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ENERGY EFFICIENT CLUSTER HEAD SELECTION IN WSN – A SURVEY

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ABSTRACT: Applications for Wireless Sensor Networks (WSN) have increased dramatically in the earlier decade. Clustering is a mechanism employed in WSNs to increase the network's lifespan and offer more effective operational processes. The process of creating many clusters within a sensor network's sensing field is known as clustering. Every cluster selects a leader, also stated as a cluster head. The network administrator may pre-assign a cluster head or the sensor nodes within the cluster may decide the cluster head. In the network, optimized clustering can save a great deal of energy. The tiny sensor node in a WSN utilizes a tiny, energy-constrained battery. There is no way to change or replenish the battery. Thus, WSN's energy-efficient operation is the crucial element. WSN strategies have been proposed by numerous researchers in an effort to maximize WSN energy and lifespan. This document reviews a number of widely used WSN protocols, primarily LEACH, HEED, SEP, DEEC, DDEEC, EESAA, IAATPC and EESCA.

Keywords: Low-energy adaptive clustering hierarchy (LEACH), Hybrid Energy-Efficient Distributed Clustering (HEED), Stable Election Protocol (SEP), Distributed Energy Efficient Clustering Protocol (DEEC), Developed Distributed Energy-Efficient Clustering (DDEEC), Energy Efficient Sleep Awake Aware (EESAA), Interference Aware Adaptive Transmission Power Control (IAATPC), Energy-Efficient Structured Clustering Algorithm (EESCA)

1. INTRODUCTION

WSN is a newly industrialised platform that has real-time applications in a variety of disciplines, including agriculture, the military, home networks, the healthcare system, entertainment, and other areas [1]. The use of WSNs in the actual world is expanding, particularly in areas such as residential and industrialised domains, as well as security surveillances. A WSN is constructed by several tiny sensors that have memory, CPUs, and short-range communication features. The sensor nodes work together to gather information about the phenomenon being observed.

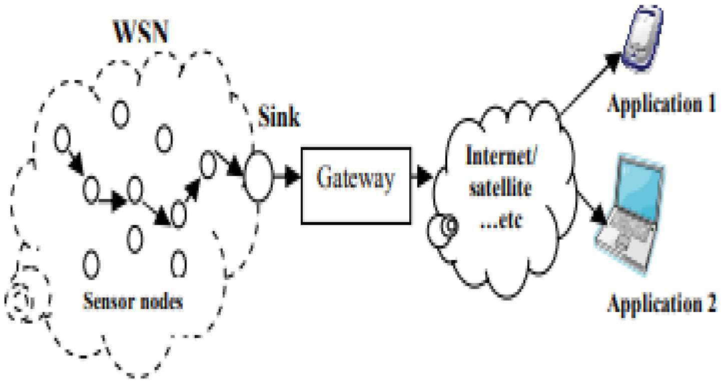

Figure 1 Typical Architecture of Wireless Sensor Network

The standard layout of a WSN is shown in Figure 1. It is formed up of three primary kinds of nodes: sinks, gateways, and sensors. The sinks receive information from every sensor and communicate with apps through the gateway, whereas the sensors carry out real-time sensing [3]. The final one, which has two network interfaces, serves as a conduit among the WSN and the external environment by converting protocols and carrying out the necessary mapping. The sink and the gateway are typically positioned together and are just termed the sink or the gateway.

Wireless propagation is used to carry information from the source node (sensors) to the end node (endpoint) over a wireless connection [4]. Saving energy is one of the important innovative approaches that need to be suggested with a view to regulate this data transmission. Each sensor uses 1nJ (1*10-9 joule) of energy for analysing a command, according to the research [5].

A cluster of sensors in a WSN selects a cluster head, or CH. Cluster nodes are responsible for data aggregation and data communication with CH. The base station (BS) receives the data that CH has compiled and processed [6]. Energy was thus depleted in CH high. Therefore, in order to ensure better node and network life, researchers have suggested choosing CH energetically within the cluster to address this issue [7]. Gathering data from the sensor node, combining it, and sending it to BS is the primary duty of CH. Therefore, it is crucial to carry out research to increase node energy and, in turn, network longevity.

2. LITERATURE REVIEW

Adumbabu and Selvakumar [8] presented an energy-efficient routing system based on dynamic cluster heads. In this instance, the three steps of the ICOA are setup, transmission, and measurement. The path between the BS and the CH is then determined by the IJO-LF. According to the node degree, distance, and remaining energy, it chooses the best course. When using the MATLAB system for execution, the recommended strategy is contrasted with conventional techniques and the routing protocols PEGASIS and TEEN. According to the recommended methodology, the BS gathers data packets, energy consumption, alive nodes, and dead nodes are used as performance indicators.

Rao et al [9] suggest PSO-ECHS, a cluster head selection method built on the principles of PSO. An effective particle encrypting and fitness technique is used in the development of the program. Many variables are considered, which involves the intra-cluster distance, and the residual energy of the sensor nodes, to determine the energy efficiency of the suggested PSO technique. Additionally, cluster creation whereby non-cluster head sensor nodes connect to their CHs according to a weight function that is computed. The process undergoes rigorous testing on a range of WSN scenarios with dissimilar numbers of CHs and sensor nodes. To show how much better the suggested method is, the results are contrasted with those of a few other algorithms that are currently in use.

Jadhav and Shankar [10] WOA-Clustering (WOA-C), a cluster head selection approach created by the WOA, is suggested. Thus, the suggested approach assists in choosing power-conscious cluster heads by employing a fitness parameter that requires the node's remained energyas well as the total energy of neighboring nodes. The suggested method is assessed by throughput, power efficacy, and overall stability. Additionally, WOA-C's performance is assessed in comparison to other widely used modern routing protocols, such LEACH. Numerous simulations demonstrate the suggested algorithm's improved results with regard to of stabilization duration, network lifespan, and remaining energy.

Praveen Kumar Reddy and Rajasekhara Babu [11] suggested a cluster-based routing method that makes use of cluster formation is termed as LEACH. The LEACH designates one head, including the CH, among the network sensor nodes in an attempt to rotate its workload to a newly shared energy load. The CHs were selected at random, and it's possible that some of them are concentrated in a single area. The main rationale for this kind of dynamic clustering was that the CH and advertising adjustments led to increased overheads. Large networks were therefore not a good fit for the LEACH. In this case, the CH selection is optimized by the use of PSO and RFD. The outcomes demonstrated that, in comparison to alternative approaches, the suggested method had performed better.

Sekaran et al [12] introduced the grey wolf optimization method (GWO), to offer the GWO-CH, a unique cluster head selection strategy that takes the intra-cluster, residual energy, and sink distance into account. Furthermore, it developed an objective function and weight factors to ensure effective cluster creation and cluster head selection. The quantity of sensor nodes and cluster heads is changed to test the suggested technique in various wireless sensor network settings. The observed results demonstrate that, when compared to alternative methods, the recommended method achieves better according to improved network performance.

Doryanizadeh et al [13] Proposed for a multihop IoT, an EEMST is provided to choose the best data routing and cluster head founded on graph theory. Based on a weighted graph, this approach determines the least spanning tree based on Euclidean distance. Consequently, in order to select the best cluster head and ascertain the quickest route for data transfer across the cluster head and member nodes, employ a weighted minimum spanning tree. Intercluster single-hop routing as well as intracluster multihop routing are possible with the suggested EEMST algorithm. In comparison to baselines, the simulated experimental findings validate a noteworthy enhancement of the suggested algorithm in the lifetime of IoT systems.

Babu et al [14] proposed the GWO and its improved variations are suggested. The retaining energy at the sensor node and sink distance to CH are used to define the fitness function. Cost-effective routing and an effective CH selection are provided by the fitness function's optimal values. The core objective is to use the IGWO process to pick CHs optimally to optimum the WSNs. The suggested IGWO-based LEACH technique addressed early convergence, established the optimum selection of CH with the lowest amount of power use, and extended the network's lifespan by balanced the amount of active and dead nodes in WSN.

Jagan and Jesu Jayarin [15] introduced a novel FCEEC method that generates the electrostatic discharge method to build an interconnected system with the shortest possible routing from SNs to CH in a multi-hop circumstance. The suggested ESDA achieves comprehensive and highly efficient link among sensor nodes while prolonging the network lifespan. ESD lengthens the system's period by drastically lowering the quantity of dead nodes. Ultimately, when compared to other traditional CH selection methods, simulation results showed enhanced performance metrics like energy economy, dead node count, and network latency.

Lavanya and Shankar [16] proposed the Camel algorithm's random occurrences through the EHO process for the best CHS, a brand-new CSEHO method is put forth. For the scavenging process, it mimics the nomadic behaviours of a camel in the desert. While the EHO optimally compensates for the study inadequacy of a Camel system, exploit performance is increased by the Camel algorithm's availability tracking requirement. The higher performance of the suggested CSEHO process is confirmed through performance comparison with several different CHS algorithms that are currently in use. The provided CSEHO algorithm outperforms CA, EHO, LEACH, PSO, and DT, in that order, in terms of total attainment.

Prakash and Pandey [17] proposed the use of the M-PSO algorithm to pick CHs and NCHs in a new DMPRP. The best cluster heads were chosen after the probabilities were calculated, and the outcomes were then utilized to discover the optimal direct path utilizing the GA. The GA determines the best route by using an objective function made out of a network.

Abraham and Vadivel [18] introduced for cluster head (CH) selection, the Flamingo Search Algorithm is used due to its great solidity and short computation complexity. Ultimately, the Q-Learning technique is utilized to choose the most direct route between CHs and BS due to its ability to identify paths in intricate network conditions. In this method, the goal function which assesses the separation amongst BS and CH, the coverage range and energy usage generates the reward points. According to alive nodes, rounds for past node dead, time consumption, half node dead, first node dead, and overall remained energy, experiments are assessed and analysed using the methods currently in use. The findings demonstrate that, in comparison to comparable current methods, the proposed technique can improve WSN's energy efficiency.

Chung et al [19] proposed a cluster head selection is frequently optimized using genetic-based evolutionary processes like DE and GA to extend network lifespan and improve energy utilization. Thus, in order to ascertain the effectiveness of GA and DE in cluster head selection optimization, their performances are assessed using comparative analysis. According to simulation studies, GA surpasses DE in terms of network longevity, with a greater round number for First Node Deaths (FND) but a lower round number for Last Node Deaths (LND).

Additionally, compared to DE, GA results in a network with fewer transmission problems. Conversely, GA has a slower rate of fitness convergence but a larger population fitness value.

Zhao et al [20] proposed a revised LEACH centered cluster-head selection technique called LEACH-M. The cluster-head threshold equation was optimized by considering both the nodes' network locations and remaining power, based on the ZigBee Distributed Address Assignment Mechanism (DAAM). Furthermore, by using a cluster-head competing method, LEACH-M distributed the energetic load on the system and greatly boosted energy conservation. The volume of data obtained at the BS can be improved by the recommendation technique, reduce energy utilization, and lengthen the network period, Utilizing the findings in NS-2.35.

Kusla and Brar [21] suggested a cluster head selection method according to meta heuristics created African Vultures Optimization Process, and it has proven to be more effective than previous cutting-edge methods. Cluster compactness, remaining energy, and intra-cluster range are considered into while choosing CH with a multidimensional value. When the CHs are identified, data flow among the CHs to the BS proceeds. The nodes' remaining energy is updated at the end of the data transfer. Data were analysed according to average electrical utilization, overall energy use, network lifespan, and throughput utilizing two different WSN settings.

Rawat et al [22] suggested the ECSS is a clustering protocol. The suggested ECSS protocol choose a CH, which extends the network's period and improves its overall efficacy. The energy levels of nodes are utilized by the ECSS protocol for the CH selection procedure. The suggested procedure is made for a diverse location and is intended to minimise the energy value used by the network, extending its lifespan. Using the MATLAB simulator, through a comparative analysis of multiple existing standards, the efficacy of the suggested ECSS method is assessed. The simulation's findings demonstrate how the suggested ECSS procedure has improved the network's throughput, longevity, and energy usage.

Table 1. Comparison of Cluster Head Selection methods in WSN with Existing Methods

Author	Methods	Merits	Demerits
Adumbabu and Selvakumar [8]	Improved Coyote Optimization Algorithm (ICOA), Improved Jaya Optimization Algorithm with Levy Flight (IJO-LF),	Along with increasing the network lifespan, general energy usage is optimized.	Selecting the CH and efficient route creation are considered issues.
Rao et al [9]	Particle Swarm Optimization- energy efficient Cluster Head Selection	It increases the amount of resources consumed overall, the lifespan of the network, and the quantity of data packets the BS receives.	With the right metaheuristic strategy, attempt to create a routing system.

Jadhav and Shankar [10]	Whale Optimization Algorithm (WOA)-Clustering	Its ability to choose cluster heads for maximum energy utilization and outperforms other contemporary routing protocols.	The data transmission is one of the biggest reasons for energy depletion in WSN.
Praveen Kumar Reddy and Rajasekhara Babu [11]	Low-Energy Adaptive Clustering Hierarchy (LEACH)	In addition to its rapid converge, it provides greater integrity and the ability to evade the local optima.	Energy-efficient solutions are nonexistent in large-scale WSN.
Sekaran et al [12]	Grey Wolf Optimization Algorithm	enhances weight variables, renewable variables to choose the best CHs and develop clusters.	Need to improve load balancing, fault tolerance by using heterogeneous network.
Doryanizadeh et al [13]	Energy Efficient Minimum Spanning Tree (EEMST)	Transmission amongst the member node and cluster head take shortest path and improves the energy efficient.	enhance precise weights and increase the correctness of selecting process.
Babu et al [14]	Metaheuristic Algorithm	Maximize the network Lifetime, Economical routing and proper CH selection are provided by the fitness function's greatest values.	Need to reduce the quicker rate of energy depletion at CHs.
Jagan and Jesu Jayarin [15]	Fully Connected Energy Efficient Clustering (FCEEC)	Longer network lifespans are achieved by drastically lowering the quantity of dead nodes.	Need to eliminate redundant data being transmitted.
Lavanya and Shankar [16]	camel Series Elephant Herding Optimization Algorithm (CSEHO)	It improves energy consumption, fitness function, and develops the proficiency of exploitation.	The EHO method optimally compensates for the search inefficiencies of the Camel method.

Prakash and Pandey [17]	Modified -Particle Swarm Optimization (M-PSO) and Genetic Algorithm (GA)	By choosing the CH, it enhances the effective ECR to equalize the load and boost effectiveness.	It is necessary to select CHs and NCHs and employ clusters to enhance sensor nodes.
Abraham and Vadivel [18]	Flamingo Search Algorithm	To enhance the energy efficiency, alive node, time consumption, throughput and whole remaining energy.	Need to reduces the transmission distance, creation of clusters to prevent the less energetic nodes.
Chung et al [19]	Genetic-Based Evolutionary Algorithms	It leads to a network with lower number of transmissions, fitness Convergence and fitness value of populations.	Need to improve better ability in exploring and exploiting the solution space.
Zhao et al [20]	Modified Cluster Head Selection Algorithm based on LEACH-M	It increases the quantity of data obtained at the BS, minimizes usage of energy, and extends the network's life.	The irrational cluster-head selection and high energy usage in WSN
Kusla and Brar [21]	African Vultures Optimization Algorithm	It enhances the system's longevity and lessens its average energy usage.	Need to develop a routing technique employing a meta-heuristic technique.
Rawat et al [22]	Energy Efficient Cluster Head Selection Scheme (ECSS)	The standard focuses on choosing the CH, that contributes to improving the network's entire lifespan and efficiency.	It is necessary to increase the node's battery capacity and the network's lifespan.

INFERENCE

These methods consider the cluster head's role rotation in the neighboring cluster as an element for selecting a cluster head for a cluster under examination. Cluster head selection in a cluster to the BS affects the cluster head's energy usage in the cluster under evaluation whilst employing multihop data forwarding to transport the cluster data to the BS. The space across cluster heads in adjacent clusters needs to be generally constant during data collecting cycles to maintain the same energy consumption. Energy savings throughout cluster formation are expected to come from fewer transmissions and receptions from cluster heads.

3. CLUSTER HEAD SELECTION

The partition of a collection of data (or objects) into a series of logical components, referred to as clusters, is the clustering approach. This enables users to think about classification or standard form within a dataset. High-quality clusters with high intra-class and between-class similarity are produced by a good clustering technique. Both the comparison and the method's application affect how effectively the clustering result turns out. The clustering system's ability to find any or all of the cached pattern is another factor used to determine consistency.

3.1. CLUSTER-BASED ROUTING AND CHS

Cluster-based routing techniques serve as the foundation for hierarchical routing. Higher-energy nodes are designated as cluster chiefs by this protocol, which groups nodes into clusters. Numerous factors affect cluster design, such as the quantity of clusters and their communication, node kinds, CH mobility, number of nodes, CHS, and multi-level clustering. The clustering design is primarily concerned with energy and network longevity. As seen in Figure 2, clustering arranges a network to a linked hierarchy while balancing network load and extending system lifespan.

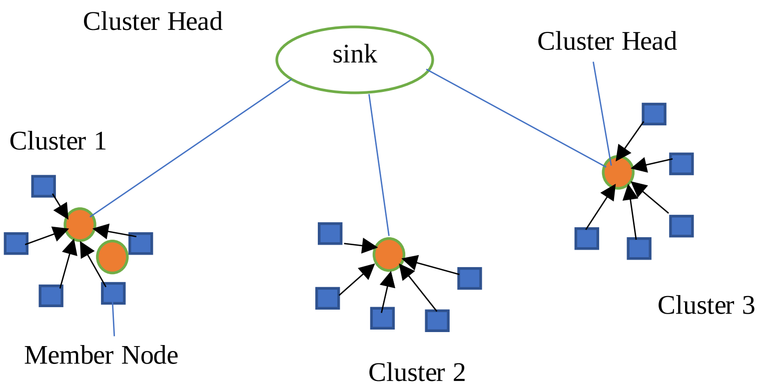

Figure.2. Energy-Efficient Cluster Head Selection

3.1.1. Low-Energy Adaptive Clustering Hierarchy (LEACH) (2000):

The creation of LEACH clusters is dispersed. Every sensor node has the random opportunity to be the head during each round of this method, which rotates CH across all nodes. A sophisticated hierarchical clustering mechanism called LEACH is used to reduce the network's energy loss. This technique uses a random rotation for CH selection and well-coordinated cluster setup and operation with localized control. Global transference from the CH to the BS is reduced using local compression techniques [23].

These factors indicate that LEACH surpasses substitute static clustering methods that choose the highly energetic nodes to be CHs. LEACH minimizes transmitting energy by a factor of eight as contrasted with equivalent standard transmission & energy routing approaches. As indicated by the threshold T(n) in Eq. (1), the choice of CH is reached.

$$T(n) = \begin{cases} \dfrac{P}{1 - p * \left(r \, mod \, \dfrac{1}{p}\right)} & if \; n \in G \\ 0 & otherwise \end{cases} \tag{1}$$

G is the quantity of nodes which stayed ignored as CH in the previous $\frac{1}{p}$ rounds, and P is the chance to acquire CH. The quantity of rounds is indicated by r.

Advantages in the LEACH protocol are:

1. In sensor networks, the most popular hierarchy routing techniques.

2. The entire wireless sensor network is previously separated into numerous clusters by the LEACH protocol. As a result, each node can distribute the burden placed on Cluster heads equally. Every node that provided the CH in the current round is not eligible to be chosen as the CH again.

3. The cluster head node is chosen at random, and the average energy consumption of the whole network determines the equal probability of each node being chosen as the cluster head. LEACH will therefore prolong the network's life cycle.

Drawbacks in LEACH:

1. When choosing CH, the remaining energy between the nodes has not considered.
2. It was decided to employ random and variable size clustering.
3. The CHs are distributed unevenly and randomly. When energy consumption from CH to BS is lower, single-hop transmission has been suggested.

3.1.2. Hybrid Energy-Efficient Distributed Clustering (HEED) (2004)

It generalizes the initial system of LEACH by employing remaining energy as the main variable and network layout includes node degree and distances to neighbours as additional variables to dissolve the tie among potential cluster heads and as an indicator for cluster preference to accomplish power balance purposes. For every node that isn't encompassed by a cluster head, the probability of it acquiring a cluster head is doubled during every iteration of the clustering procedure [24]. Each node can choose its place in the clustered network freely and probabilistically thanks to these energy-efficient clustering methods. Furthermore, they are unable to ensure the best elected group of cluster chiefs.

Advantages of HEED protocol are:

1. It is a method of distributed clustering which makes utilization of the two essential CH election parameters.

2. Lower cluster intensity levels encourage greater spatial reuse, while greater cluster power rates are required for inter-cluster transmission. This results in load balancing and consistent CH distribution throughout the network.

3. Compared to single-hop communication, while the LEACH protocol employs direct long-distance interactions from CHs to the sink, multi-hop interaction among CHs and BS allows for greater scaling and energy savings.

Limitations with HEED protocol:

1. Certain nodes remain exposed when tentative CHs fail to materialize into final CHs. These nodes are compelled to become CHs due to the introduction of HEED, and these forced CHs may or may not have any related members or may be within communication range of other CHs. This leads to the generation of more CHs than anticipated, which is also the cause of the network's uneven energy consumption.

2. The clustering in every round places a large burden on the network, much like LEACH does. The network lifetime is shortened by this overhead due to its exceptional energy dissipation.

3. Because HEED requires multiple iterations to construct the clusters, it suffers from a subsequent overhead. As such, a large number of packets are broadcast throughout each iteration.

4. Certain CHs, especially those next to the sink, have a heavy duty and may pass out sooner.

3.1.3. Stable Election Protocol (SEP) (2004)

Additionally, the LEACH protocol has been further modified by this protocol. The protocol is aware of heterogeneity and allows for the weighted selection of each node's likelihood of becoming the cluster leader based on its unique energy. This method provides proper utilization of the nodes' energy by ensuring that the cluster head election is picked at arbitrary and allocated based on each node's energy allocation [25]. Two kinds of nodes two tiers in clustering and two-level hierarchies were taken into consideration in this protocol.

By leveraging the heterogeneity constraints, the SEP optimizes the constant region of the clustering hierarchical process. This is the percentage of the progress node (m) and increased energy factor (α) compared to normal and advance nodes. Assuming the starting energy of every typical sensor were E_o. subsequently $E_o(1 + \alpha)$ is the energy of each and every proceeded node. Equation 2 displays the innovative heterogeneity network's total energy.

$$n.(1-m).E_O + n.m.E_O(1+\alpha) = n.E_O.(1+\alpha.m) \quad (2)$$

here α specify added energy factor amongst normal and advance node, m displays the advanced node fraction, and n specifies the entire population count within the cluster. Equation (3–4) provides the assessed probability for advanced and normal node.

$$P_{nrm} = \frac{P_{opt}}{1+\alpha.m} \quad (3)$$

$$P_{adv} = \frac{P_{opt}}{1+\alpha.m} * (1+\alpha) \tag{4}$$

Where P_{opt} indicates optimal population, P_{nrm} displays the normal node probability and P_{adv} specifies the advance node probability. The advance node and normal node thresholds were T_{adv} and T_{NRM} revealed in (5-6).

$$T_{Nrm} = \begin{cases} \dfrac{P_{nrm}}{1 - P_{nrm} * \left(r \bmod \dfrac{1}{P_{nrm}}\right)} & if\ n_{nrm}\ \epsilon G' \\ 0 & otherwise \end{cases} \tag{5}$$

$$T_{adv} = \begin{cases} \dfrac{P_{adv}}{1 - P_{nrm} * \left(r \bmod \dfrac{1}{P_{adv}}\right)} & if\ adv\ \ \epsilon\ G'' \\ 0 & otherwise \end{cases} \tag{6}$$

The disadvantage of SEP is that it retains the random selection CH method, that has a feature of the LEACH system. The SEP method uses a single-hop transmission technique to send data between its nodes. When there is this kind of communication, the CH node is additional distant from the BS and must use more energy to transmit data over long distances, which shortens its life cycle and causes nodes to die in the network.

3.1.4. Distributed Energy Efficient Clustering Protocol (DEEC) (2006)

The DEEC method is a cluster-based method for multi-level energy heterogeneity WSN. This method selects the cluster heads by applying a possibility depends on the proportion of the remained energy of every node to the network average energy [26]. Nodes in the period of cluster heads varied significantly depending on their original and remaining energy. Nodes with higher original and remaining energy are inclined to develop into cluster leaders than low-energy nodes.

Advantages of DEEC:

1. DEEC never require a comprehensive understanding of energy for each election cycle.
2. DEEC function successfully in multi-tiered heterogeneity wireless connections in contrast to SEP and LEACH.

Drawbacks of DEEC

Advancing nodes in the DEEC tend to penalize, particularly when their remaining power decreases and they become closer to the normal node range. Here, the progressive nodes degrade more swifter than others.

3.1.5. Developed Distributed Energy-Efficient Clustering (DDEEC -2010)

DDEEC outperforms DEEC and SEP in a complex diverse WSN circumstance. An energy-aware dynamic clustering technique is called DDEEC. By using the network's typical energy to arrive to configurable methods. As a result of meticulously dividing the energy used across nodes, the DDEEC established a balanced and adaptive system. According to Eq. (7), the average energy of the r th round is E.

$$E = \frac{1}{N} E_{total} \left(1 - \frac{r}{R}\right) \tag{7}$$

here R indicates that the wireless sensor network's complete round is provided by Eq. (8)

$$R = \frac{R_{total}}{E_{round}} \tag{8}$$

E_{round} is the entire energy dispersed throughout a round in the system. E_{round} is revealed in Eq. (9).

$$E_{round} = \mathrm{L}(2\,\mathrm{N}\,L_{elec} + N\,E_{DA} K\,E_{mp}\,d_{to\,BS}^{4} + N\,E_{fs} d_{to\,CH}^{2} \tag{9}$$

Where N is iterations number, L is message length, K specifies clusters number, E_{DA}has presented the data aggregation expense utilized in the CH. The $d_{to\,BS}$ displayed as the usual length between CH and BS. The $d_{to\,CH}$ provides the average distance between cluster members and the CH.

Drawback in DDEEC:

The advance node in DDEEC continually has less residual energy and turns into a regular node. Therefore, in contrast to normal nodes, the remaining energy of advanced nodes depletes more quickly.

3.1.6. Energy Efficient Sleep Awake Aware (EESAA -2012)

An enhanced strategy for WSNs was unveiled by EESAA [22]. In [18], CHs are chosen at regular intervals and energy is distributed evenly by moving the node. Network energy load is distributed in [19] by either building a chain on its own or by having BS sustain it. The global perception of the network required for the formation of the chain, which ultimately reveals waste of resource.

According to the initial and remaining energy, sensor nodes are chosen separately as CHs in the DEEC method. Advanced and regular nodes are accepted for CH election in the SEP architecture to address the varied system. All of these metrics were attempted to be improved in EESAA while maintaining consistency.

CHs are chosen in EESAA according to remaining energy. EESAA nodes can transition among active and sleep modes in order to save energy. Nodes in active mode will choose itself as CHs during the initial phase, when every node has an identical initial energy E_o, which improves their probability of selecting CH utilizing the shared procedure. As indicated by Eq. (10), each selects a random number from 0 to 1, which it then evaluates to the threshold T_h.

$$T_h = \begin{cases} \dfrac{P_d}{1 - P_d\ (first\ round) mod \dfrac{1}{P_d}} & if\ n\ \epsilon A \\ 0 & otherwise \end{cases} \tag{10}$$

here G is the intended proportion of CHs and A is the quantity of nodes that were in the inactive mode during the initial round.

Drawback in EESAA:

According to the EESAA procedure, a single network

3.1.7. Interference Aware Adaptive Transmission Power Control (IAATPC -2017)

In addition to channel volatility, characteristics of QoS have to be considered into account to improve WSN efficiency. Failures during interaction and cochannel congestion throughout transmission power control (TPC). There are two phases to the suggested method: the operational stage and an initialization stage. The received signal strength indicator (RSSI), signal to interference noise ratio (SINR), basic transmission power, and other variables are evaluated through the startup step in order to determine the data transfer effectiveness and build the communication power matrices. The transmitter node transmitting data streaming to the receiver node during the second step of the suggested method, stated as the active stage. Eq (11) provides the RSSIij. In Equation (12), the values at N_i and N_j are calculated.

$$RSSI_{ij} = 10.q.\log_{10}\left[D_{ij} + I + N\right] \tag{11}$$

$$I = \sum Im \qquad\qquad m = 1\ to\ M \tag{12}$$

Where D_{ij} is the distance amongst node j and node i, I is whole interference energy. whear N is revealed noise power, Im is interfering node m's interference, M is the entire interferer, where "m" denotes the interferer node. Then the $SINR_{ij}$ at N_i OB w.r.t. to Nj OM is calculated utilizing Equation (13),

$$SINR_{ij} = 10.\log_{10}\left[\frac{D_{ij}}{1 + N}\right] \tag{13}$$

here I is whole interference power, D_{ij} is distance among node i^{th} and node j^{th}, and N specifies noise power.

3.1.8. Energy-Efficient Structured Clustering Algorithm (EESCA -2018)

The suggested EESCA [24] be used in environmental monitor fields. Numerous energy-efficient processes, including SEP and LEACH were developed to improve the network. The network lifetime, CH selection procedure, and energy efficiency are the primary areas of attention for the optimized algorithms. EESCA offers a hybrid CH selection procedure and is very easy to use. According to this protocol, CHs are chosen the node's enduring energy and the average communication distance amongst BS and CH. Additionally, a new constraint known as the CH to traditional ratio (CTNR) was developed. The revolution of the CH location amongst the nodes was introduced by it. Within this formula. to calculate the network's stability metrics, such as Execution Time, First Node Die (FND), Load Balancing, Scalability, and Complete Useful Data Percentage (CUDP), which is novel metrical taken into consideration. The writers of this research work can designate roles for normal nodes and CH in accordance with the necessities in each round. The energy dissipated for each round is displayed at Eq. (14-16).

After detecting data from the surroundings, the normal node sends it to CH. As a result, Eq. (14) approximates the whole energy needed for a data packet transmitted to the CH based on the energy necessary for data transfer to the CH.

$$E_r(k,d) = \begin{cases} k\,E_{elec} + k\epsilon_{fs}d^2 \;\; for\ d \le d_o \\ k\,E_{elec} + k\epsilon_{mp}d^4\ for\ d > d_o \end{cases} \tag{14}$$

The CHs separated into two classes: low-level CHs and high-level CHs, according to the remaining energy. Information from cluster member nodes is received by the lower level CH, which then aggregates it and sends it to the higher-level CHs. Therefore, the energy needed overall is represented by E_T in Eq. (15).

$$E_T = k\,E_{elec}\left(\frac{n}{c} - 1\right) + k\,E_{DA}\left(\frac{n}{c}\right) + K\,E_{elec} + \begin{cases} k\epsilon_{fs}d^2_{t\_highCH} \;\; for\ d_{to\_highCH} \le do \\ k\epsilon_{mp}d^4_{to\_highCH} \;\; for\ d_{to\_highCH} > do \end{cases} \tag{15}$$

The cluster member nodes provide information to the upper level CH. Additionally, it gets data from the CH at a lower level, aggregates, and transmits to the BS. For lower layer CH, the high layer CH serves as a relay node. There is single aggregation message sent from the low layer to the CH in the higher tier. ET, the total energy needed, as displayed in Equation (16).

$$E_T = k\,E_{elec}\left(\frac{n}{c} - 1\right) + k\,E_{DA}\left(\frac{n}{c}\right) + kE_{elec} + \begin{cases} k\epsilon_{fs}d^2_{to\_BS}\ for\ d_{to\_BS} \le do \\ k\epsilon_{mp}d^4_{to\_BS}\ for\ d_{to\_Bs} > do \end{cases} \tag{16}$$

4. Discussion on Performance Protocol

Regarding cluster connection, clustering technique, cluster measure, CH, and their importance, this part provides the relative and comparative evaluation for energy-efficient procedures. The operation of energy-efficient protocols, like LEACH, HEED, SEP, DEEC, EESAA, DDEEC, IAATPC, and EESCA, is compared in Table 2.

Table 2. Energy Efficient WSN Protocol Comparison

Parameters	Energy Efficient Protocols							
	LEACH	HEED	SEP	DEEC	DDEEC	EESAA	IAATPC	EESCA
No of Rounds	✓	✓	✓	✓	✓	✓	✓	✓
No of Nodes	✓	✓	✓	✓	✓	✓	✓	✓
Energy dissipated	✓	✓	✓	×	×	✓	✓	×
No of nodes Alive	✓	✓	✓	✓	✓	✓	✓	✓
Packets to Base Station	✓	×	✓	×	×	✓	✓	×
The average no of CHs per round per epoch	×	×	✓	×	×	✓	×	×

An examination of energy-efficient methods in relation to cluster features is presented in Table 3. Displayed are inter-cluster connection, cluster measure, cluster category, CH choices, and the significance of WSN energy-efficient methods.

Table 3. A Comparative Analysis for Energy Efficient Protocols W.R.T. Cluster Properties

Protocols	Energy Efficient Protocol Properties				
	Inter Cluster Connectivity	Clustering Methods	Cluster Count	Selection	Value added with Protocols
LEACH	Single Hop	Distributed	Variable	Random	-
HEED	Single Hop	Distributed	Variable	Random	Reduced Spent per round
SEP	Single Hop	Distributed	Variable	Random	Prolonged Network lifetime
DEEC	Single Hop	Distributed	Variable	Random	Increase the life of node with low energy
DDEEC	Single Hop	Distributed	Variable	Random	Increase Network Lifetime
EESAA	Single Hop	Distributed	Variable	Random	To enhance network stability period and network lifetime
EESCA	Single Hop	Distributed	Variable	Random	Prolonged network life time

Conclusion

The problem of designing reliable, scalable, and efficient routing protocols for WSNs is difficult. Clustering routing techniques can be thought of as an efficient way to address the limitations and difficulties present in WSNs. This paper discusses a number of clustering methods along with cluster head selection tactics like intra-cluster correspondence cost, remaining energy, and the proportion of remained energy in every node to average energy, among others. The assortment of the cluster head has been justified by employing these factors.

Additionally, this research analyses the swarm intelligence-based PASC-ACO method for energy-efficient cluster head selection. Thus, it is clear that additional effort was invested in developing effective clustered routing algorithms for WSNs during the recent years. The cutting-edge various clustering techniques for heterogeneous and homogeneous wireless sensor networks has been reviewed in this research. Ultimately, it is determined that further research into more energy-efficient and scalable clustering schemes for data aggregation in WSNs is worthwhile. The study's conclusion is that comparing different WSN clustering techniques can help researchers discover obstacles to using them in practical settings and make wise judgments going forward. More cluster parameters that are used to create clusters and better energy-efficient cluster head selection utilizing a variety of optimization algorithms will also be added to this survey.

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