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Prolonging Network Survivability and Optimizing Energy Consumption in Heterogeneous Wireless Sensor Networks

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Abstract: WSNs embedded device can be extended to a wide range of implementation in reality. Clustering is efficient way to lessen the energy utilization and improve WSN's lifespan. To improvise network lifespan numerous clustering approaches, implement various parameters for election of CH. An effective clustering algorithm depends upon the number of factors such as number of CHs, uniform cluster size, CHs distribution, energy of the CHs etc. In our research we strengthen our methodology for election of cluster head in HWSN depending on multiple node parameters such as distance, density and residual energy. This paper aims to optimize energy and improve network with Energy Balanced Cluster Technique (EBCT). In our research we reformulated for probability estimation to identify the CHs in each round characterized by node parameters: distance, density, residual energy and node dormancy mechanism. Mathematical analysis and simulations show the proposed method extends the service life by around 8% to 53% relative to the other protocols and optimizes energy utilization of HWSNs.

Keywords: Clustering, Energy efficient, Cluster-heads (CHs), Heterogeneous wireless sensor networks (HWSN), network lifespan.

1. Introduction

The development of compact infrastructure, increasing the need for instant information retrieval from different environments, Researchers have developed WSNs consists of a significant number of sensors that are implemented in field sensing with recent developments in wireless technology and for tasks such as surveillance of health care, agricultural supervision, identification of intruders, traffic management, etc. During control, data is redirected to a base station via intermediate nodes to be transmitted. Without fuel, supplied by a battery, the sensor network cannot communicate. In some applications, it is tough to alter a battery, such as calculating the temperature of a volcanic site. Therefore, energy effective battery usage is desirable and Critical task in designing WSN routing protocols to extend the communication range [1–4]. Throughout idle state, communication, computation, analysing energy is consumed. By regularly transferring node to sleep, idle listening could be reduced. In data transfer and relaying, energy consumption can be reduced by an energy proficient routing method. The routing protocols implemented conventionally are not appropriate for WSN, so it is a difficult task to develop an effective routing protocol. Several algorithms for routing have already been suggested. Communication from one of two approaches to the BS is normally accomplished. One approach is via direct contact. The concern with direct communication is that the far from the BS a node are placed, the higher the energy needed for transmission, leading to higher energy consumption. Routing via intermediate nodes is used in the second process. Initially, the setting up of routes requires energy, but it typically needs lower energy for data transfer than direct communication. The complexity of preserving the network topology and connections from transmitter to receiver is another weakness to this cluster-based second approach. Direct communication is the best option if the network comprises of sensors that are adjacent to the BS.

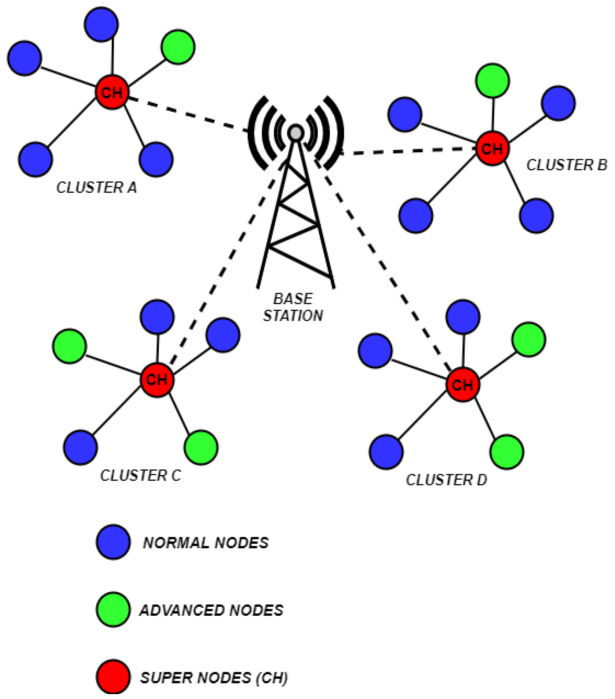

Figure. 1 Heterogeneous wireless sensor networks

However, several sensors are commonly deployed in real-time environment, cluster-based hierarchical routing for powerful and energy proficient contact. Low Energy Adaptive Clustering Hierarchical (LEACH), power-efficient gathering in sensor information system (PEGASIS), Threshold-Sensitive Stable Election (TEEN), Energy Efficient Clustering Scheme (EECS), Hybrid Energy Efficient Distributed (HEED), Stable election protocol (SEP), Zonal-Stable Election Protocol (Z-SEP), Developed Distributed Energy-Efficient Clustering (DDEEC) etc. are the most exceptional cumulative routing convention in WSN.

The aim of this paper is to implement an optimized routing scheme for heterogeneous WSNs by refining the standard probabilistic methodology to address the issue of how to conserve energy, maintain a balanced system throughput, and extend the lifespan of wsn. The suggested scheme strengthens the CH selection threshold by taking into account the node's residual power, distance between the node, BS, node dormancy mechanism and CH Re-election process. In order to prevent overhearing and save resources, the CHs often implement multi-hop wireless communication. This enhanced protocol will save energy and extend the life of a network.

Section 2 describes literature survey; Section 3 demonstrates network model assumption. Section 4 suggests convention. Section 5 gives of findings and performance. Section 6 presents conclusion.

2. Literature survey

The configuration and analysis of the energy-saving Cluster Protocol calls for a various aspect to be resolved during real-time work. Implementing energy stable routing on the basis of a cluster framework to facilitate diversification, adaptable and hierarchy in layout are the main objectives of investigator in the field of the WSN to extend their lifespan [5-8]. Energy competent clustering is essential by starting load balancing between nodes and must keep the framework free in terms of energy. In order to extend the life of heterogeneous WSN, investigator have configured a power stable clustering with a distinct suggestion than clustering with hierarchical layout as described in [9].

LEACH [10] is the most common, more effective hierarchical routing protocol in contrast to conventional protocols. A probabilistic algorithm determines the cluster head and aims to spread the network capacity at every node. This procedure does not assure the count and CHs location. It is an efficient self-organizing mechanism, utilizing a hierarchical clustering algorithm. This protocol is intended to arbitrarily pick nodes as CHs such that the energy loss in reference to BS extends over all nodes. Growing clustering process includes setup state (cluster creation) and continuity state (data transfer). A sensor node chooses a random value between 0 and 1, during the initialization process. If random number is less than T(n) level, sensor node will be selected as the head of the cluster. This determines T(n) as follows:

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

In Eq (1), p gives proportion of nodes preferred to be a CH, r is round's count for selection, G is collection of nodes not yet chosen as CH in final round of 1 / p. Upon being picked the CH alert other nodes. After getting an advertising packet, the sensor nodes decide the cluster they choose to belong to depending on the signal strength of the acknowledged message. Based on a Time Division Multiple Access (TDMA) strategy, the CHs then determine the period on which the sensors submit data to CHs. The nodes will be able to transmit to cluster heads during steady-state. CH gather data from nodes in prior sending these data to BS. The network rebuilds the setup phase after steady-state and take up cycle of CH election. Although utilizing this protocol has strengths of spontaneous, flexible and self-organized mechanism, but does not ensure the cluster head nodes count and location. Furthermore, using a centralized algorithm to create quality clusters by distributing CH in network.

SEP [11] is implemented to improve stability and existence of the heterogeneous WSN. Two categories energy nodes are added in this protocol, i.e., regular and advanced. The election of CH is dependent on node's initial energy. Usually, the advanced nodes possess higher extent of power assistance as compared to its associate node. The prospect of becoming CH varies for both categories of node as advanced nodes are more likely to be elected as CH than normal node. In the analysis, the strengthening the infrastructure of advanced nodes and therefore likelihood of choosing CH enhances efficiency in the context of durability and lifespan, which also increases network throughput. The system's advanced node limitations are significantly penalized as there is no relation to the gap between the selected CH and the BS node, they are often more likely to be chosen as CH and therefore minimize the network life expectancy. DEEC [12] convention is formulated in effort to lessen the prospect of choosing perhaps one node category (advanced nodes) for CH. The assignment of CH in DEEC is dependent on the proportion of remaining energy to average network energy. We can provide a possibly the best framework of CH election for varying sorts of node by modifying the epoch duration. Though as the network lifespan is registered, DEEC has constraints and helps in determining the relative energy available for more operation. Like the SEP protocol, DEEC has the same problem as the extreme action of advanced nodes and the need to preserve details of the massive infrastructure. In the context of the Evolved Distributed Energy-Efficient Clustering Protocol, a separate method to DEEC is given in [13]. In the analysis, CH is defined by initial and residual energy. So, all nodes had to have geographical information about the network for such a choice. The concept of measuring the reference capacity for cluster session is also used. For various nodes, the convention has a different prospect of CH selection. Enhanced Developed Distributed Energy-Efficient Clustering EDDEEC [14] proposes CH election factors dependent on remaining as well as average energy and changes the potential of CH election for various node types. The energy effective heterogeneous DEEC framework for longevity enhancement is set out in [15]. As three kinds of nodes are given by this convention, the likelihood of CH choice depends on the respective scales. Non-probability strategy in the discovery of the CH node which brings minimal significance to the relative and average range. There is also a weaker association with various members; this can be strengthened by incorporating the CH choice with a range factor.

Many clustering-based routings strategies have been designed to increase the life cycle of the network. HWSNs are currently adopted in practice, due to advancement in node infrastructure and network architecture. HWSNs primarily consider the heterogeneity of energy. The suggested energy node heterogeneity HWSN routing conventions, like SEP [11], Modified SEP (M-SEP) [16], Prolong-SEP P-SEP [17], improved energy aware distributed unequal clustering (EADUC) [18], and DEEC [19]. Primary challenges of HWSN routing given in [20, 21] nevertheless, is how to make better utilization node energy diversity to extend the service life of the network and boost system performance.

SEP [11], stable election protocol with a random distribution of usual and sophisticated nodes. If normal nodes travel as far as possible from BS, when transmitting data to BS, nodes would use more resources, resulting in less efficiency and productivity. The infrastructure is then dispersed into domains where distant nodes from the BS that are exceptions need more energy to send the data in able to fix this they are given more resources, named advanced nodes, contrast to nodes closed to BS and are considered normal nodes that transmit messages straightway to BS. In SEP, the weighted election prospect of node to be CH is based on leftover energy in each node. In this case, the threshold for usual nodes and sophisticated nodes is described in the eq (2) and eq (3):

$$T(\alpha_{nrm}) = \begin{cases} \dfrac{\mu_{nrm}}{1-\mu_{nrm}\times\left(r \bmod \frac{1}{\mu_{nrm}}\right)} & \alpha_{nrm}\in\emptyset' \\ 0\;, & otherwise \end{cases} \tag{2}$$

Where $\mathbf{\mu}_{nrm}=\frac{\mu_{opt}}{1+\beta m}$, is measured estimate for regular nodes, r is present round and $\emptyset'$ is group of regular nodes didn't serve as CHs last $1/\mu_{nrm}$ phase of cycle. The μ_{opt} is the optimum chance. m is proportion of advanced nodes, and β is extra attribute of energy amongst advanced and regular nodes.

$$T(\alpha_{adv}) = \begin{cases} \dfrac{\mu_{adv}}{1-\mu_{adv} \times \left(r \bmod \frac{1}{\mu_{adv}}\right)} \alpha_{adv} & \in \emptyset'' \\ 0 \ , & otherwise \end{cases} \quad (3)$$

Where $\boldsymbol{\mu}_{adv} = \frac{\mu_{opt}(1+\beta)}{1+\beta m}$, is the value of $\boldsymbol{\mu}_{adv}$ is equal to the likelihood of advance nodes, r is present cycle, and $\emptyset''$is the group of forward nodes that group CHs in the previous $\frac{1}{\mu_{adv}}$ iterations of the epoch.

Z-SEP [22, 23] another expansion of SEP, refers to Zonal Stable Election Protocol. It is a combined method wherein the network sector is categorized into three regions, namely region 0, region 1 and region 2, on the principle of the energy proportion and Y coordinates of network domain. The standard nodes are arbitrarily dispersed in region 0, half of specialized nodes are dispersed in region 1, and the remaining parts of specialized nodes are dispersed in region 2. To propagate data to BS, Z-SEP employs various technologies; direct interaction and transmission via CH. In direct contact, standard nodes in region 0 recognize and accumulate data of interest and transmit directly to BS. In other scenario, CH is identified between the nodes in both sites in region 1 and region 2, and then senses the obtained data, consolidate it and transmit to BS.

In Z-SEP, in the present round, each node prefers to represent as CH, or finds a randomized value around 0 and 1. This value is then contrasting with threshold value, if in range node act as CH; else behave like standard nodes for this round. The threshold value presented in eq (4):

$$T(\alpha_{adv}) = \begin{cases} \dfrac{\mu_{adv}}{1-\mu_{adv} \times \left(r \bmod \frac{1}{\mu_{adv}}\right)} \alpha & \in \emptyset \\ 0 \ , & otherwise \end{cases} \quad (4)$$

Where, $\emptyset$ is group of nodes which did not act as CHs in previous $1/\mu_{adv}$ iterations. Chances of advanced nodes to act as CH is eq (5):

$$\mu_{adv} = \frac{\mu_{opt}(1+\beta)}{1+\beta m} \times (1+\beta) \quad (5)$$

DEEC [19, 24] is cluster dependent framework for multi-level HWSNs. This strategy identifies CHs based on the likelihood of correlation in leftover energy of each node and the average network power. Epochs vary as per their starting and residual energy from CHs for nodes. The probability of being CHs depends on beginning and remaining energy of nodes, higher energy nodes have more chances of CH. HEED [25] employs leftover energy as a predominant factor and network layout features as node degrees, distances to neighbours are operated as supplementary parameters to separate associations amongst contestant CHs, as cluster selection criterion to attain power management. Clustering method splits series of instances and nodes not associated with CH show their chances of becoming a cluster head in each instance. Such energy efficient clustering conventions allow each to determine separately and probabilistically on its location in a clustered network, they never assure the minimal chosen cluster headset [26].

Therefore, in order to develop and implement energy effective clustering with HWSNs, an innovative strategy for selection of CH is suggested in this paper to maximize the energy usage of the network. It also strengthens all of the relevant performance parameters. As our approach dynamically change clusters count in each round to balance the energy load, we were able to achieve these results. Furthermore, the choice of sensor nodes to become CHs is dynamic. As a result, the roles of sensor nodes can be changed every round to achieve a network configuration that consumes less energy and extends the nodes lifespan.

3. Network paradigms

Three-level sensors heterogeneity is employed in proposed network architecture. The network framework includes of n sensor nodes randomly distributed on the M × M sensing configuration. It is predefined since post implementation is static across all nodes, including BS. It is presumed that communication connections between each other are symmetric [11]. The CH is responsible for forwarding the collected data directly to BS on behalf of the sensing network. Both data messages that are supervisory and unsupervisory are accessed via wireless devices. Initially, the network architecture is split into four population-based areas, and BS is at the core of the network sector. The capacity of each node is to sense, aggregate, and forwards the data. The fact that the node still has data for transfer is a top priority. Nodes, i.e., regular, advanced, and super with increasing energy level order, as shown in [11].

3.1 Network model assumptions

Assumptions of network model are:

1. In geographic region, all nodes are arbitrarily positioned. If the position has been decided, the position of the nodes would not alter regardless of anything occurs.
2. In HWSNs, nodes are allocated different starting ranges of energy.
3. BS is situated in middle of the sensing field and energy is provided from external sources.
4. The capacity of node is constrained and it is unlikely to charge it up.
5. As power of the node sensor is drained, node is declared dead.

4. The proposed energy balanced cluster technique (EBCT) approach

The main objective of the model suggested is to prolong the lifespan of the network and reduce energy usage via an effective selection mechanism for CHs. In EBCT, by using clustering strategy the vast number of sensor nodes can be split into many clusters. Sensor is nominated as CH for each corresponding cluster. CH choice is focused upon a modified probabilistic function. Non-CH nodes will track the system only, and transfer information to their CH. The CH gathers the data from regular cluster nodes. It then collects information, and transfers it to the BS. An ordinary node is unable to forward data straight to the BS. This can be extended to partitioning a WSN with ease. The objective is to segment the WSN into many heterogeneous clusters. In this section, we explain proposed EBCT algorithm. The search feature consists of steps as: pre-processing, clustering, selection of CHs, data transfer and re-election of CH. To manage the network continuously, we assume a heterogeneous network with N nodes distributed on a square area. The BS is situated beyond the field of square. Our suggested solution takes original node energy, leftover energy, cumulative network energy, distance from BS, node density and node dormancy function to determine the cluster heads.

4.1 Pre-processing step

The pre-processing phase starts after random distribution of nodes within sensing region. At the start, the BS transmits a signal of "hello" to all nodes at a specific energy level. Using this approach, the average distance to the BS will be determined by each node depending on the signal intensity obtained. It assists nodes to identify the appropriate power level for communication with the BS. Further it then gathers the various locations of nodes and starts the clustering method.

4.2 Clustering step

This step helps to analyse the optimal clusters count and to resolve the WSN cluster set scheduled. Sensors have to be clustered using the EBCT clustering method. The method uses a metric of distance dependent on the amount of the closest mutual neighbourhood. The clustering phase for the solution suggested is as follows in Algorithm 1.

1. Identify sensor node placement at the BS. That sensor node recognizes where it is situated (using localization techniques) and forward to BS.
2. Assess a sequence of k neighbours adjacent to every other network node. This should be remembered that in context of the Euclidean distance, the values of adjacent nodes are nodes closest to the source.
3. Evaluate couple wise distances across each node highest closest neighbour's list.
4. Integrate all couples of nodes with a range of distances less than threshold.

Notation List**:**

SNs ← sensor nodes
D[i] ← Euclidean distance
E[i] ←Initial Energy of SNs, E0
Ea[i] ← Average Energy Ea
Er[i] ← Residual Energy Er
$T(n)$ ←Threshold
R[i] ← RSSI value
E_{TX} ← Transreceiving Energy
E_{RX} ← receiving Energy
BS ← Base station
ACK ←Acknowdgement

Algorithm 1: EBCT Clustering Algorithm

EBCT Algorithm (Clustering)

1. Input: {(x1, y1), (x2, y2),….,(xn,yn)
2. Assign random position to SNs
3. Initialization: ∀ SNs for (i: =1 to 100)
4. Each node sends its position to BS
5. For every node in WSN compute Euclidean distance D[i] to other nodes and Set node density
6. Compute E[i]= Initial Energy of SNs initialized as E0
7. Compute Ea[i]= Average Energy of SNs and is initialized by Ea
8. Compute Er[i]= Residual Energy of SNs and is initialized by Er
9. Computer $SN[i] = \alpha \frac{Er[i]}{E0} + \varphi(D[i])$
10. End For

4.3 Cluster head selection step

The next move after cluster forming is to pick the head of the cluster between the nodes of the member sensor. As previously pointed out, the clustering phase is done only once until repetitions of the algorithms are implemented, and only the cluster head is to be substituted in each process. The choice of cluster heads is randomized in the suggested solution, which relies on the nodes' residual energy. Cluster head choice is so that it is first checked for each round even-if actual CH energy is higher than network's overall total energy. When the cluster head's energy level is higher than average energy of nodes, it will still be active in succeeding stage, so doesn't assign its position to next node. But if its energy level is below the average energy value of other nodes, then next node is arbitrarily chosen as candidate, ensuing its energy level, whether it has the requisite energy capacity, it is chosen as the cluster head. Node must send a node identification advertising message to its neighbours to declare itself as the new round head of the cluster. As a consequence, any CH will accumulate knowledge from nodes and pass the data gathered to BS. If CH crash, this occurrence may be observed by adjacent nodes, and the algorithm is performed to locate succeeding cluster head from the rest of nominees. Algorithm 2 gives CH selection phase inside EBCT algorithm.

In this step both SN must access the BS to choose CHs. Initialize each SN with a notification to BS. BS generates vector array from this advertisement with SN ids and RSSI reference. The BS then selects CH dependent on highest RSSI value. As initial energy of SNs is different, energy factor for locating initial CHs is often addressed during setup process. Now the BS transmits a notification to all SNs about initial CHs, SN must send join-request response to CH in close vicinity. Correspondingly the CH will recognize them.

Algorithm 2 : EBCT Cluster Head Selection

EBCT Algorithm (Cluster Head Selection)

1. Threshold= $T(n)$
2. Compute R[i]= RSSI value
3. Assign a central fixed location to BS.
4. Fix the coordinate of SNs & BS.
5. For every node in WSN compute SN (i: =1 to 100)
6. Modified Threshold = $T(n)$* SN[n]
7. If Random_num ≤ $T(n)$
8. SN[n]= CH_list
9. else
10. SN[n]= nonCH_list
11. End If
12. Repeat step 13 to 18 for each SN (i: =1 to 100)
13. Redirect R[i] of SN to BS.
14. BS generates lookup-table as (node-id, R[i])
15. BS selects CH as Max(R[i]) and Send ACK to SN as 0 or 1(Standard=0, CH=1)
    a. if SN.receive is 1, swap Type[i] as CH
    b. if SN.receive is 0, swap Type[i] as SN
16. All SN will forward connect.call message to adjacent cluster's CH.
17. Forward CH.ACK to SNs as tuple (SN_id, reply).
    a. If reply is 1, SN ∈ CH
    b. If reply is 0, SN ∉ CH.
18. i: =i+1
19. End For

4.4 Data transmission step

TDMA would be generated spontaneously, depending on the Id and the node count in the cluster k, to give each node a window to send data to CH. In addition, we reduce energy usage due to cluster node synchronization when CH chosen to allocate TDMA. To conserve resources, we presume that if the range in node and BS is greater than the distance between node itself and CH, we conclude that node directly propagates its data to BS. CHs store and aggregate the data from SNs and directed to the BS.

Algorithm 3 : EBCT Data Transmission

EBCT Algorithm (Data Transmission)

1. For each cluster C in {1,2,3,….C}
2. Collects measurements from Cluster nodes and SNs transmit perceived data to CH.
3. Compute SN.Energy as $Ea[i]=E[i] - E_{TX}$
4. CHs send data to the BS
5. Compute SN.Energy as $Ea[i]=E[i] - E_{RX}$
6. End For
7. Output: {Global area Knowledge, Cluster Count}

4.5 CH Re-election

This process decides the need to get CHs re-elected. Through experimentally evaluating diverse domain of leftover energy level of CH is greater than the average energy level of all available CH, threshold estimate for flipping CH is calculated. The CH must communicate CH. Selected to all SNs inside the cluster, once the CH's residual energy decreases to 40 percent of its initial capacity. It implies that the new CH does not have enough resources to do the CH's function and an immediate transfer is required to prolong WSN's lifespan. Once each SN receives this transmission, it sends a reference S[i] to CH, determined by adding up the residual energy level and RSSI of SNs. Now the present CH must determine criteria for picking the next CH, $S_{CH[i]}$. From the following equation 6, the threshold for choosing the next CH is estimated:

$$S_{CH[i]} = \sum_{i=0}^{n} \left(\frac{Er[i] + Ea[i]}{n}\right) \qquad (6)$$

n represents cumulative SNs in cluster, current CH for increasing SN as $S_{CH[i]}$. The SN that only has a maximum S[i] value than $S_{CH[i]}$ level will be chosen as next CH.

Algorithm 4 : EBCT CH Re-election

EBCT Algorithm (CH Re-election step)

1. if Er[CH] < 40% * E_0
   a. CH send CH. Selected → BS ∀ SNs ∈ cluster
   b. otherwise Keep being CH.
2. After obtaining CH. Selected, SNs ∈ cluster transmit R[i], Ea[i] →CH
3. CH select new.CH Analysis and correlation of $S_{CH[i]}$ ∀ SNs Including S[i]
4. ∀ SNs ∃ max(S[i]. value) than $S_{CH[i]}$selected → new.CH.
5. CH.ACK all SN with 0 or 1(Normal=0 and CH=1)
6. CH alter Mode[i] →CH and other SNs receive 0 then alter Mode[i] →SN.

5. Performance evaluations

This segment explains the simulations and efficiency parameters used to test the method. We also specified the threshold criteria for the detection of CH in the evaluation. We have actually provided findings and shown our approach's competence study.

Table 1. Simulation parameters table

Parameter	Value
Probability of becoming CH, p	0.5
Eelec	50 nJ/bit
Efs	10 pJ/bit/m4
Emp	0.013 pJ/bit/m4
Data size	500 bytes
Round time	10 * Eo
Control packet size	25 bytes

5.1 Simulation and performance metrics

Analysis is carried on MATLAB in network region of 100 m X 100 m dimensional where WSN is randomly deployed with 100 sensor nodes. The suggested algorithm is contrasted to the pre-existing procedure focused on probabilistic approach. We conducted analysis with LEACH [10], SEP [11], Z-SEP [22]and DDEEC [13]and to examine the effectiveness of our methodology EBCT. Simulation factors are given in Table. 1.

5.2 Performance metrics

On the basis of various metrics, we assessed the competence of the proposed approach:

Energy Consumption: The energy intake relates to the resources expended by nodes across various phases of transmission, receiving and working. The network model of proposed approach, the simulation contributes to consistent distribution of energy consumption in WSN.

Network Lifetime: Period for network with sufficient node density before First Node Dies (FND); node density before half nodes is alive (HNA), and time for scattered node arrangement before the Last Node Dies (LND).

5.3 Results and discussion

The simulation parameters used to investigate the performance of our algorithm as described in Table I.

5.3.1. Network energy consumption evaluation

Further parameters that impact CH preference are included in the developed model, resulting in an optimal cluster organization that requires the least amount of energy in each round. Figure 2 illustrates energy consumption in LEACH, SEP, Z-SEP, DDEEC and EBCT corresponding to the Number of rounds. The DDEEC approach produces suboptimal cluster topologies that result in greater consumption. Furthermore, chosen CHs do not always have the highest level of residual energy, due to ineffective

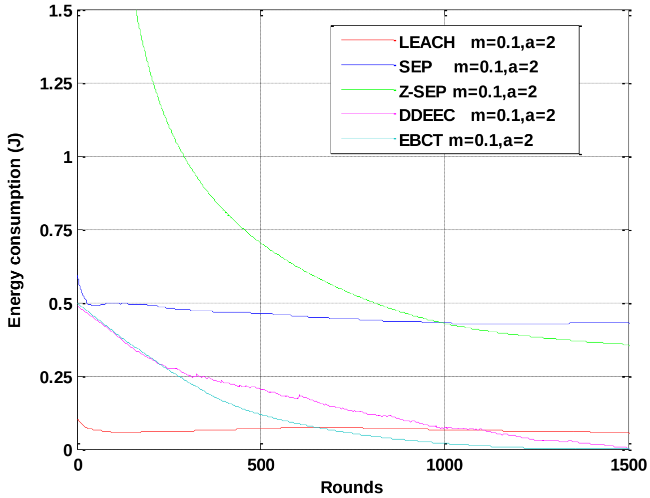

Figure. 2 Comparison of total energy consumption of the network

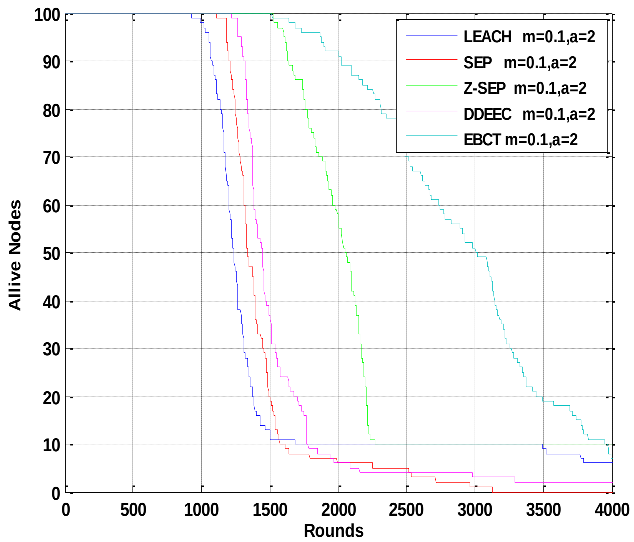

Figure. 3 Comparison of Alive Nodes in the network

energy consumption. In DDEEC, cluster formation also comes to a halt quickly, forcing regular nodes to interact directly with BS, resulting in rapid node depletion. Figure 2 demonstrates that the correct selected CHs in the EBCT algorithm significantly improve the utilization of network resources relative to the other protocols.

5.3.2. Network lifetime evaluation

We analyzed the influences of the suggested EBCT on network existence with FND, HND and LND criterion in comparative clustering techniques. Figure 3 indicates the total number of nodes that stay alive throughout the simulation phase. Nodes stay alive for a longer period for EBCT since its CH selection algorithm considers remaining energy, distance of node from BS and node dormancy

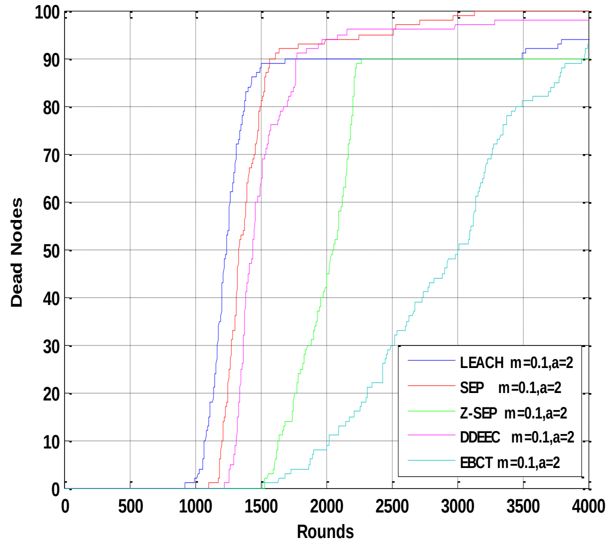

Figure. 4 Comparison of Dead Nodes in the network

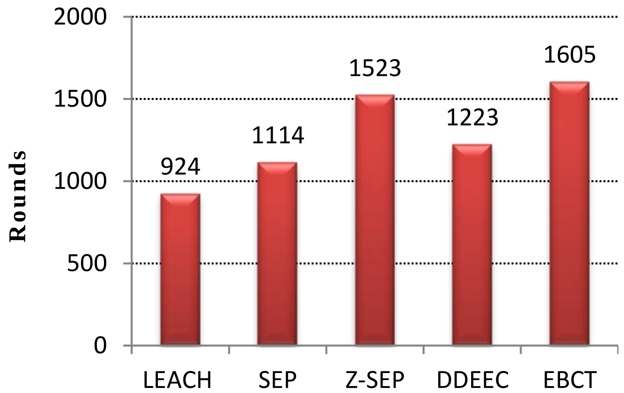

Figure. 5 First Node Death (FND)

mechanisms to be node parameters together with probabilistic method for CH selection. Figure 4 shows the comparison of Dead Nodes in the network over simulation time. In comparison, the count of rounds for all dead nodes in the EBCT protocol is 3994 relatives to 2205 rounds in the LEACH protocol.

Figures 5, 6 and 7 demonstrate the efficiency of the comparable algorithms with specific primary energies with FND, HND and LND criterion, respectively. It is evident from figure 5 that shows nodes start dying (FND) after 924, 1114, 1523, 1223 and 1605 rounds for the LEACH, SEP, Z-SEP, DDEEC and EBCT protocols. Furthermore, with the new EBCT, nodes don't continue to expire until 1605 rounds. Similarly, the simulation results between HND and count of rounds for the various protocols LEACH, SEP, Z-SEP, DDEEC and our proposed EBCT approach with varying initial energies are shown in Figure 6. Round count for HND for LEACH, SEP, Z-SEP, DDEEC and EBCT protocols is 1239, 1336, 2058, 1443 and 3014

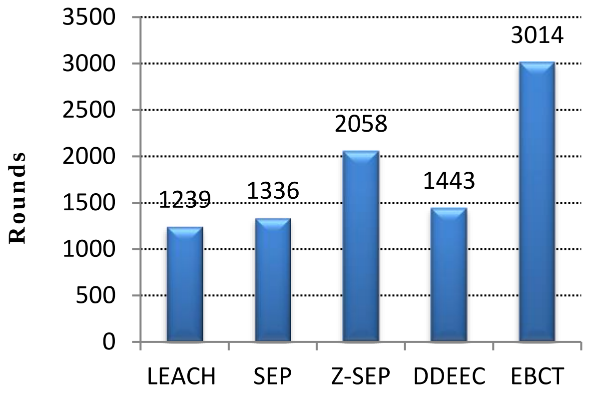

Figure. 6 Half Node Death (HND)

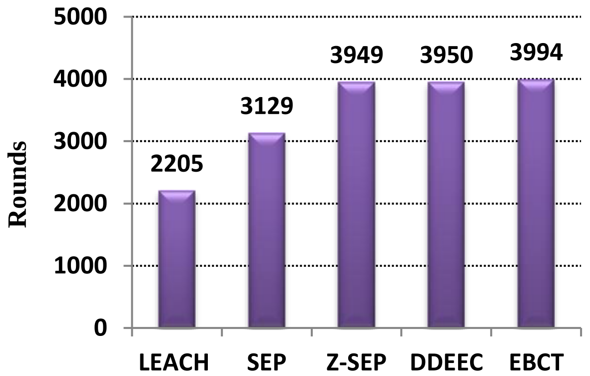

Figure. 7 Last Node Death (HND)

respectively. In contrast to other methods, the EBCT algorithm requires more rounds for HND.

Additionally, the simulation analysis of LND and round count for various strategies LEACH, SEP, Z-SEP, DDEEC and our suggested EBCT approach is shown in Figure 7. The round count for LND of LEACH, SEP, Z-SEP, DDEEC and EBCT is 2205, 3129, 3949, 3950 and 3994 respectively. The EBCT algorithm requires more rounds for the LND relative to the other approaches. EBCT employs a clustering technique that is distinct from several protocols, as well as a set time frame transmission, which minimizes count of nodes involved in actual data transfer and increases the lifespan.

5.3.3. Data Transmission evaluation

Figure 8 indicates the amount of messages BS receives for the approaches it compares. As shown in Figure 8, in the comparative curve, the incremental pattern of data transfer in the comparative algorithms is set at a given time moment. This means at LND the network lifespan has been over. Such packets are a set of advertising messages and data which CHs collect. Channel failure challenges are not addressed when implementing

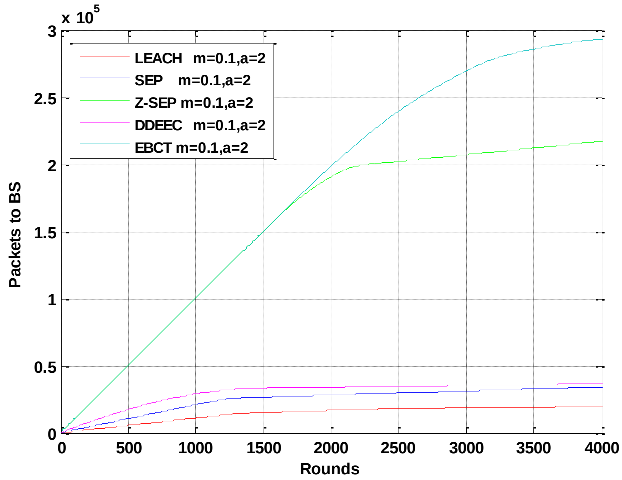

Figure. 8 Comparison of messages Count at BS

these algorithms; thus, all nodes can transmit data gathered from network to CH. It can be inferred that disparity in messages sent to BS has to do with advertisers broadcasted by LEACH, SEP, Z-SEP, DDEEC and EBCT algorithms. As per Eq. (2, 3, 4) volume of energy expended depends on scale of packets; thus, larger the message count transmitted and retrieved in sensors, higher the network power usage.

The EBCT increases network lifespan by around 8% to 53% relative to the other protocols from the data received. Based on the above mentioned analyzes and observations, it has evidently been established that EBCT provides better energy performance and longer network existence.

6. Conclusions

We implemented an optimized EBCT solution to CH selection in order to increase energy performance and maximize a WSN's network lifetime. The EBCT decreases overheads for information exchange and helps avoid selection of CHs. The simulation findings also stated that our suggested methodology increased the lifespan of the network compared with LEACH, SEP, Z-SEP and DDEEC. Contrast with LEACH, SEP, Z-SEP and DDEEC, the algorithm has obtained considerably more performance in terms of energy conservation. EBCT's competency was assessed on the basis of energy and Network existence (FND, HND and LND). It is evident that round count of LEACH, SEP, Z-SEP, DDEEC and our proposed EBCT approach for FND found to be 924, 1114, 1523, 1223 and 1605. Also, round count of HND for LEACH, SEP, Z-SEP, DDEEC and EBCT protocols is 1239, 1336, 2058, 1443 and 3014 respectively. And the round count for LND of LEACH, SEP, Z-SEP, DDEEC and EBCT is 2205, 3129, 3949, 3950 and 3994 respectively. Our suggested algorithm eliminates overhead communications and prevents excessive collection of CHs in each iteration and in contrast, outperforms other regular protocol.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

The paper methodology, conceptualization, analysis, investigation, original draft preparation has been done by 1st author. The supervision and project administration have been done by 2nd author.

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