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OPTIMIZED ENERGY USING CENTRALIZED CLUSTERING PROTOCOL IN HETEROGENEOUS WIRELESS SENSOR NETWORKS

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ABSTRACT

The imminent wireless sensing technologies are untied up for the smart and automation development era. An advantageous user system should be capable of undertaking effective monitoring topology and effective utilization of the energy in heterogeneous network such as data transmitting/receiving, data aggregation and, data forwarding from the monitoring area. In classical protocol corresponding to Hierarchical clustering has an irregular distribution of clustering due to the random selection of cluster head. To diminish this problem, the proposed an Optimized Energy using Centralized Clustering Protocol (OE-CCP) for static topology by considering energy and distance towards the sink node. At first number of clusters are determined and secondly node's distance to the sink, from that the mode of communication has been determined either direct or cluster-based data processing. To balance the energy in the network, Swarm Intelligence Optimization has been adopted for the optimal cluster head selection. The proposed protocol has better performance in longer network life, increased stability period, scalability, and minimum energy consumption in the monitoring area of heterogeneous wireless sensor networks.

Keywords: heterogeneous WSN, centralized clustering, PSO, topology.

1. INTRODUCTION

Sensors are being all over the requests such as manual control, monitoring applications, intelligent systems, quality management, measurements, security, surveillance, tracking, and so on. In real-time implementation selection of sensor mote, plays a major part. In [1] the author considers the controller usage and low power consumption techniques to minimalize the energy feeding finally that describes the node lifetime.

For the complex network and multi-targeting systems, different types of sensing nodes may be deployed with different initial energies. For those cases, it is very difficult to achieve the energy-efficient clustering. It is considered as energy heterogeneity in WSNs. WSNs has an exhaustive role in the rising automated scenarios. Here we need to consider the power consumption basics of the wireless sensor node. [2] As a part of the sensor node which continuously detecting and reporting event the power can be negligible, but another part of processing and communication consumes more power. So, we need to concentrate on the processing and communication system to attain the required task.

The requirements of the different applications have different tradeoffs and different architectures need to be used [5]. This is highly motivated to design and employ a heterogeneous network to complete firm responsibilities. [8] Even though in hierarchical clustering algorithm has a moderate stability period, the uneven distribution of Clusters and probability-based cluster head allocation makes rapid death of certain nodes.

In view of the previous research works on hierarchical clustering protocol problems, in this paper, we proposed an Optimized Energy and Centralized Clustering Protocol (OE-CCP) applied in the Energy Heterogeneous WSN. Here a static topology has been modeled to achieve optimized energy throughout the lifetime by applying centralized clustering to minimalize the energy feeding. Clustering and the cluster head selection process carried out by two objective functions which are performed in the Sink node to balance the computational process of the node and to avoid without considering the energy level, distance and to balance probability-based selection of CH of the node. The proposed algorithm provides an improved stability period; hence the network lifetime has been increased.

The paper is organized as follows, motivation and related works are provided in section 2, the proposed three-level heterogeneous network model and the protocol adopted is discussed, in section 3 the simulation and implementation results are discussed, compared in section 4. Finally the findings are concluded in section 5.

2. RELATED WORK

In Stable Election Protocol (SEP) [10] initiates the energy heterogeneity and also the proposed stability of the entire network lifetime acknowledged from the First Node Dead. The author developed two-level energy heterogeneity, known as normal nodes with E_0 initial energy and Advanced Nodes with $E_0(1+\alpha)$ times of initial energy. 10% of nodes are considered as the advanced nodes from the overall population. The cluster formation initiates from the election of Cluster Head (CH) as similar to the [16] LEACH protocol. Throughout the setup phase each node produces a random number between 0 and 1, if the random number is less than the threshold is mentioned below is elected as a CH:

$$T(S_x)=\begin{cases}\frac{P_x}{1-p_x\left(r \bmod \frac{1}{P_x}\right)} & if\ S_x \in G' \\ 0 & otherwise\end{cases} \qquad (1)$$

Where p_x is the percentage of nodes elected as CH from the particular energy level of the nodes, α is the additional initial energy level of the node and m is the

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portion of nodes that has been allocated as advanced nodes. Normal nodes and advanced nodes having different probability to elect the CHs separately. After the CH election, CH broadcast the advertisement message to form clusters and waiting for the join request. Other non-cluster head members are sending the join request based on the acknowledged signal strength, the CH provides the TDMA schedule to their cluster members. Then the next phase of steady state phase starts to transfer the sensed data from the cluster members to the CH, then the aggregated data forward to the BS or Sink. This process repeats in each round. In SEP two different energy levels are proposed normal nodes and advanced nodes. SEP determines the CH according to their initial energy, since it is having 2 different level of initial energy the stability period extents by 26% in comparison with LEACH Protocol. The overall throughput is greater than the LEACH. Each round the random election process repeats. Since all the nodes directly communicating to the Base Station or Sink, so the single hop communication leads to the shorter unstable region.

Similar to SEP, Enhanced Stable Election Protocol [18] (E-SEP) is a 3 level heterogenous network. In these normal nodes with (Eo) initial energy, intermediate nodes with Eo(1+µ) of initial energy and Advanced nodes with Eo(1+α) of initial energy considered. 10% and 20% of intermediate and advanced nodes allocated respectively. From that the Stability period obtained by E-SEP ins limited to LEACH. In [20] (Z-SEP) Zonal Stable Election Protocol, the network environment separated in to 3 Zones, Zone 0, Head Zone 1, Head Zone 2 in which normal nodes, advanced nodes distributed respectively. 20% advanced nodes deployed in the overall population. Nodes in Zone 0 directly transfer the sensed data to the BS, and the advanced nodes in the Head Zone 1 and Head zone 2 transmitting the data through the Cluster Head. CH election, Cluster formation, Data aggregation takes place in these Zones. Approximately 50% of increased stability achieved in comparison with SEP and LEACH, and the throughput are also increased. In E-SEP. I-SEP designed for the IoT based Environment monitoring, the improved SEP similar to the E-SEP 3 level energy network. The dual power level is assigned for the nodes while in CH and for the sensing nodes. From that the threshold-based CH-replacement algorithm is carried out. Which improves the throughput increased by 50% and 240% as that of SEP and DEEC [17] and achieving longer stability period as compare to SEP and DEEC.

DEEC: Distributed Energy Efficient Clustering, it is an energy efficient adaptive clustering protocol for the multi-level HWSNs. DEEC considers the node's residual energy for the CH election. In [17] DEEC, Total initial energy and the average energy per round used to estimate the life time of the network prior to the implementation, so each node will substitute its average probability and get the election threshold. Stability period is longer than 10% in compare with SEP.

In the heuristic approach, node itself will undergone the election of CH, in addition to that CH has to advertise its CH status and receive ACK from their cluster member, and CH has to allocate TDMA schedule. All these have to be performed during the set-up phase itself. Data collection, Data accumulation and data accelerating to the BS like all the process have to complete. So, to reduce the over burden of the node and the energy imbalance in the network researches applying the optimization algorithm. Many researches applied the optimization algorithm on the BS or Sink which is not having energy constrain. In that way many Centralized algorithms like LEACH-C that is Centralized LEACH and (PSO-SSM) PSO with Superior Student Management for energy aware clustering, (PSO-C) centralized PSO, clustering and CH selection based on the distance and the residual energy of the node. MST-PSO, Minimum Spanning Tree- PSO best route between the node and the CH is searched from all the optimal trees on the criterion of energy consumption.

PSO-ECHS [26] Particle Swarm Optimization based Energy Efficient Cluster Head Selection. For the fitness function calculation, author considers average intra cluster distance and the residual energy of the nodes. The fitness function is to minimize the following equation

$$F = \alpha f_1 + (1-\alpha) f_2 \tag{2}$$

Where f_1 is the function of regular intra cluster and sink node distance of the CH, f_2 is the reciprocal of total remaining energy of the CHs and α is the normalization factor ranges from 0 to 1. For the optimal CH f_2 need to be maximize since it is in the reciprocal. For the cluster formation four weighting parameters like CH residual energy, Distance between the sensor node and the CH, Distance between the CH and the BS, CH node degree are considered to obtain the balanced load for the CHs. Here the author considers the single hop communication for the homogenous network, the weighting factors for the cluster formation unable to obtain the longer stability period for network and routing of the network also not considered.

The (EPSO-CEO) [25] Enhanced Particle Swarm Optimization based Clustering Energy Optimization, used to select the CH and also for the cluster formation. Based on the centralized manner, for the maximum value of the fitness function is calculated by the BS using the node's basic information, from the order of the fitness function BS forms the clusters. After cluster formation, each cluster members have the cluster list based on that, by applying maximization of the fitness function using PSO [23] used to select the CH on the basis of distance between the cluster members and the residual energy for the population of cluster members. Followed by the CH selection the data forwarding is done by the multi hop technique. The inter cluster routing is established on minimum cost function of the relay CH node to forward the data to the BS. The clustering energy consumption is compared with (CC) Competitive Clustering, which is having mobile sink. It provides relatively 20% less in energy consumption range.
Other ERP, EAERP and SAERP are based on the Genetic Algorithm, to find the maximum fitness value for the selection of Cluster Head in a Heterogenous network

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environment. In this work they concentrated only on the cluster formation and rotation of CH. Still is not considered for the data forwarding.

3. PROPOSED NETWORK MODEL

The following expectations are made for this problem: 1) *n* Number of static sensor nodes is randomly deployed in the Wireless Sensor Network. 2) The nodes in the network area are subject to certain method to get their co-ordinates information such as GPS. 3) Sink node is fixed at center of the network which is not a battery powered node. 4) The *n* number of sensor nodes has 3 different heterogeneous energy levels such as advanced, intermediate and normal nodes. 5) The system routing model is based on a centralized routing protocol. Cluster information and Cluster Head node for that particular cluster are assigned by the sink node using the novel Centralized Clustering Protocol based on coverage ratio and energy.

3.1 Network Topology

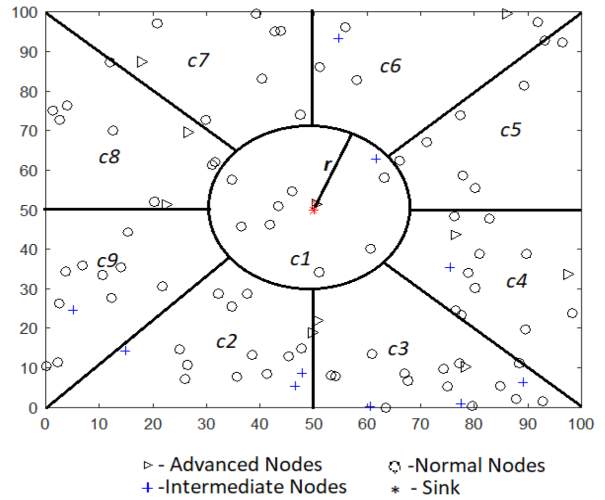

Figure-1. Proposed HWSN topology.

The Proposed Centralized Clustering Protocol Based on Optimized Energy (OE-CCP) clustering executes in a multilevel energized network topology. In Figure-1 the randomly deployed 3 level energy nodes such as 10% of Advanced Nodes (E_{adv}), 10% of Intermediate Nodes (E_{int}) from the overall *n* nodes and the remaining all the other nodes are considered as Normal nodes (E_{nrm}). Here the clusters are separated by the location of the sensor nodes deployed. The overall 100x100 m^2 wireless sensor network is split in to 8 right angle triangles and based on the sink node coverage radius for our topology it is considered one more cluster. So totally 9clusters are planned in the WSN area.

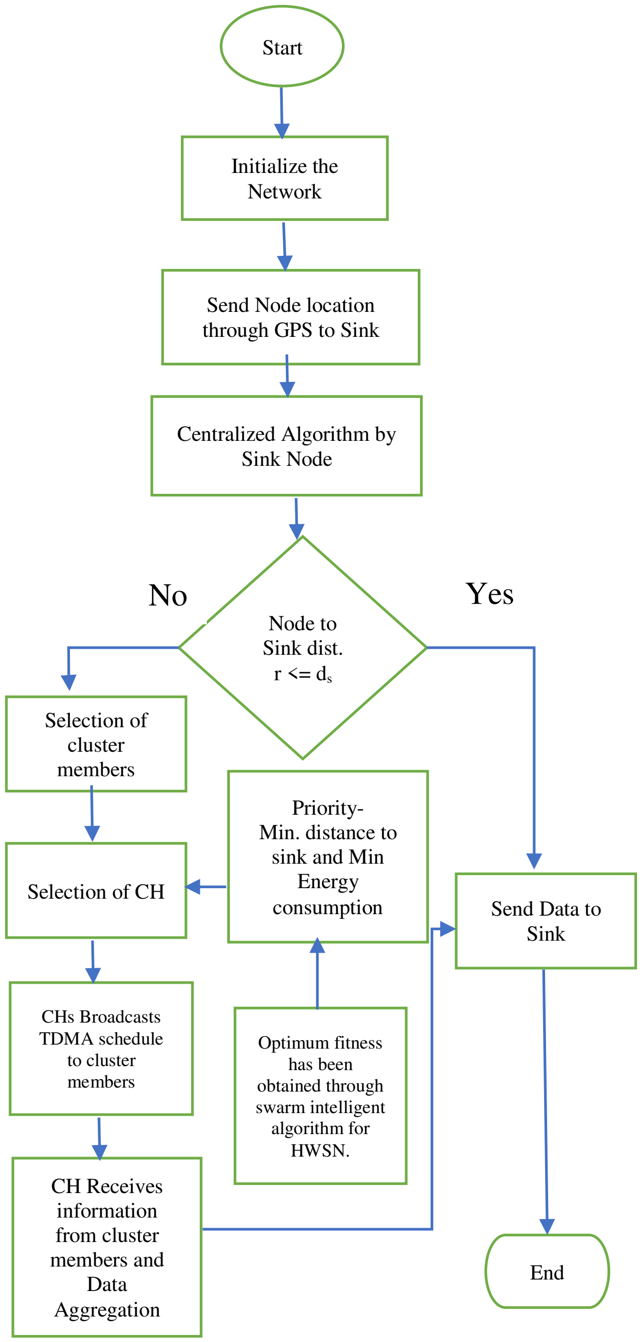

Figure-2. Flow diagram for OECC Protocol.

In cluster based hierarchical routing protocols such as LEACH and SEP always selects its Cluster Head on random election and on probability each and every node become a CH on the epoch basis. Hence to resolve these problems, in this proposed work 2 types of clustering techniques are used, 1) Direct Communication cluster (No cluster head selection process). 2) Centralized clustering process (Cluster Head selection process to forward the data to Sink) the three essential factors have been considered to become an CH in each cluster and centralized clustering algorithm helps to reduce the computational energy each round of each node because sink node executes the algorithm once it is received the two dimensional co-ordinate information through the GPS system. The node co-ordinates are considered as {Xi, Yi} where i={1,2,3...n} 1) Number of clusters members,

Residual energy and co-ordinates of each node identified based on the coverage area of the topology. 2) Distance of each cluster members (C(Xj, Yj) where j={1,2,…k} and k stands for the number of cluster members) and the distance between Sink to the cluster members measured. 3) Cluster Head Choice based on the minimum distance to cluster member and minimum distance with the sink node using Swarm Intelligence based optimization.

3.2 Energy Model

3 level energy nodes such as 10% of Advanced Nodes (E_{Adv}), 10% of Intermediate Nodes (E_{Int}) from the overall n nodes and the outstanding all the other nodes are considered as Normal nodes (E_{Nrm}), the energy distributions are as follows:

$$E_{Nrm} = E_0 \tag{3}$$

$$E_{Int} = E_0 * (1+a) \tag{4}$$

$$E_{Adv} = E_0 *(1+b) \tag{5}$$

here a=1, b=2 Initial energy for Intermediate nodes and Advanced Nodes respectively and E_0 is the Initial Energy=0.5J, so the initial energy of advanced nodes, intermediate nodes and normal nodes are 1.5J, 1J and 0.5J respectively. So, the total initial energy of the network is

$$E_{Total} = \sum_{i=1}^{nAdv} EAdv + \sum_{i=1}^{nInt} EInt + \sum_{i=1}^{n-(nAdv+nInt)} ENrm \tag{6}$$

The basic radio model has been considered for data transmission and reception. Here the transmitter dissipates considerable energy for the radio electronics operation and power amplification process and if the node is elected as CH, in addition to that data aggregation process consumption energy also need to be considered. The receiver node dissipated energy for the radio electronics process. The energy consumption of a node is based on the amount of data and distance to be sent. In [2] the threshold distance has been considered as d_0, if the propagation distance is greater than the threshold distance then the energy consumption of a node is proportional to d^4 and if less than the threshold distance is proportional to d^2. If each node transmitting with k bit of data, then the energy of each node can be expressed as following equation.

$$E_{TX}(k,d) = \begin{cases} k * E_{elec} + k * E_{fs} * d^2, & if\ d < d_0 \\ k * E_{elec} + k * E_{mp} * d^4, & if\ d \geq d_0 \end{cases} \tag{7}$$

Where, E_{elec} is the transmitting or receiving energy of the node? Amplification energy E_{fs} is for free space and $E_{mp}$is for multipath model.

$$E_{RX}(k, d) = k * E_{elec} \tag{8}$$

Swarm intelligent based optimization technique is used for the minimized energy consumption. The effective utilization of minimized energy achieved through particle swarm optimization. Based on the fixed topology WSN the first aspect is Average distance between the intra cluster distance that is minimum distance between the CH and the cluster members and the second aspect is minimum CH energy utilization. From that the fitness function is formulates as two objective functions.

$$Fitness= r * f1 + (1-r) * f2 \tag{9}$$

$$f1=\sum_{N=1}^{m}(dnCH - dCH)/nCM \tag{10}$$

$$f2=\sum_{i=1}^{n} ETotal \,/\, \sum_{N=1}^{m} ECH \tag{11}$$

Where r is the random number. (dnCH-dCH) is intra cluster distance between the CH and the cluster member

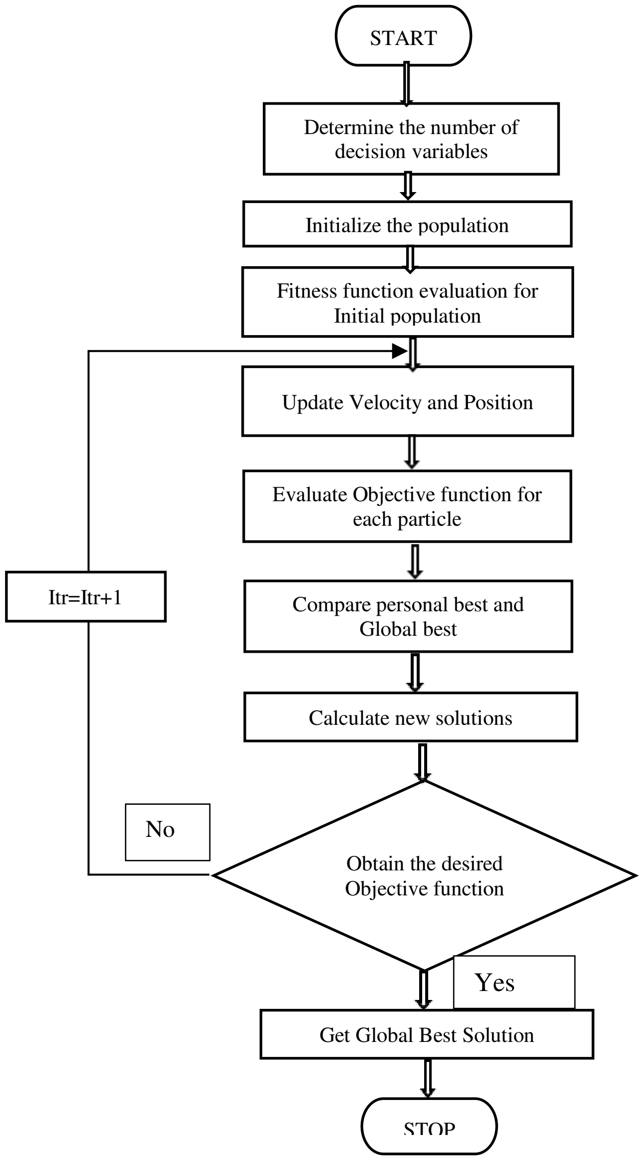

Figure-3. Flow diagram for PSO.

nodes of the desired cluster. nCM is the number of cluster members. Etotal is the total initial energy of HWSN and ECH is the total Cluster Heads energy of the corresponding round, i = {1, 2…*n*}, where n is the number of nodes, N= {1, 2…m}, where m is the no. of CHs in the current round. By the optimized fitness function measurement that the minimum energy consumption has been carried out and explicate by the flowchart.

3.3 Coverage Problem Description:

Assuming that the observing area is a square of 100 m x 100 m, it is a circle in the middle and 8 quadrilaterals totally 9 clusters and 100 sensor nodes are put in to the area. Sink node coverage area of the radius *r* meters and the area is πr^2. The two-dimensional co-ordinates of sensor nodes with in this area of coverage can get it by establishing the system. Each quadrilaterals area can be measured from the removal of 8 in 1 part of each right-angle triangle. Hence the area of the quadrilateral becomes (bp/2) - ($\pi r^2/8$). The aspects of sensing quality are directionality and distance. For an external event at a certain distance is not a fixed one. In many of the sensing model focus on the distance and assumed as omnidirectional sensing and no random variation. The best coverage support path has been preferred, so the coverage path between two points has been considered as the path having the smallest maximal distance to the sensor set.

3.4 Clustering Process and Working Phase:

The data transmission phase is also considered as the working phase. The CH broadcasts a TDMA data stream to notify its cluster member to initiate the data procurement progression. According to the timeslot the cluster member send data to the CH. Subsequently CH collections the data and it forwards the data to the Sink node. After completion of the data transmission to the sink node, the algorithm will enter the next iteration. The node which is having the maximum distance with in the limit to the sink node and maximum residual energy has been considered as the CH.

Table-1. Cluster head allocation for zone2 in r= 1355.

Node ID	Energy	Distance to Sink	CH
4	1.030602	56.16459	1
21	0.487889	62.78487	2
50	0.214154	53.83101	3

Table-2. Cluster head allocation for zone2 in r=1748.

Node ID	Energy	Distance to Sink	CH
4	0.8949	56.16459	1
21	0.33984	62.78487	2
176	0.131568	53.73368	3

4. SIMULATION RESULTS AND DISCUSSIONS

The protocols are implemented in MATLAB. The simulations are performed on four different scenarios to know the load balancing and scalable routing in 100m X 100m monitoring area with sink node placed at the center. In scenario1, 100 heterogeneous nodes with 10% of advanced nodes and 10% of intermediate nodes assumed. In scenario2, 100 heterogeneous nodes with 20% of advanced nodes and 20% of intermediate nodes, in scenario 3, 200 heterogeneous nodes with 10% of advanced nodes and 10% of intermediate nodes assumed. In scenario4, 200 heterogeneous nodes with 20% of advanced nodes and 20% of intermediate nodes are assumed. The parameters of the algorithm are initialized [16]; the key parameters are enumerated in the Table-3.

Table-3. Initial parameters.

Parameter	Value
Target Area	100 x 100 m^2
Number of Sensor nodes	100 - 200
Normal Node Initial energy	0.5J
E_{elec}	50 nano J/bit
E_{fs}	10 pico J/bit/m^2
E_{mp}	0.0013 pico J/bit/m^4
d_0	87m
Packet Length(k)	4000 bits

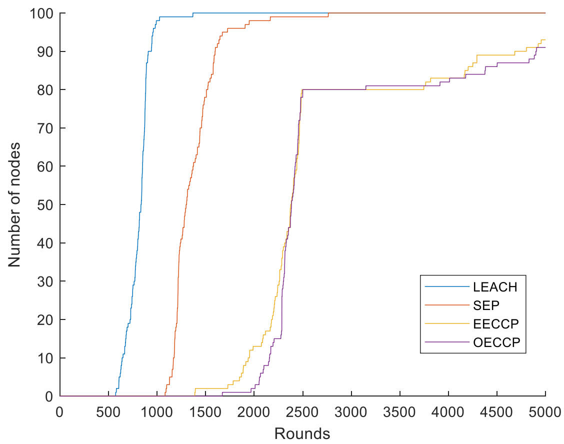

Figure-4. Number of dead nodes in each round when n=100 with 10% of heterogeneous nodes.

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Table-4. Network stability (First Node Dead).

% of HWSN	10%	20%	10%	20%
Number of nodes	100	100	200	200
LEACH	574	574	732	732
SEP	1083	1074	1045	1130
EECCP	1389	1759	2014	2057
OECCP	1672	1897	2065	2122

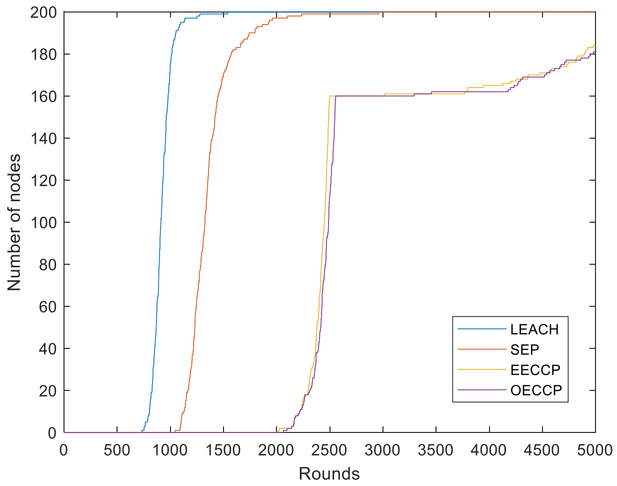

Figure-5. Number of dead nodes in each round when n=200 with 10% of heterogenous nodes.

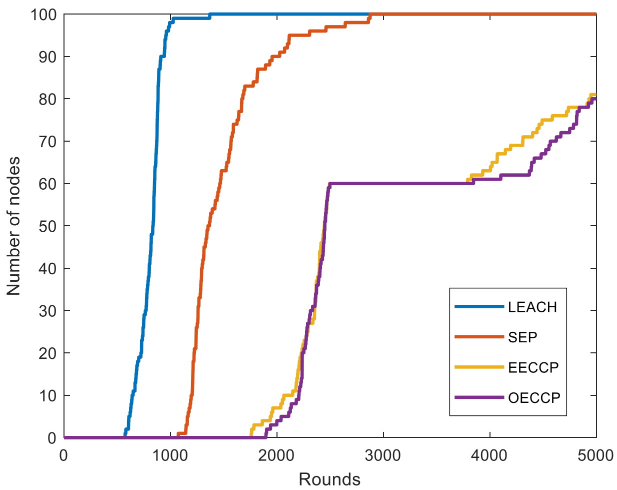

Figure-6. Number of alive nodes in each round when n=100 with 20% of advanced and intermediate nodes.

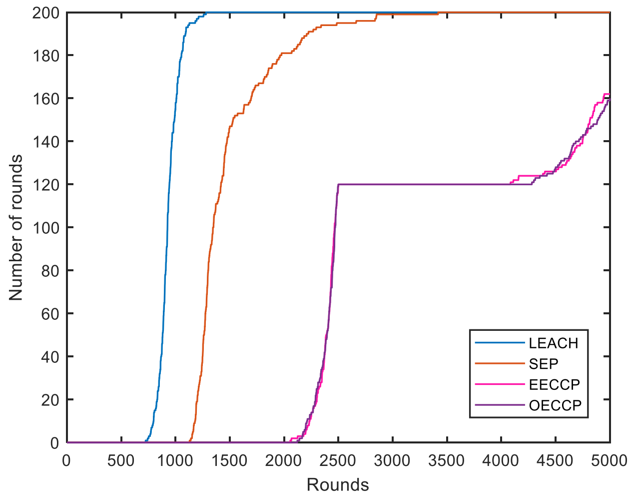

Figure-7. Number of alive nodes in each round when n=200 with 20% of advanced and intermediate nodes.

Figures 4 to 7 shows the simulation results of network stability period and network life time. Our proposed OECCP performs well when compare to LEACH and SEP even when increase the number of nodes this used to complete the objective of scalable issues. It is the initial round of the network to till the first node death. In Table-4 comparison of each protocol stability period, from that the OECCP provides the better stability while comparing to LEACH and SEP. From that the OECCP maximizes the Network life span by covering more than 5000 rounds of operation.

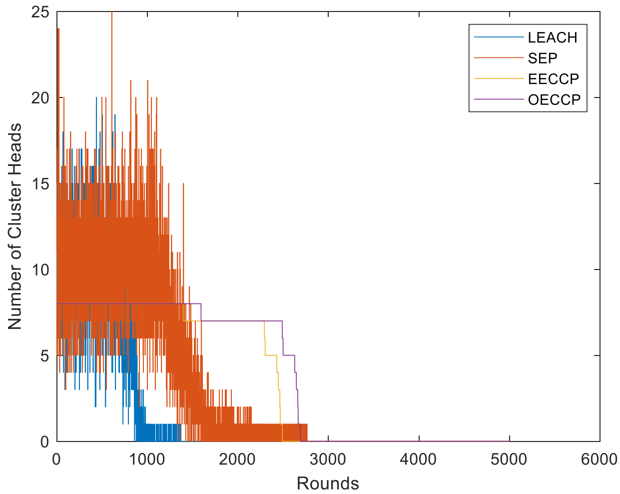

Figure-8. Number of cluster heads allocation in each round when n=100.

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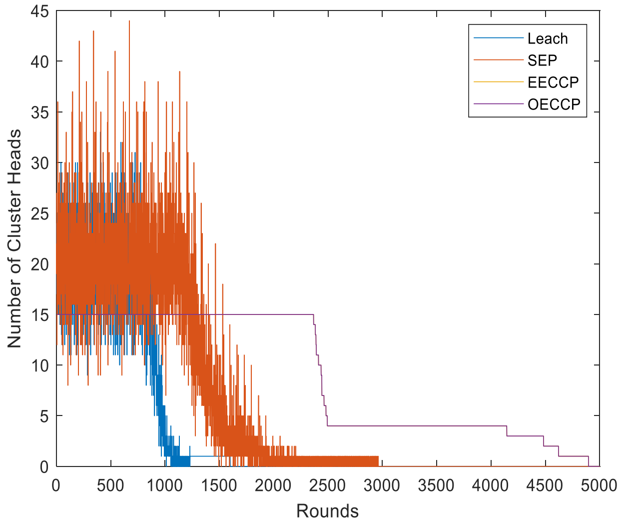

Figure-9. Number of cluster heads allocation in each round when n=200.

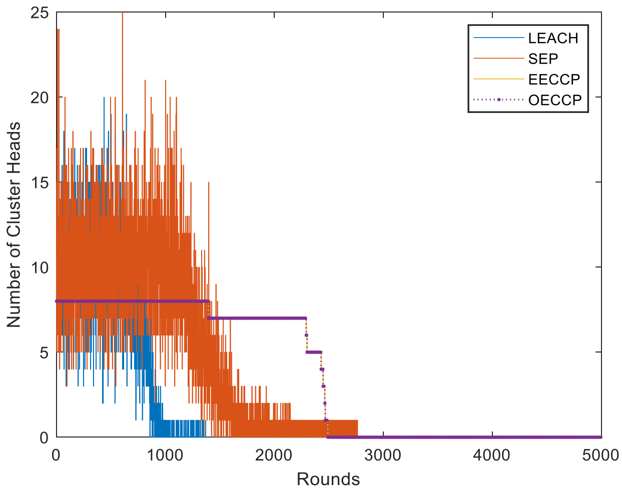

Figure-10. Number of cluster heads in each round when n=100 with 20% of advanced and intermediate nodes.

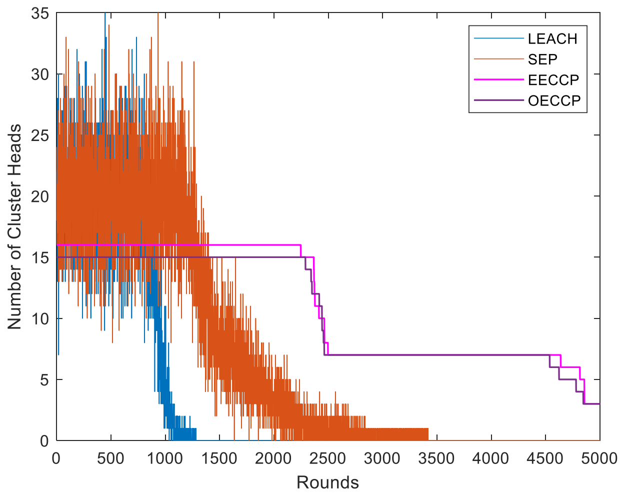

Figure-11. Number of cluster heads in each round when n=200 with 20% of advanced and intermediate nodes.

From the Figures 8 to 11, random allocation of CH has been completely replaced to minimize the energy consumption and stable CH allocation has been achieved.

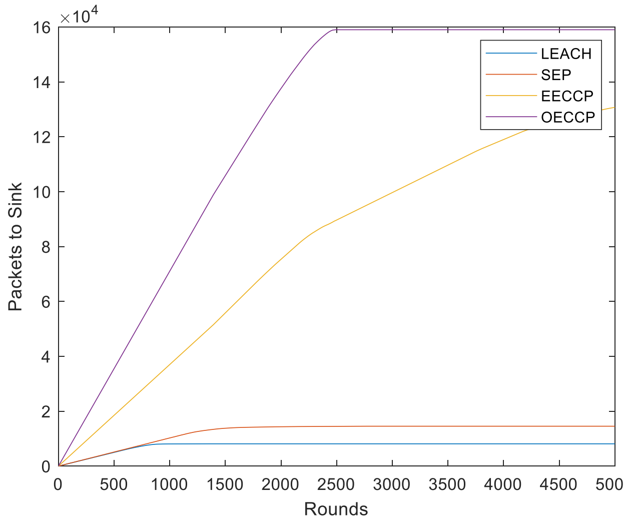

Figure-12. Number of packets delivered to the sink when n=100 with 10% of advanced and intermediate nodes.

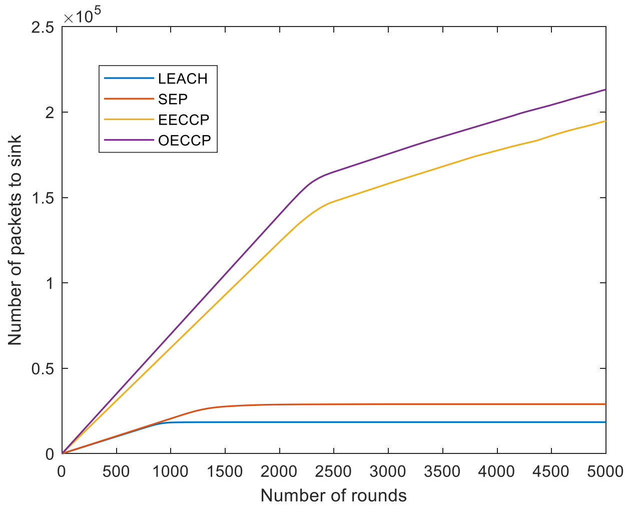

Figure-13. Number of packets transmitted to the sink in each round when n=200 with 10% of advanced and intermediate nodes.

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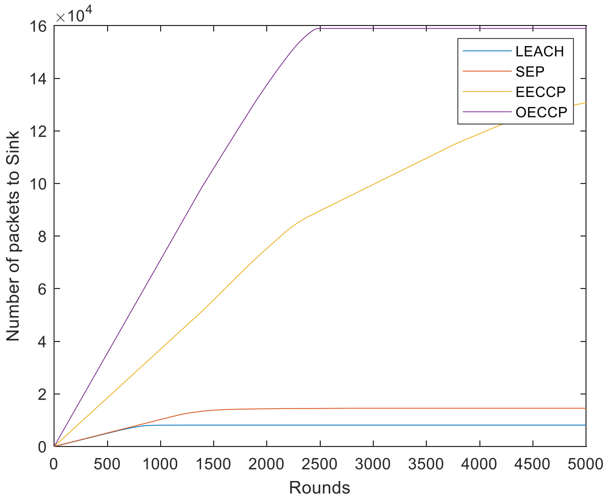

Figure-14. Number of packets transmitted to sink in each round when n=100 with 20% of advanced and intermediate nodes.

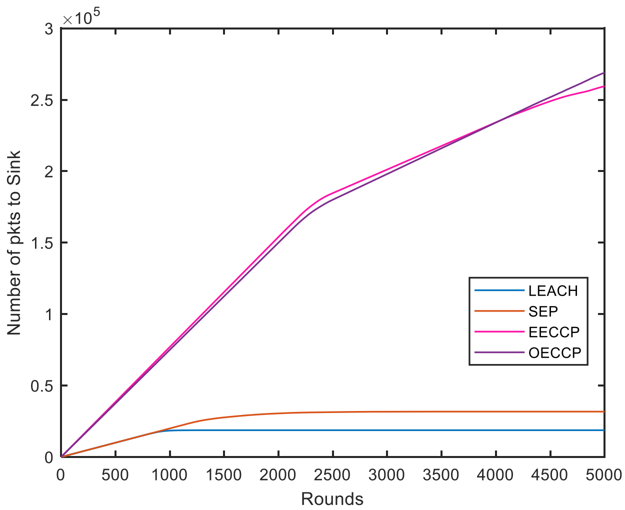

Figure-5. Number of Packets transmitted to sink in each round when n=200 with 20% of advanced and intermediate nodes.

From the Figures 12-15 the important aspect of increased throughput is achieved is clearly shown. Throughput has been increased by 80% even when compared to SEP and 90% increases when compared to LEACH.

5. CONCLUSIONS

Optimized Energy using Centralized Clustering Protocol (OECCP) is a 3-level heterogeneous wireless sensor network with static Topology is proposed to control the dynamic clustering and also Cluster Head allocation randomly. The longer stable period and increased life time is achieved on introduction of PSO along with the proposed algorithm. The important aspect of dynamic CH selection is completely stabilized. Throughput has been increased by 80% even when compared to SEP and 90% increases when compared to LEACH. The overall performance of the centralized clustering protocol achieves the increased network life time for the designed topology.

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