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A New Unequal Clustering Method for Energy Efficient Computation in WSN Using Cuckoo Search Based Particle Swarm Optimization (CBPSO)

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Abstract- There have been recent advances in micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics. These advances have enabled the development to low-cost, low-power, multi-functional sensor nodes that are small in size and communicate with each other using radio frequencies.

They have limited processing capabilities, transmission range, and most importantly available energy. For load balancing and efficient data collection in the network, clustering is used. Sensors in each cluster send the data to their corresponding cluster heads. The cluster head performs data aggregation and transmission of the aggregated data to the base station. This paper proposes a methodology to achieve load balancing & cluster head selection using cuckoo search algorithm and cluster formation is done using particle swarm optimization algorithm in anticipation of minimizing energy consumption and network lifetime.

Keywords—Wireless Sensor Network, Unequale Clustering, Cuckoo Search, Particle Swarm Optimization

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I. INTRODUCTION

WSN have many applications, ranging from military applications like battle field surveillance to measuring environmental quantities like sound, pressure, vibrations and temperatures [1]. Because of their size, sensors are usually constrained in terms of the resources available to them [2][3].

Several review articles, survey articles, and techniques are proposed for the past one decade on the energy conservation of WSNs.
This paper proposes a new optimization-based cluster formation and cluster head scheme incorporating Cuckoo Search (CS)[8] and Particle Swarm Optimization Algorithm (PMO)[14]. The formulated technique of combining the above algorithms is stated as Cuckoo Based Particle Swarm Optimization Algorithm (CBPSO).

The proposed technique shows higher performance in optimum range of clusters, total energy consumption and prolonging of network lifespan. The detailed review of related work is explained is Section III. The problem formulation and Energy Model is explained in Section IV. Cuckoo Based Particle swarm optimization (CBPSO), chain formation, proposed methodology is explained in Section V. Results and analysis are described in Section VI. Lastly conclusion is drawn in Section VII.

II. RELATED WORK

Low Energy Adaptive Clustering Hierarchy (LEACH) is a distributed single-hop clustering algorithm proposed for energy consumption problem in Wireless Sensor Networks. The cluster head's role is occasionally switched among the sensor nodes to balance energy utilization [5]. But cluster head rotation requires that, all the nodes be capable of performing data aggregation, cluster management and routing decisions. This results in extra hardware complexity in all the nodes. Hybrid Energy Efficient Distributed clustering (HEED) is one of the effective data-gathering protocols for Sensor Networks [4]. Both LEACH and HEED are applicable for mobile and static data collection. In PEGASIS clustering algorithm, sensor nodes form a chain from the node to the base station [7]. Each node collects data from one of its neighbor sensor nodes, fuses data with its own, and communicates them to the other neighbor node on the chain until all of data to be forwarded to the base station.

The aspect of formulating these techniques is incorporation of constraints that helps in energy efficient cluster formation, by eliminating residual nodes and minimization of energy consumption.

PSO-C [15] is a brought together energy efficient clustering convention that utilizations PSO calculation at the BS for forming the clusters. It considers both vitality accessible to nodes and physical separations between the nodes and their CHs. This convention characterizes a cost work which attempts to limit both the maximum average Euclidean distance of nodes to their related CHs and the proportion of aggregate energies of all nodes to the aggregate energy of the CH competitors. In addition, it guarantees that lone nodes with adequate energy are chosen as CHs. PSO-C performed better than both LEACH and LEACH-C in terms of network lifetime and throughput.

The Cuckoo search algorithm has been previously used to resolve the problems such as data aggregation and node locating in WSNs [8,10]. The parameters such as residual energy of sensor nodes, distance of the sensor nodes from each other, the energy of the path length and etc., are used for clustering in WSNs. In one clustering approach based on Cuckoo behavior has been introduced towhich we refer as "Cuckoo" algorithm in this paper [9].

III. Energy Consumption Model and Network model for Wireless Communication

A. System Model 'N' sensor nodes are randomly deployed which is the primary network model used in our proposed work. The assumptions made to design the network model are

- After deployment of all the sensors in the sensing field, the BS and the sensor nodes are kept stationary. Sensors are assumed to have different amount of energy. (heterogenous wireless sensor network)
- Sensors are placed randomly within the network.
- The sensor nodes are energy limited and the sensor nodes are not attended after they are placed. Hence it is impractical to recharge the batteries.
- The received signal strength between the nodes decides the distances between them.
- In the proposed CBPSO, the BS is placed anywhere inside WSN.
- The BS once in a while sends a request message in terms of the packet to the cluster head for getting sampling data from sensors.
- Links are symmetric.

The radio model adopted is, stated by Heinzelman et al [5]. A network operation model similar to that of LEACH and HEED [10] is acquired here.

$$E_{Tx}\begin{cases} l.E_{\text{electrical}} + \varepsilon_{fs} \cdot d^2 & \text{for} \quad 0 \le d \le d_{\text{crossover}} \\ l.E_{\text{electrical}} + \varepsilon_{mp} \cdot d^4 & \text{for} \quad d \ge d_{\text{crossover}} \end{cases}$$

IV. Proposed work

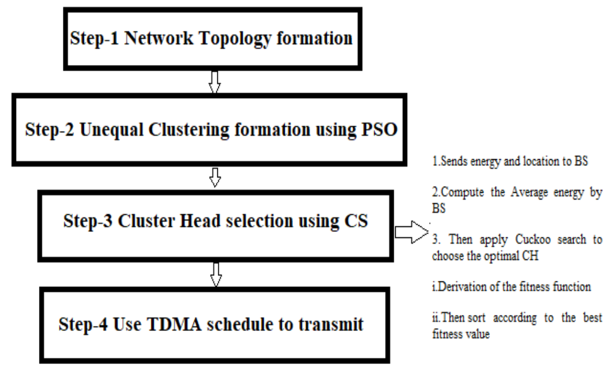

Figure 1. Proposed work flow chart

The proposed methodology is composed of three phases:
1) The Cluster Formation Phase
2) The Clusters Head Selection Phase
3) The Transmission of information phase

1) Cluster Formation Phase-PSO is referred as a procedure technique that optimizes a difficulty by employing a series of iterations trying to reinforce a candidate resolution relating to given quality live or application. PSO typically optimizes a difficulty supported candidate population within the search-space in conformity with the mathematical formulae over rate and position of the particle. In each iteration, *velocity* of each particle is updated using the *current velocity* of the particle and the *previous local_best* and *global_best position*. Based on it, *new_velocity*, *new_position* of the particle can be estimated [13] [14]. The same procedure is perennial for every iteration. PSO encompasses swarm of particles. In general, every and each particle occupies position within the search space. The position 's quality is mostly being incontestable by the fitness of every particle that revolves within the search space with a particular velocity.

$$\boldsymbol{fitness = \alpha 1x1 + \alpha 2x2 + \alpha 3x3}$$

where, α_1 and α_2- constant value between 0 and 1
& $\alpha 3 = 1 - \alpha 1 - \alpha 2$

$$x_1 = \sum_{1}^{m} \frac{dN - dP}{Cn}$$

where,
$d_N - d_P$ - distance between the particle '*p*' and the Nth node
N - *{1,2,3…m}*, m is the highest number of nodes available to the cluster particle
C_n - number of cluster nodes nearby from the particle *p*

$$x_2 = \frac{Eavg(Cn)}{E(p)}$$

$$x_3 = \frac{1}{Cn}$$

where,
n - number of nodes nearby to a particular particle.

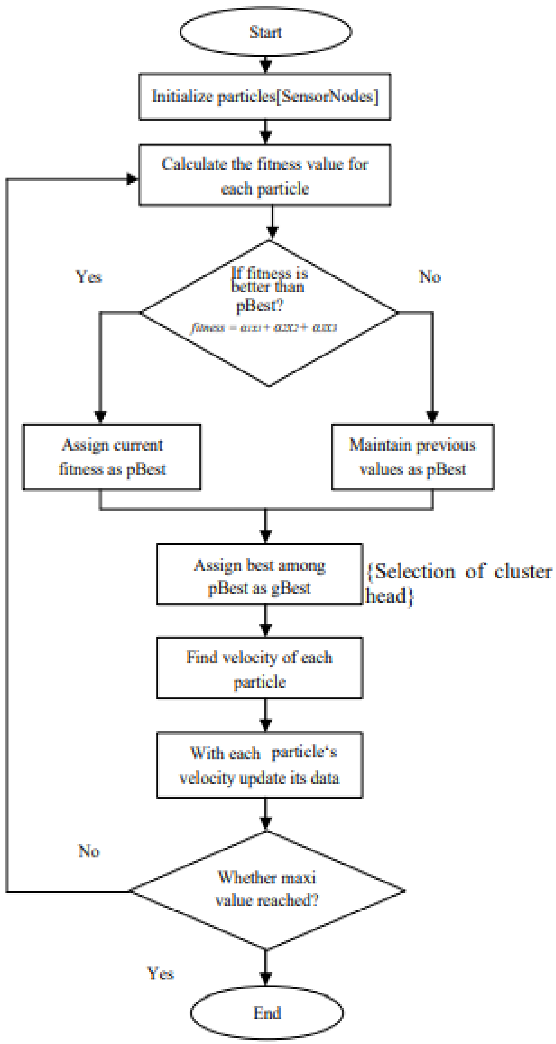

Figure 2. Flowchart of PSO in CBPSO

2) Clusters Head Selection Phase - In this paper, the best cluster heads are chosen among the test CHs based on the suggested fitness function. After the cluster formation phase some of the cluster heads are formed. These cluster heads broadcast a control packet to attract ordinary sensor node in the network. The packet includes the remaining energy of the cluster head. The ordinary sensor nodes in the network treat CHs as the nest and tries to select the best CH for laying egg.

The ordinary sensor nodes select the best cluster heads based on the proposed fitness function by:

$$F = ((Energy_{CH} + Energy_{Node}) \; / \; (distance_{CH,Node}))$$

Where $Energy_{CH}$ represents the sum of remaining energy of CH, $Energy_{node}$ is the residual(remaining) energy of the source node (the ordinary sensor node) and $distance_{CH,node}$ is the distance between the ordinary sensor node and the cluster head. The candidate node relates the F value of its cluster head (F(nown_ID)) with the F value of other cluster heads(F(n)). The node with highest F value is selected as the best cluster head. Each ordinary node forwards its packets to the selected best cluster head. Each ordinary node communicates the packet if:

a) The maximum F value of the other cluster head(F(n)) to be more than the F value of its cluster head (F (nown_ID)).

b) The distance between the ordinary node to CH is lower than 25 meters (dist.<=25) and ASR>0. The intuition is to prevent transmission of packets of source nodes too outlying far cluster heads. The distance of the source node to cluster head is considered to be less than 25 meters. This amount is the minimum of the radio range. Since the control packet is moved from the source node to the destination node, ASR is considered to be positive.

3) Transmission of information phase- Lastly the transmission of information is done after the formation of clusters phase and the selection of the best cluster heads. In this phase, the cluster head aggregates the data according to TDMA scheduling and forwards the aggregated data to the Base Station directly.

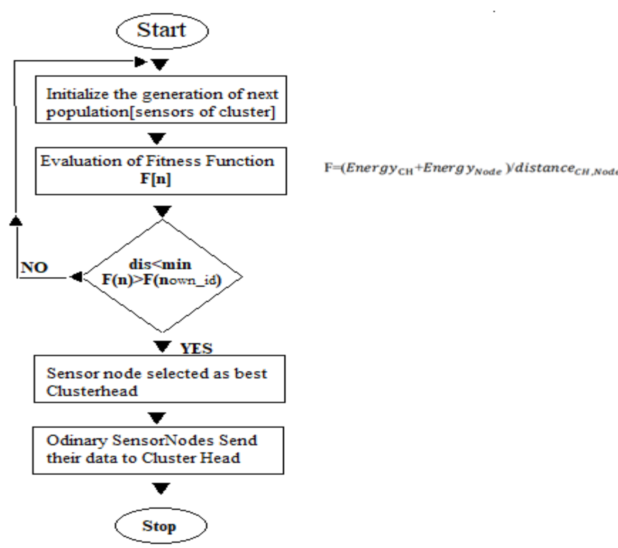

Figure 3. Flowchart of Cuckoo search algorithm in CBPSO

V. Results and Analysis

In this section the performance of the proposed technique is evaluated via simulation results. The network model is simulated using MATLAB. The results are summarized after running several iterations. The focus in this paper, as by the objective function, is the minimization of energy and the maximization of the network lifetime. As we can observe from figure 4 and figure 5 how proposed work have outperformed in comparison to the traditional algorithms with respect to network lifetime and throughput [5] [10] [12].

In figure 7 the proposed work's energy consumption is comparatively low then LEACH and other algorithms, and in terms of number of sensor nodes alive in network are higher than LEACH, which was main moto of this paper. Simulation results exhibit that our proposed algorithms have better performance than two another algorithm in terms of the proper distribution of energy consumption, the number of receiving packets to the BS and number of alive nodes.

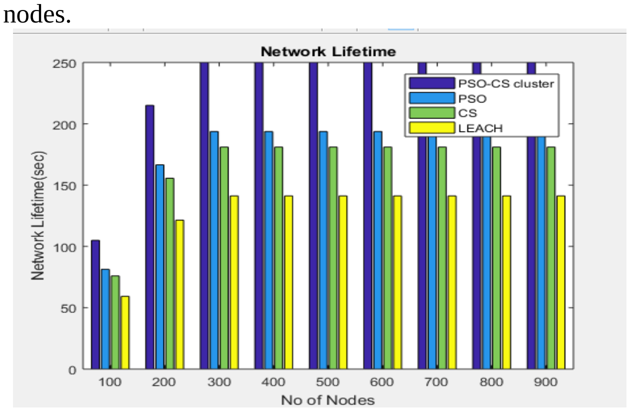

Figure 4. comparison of network lifetime of WSN in different methods

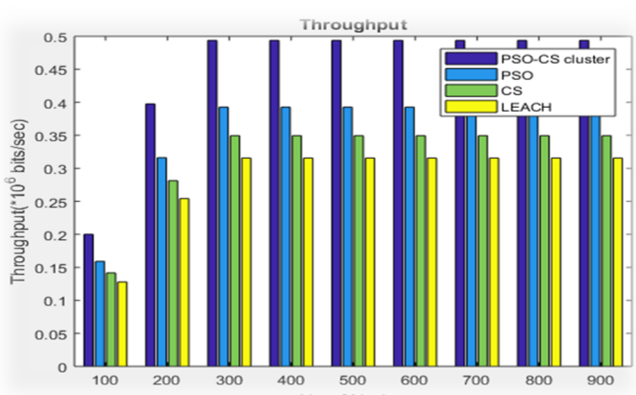

Figure 5. comparison of throughput of WSN in different methods

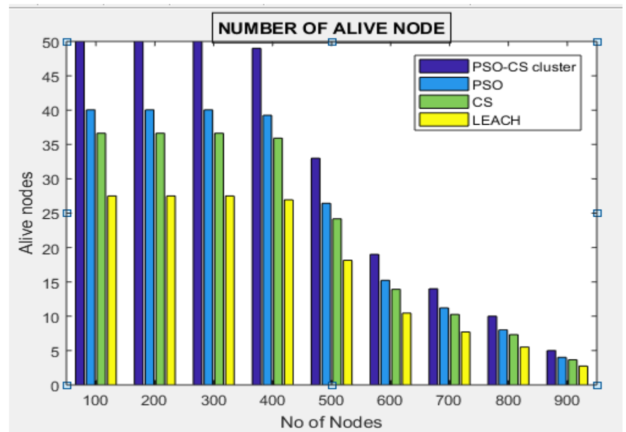

Figure 6. comparison of number of nodes alive in WSN in different methods

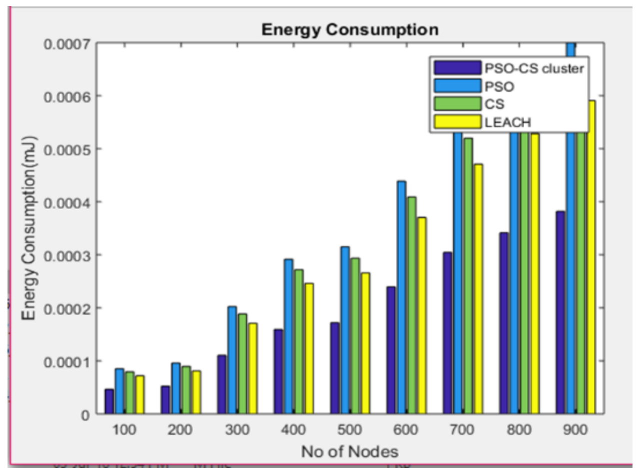

Figure 7. comparison of energy consumption of WSN in different methods

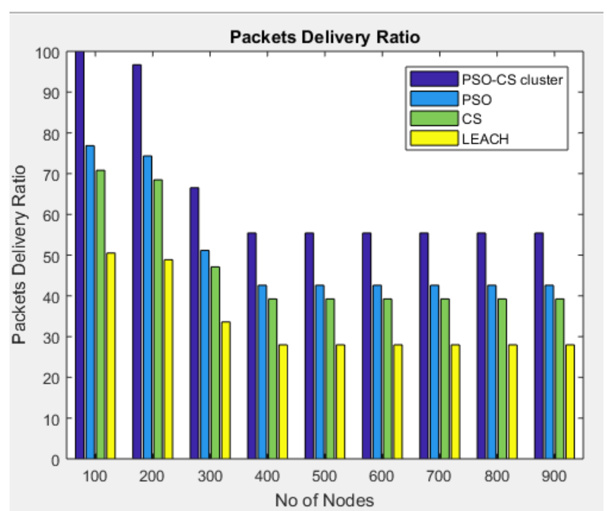

Figure 8. comparison of Packet Delivery Ratio of WSN in different methods

VI. Conclusion

In this paper, an energy efficient unequal clustering algorithm is proposed embedding particle swarm optimization and cuckoo search. The particle swarm optimization algorithm is used at base station to form optimized clusters keeping in mind minimum distance and neighboring nodes. Secondly as its known that the cluster head selection process is considered as NP hard problem so this paper proposed an optimization technique for cluster head selection in every iteration using cuckoo search technique. The proposed methodology achieves considerable energy efficiency, as shown through simulation results.

In future work, proposed methodology can be further improved by taking into consideration metrics related to QoS and time limitations. Furthermore, we plan in future work to consider mobile sensors and to define a dynamic version of CBPSO which also handles mobility of sensor nodes.

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