensor Network protocol (TEEN) prolongs Network Lifetime.

Artificial Bee Colony (ABC) [9] is distributed technique except for the base station (BS) which uses centralized clustering algorithm. A new bio-inspired optimizer called AHA is proposed in paper 10 and Zhao et al. applied it in 10 engineering applications. TEEN [11] is an energy efficient hierarchical cluster network. The hierarchy is formed in such a way that base station forms the root node, upper most CHs (CH 1,2,….) reports to BS and second level CH (CH 1.1,2.1,….) communicates with upper most CH (CH 1,2,….) and so on. PEGASIS [12] is based on chain method in which nodes receive and transmit data to each other nodes using greedy approach in such a way that only one node transmits data to sink node.

III. PROBLEM DEFINITION

WSNs have limited lifetime due to draining of batteries of nodes. A lot of techniques are propose to overcome the problem of limited lifetime of WSNs. One such technique is AHA. In this paper we propose AHA in WSNs. Also, TEEN has limitation that it can't be implemented for real-time applications [3]. However, AHA has been applied successfully in real-world problems.

IV. METHODOLOGY

In the proposed technique we .consider 50 nodes that are arranged in a 100 square meter area. The communication with nodes takes place via. Radio model. In this model, if the distance is less than the threshold defined then we use free space other we use multipath. For clustering to take place we use AHA to choose CH. It is necessary to design an algorithm for choosing CH because most of the energy is dissipated in sending packets from CH to BS.

The steps involved in AHA are initialization, guided foraging, territorial foraging and migratory foraging.

Initialization: Hummingbirds are randomly initialized using the below equation:

$$X_i = \text{Low} + r.\ (\text{Up-Low}) \quad (1)$$

Here X_i indicated i^{th} food source, r is a random variable between 0 and 1. Low and Up are lower and upper boundries of the given dimensions.

Guided foraging: In the guided forage, hummingbirds forage in the local search space using the below equation:

$$v_i(t+1) = x_i(t) + D \cdot \left(x_{\text{bs}}(t) - x_i(t)\right) \cdot a \quad (2)$$

Where $(\boldsymbol{v_i}(t+1))$ is Candidate position for the next iteration. $\boldsymbol{x_i}(t)$ *is* Current position of hummingbird (i) at time (t), $(\boldsymbol{x}_{\text{bs}}(t))$ is Position of the best food source (solution) in the population. (D) *is* Binary vector (each element is 0 or 1 with 50% probability). Controls dimension-specific updates and $(a \sim \mathcal{N}(0,1))$ *is*Random number from a standard normal distribution.

Territorial foraging: In the territorial forage, hummingbirds search in the nearby search area using the equation:

$$v_i(t+1) = x_i(t) + c \cdot d \quad (3)$$

Where - $(c \sim \mathcal{N}(0,1))$: Random number from a standard normal distribution and d is a random vector where each component $d_j \sim$ U lies between -1 and 1.

Migration foraging: In the migration forage, hummingbird migrate to far off area using the equation:

$$\boldsymbol{x_{worst}}(t+1) = \boldsymbol{lb} + \boldsymbol{r} \cdot (\boldsymbol{ub} - \boldsymbol{lb}) \quad (4)$$

where X_{worst}(t+1): Position of the hummingbird with the lowest fitness. Lb isVector of lower bounds for each dimension. Ub is Vector of upper bounds for each dimension. R is Random vector where each component $r_j \sim$U(0,1)

When hummingbirds forage, they use three moves which include axial, diagonal and omnidirectional movement. Hummingbirds has excellent memory power. AHA uses visit table that has value 0 if jth food source is visited be ith Hummingbird and value null if hummingbid visits the same food source at the same position [9].

V. REULTS

We compared Alive nodes, energy efficiency and Cluster head count for PSO-EEC, ABC, LEACH with Artificial Hummingbird Algorithm (AHA). Alive nodes for 50 nodes were 50 for all algorithms except for PSO, for which alive nodes started to deplete at 650th round and fall to 6 alive nodes from 850th round onwards.

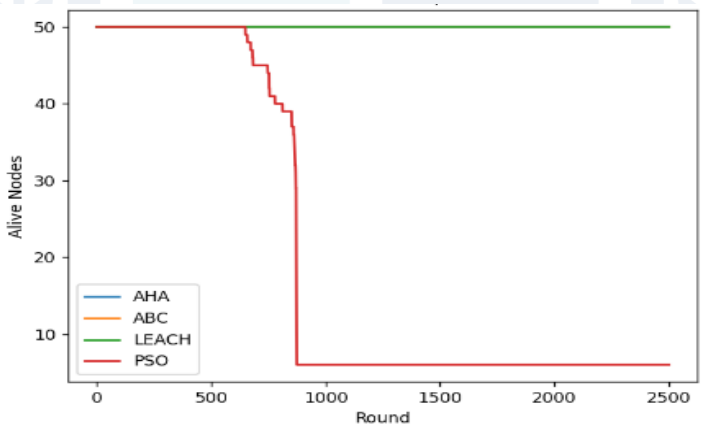

Fig. 2: Alive Node comparison for 50 Nodes

As shown in figure 3, the energy efficiency for AHA was highest (2 Joule) at the beginning. It showed linear degradation throughout the curve and fall to 1.65 at the end of 2500th round. Similar curve was seen for energy efficiency in case of LEACH.

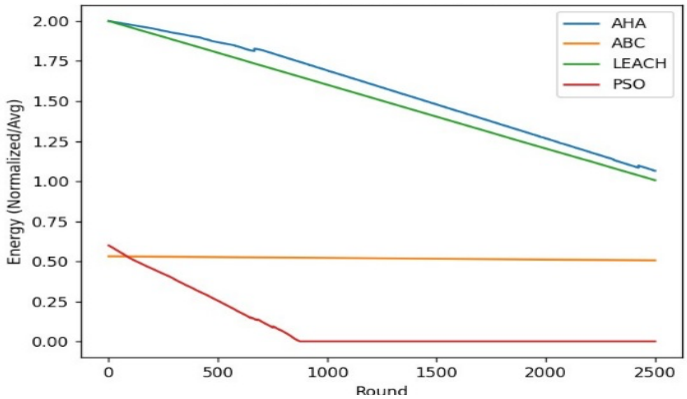

Fig. 3: Energy efficiency comparison of 50 Nodes

While the cluster head count of PSO-EEC was highest (7) till 874th round, following which it decreased to 0 CH. Overall, the cluster head count of AHA remained high at 6 throughout all the rounds as shown in figure 4

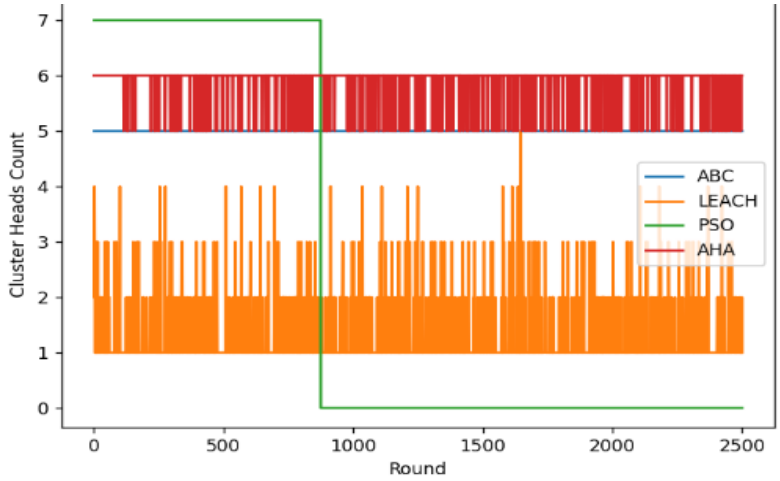

Fig. 4: Cluster head comparison for 50 Nodes

VI. CONCLUSION AND FUTURE SCOPE

In this study we proposed Artificial hummingbird algorithm which outperformed all other existing algorithms namely: ABC, LEACH and PSO. AHA is a bio- inspired algorithm which mimics the foraging behaviour of hummingbirds. AHA has highest Cluster head count , energy and alive nodes for 50 nodes. In future this algorithm can be extended to higher number of nodes.

VII. REFERENCES

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