PARTICLE SWARM OPTIMIZED ENERGY EFFICIENT CLUSTERING (EDEEC-PSO) CLUSTERING FOR WSN

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Abstract— Heterogeneous wireless sensor network (WSN) consists of sensing element nodes with completely different ability, computing power and sensing range. Compared with homogeneous WSN deployment and network topology control are more complicated in heterogeneous WSN. Several routing protocols are suggested in this regard for achieving energy efficiency and improving the life time of Wireless Sensor Networks in heterogeneous scenarios. However, every protocol is not appropriate for heterogeneous WSNs. In this paper, first of all we tend to check Distributed Energy-Efficient Clustering (DEEC), Developed DEEC (DDEEC), Enhanced DEEC (EDEEC) and compare it with our suggested Methodology Enhance distributed Energy Efficient Clustering with Particle Swarm Optimization (EDEEC-PSO)under several different scenarios containing high level heterogeneity to low level heterogeneity ,in order to conclude the behavior of those heterogeneous protocols.

Keywords: DEEC, DDEEC, EDEEC, EDEEC-PSO.

I. *INTRODUCTION*

Routing in Wireless device Networks (WSNs) [1] has been the topic of intense analysis efforts for years. As the battery, capability of computing, storage and data processing of a sensor are limited, how to reduce the energy consumption while prolonging the network lifetime stays the key problem.

Clustering is wide adopted in WSNs, wherever the whole network is split into multiple clusters. Clusters have cluster heads (CHs) be answerable for information aggregation. It has the benefits of low energy consumption, easy routing theme and sensible measurability, and it cut back the energy hole downside to some extent. Most ancient agglomeration routing protocols for WSN square measure supported uniform networks wherever all device nodes square measure identical in terms of battery energy and hardware configuration. However, due to the variation of nodes' is known to increase network reliability and lifetime [3]. resources and possible topology change of the network, heterogeneous sensor networks [2] are more practical in reality. The presence of heterogeneous nodes with enhanced capacity

Technological developments in the field of Micro Electro Mechanical Sensors (MEMS) have enabled the development to tiny, low power, low cost sensors having limited processing, wireless communication and energy resource capabilities. With the passage of time researchers have found new applications of WSN. In many critical applications WSNs are very useful such as military surveillance, environmental, traffic, temperature, pressure, vibration monitoring and disaster areas. To achieve fault tolerance, WSN consists of hundreds or even thousands of sensors randomly deployed inside the area of interest [4].All the nodes have to send their data towards BS often called as sink. Usually nodes in WSN are power constrained due to limited battery, it is also not possible to recharge or replace battery of already deployed nodes and nodes might be placed where they cannot be accessed. Nodes may be present far away from BS so direct communication is not feasible due to limited battery as direct communication requires high energy. Clustering is the key technique for decreasing battery consumption in which members of the cluster select a Cluster Head (CH). Many clustering protocols are designed in this regard [5, 6]. All the nodes belonging to cluster send their data to CH, where, CH aggregates data and sends the aggregated data to BS [7-9]. Under aggregation, fewer messages are sent to BS and only few nodes have to transmit over large distance, so high energy is saved and over all lifetime of the network is prolonged. Energy consumption for aggregation of data is much less as compared to energy used in data transmission. Clustering can be done in two types of networks i.e. homogenous and heterogeneous networks. Nodes having same energy level are called homogenous network and nodes having different energy levels called heterogeneous network. Low-Energy Adaptive Clustering Hierarchy (LEACH) [8], Power Efficient Gathering in Sensor Information Systems (PEGASIS)[10],Hybrid-Energy-Efficient-Distributed-clustering (HEED) [11] are algorithms designed for homogenous WSN under consideration so these protocols do not work efficiently under heterogeneous scenarios because these algorithms are unable to treat nodes differently in terms of their energy.

Whereas, Stable Election Protocol (SEP) [12], Distributed Energy-Efficient Clustering (DEEC) [13], Developed DEEC (DDEEC) [14], Enhanced DEEC (EDEEC) [15] and Threshold DEEC (TDEEC) [16] are algorithms designed for heterogeneous WSN. SEP is designed for two level heterogeneous networks, so it cannot work efficiently in three or multilevel heterogeneous network. SEP considers only

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normal and advanced nodes where normal nodes have low energy level and advanced nodes have high energy.

DEEC, DDEEC, EDEEC and TDEEC are designed for multilevel heterogeneous networks and can also perform efficiently in two level heterogeneous scenarios.

Distributed Energy Efficient Clustering (DEEC) Protocol:

Let pi = 1/ni, which may be additionally considered as the average probability to be a cluster-head during n_i rounds. Once nodes have an equivalent amount of energy at every epoch, selecting the average probability pi to be popt will make sure that there are popt N cluster-heads each round and every one nodes die some at an equivalent time. If the nodes have completely different amounts of energy, pi of the nodes with a lot of energy ought to be larger than popt. Let E (r) denotes the average energy at round r of the network, which may be obtained by as follow:

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} Ei\ (r) \qquad (1)$$

The chance of the nodes to be a cluster head at every round per epoch is going to be given by:

$$\sum_{i=1}^{N} P_i = \sum_{i=1}^{N} P_{opt}\frac{E_i(r)}{\bar{E}(r)} = \sum_{i=1}^{N}\frac{E_i(r)}{\bar{E}(r)} = Np_{opt} \qquad (2)$$

It is the optimal cluster-head number. The probability threshold that each node si use to determine whether itself to become a cluster-head in every round, as follow:

$$T(S_i) = \begin{cases} \dfrac{p_i}{1 - p_i\,(r \bmod \frac{1}{p_i})} & if\ s \in G \\ 0 & otherwise \end{cases} \qquad (3)$$

Where, G is the set of nodes that are eligible to be cluster head at round r. If node s_i has not been a cluster-head during the most recent n_i rounds, we have s_i 2 G. In every round r, once node si finds it's eligible to be a cluster-head, it'll select a random range between Zero and One. If the chosen number is smaller than threshold T (si), the node si becomes a cluster-head throughout this round.

Developed DEEC (D-DEEC) Protocol:

We find that nodes with more residual energy at round r are more probable to become CH, so, in these way nodes having higher energy values or advanced nodes will become CH more often as compared to the nodes with lower energy or normal nodes. A point comes in a network where advanced nodes having same residual energy like normal nodes. Although, after this point DEEC continues to punish the advanced nodes so this is not optimal way for energy distribution because by doing so, advanced nodes are continuously a CH and they die more quickly than normal nodes. To avoid this unbalanced case, DDEEC introduces threshold residual energy as in [14] and given below:

$$TH_{REV} = E_0\left(1 + \frac{aE_{disNN}}{E_{disNN} - E_{disAN}}\right) \qquad (4)$$

Threshold residual energy Th is given as in [14] and given below:

$$TH_{REV} \simeq (7/10)E_0 \qquad (5)$$

DDEEC implements the same strategy like DEEC in terms of estimating average energy of networks and the cluster head selection algorithm which is based on residual energy Average probability pi for CH selection used in DDEEC is as follows as in [14]:

$$pi = \begin{cases} \dfrac{p_{opt}E_i(r)}{(1+am)\bar{E}(r)} & for\ Nml\ nodes,\ E_i(r) > TH_{REV} \\ \dfrac{p_{opt}E_i(r)(1+a)}{(1+am)\bar{E}(r)} & for\ adv\ node,\ E_i(r) > TH_{REV} \\ C\dfrac{p_{opt}E_i(r)(1+a)}{(1+am)\bar{E}(r)} & for\ adv\ node, ml\ nodes\ E_i(r) \le TH_{REV} \end{cases} \qquad (6)$$

Enhanced –DEEC (E-DEEC) Protocol:

EDEEC uses concept of three level heterogeneous networks show above. It contains three types of nodes normal, advanced and super nodes based on initial energy. pi is probability used for CH selection and popt is reference for pi. EDEEC uses different popt values for normal, advanced and super nodes, so, value of pi in EDEEC is as follows:

$$p_i = \begin{cases} \dfrac{p_{opt}E_i(r)}{(1+m(a+m_0b))\bar{E}(r)} & if\ s_i\ is\ the\ normal\ node \\ \dfrac{p_{opt}(1+a)E_i(r)}{(1+m(a+m_0b))\bar{E}(r)} & if\ s_i\ is\ the\ advanced\ node \\ \dfrac{p_{opt}(1+b)E_i(r)}{(1+m(a+m_0b))\bar{E}(r)} & if\ s_i\ is\ the\ super\ node \end{cases} \qquad (7)$$

Threshold for CH selection for all three types of node is as follows:

$$T(s_i) = \begin{cases} \dfrac{p_i}{1 - p_i\left(r\ mod\ \frac{1}{p_i}\right)} & if\ p_i \in G' \\ \dfrac{p_i}{1 - p_i\left(r\ mod\ \frac{1}{p_i}\right)} & if\ p_i \in G'' \\ \dfrac{p_i}{1 - p_i\left(r\ mod\ \frac{1}{p_i}\right)} & if\ p_i \in G''' \\ 0 & otherwise \end{cases} \qquad (8)$$

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$$T(s_i) = \begin{cases} \dfrac{p_i}{1 - p_i\left(r \bmod \dfrac{1}{p_i}\right)} & if\ p_i \in G' \\ \dfrac{p_i}{1 - p_i\left(r \bmod \dfrac{1}{p_i}\right)} & if\ p_i \in G'' \\ \dfrac{p_i}{1 - p_i\left(r \bmod \dfrac{1}{p_i}\right)} & if\ p_i \in G''' \\ 0 & otherwise \end{cases} \quad \textbf{(9)}$$

EDEEC-PSO

The Optimal probability defined in Enhanced distributed energy-efficient clustering protocol(EDEEC) is not user defined in our work, we are optimizing it through particle swarm optimization(PSO), by simply selecting our protocol as a fitness function for PSO and calculate the optimal value for which our fitness function becomes zero.

Particle Swarm Optimization (PSO)

The PSO has various phases consist initialization, Evaluation, Update Velocity and Update Position

$$\overline{v_1(t)} = \underbrace{w\overline{v_1(t-1)}}_{inertia} + \underbrace{c_1 r_1\left(x_1^{\#}(t-1) - \overline{x_1(t-1)}\right)}_{Personalinfluence} + \underbrace{c_2 r_2\left(x^{*}(t-1) - \overline{x_1(t-1)}\right)}_{Socialinfluence} \quad \textbf{(10)}$$

Where

$\overline{x_1(t)}$ = The position-vector in iteration t

i = The index of the particle

$\overline{v_1(t)}$ = The velocity- vector in iteration t

$x_1^{\#}(t)$ = The position so for of particle i in iteration t and its j th dimensional value is $x_{ij}^{\#}(t)$.The best position vector between the swarm here to force it then stored in a vector $x^{*}(t)$ and its j th dimensional value is $x_{ij}^{*}(t)$.

r_1, r_2 = random numbers in the interval [0, 1].

c_1, c_2 = positive constants and w is called the inertia factor.

$$\overline{x_1(t)} = \overline{x_1(t-1)} + \overline{v_1(t)} \quad (11)$$

Each of the three terms of the velocity update equation has different roles in the PSO algorithm. This procedure is this procedure recurrent till some stopping condition is met. Some general stopping conditions include: a pre-set range of iterations of the PSO algorithmic rules or **method**, variety of iterations since the last update of the global best candidate solution, or a predefined target fitness value:

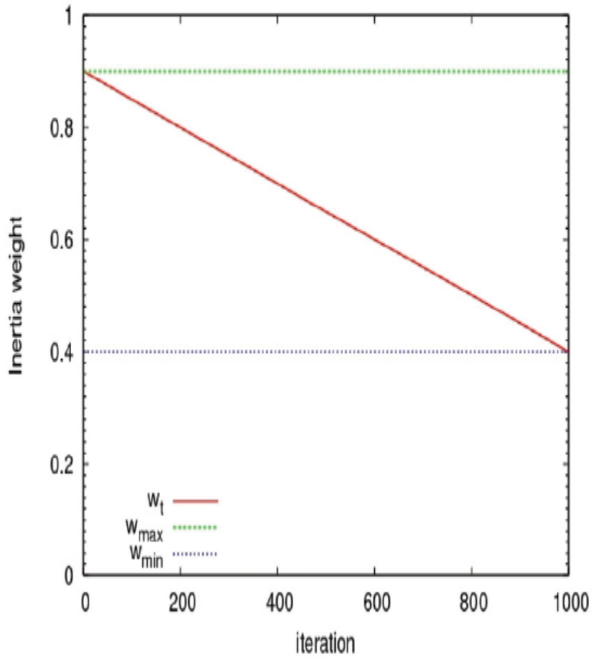
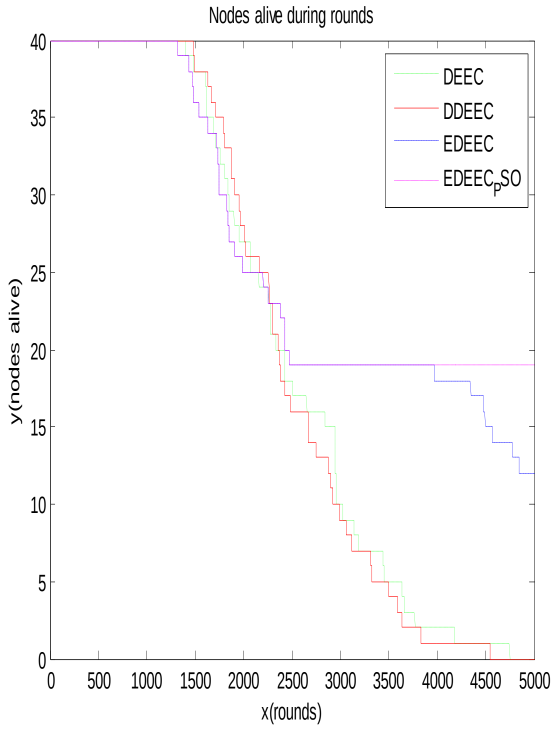


Fig.1.1 The value of the inertia weight is decreased during a run.

II. *Simulation Parameters:*

Parameters	**Value**
Network Field	(100,100)
Number of nodes	100
Eo (Initial energy of Normal Nodes)	0.5 J
Max.No. of Rounds	5000
Message Size	4000 Bits
Eelec	50nJ/bit
Efs	10nJ/bit/m^2
Eamp	0.0013pJ/bit/m^4
EDA	5nJ/bit/signal
d_o(Threshold Distance)	70m
Popt	0.1

III. Simulation Results:



Fig, 1.2 Comparison of Alive nodes

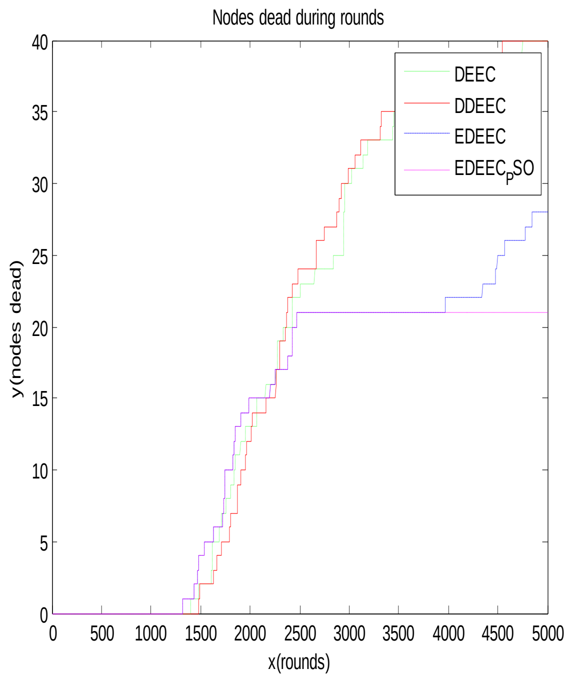


Fig.1.3 Dead Nodes Comparison

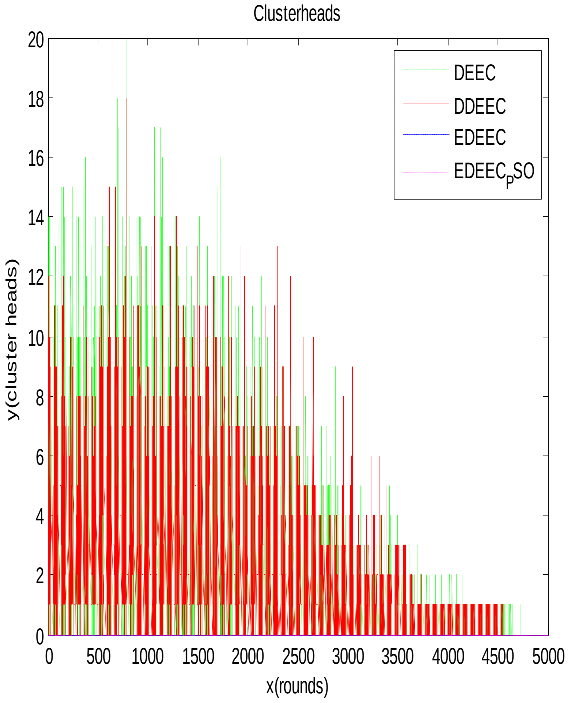


Fig.1.4 Cluster Head Formation

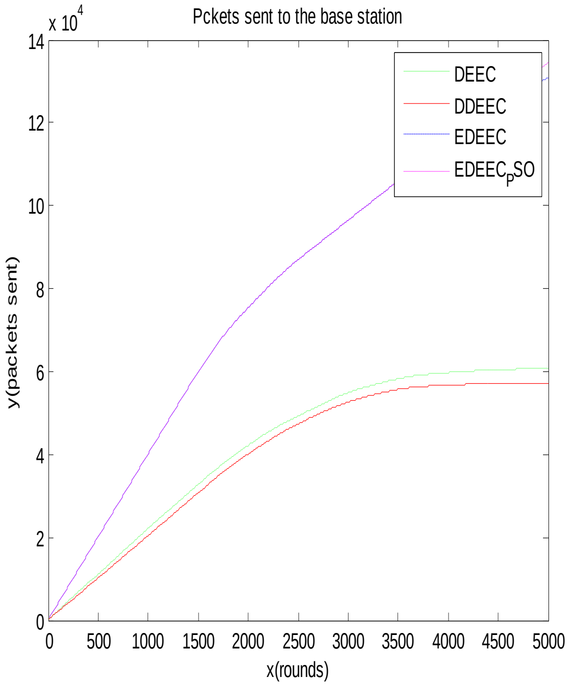


Fig. 1.5 Comparision of Data packets reaches to the Base Station

IV. Conclusion

We have examined DEEC, DDEEC, EDEEC and EDEEC with PSO for heterogeneous WSNs containing different level of heterogeneity. Simulations prove that DEEC and DDEEC perform well in the networks containing high energy difference between normal, advanced and super nodes. Whereas, we find out that EDEEC-PSO perform well in all scenarios. EDEEC-PSO has best performance in terms of stability period and life time.

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