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Enhanced Clustering Algorithm for Efficient Clustering in Wireless Sensor Network

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Abstract: Wireless sensor network (WSN) is a network formed as resultant interconnection of multitude of sensor nodes. The main challenging question here is to lessen energy ingesting during sensing, processing and communication. In this paper, a well evaluated distributed clustering strategy, the Hybrid Integrated Clustering Algorithm (HICA) has been proposed for interconnecting two sensor fields. The proposed clustering algorithm is a hybrid and integrated clustering procedure which employs grid nodes, range-based transmission power, one-step clustering mechanism and cluster head panel. The performance evaluation of the suggested procedure is compared against O-LEACH and HEED. Simulation results clearly show an excellent upgrading in network lifetime, improved residual energy, reduced energy consumption, improved throughput and evenness in cluster head selection, thereby applicable for connecting two detached wireless sensor network fields.

Keywords: WSN, Distributed Clustering, Grid Nodes, Range-Based Transmission Power, Throughput And Network Lifetime.

1. INTRODUCTION

Wireless sensor network entails a collection of sensors that are deployed in buildings, forests and numerous infrastructures. Sensors gather data regarding the neighboring environs, updates the base station (BS) thereby responding to intermittent monitoring demands. For this purpose, the sensors are assembled into dissimilar cluster, with each cluster containing one leader commonly referred as cluster head (CH) and this mechanism is termed as clustering. Clustering is classified into centralized and distributed clustering. In centralized approach, the CH has a fixed architecture. In distributed clustering, the CH is not static and this shifts on the basis of few parameters. Distributed clustering strategy could be employed for some valid reasons like preventing network failure, improved information gathering and minimizing redundant information transmittal. In this paper, a well-evaluated distributed clustering strategy, the Hybrid Integrated Clustering Algorithm (HICA) has been proposed for interconnecting two sensor fields.

The proposed clustering algorithm has some specific uniqueness like employment of grid nodes, range-based transmission power, one-step cluster formation and cluster head panel. This section gives a brief overview of the novel concepts employed in the proposed HICA algorithm. Grid nodes are dedicated backup sensors which are used only for forwarding the data from CHs to the BS. Grid nodes are positioned halfway among two separated sensor fields. The sensor field is organized into several zones starting from the cluster head. The energy utilization will be ranging from minimum to maximum from first zone to last zone. In the existing clustering procedures O-LEACH and HEED, the power utilization of every node is equivalent to the power used by the nodes in the last zone of the proposed algorithm. In both LEACH and HEED, many messages are needed for cluster formation. But the proposed algorithm employs one-step cluster formation procedure. In the proposed HICA algorithm a novel perception of cluster head panel is employed. Each cluster consists of one CH and dual delegate CHs. This arrangement of one CH and dual delegate CHs is called as cluster head panel.

The foremost target in formulating this proposed structure is to decrease energy during communication and increasing the overall network lifetime, when two separate sensor network fields have to be connected together by using grid nodes. The proposed HICA algorithm is assessed against two well-formulated clustering schemes Optical Low Energy Adaptive Clustering Hierarchy (O-LEACH) [1] and Hybrid Energy Efficient Distributed

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Clustering (HEED) [2]. The remaining sections of the paper have been organized as follows. A literature review of the associated distributed clustering procedures in the closer vicinity of our research is entailed in Section 2. The conceptual view of the suggested HICA algorithm is explained in Section 3. The detailed evaluation of the simulation results is enumerated in Section 4. Finally, Section 5 provides the conclusion.

2. LITERATURE REVIEW OF PREVAILING DISTRIBUTED CLUSTERING STRATEGIES

The clustering algorithms entailed here mainly aims in reducing energy usage and extending network lifespan but they alter by the methodology by which CH gets rotated. (LEACH) [5], CLUBS [6], and (DWEHC) [9, 10] employs different CH election strategies.

Algorithm for Cluster Establishment (ACE) [3] represents a linear clustering architecture, cluster overlap is very less, better coverage among clusters, and automatic cluster formation is exhibited. This algorithm can be selected when the scalability of the entire wireless sensor network has to be altered or increased in future. This strategy performs better with the absence of geo-location of the wireless sensor nodes and also the communication overheads is also less.

When comparing centralized WSN and distributed WSN, the latter have better possibility for taking decisions by their own. Coming to the Hausdroff Clustering (HC) [7], this operates on the criterion that, the formed clusters remains unaltered during the whole clustering phenomenon. Also, the CHs will be shifted periodically among all the participant sensor nodes in the network. The foremost advantage of this algorithm is that, the overall network lifetime gets prolonged when compared with the predecessors. The remaining energies of the sensor nodes are considered as the main parameter for clustering in HC.

Distributed clustering architectures have trimmed down the energy usage in WSN. Ring structured Energy efficient Clustering Architecture (RECA) [4] employs a structured cluster head election strategy so as to uniformly disperse the load balancing among the clusters. This algorithm was found to be highly intellectual in managing and balancing loads in wider network scenarios.

The advanced clustering strategy commonly called as Fast Local Clustering Service (FLOC) [8] was proposed and implemented so as to satisfy larger scale networking environments. The main drawback of this algorithm is that, it is only available locally, that is, clustering can be accompanied only over two unit distance.

Hence, in current years, there is a wider scope of research so as to design and implement an algorithm that outperforms the aforementioned approaches. Hence, the proposed algorithm was mainly fashioned so as to overcome the drawbacks of the existing approaches.

The two clustering procedures that are targeted are O-LEACH [1] and HEED [2]. O-LEACH possesses a network topology with two separate sensor fields which gets connected by means of optical fiber. On one side of the optical fiber, the BS is situated. The CH does information aggregation on the information received from the member nodes so as to further reduce the CH node compress the amount of information transmission. Subsequently, CH rotation is accompanied in random manner as that of the basic LEACH algorithm. Nodes designate themselves as local CHs at some time with particular probabilities. O-LEACH procedure is merely a fair incremental alteration over original LEACH procedure. Although O-LEACH procedure is moderately much more energy effectual, the principal disadvantage in this technique is the arbitrary assortment of CH. In the worst case, the CH might not be moderately dispersed among the sensors and consequences occur on information collecting. When we employ optical fiber as connecting medium, the losses encountered are additional and cost of the link is also high. Hence the suggested clustering procedure uses grid nodes for linking two distinct sensor fields. Hybrid Energy Efficient Distributed Clustering (HEED) [2] is a distributed cluster formation strategy that picks CH on the basis of remaining energy and communication cost. Mainly HEED was suggested to evade the arbitrary assortment of CH.

3. THE HICA ALGORITHM

The suggested procedure, hybrid integrated clustering algorithm (HICA) is a purely-distributed clustering strategy where the sensors are positioned for sensing the targeted environment. The sensor fields are separated into two distant fields. The two distant fields are connected together by means of grid nodes. The broader sensor field is divided into small clusters with each clusters having one CH and two delegate CHs. The sensors transfer their gathered data at their corresponding TDMA time-slot to the corresponding CH, thereby the CH fuses the information for avoiding dismissed data transmission by the method of information aggregation. The aggregated information will be directed to the grid nodes either directly or hopping through other CHs. These grid nodes perform routing of the information packets to the BS. The proposed HICA clustering possess four distinct features:

(1) Grid nodes are devoted backup sensors which are used only for forwarding the information from CHs to the BS. Grid nodes are situated halfway amongst two separated sensor fields, thereby serves two peculiar functions. It forwards the data from cluster head to the base station and serves as connectivity between two separated sensor fields. Since, the CH does not forward the data directly to the BS huge communication energy could be reduced by employing grid nodes.

(2) The network is apportioned in to numerous clusters. The overall sensor network is allocated in to L-zones. Sensors in the first zone use minimum power (P1). The

sensors in second zone use transmission power (P2) where P2=2xP1. The sensors in the third zone use transmission power (P3) where P3=3xP1. Finally, the sensors in the Lth zone uses transmission power (PL) where PL=LxP1. In the existing clustering procedures O-LEACH and HEED, the power utilization is equivalent to PL of the suggested algorithm, whatever the distance it may be. Huge energy reduction could be attained by using this concept in the suggested procedure.

(3) In both LEACH and HEED, many messages are needed for cluster formation. But the proposed algorithm employs one-step cluster formation procedure. Initially in each clusters, one node will be randomly elected as deputy cluster head. This deputy CH sends a message requesting the remaining energies of the member nodes. Upon receipt, it compares the residual energies of member nodes with its one remaining energy and assigns cluster headship to the nodes possessing better remaining energy. Thus the cluster formation will be stabilized with the help of only one message. This helps in reduction of communication power.

(4) In the proposed HICA algorithm a novel perception of cluster head panel is employed. Each cluster consists of one CH and dual delegate CHs. This arrangement of one CH and dual delegate CHs is called as cluster head panel. Therefore these dual delegate CHs are denoted as cluster management nodes. The cluster head panel serves three functions: when the CH fails this delegate CHs become CH, when the path between CH to CH fails these delegate CHs compensate the failure and when the cluster fails these delegate CHs recover the cluster failure.

3.1 Zone-Dependent Transmission Power

The sensing field is sub-divided in to numerous zones. Since the CH or the regular sensors automatically decide the transmission power depending on the zone in which it gets located, thereby the proposed methodology is said to employ zone-dependent transmission power. At the stage of initial deployment, the BS is responsible for intimating the nodes that in which zone they belong to. The sensors in the field are separated into zones on the basis of their remoteness to CH, and zone values are allotted. Lowermost value gets allotted to the sensors in the adjacent region to CH. The sensors in the outermost zone are allotted with maximum zone value. The sensors in the outermost zone employ supreme transmission power and sensors in the first zone use least transmission power. In HICA, the first zone sensors utilize power (P1), the second zone sensors utilize power (P2) and so on. The transmission power upsurges with rise in zone value.

3.2 Use of Grid nodes

Grid nodes (GNs) are sensors that are richer in properties such as batteries, memories, etc. Generally, alike these regular sensors, GNs are battery-operated devices exceptional for wireless routing of the information packets. These GNs also shortens the communication space among a pair of remotely positioned sensors by performing as a hop among them. GNs are expected to be greater in possessions when compared to normal sensors in their initial energy provisioning, communication range and information processing (information gathering and information aggregation) competency. In the suggested procedure, GNs accomplish two core functions: it forwards the information from CH to the BS and serves as connectivity between two separated sensor fields. The foremost advantages in using grid nodes are: extending the overall life of sensor network, energy-efficient with stable information gathering, offering fault tolerance in sensor network and establishing wireless connectivity among separate sensor fields. Subsequently, as the CH does not forward the information directly to the BS, greater communication energy could be reduced by employing GNs.

3.3 One-Step Cluster Formation Procedure

The suggested procedure HICA employs one-step cluster formation strategy for establishing the sensors into clusters. The overall network with ‘N’ sensors gets parted into ‘n’ separate groups. Originally, a sensor that possess maximum remaining energy (RE) and decent coverage towards cluster nodes will be selected as deputy CH. This deputy CH sends a message to the sensors coming under its cluster to send their remaining energies in their respective TDMA time slots. The nodes possessing highest value will be assigned as CH for that current round. The left over nodes join to that specific CH as fellow nodes. The CH occasionally perform checking of the RE with its own, thereby if it finds any to possess greater than its own RE, CH role is moved to that specific sensor with advanced proficiencies. Thus the proposed HICA algorithm forms clusters in one single step. HICA is expected to be fashioned with ‘N’ nodes, such that ‘n’ clusters are created as mentioned in equations 1 and 2.

$$N = (N_1 + N_2 + N_3 + \ldots + N_N) \qquad (1)$$

$$N_N = (IN_1 + IN_2 + IN_3 + \ldots + IN_N) \qquad (2)$$

Where ‘Nn’ is the quantity of sensors in n^{th} cluster and ’IN’ is an individual sensor in particular clusters. The enduring concept of threshold is employed in HICA algorithm, which is extremely necessary for some real world applications like fire alerting, environment monitoring, etc. The sensors send its sensed value to the CH only when the value is above the threshold value (t) which is set in the sensor nodes. This concept reduces the number of redundant information transmission. Significantly, this threshold will also further decrease the quantity of transmission if there is minute or no alteration in the values of sensed attributes. The value of this threshold can be tweaked during configuration for controlling the quantity of packet transmission. The aggregated information gets transmitted by the CH to the grid nodes less occasionally. This idea of threshold is engaged here to evade needless transmissions among sensor nodes, CH and grid nodes, thereby cutting down substantial energy usage. For O-LEACH, a node *n* selects an arbitrary number between 0 and 1 and calculates a threshold *T*(*n*) (equation 3) as follows if n belongs to G.

$$T(n) = \frac{P}{1 - P \times \left(r \bmod \frac{1}{P} \right)} \quad (3)$$

Where, P represents the percentage of sensors that could convert to CH at any time, 1/P represents the quantity of sub-intervals of the interval, r is the present sub-interval, G is the group of sensors which have not yet functioned as CH at the present interval. On comparing the random value with their threshold value, a sensor could act as CH or follower in any one of 1/P sub-intervals of an interval. If the random value is less than the threshold value T(n), the sensor chooses in becoming a CH. Else, it selects itself in becoming a follower. During the initial sub-interval of an interval, every node has a possibility P for becoming a CH. The sensors that were CHs during the initial sub-interval are not permitted to be CHs in the subsequent (1/P – 1) sub-intervals of the same interval.

The suggested HICA procedure will set the threshold value at the sensor node level for avoiding redundant information transmission towards CHs. This threshold value K_{thres} will be calculated by the expression assumed in equation 4.

$$K_{thres} = \frac{\sqrt{n}}{\sqrt{2\pi}} \sqrt{\frac{E_{CAE}}{E_{BAE}}} \frac{M}{{D_{BS}}^2} \quad (4)$$

Where, N is the quantity of sensors in the network, M is the dimension of the sensing area, D_{BS} is the distance among the CH and the BS, E_{CAE} amplifier energy of CH and E_{BAE} is the amplifier energy BS correspondingly. For finding optimal threshold value equation 5 is engaged.

$$K_{thres(opt)} = \frac{\sqrt{n}}{\sqrt{\pi}} \sqrt{\frac{E_{CAE}}{E_{BAE}}} \frac{M}{{D_{BS}}^2} \quad (5)$$

In CH level there becomes mandatory in finding optimum probability of selection of CHs which is depending on energy comprising of processing energy and energy necessary towards data aggregation, and is enumerated in equation 6.

$$P_{(opt)} = \frac{1}{2} \sqrt{\frac{E_{CAE}}{\lambda (E_{BAE} {D_{BS}}^4 - E_{ELEC} - E_{DA})}} \quad (6)$$

Where, λ represents the concentration of sensor nodes, E_{ELEC} signifies the energy necessary for sensing, coding, modulation etc. and E_{DA} signifies the energy essential towards data aggregation. The energy expended at the CH level towards data aggregation E_{DA} is entailed in equation 7.

$$E_{DA} = \sum_{i=1}^{n} E_{IN\,(i)} \quad (7)$$

Where, E_{IN} signifies the energy expended by CH for processing data of every individual sensor inside a specific cluster. Commonly, E_{DA} will be proportionate to the quantity of sensors in the clusters and rises in linear manner with the increase in number of cluster nodes.

Considering single WSN field with N-nodes and n-clusters, the complete energy usage E_{TOT} (equation 8) for one comprehensive cycle will be on the basis of communication energy E_{Comm} of a sensors, sensing energies E_{Sense} and processing energies E_{Proc} of the sensor nodes in the sensor network.

$$E_{TOT} = \sum_{j=1}^{N} (E_{\mathrm{Comm(j)}} + E_{\mathrm{Sense(j)}} + E_{\mathrm{Proc(j)}}) + E_{DA} \quad (8)$$

The suggested HICA procedure could be proficiently employed for connecting two separate wireless sensor network fields by using grid nodes as connecting medium. As we are considering two separate sensor fields, the overall energy E_{Over} (equation 9) expended by the sensors inside two fields will be on the basis of the consideration of the energies expended at the grid node level E_{DRNs}

$$E_{Over} = 2 \times E_{TOT} + E_{DRNs} \quad (9)$$

4. SIMULATION STUDY

4.1 Simulation Settings

For concentrating on energy consumption, first-order radio model as defined in [5] has been engaged. Every simulation works have been carried out using the network simulator NS-2. The suggested distributed clustering procedure has been simulated with 30 sensor nodes over a sensor field of dimension 500mx500m sensing area, and at every time duration the energy exploitation, remaining energy, etc are noted. Lastly, the performance of the proposed HICA algorithm is assessed against two existing clustering algorithms O-LEACH and HEED on the basis of the above recorded values.

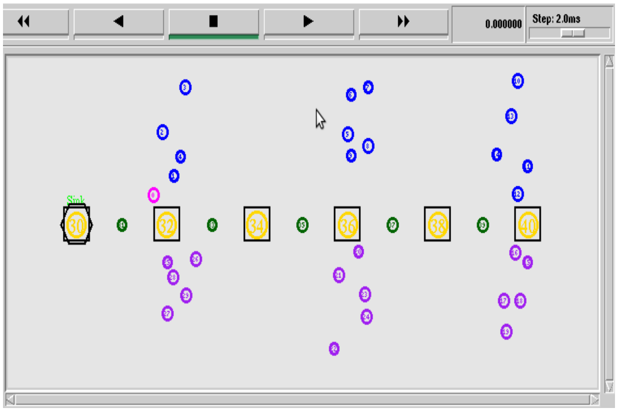

Figure 1. Snapshot signifying two WSN fields linked by grid nodes in HICA algorithm.

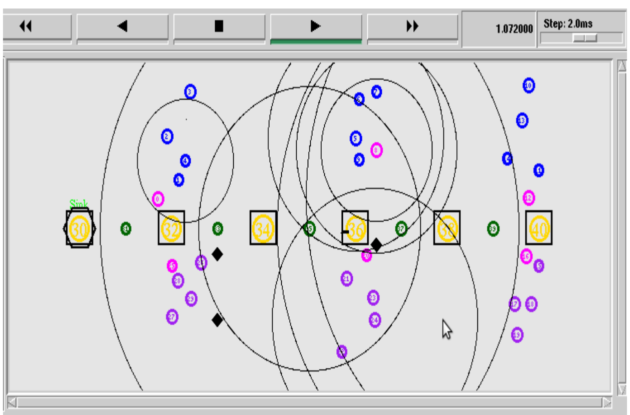

Figure 2. Snapshot signifying CH rotation in HICA algorithm.

4.2 Simulation Results

The suggested procedure HICA has been simulated and the outcomes are documented for network lifetime over number of rounds, energy remaining against time, energy consumption, throughput and CH selection against number of rounds. These parameters are then evaluated with the well-evaluated prevailing procedures O-LEACH and HEED.

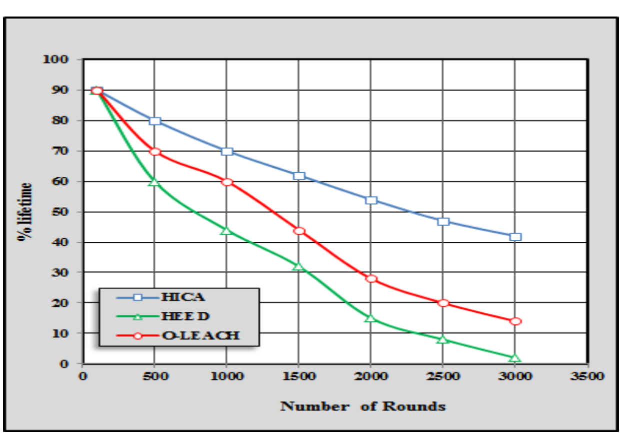

Figure 3. Lifetime against Number of Rounds (HICA, O-LEACH and HEED).

First, the proposed HICA algorithm is evaluated in terms of the network lifetime and compared with O-LEACH and HEED. From figure 3, the network lifetime of HICA increases broadly when compared to O-LEACH and HEED. HICA employing grid nodes, range-based transmission power, one-step clustering mechanism and cluster head panel for connecting two distant sensor fields is the major reason for this improvement.

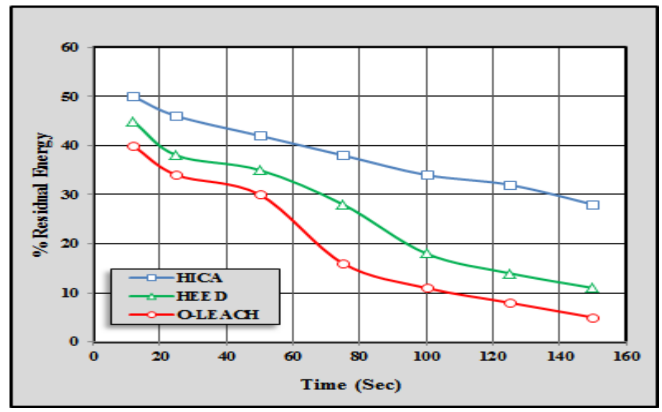

Figure 4. Residual Energy against Time (HICA, O-LEACH and HEED).

Originally at 100 rounds, the percentage lifetime is 90 for all the three algorithms. Considering the situation at 500 rounds, the percentage lifetime is 80 in HICA, but in O-LEACH and HEED the percentage lifetimes are 72 and 60 respectively. This reduction (in O-LEACH and HEED) is mainly due to the exponential increase in communication energy.

Similarly in 3000 rounds, the percentage lifetime of HICA is 44, but in the two existing algorithms O-LEACH and HEED, the percentage lifetime is found to be significantly reduced to 14 and 2 correspondingly. At an average, HICA shows 50% and 29% lifetime improvement over HEED and O-LEACH correspondingly. This obviously displays that HICA could be effectively employed towards dense wireless sensor network.

Residual energy is the total energy residual inside a specific sensor subsequent to specific number of rounds. A procedure which makes best use of the residual energy inside a sensor node is said to be appropriate. Figure 4 depicts the performance assessment of HICA in terms of residual energy in judgment with O-LEACH and HEED. At specific instance of time, the complete residual energy of all the sensors in the WSN system is the dissimilarity among the complete initial energies of all the sensors and their associated communication energies. The total residual energy every sensors in WSN system is articulated as

$$E_{RES(T)} = E_{INI} - E_{TOT(T)} \tag{10}$$

Where, ERES(T) is the total residual energy of the complete WSN system at specific interval T, EINI is the total of initial energies of every nodes in the WSN system and ETOT(T) is the total energy expended by every nodes in the WSN system at specific interval T. At the commencement of the clustering process, residual energies of all the nodes in the system (ERES) corresponds to the initial energy of every nodes in the system (EINI) and is enumerated as in equation 11.

$$E_{RES} = E_{INI} \tag{11}$$

At 10 seconds, the percentage residual energies of O-LEACH, HEED and HICA are 40%, 45% and 50% correspondingly. A 10% increase and 5% rise in residual energies is realized in HICA in evaluation with O-LEACH and HEED even at the very beginning, which is primarily due to the engagement of zone-dependent transmission power. At 150 seconds, the percentage residual energies of O-LEACH, HEED and HICA are 5%, 11% and 27% correspondingly. Thus the performance of HICA is much enhanced in terms of residual energy till the last node ends-up functioning.

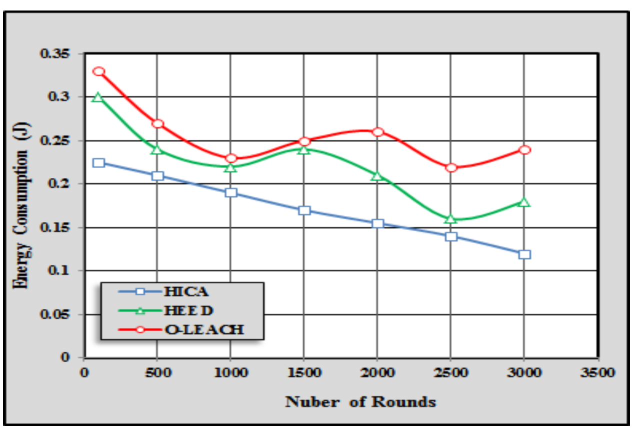

Figure 5. Energy Consumption against Round Number for the three Algorithms

Figure 5 illustrates the performance comparison of HICA with respect to energy utilization against O-LEACH and HEED. Initially at 100 rounds, the energy utilization of O-LEACH, HEED and HICA are 0.33, 0.30 and 0.225 Joules respectively. The total energy utilization of the two WSN fields, is due to the effect of total energy utilization of the wireless sensor nodes in the two fields and the distributed relay nodes. The energy utilization is greatly reduced at the GN level in HICA. At 3000 rounds, the energy utilization of O-LEACH, HEED and HICA are 0.240, 0.180 and 0.125 Joules respectively. A reduction in energy utilization of 0.055 Joules and 0.115 Joules is seen in HICA over HEED and O-LEACH at the final round. For a perfect and reliable sensor system, the slope of the resulting curve should be minimum with lesser irregularities.

HICA displays better output when compared with the two existing algorithms. The energy utilization of HICA is less when associated with O-LEACH and HEED. This lesser energy utilization is mainly achieved at the clustering level, GN level and also due to zone-dependent transmission power. Less energy is used by the nodes that are in first zone and maximum energy is used only by the nodes that are in the last zone. But in the two existing algorithms, maximum energy (equal to the energy used by the last zone nodes in HICA) is used by every node in the WSN system.

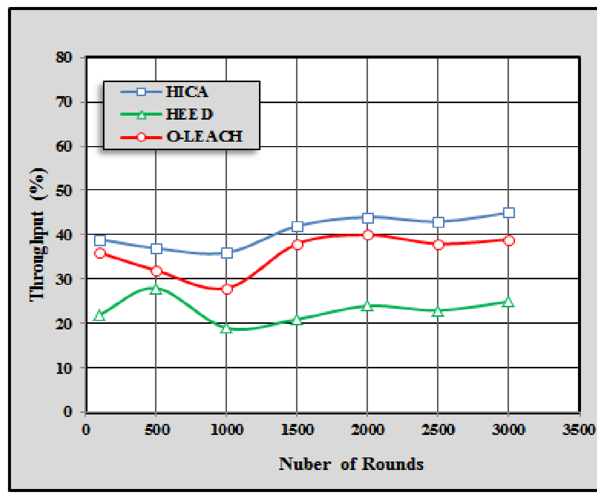

Figure 6. Throughput against Round Number for the three Algorithms.

Figure 6 illustrates the performance evaluation of HICA in terms of throughput in comparison with O-LEACH and HEED. Originally at 100 rounds, the throughput of HEED, O-LEACH and HICA are 22%, 32% and 40% correspondingly. An 18% and 8% alteration in throughput is seen over HEED and O-LEACH very initially. HICA use threshold based techniques at sensor node level, which lessens undesirable packet transmissions thus leading to better throughput. Also the information packets are transmitted by CHs to GNs only at fixed intervals of time. At an average, 46% upgrading and 22% upgrading in throughput is seen in HICA, over HEED and O-LEACH for every 3000 rounds. Thus in HICA, the packets are more effectively transported to the BS with lesser packet drop. Thus HICA can be instigated in WSN fields, where throughput is a major parameter under deliberation.

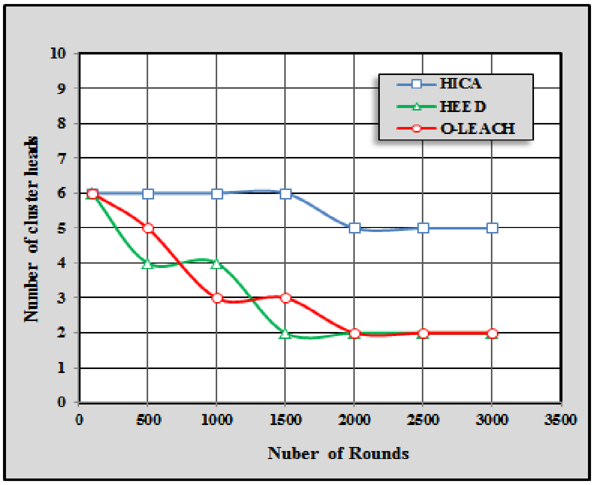

Figure 7. Number of cluster heads versus Round Number for the three Algorithms

Figure 7 demonstrates the assessment of the number of CHs elected for specific number of rounds. Random CH selection in O-LEACH results in failure of a specific cluster, when a sensor possessing very diminutive remaining energy is arbitrarily elected to be a CH. For an active and optimum clustering mechanism, the number of CH should not decline speedily for succeeding rounds. For a network with 30 nodes, till 100 rounds all the three procedures have 6 cluster heads. But at 500 rounds, the cluster heads of HEED, O-LEACH and HICA are 4, 5 and 6 respectively. Thus the cluster head failure is less in the proposed HICA algorithm mainly because of the employment of cluster head panel.

5. CONCLUSION

This research work proposed a well-distributed clustering algorithm, hybrid integrated clustering algorithm (HICA) in which the optical fiber link is complemented by grid nodes for connecting two separate sensor fields. The suggested algorithm is a hybrid and integrated clustering procedure which employs grid nodes, range-based transmission power, one-step clustering mechanism and cluster head panel. The assessment towards the suggested procedure is done against O-LEACH and HEED. Simulation outcomes obviously display an excellent upgrading in network lifetime, improved residual energy, reduced energy consumption, improved throughput and evenness in cluster head selection, thereby applicable for connecting two detached WSN fields. Nevertheless, the suggested procedure can greatly extend the complete network lifetime of the WSN system.

REFERENCES

[1] Lianshan Yan, Wei Pan, Bin Luo, Xiaoyin Li, Jiangtao Liu, (2011), “Modified energy-efficient protocol for wireless sensor networks in the presence of distributed optical fiber sensor link”, IEEE Sensors Journal, Volume 11, Number 9, pp 1815-1819.

[2] O.Younis, S.Fahmy, (2004), “HEED: A hybrid energy-efficient distributed clustering approach for Ad Hoc sensor networks”, IEEE Transactions on Mobile Computing.

[3] H.Chan, A.Perrig, (2004), “ACE: An emergent algorithm for highly uniform cluster formation”, in Proceedings of 1st European Workshop on Sensor Networks (EWSN), Germany.

[4] Guangfeng Li, Taieb Znati, (2007), “A ring-structured energy-efficient clustering architecture for robust communication in wireless sensor networks”, IJSN, Volume 2.

[5] W.Heinzelman, A.P.Chandrakasan, H.Balakrishnan, (2002), “Application specific protocol architecture for wireless microsensor networks”, IEEE Trans. on Wireless Networking.

[6] R.Nagpal, D.Coore, (1998), “An algorithm for group formation in an amorphous computer”, in Proceedings of the 10th International Conference on Parallel and Distributed Systems.

[7] A.Youssef, M.Younis, M.Youssef, A.Agrawala, (2006), “Distributed formation of overlapping multi-hop clusters in wireless sensor networks”, in Proceedings of the 49th Annual IEEE Global Communication Conference (GLOBECOM ’06), San Francisco, CA.

[8] M.Demirbas, A.Arora, V.Mittal, (2004), “FLOC: A fast local clustering service for wireless sensor networks”, in Proceedings of Workshop on Dependability Issues in Wireless Ad Hoc Networks and Sensor Networks (DIWANS’04).

[9] P.Ding, J.Holliday, A.Celik, (2005), “Distributed energy efficient hierarchical clustering for wireless sensor networks”, in Proceedings of the IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS’05), Marina Del Rey, CA.

[10] A Novel and Enhanced Distributed Clustering Methodology for Large Scale Wireless Sensor Network Fields, Journal of Computational and Theoretical Nanoscience, Volume 16, Number 2, February 2019, pp. 633-638(6), 2019.

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