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Energy efficient clustering and routing optimization model for maximizing lifetime of wireless sensor network

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ABSTRACT

Recently, the wide adoption of WSNs (Wireless-Sensor-Networks) is been seen for provision non-real time and real-time application services such as intelligent transportation and health care monitoring, intelligent transportation etc. Provisioning these services requires energy-efficient WSN. The clustering technique is an efficient mechanism that plays a main role in reducing the energy consumption of WSN. However, the existing model is designed considering reducing energy- consumption of the sensor-device for the homogenous network. However, it incurs energy-overhead (EO) between cluster-head (CH). Further, maximizing coverage time is not considered by the existing clustering approach considering heterogeneous networks affecting lifetime performance. In order to overcome these research challenges, this work presents an energy efficient clustering and routing optimization (EECRO) model adopting cross-layer design for heterogeneous networks. The EECRO uses channel gain information from the physical layer and TDMA based communication is adopted for communication among both intra-cluster and inter-cluster communication. Further, clustering and routing optimization are presented to bring a good trade-off among minimizing the energy of CH, enhancing coverage time and maximizing the lifetime of sensor-network (SN). The experiments are conducted to estimate the performance of EECRO over the existing model. The significant-performance is attained by EECRO over the existing model in terms of minimizing routing and communication overhead and maximizing the lifetime of WSNs.

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1. INTRODUCTION

The increased growth of sensor technologies has led to increased adoption of WSN across different for provisioning future communication systems and wireless-based applications. For example, it is utilized across different areas like industrial manufacture, health-care-monitoring, and intelligent transportation, [1] etc. Furthermore, the WSN has been utilized in different intelligent applications, non-real and real-time smart like tactical internet [2], a wearable computing device [3], and smart city [4]. The prime responsibility of WSNs is accurately gathering useful data and sensing such as yielding sensed big data, air quality, biomedical, humidity measurements and chemical information for future analysis [5]. At the similar time, the CC (Cloud-Computing) allowed technologies like Cloud-RAN [6] and Fog-RAN [7] and that provide WSNs with communication, computation advantages and the storage resources [8], as well as promising the technique to process and manage the huge amount of aggregated data [9].

The sensor-device (SD) is placed in a hazardous area where battery replacing and recharging are not possible and also human monitoring contains huge-risk. The SD can be either time or event-driven, in both cases, the battery energy is exhausted exponentially. The sensed data is either transmitted to base station (BS) or neighboring devices. In a few scenarios, similar data can be transmitted to BS. Thus, affecting energy-efficiency (EE) of the WSN. In order to overcome the redundancy problems and produce a more energy-efficient Data Aggregation (DA) method is utilized in [10]. To provision, the access of real-time [11] to sensor-data for the application of reliable industries, data processing, and accurate gathering is needed [12]. Anyways, performing the DA possess the challenging solution, which is represented in [13]. In [14], representing the scheme of energy preservation to give more efficient DA. The design of energy preservation routing adopting the clustering protocol like low-energy-adaptive-clustering-hierarchy (LEACH) and hybrid-energy-efficient-distributed (HEED) has been introduced in [15]. Anyways, they induce the energy overhead between CH that is insufficient for the larger network [16], due to direct-DT (Data-Transmission) via CH towards the sink is an unfeasible method for such type of network. In order to improve the lifetime of WSNs for overcoming the energy overhead between CH [17] designed a routing method for the selection of hop-device. However, it acquires higher communication overhead because of channel contention between cluster device and hop-device and it is improving the NP-deterministic.

In [18], it representing the design of energy-efficient for larger SN adopting a fuzzy-based clustering method. However, the performance of a lifetime in insufficient, CH devices nearer to BS that dies rapidly. To overcome these problems, [19] represented clustering design utilizing T2FL (Type-2 fuzzy logic). The distributed load model between SDs that aided in developing the lifetime of SN. However, the T2FL-clustering method can be designed and considering the homogenous network. Therefore, future routing model should assume the heterogeneity needs of WSN and its application [20-23]. In order to communicate and accumulate these data in the real-time of efficient designs are needed. In [24, 25], representing the model of data gathering and the efficient model of data routing adopting the clustering method, [26] represented data forecasting method for cluster-based WSNs and [27, 28] represented the approach of cross-layer for the cluster-based WSNs. In [24-28], this model reduced the energy consumption of the SD. However, the state-of-the-art model didn’t assume and failed to improvise the coverage time of WSN. To address these issues of coverage time, the optimization function adopting the evolutionary computing for cluster formation, which is represented in [29]. However, in [30] extensive analysis carried out and represents the evolutionary computing for the heterogeneous WSN incurs Computational-Overhead (CO) between SNs. Thus, it affecting the performance of WSN. In paper [31], representing the clustering method for heterogeneous-WSN utilizing the tree structure. This model is assumed packet loss rate and link quality in order to reduce the energy consumption of SN. However, this model didn’t assume the coverage time. As an outcome, affecting the lifetime performance of SNs.

To overcome the research challenge, this work represents the model of energy efficient clustering and routing optimization (EECRO) adopting the design of a cross-layer for improving the lifetime of WSN and coverage time. The EECRO utilizes physical layer data to get the channel gain data for gaining the parameter of link quality. Furthermore, in the MAC layer or data link, the TDMA based communication can be adapted for communication between inter and intracluster communication. In the network layer, the routing and clustering-based transmission are assumed. This work intended at conveying the good trade-off among improving coverage time, reducing the energy of CH and improving the lifetime of SN. In order to get, routing and clustering optimization are carried out and the smallest path based rioting is assumed.

The Contribution of this research work is as follows:

- This paper represented the design of energy-efficient routing for the heterogeneous WSN.
- Our model adopts the shortest path to cluster-based transmission.
- The previous work has not assumed cluster-based routing optimization adopting the design of the cross-layer and considering the environment of heterogeneous sensors.
- The previous work has not considered the evaluation of lifetime performance considering first node death, loss of connectivity and total node death considering the heterogeneous WSNs.
- The performance of lifetime analysis is carried out considering the first sensor device, loss of connectivity and total device death.
- This model develops the lifetime of SN, communication overhead and routing overhead of the real-time data access and also improves the lifetime of WSN.

This paper is organized in such a way that section-II introduced the energy-efficient of routing and the clustering optimization model is represented. The next section represents an experimental study of the EECRO over the existing technique. The future work and conclusion are discussed in the last section of this paper.

2. ENERGY-EFFICIENT CLUSTERING AND ROUTING OPTIMIZATION MODEL ADOPTING CROSS LAYER DESIGN FOR ENHANCING COVERAGE TIME AND MAXIMIZING LIFETIME OF WSN

This section present an energy efficient clustering and routing optimization model adopting cross layer design for minimizing energy consumption of cluster head, enhancing coverage time and maximize lifetime of sensor network. Firstly, we describe the system model of heterogeneous wireless sensor network, then we describe the channel model used. Then, we describe the clustering and transmission/routing optimization to enhance coverage time and the lifetime of WSN.

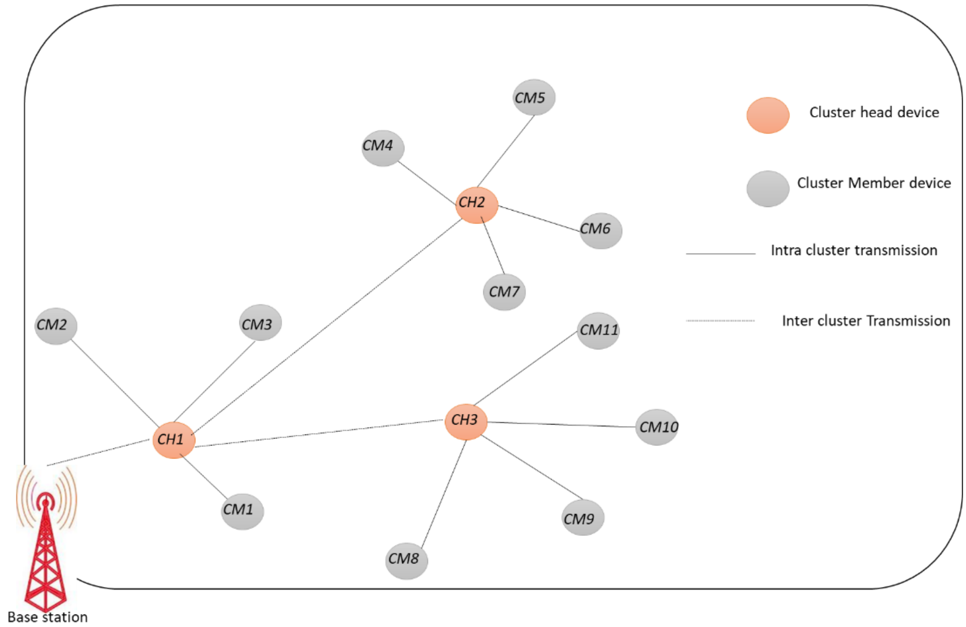

Figure 1. The Architecture of EECRO model

2.1. System architecture

The architecture of EECRO model is shown in Figure 1. From Figure 1 it can be seen that the cluster closer to base station is composed of less number of cluster members we call this as level 1 and cluster little far away from cluster head has more number of cluster members we call this has level 2. This way the far cluster will have large density of cluster members. This deployment method aid in minimizing energy consumption of cluster head. Especially, the cluster head closer to sink. Thus enhancing coverage time and lifetime of sensor network.

2.2. System, channel, transmission optimization model:

This section describes the system of research work. This work considers heterogeneous WSN i.e., let's consider classes of sensor device such class A, class B. Class A are represented as sensor device that performs operation such as sensing. These device are lower cost and the tiny devices that are deployed across sensing region. The sensor are grouped together to form a clusters. Class B sensor device is more powerful and has higher computing capability than Class A device which depicted as cluster head. The class B device collects and aggregates sensory data from its member and transmits it towards sink/base station through set of hop/intermediate cluster head device.

Let us consider there are N and O nodes that are randomly deployed in a network and their positions are known. Each sensor device are connected/associated with one cluster head device and generates mean packet load of α bits/sec and transmits it to the cluster head, which further routes to the sink/base stations (which in this work we consider it as the $(M+1)^{th}$ cluster head directly or through intermediated cluster head devices. Further, this work considers that the cluster head consumes much higher energy than its sensor devices. Since, CH is active all the time and at the same time the member device are in sleep state. As a result, this work aims to reduce the consumption of energy of CH device. As it aids in enhancing network coverage resulting in better lifetime of WSNs.

This work considers Rayleigh fading model to characterize the channel among cluster heads, and also among cluster head and the base station. Therefore the channel gain y among sender and receiver for communication is obtained as follows:

$$i(y) = M(e_0)\left(\frac{y}{e_0}\right)^{-o}\beta \tag{1}$$

where $M(e_0)$ is the path loss ~~componen~~t exponent of e_0 which can be computed as follows:

$$M(e_0) = \frac{H_u H_s m^2}{16\pi^2 e_0^2} \tag{2}$$

where H_u is the antenna gain of the sender, H_s is the antenna gain of receiver, β is a normalized arbitrary parameter that depicts the variation in the fading process, m is defined as wavelength of the frequency carrier, o is defined as the exponent of path loss. The β is arbitrary and is considered to be exponentially distributed, and the received signal is also arbitrary. Therefore, perfect reception of a signal is assured through probabilistic method. Hence it is desired that $P\{f_s \geq \delta\} \geq \gamma_m$ for ideal reception, where f_s is the energy of obtained signal, δ is predetermined energy threshold, and γ_m is the expected link ideal parameter.

Let consider d_j as the cumulated intra cluster load attained by the j^{th} CH (bit/seconds) for $j = 1, \dots, O$. The clustering optimization vector is expressed as follows:

$$d = (d_1, \dots, d_O). \tag{3}$$

An important thing to be seen here is that, the number of sensor devices associated with cluster head j i.e., the size of cluster j, is expressed as follows:

$$\frac{d_j}{\alpha}. \tag{4}$$

For $j \in \{1,2,3, \dots, O\}$ and $k \in \{1,2,3, \dots, O+1\}$, with $j \neq k$, let w_{jk} be the inter cluster load that is transmitted from CH j to the CH k. The transmission optimization matrix $\boldsymbol{S}$ is the $O * (O+1)$ matrix of element w_{jk}, $j = 1, \dots, O$ and $k = 1, \dots, O+1$. This work considers $w_{jj} = 0$. The objective of this work is to improvise the coverage time by establishing an optimized transmission matrix $\boldsymbol{S}'$ and cluster vector d'. Let consider Q_j as the mean of energy consumption of the j^{th} cluster head. Then, the Q_j is expressed as follows:

$$Q_j = f_{recv}\left(d_j + \sum_{1 \leq k \leq O, k \neq j} w_{kj}\right) + f_{trns}\left(\sum_{1 \leq k \leq O+1, k \neq j} w_{jk}\right) + \sum_{1 \leq k \leq O+1, k \neq j} w_{jk} f_{ujk}, \quad j = 1, \dots, O \tag{5}$$

where f_{trns} are the circuit energy per bit dissipated in transmitting data, f_{recv} are the circuit energy per bit dissipated in receiving data, and f_{ujk} is the energy dissipated from cluster head j to cluster head k. Let us assume that e_{jk} as the distance among cluster head j and k, therefore using (1) the received energy per bit can be expressed as follows:

$$f_{recvjk} = f_{trnsjk} M(e_0)\left(\frac{e_{jk}}{e_0}\right)^{-o}\beta. \tag{6}$$

By using Rayleigh channel model, the link ideal parameter can be described as follows:

$$\gamma_m = \mathcal{P}\{f_{recvjk} \geq \delta\} = \mathcal{P}\left\{\beta \geq \frac{\delta}{f_{trnsjk} M(e_0)}\left(\frac{e_{jk}}{e_0}\right)^{o}\right\} = f^{-\frac{\delta e_{jk}^{o}}{f_{trnsjk} M(e_0) e_0^{o}}} \tag{7}$$

From (7), we can describe f_{trnsjk} as follows:

$$f_{trnsjk} = \varphi e_{jk}^{o}, \quad j \neq k \tag{8}$$

where φ is a constant that can be expressed as definition as follows:

$$\varphi = \frac{-\delta}{M(e_0)e_0^o \log \gamma_m} \tag{9}$$

The (5) can be written considering for $j = 1, \ldots, O$, as follows:

$$Q_j \;=\; f_{recv}\left(d_j + \sum_{1\le k\le O, k\ne j} w_{kj}\right) + \sum_{1\le k\le O+1, k\ne i} w_{jk}\left(f_{trns} + \varphi e_{jk}^o\right) \tag{10}$$

Let $F_j$depicts the initial energy of the j^{th} cluster head, $j = 1, \ldots, O$. This work considers an optimization problem to maximize coverage time as follows:

$$max_{\{d,\boldsymbol{S}\}} min\left\{\frac{F_1}{Q_1}, \frac{F_2}{Q_2}, \ldots, \frac{F_O}{Q_O}\right\}. \tag{11}$$

When cluster heads are deployed with equal energy, that is,

$$P_j = P \;\forall\, j, \tag{12}$$

The optimization problem of (11) is similar to as follows:

$$min_{\{d,\boldsymbol{S}\}} max\{Q_1, \ldots, Q_O\} \tag{13}$$

This work aims at addressing optimization problem of (13). The problem in optimizing are described as follows. For cluster head j, $j = 1, \ldots, O$, the inter cluster optimization condition must be addressed

$$b_j d_j + \sum_{1\le k\le O, k\ne j} w_{kj} = \sum_{1\le k\le O, k\ne j} w_{jk} + w_{j,O+1} \tag{14}$$

where $0 < b_j \le 1$ is the performance parameter of aggregating data function in intra cluster. Along with, the packet load composed by all the cluster head considering certain instance period of time must be identical to load produced by all the sensor devices in the same instance period of time, which can be expressed as follows:

$$\sum_{j=1}^{O} d_j = N\alpha. \tag{15}$$

The objective optimization function (13) and constraint (14) and (15) can be transformed into linear programming problem of d, $\boldsymbol{S}$ and u by introducing an supplementary parameter$u$, where $u \ge \max\{Q_1, \ldots, Q_O\}$ as follows:

$$\begin{cases} min_{\{d,\boldsymbol{S},u\}} u \\ such\ that \\ \sum_{1\le k\le O, k\ne j} w_{kj} + b_j d_j - \sum_{1\le k\le O, k\ne j} w_{jk} + w_j, O+1 = 0, \quad i = 1, \ldots O \\ \sum_{j=1}^{O} d_j = N\alpha \\ \sum_{1\le k\le O, k\ne j} w_{kj} f_{recv} + d_j f_{recv} + \sum_{1\le k\le O, k\ne j} w_{jk}\left(f_{trns} + \varphi e_{jk}^o\right) + w_{jO+1}\left(f_{trns} + \varphi e_{j,O+1}^o\right) - u \le 0, j = 1, \ldots, O \\ w_{jk} \ge 0 \; and \; d_j \ge 0, j = 1, \ldots, O; k = 1, \ldots, O+1 \end{cases} \tag{16}$$

2.3. Cluster optimization

This section presents cluster optimization technique for wireless sensor network. Let $d' = (d'_1, \ldots, d'_O)$ be the optimal clustering vector outcome. For $j = 1, \ldots, O$, cluster head j is given $N'_j = d'_j/\alpha$ sensor devices. The sensor device allocation is carried out in sequential manner, i.e., one at a time. A corresponding sensor device is allocated to the nearest cluster head j, provided that number of sensor devices to cluster head j is not greater than N'_j. If it exceeds then next nearest cluster head is considered and so on. The algorithm for obtaining optimal clustering is represented in algorithm 1.

Algorithm 1: Optimal clustering algorithm
Input: $d' = d' = (d'_1, \ldots, d'_O)$
Expected outcome: $V_1, \ldots, V_O$
Initialize: $V_1 = \cdots = V_O = \emptyset$ (cluster sets)
Start: For $j = 1$ to N
For $k = 1$ to O
Set y_{jk} to distance among sensor device j and cluster head k
End for
Iteration: $l = arg_{\{k\}} \min\{y_{jk}, k = 1, \ldots, O\}$
If $d'_l > 0$

$$d'_l = d'_l - \alpha$$
$$V_l = V_l + \{l\}$$

Else

$$y_{jl} = \infty$$

go to iteration
End if
End for
End:

2.4. Transmission/Routing optimization

This section describes the routing optimization of proposed approach. This work considers a routing base on shortest path root from cluster head device to base station through number of hop devices. For minimizing hop count which varies for different transmission. As a result, this work considers quality of communication using parameter γ_q for computing probability of positive end-to-end reception. For different roots of L paths experience different fading, the root reliability γ_u must be at least $\gamma_q^{\frac{1}{L}}$ .Considering the shortest hop case, the packets are routed through nearest cluster head closer to the next level j towards the base station. In this way the data is transmitted to different level $(j = 1)$ till it reaches the base station. This work considers energy balanced cluster based routing design that balance energy of different cluster heads. The communication radius of cluster can be obtained as follows

$$\frac{1}{2}(s_1 - s_0), \ldots, \frac{1}{2}(s_L - s_{L-1}), \tag{17}$$

In (17) is the important factor of energy dissipation at different cluster heads. For example, minimizing $\frac{1}{2}(s_j - s_{j-1})$ results in smaller cluster size in the j^{th} level, which aids in reducing local traffic among these cluster, lesser routing distance among corresponding cluster heads in the $(j-1)$ level and a greater numbers of cluster heads in the j^{th} level. Since this work considers symmetrical topology and packet distribution, the load from the cluster head in the j^{th} level will be uniformly balanced among higher number of cluster heads in the j^{th} level, so the quantum of transmitted load possess by each cluster heads in the j^{th} level will reduce. This aid in reducing energy consumption at the cluster head in the j^{th} ring. Similarly, reducing area of the j^{th} level must reimbursed for other clusters i.e., cluster in the j^{th} level, because of the fixed number of level considered in the network. In a similar way, energy dissipation at cluster heads in level will increase. Thus, by regulating the size of cluster in different levels, a more balanced energy dissipation at different cluster heads is attained, which aided in enhancing coverage time of WSN. Thus improving the lifetime of WSNs which is experimentally proven in next section below.

3. SIMULATION RESULT AND ANNALYSIS

This section represents the performance evaluation of introduced the EECRO model over the existing technique considering lifetime, routing overhead and communication overhead. For lifetime analysis, this work considers first sensor device death (FSDD), loss of connectivity (LoC) and total sensor-device death (TSDD). The previous work has not considered such an evaluation to estimate the performance of WSN. The environment of the system is utilized for experiment analysis such as windows 10 enterprises edition operating-system (OS), Intel Pentium I-5 class, a 64-bit processor of Quad-core, 4GB NVIDIA-CUDA enabled dedicated GPU, 16GB RAM. The SENSORIA simulator [32] is utilized to carry out the performance evaluation of the EECRO model over existing methods like LEACH [11]. The EECRO and LEACH are modeled by utilizing the Dot Net framework 4.5 and C# programming language. The LEACH has been widely utilized the comparison protocol across different existing methods [11]. As an outcome, this work assumes the LEACH protocol as a case study for comparison. This simulation parameter is utilized for the experimental analysis, which is described in Table 1.

Table 1. Simulation parameter considered

Network Parameter	Value
The size of Wireless Network	100m ×100m
Number of the Sensor Devices	500, 1000, 1500&2000
Number of BS	1
The Initial energy of Sensor Devices	0.1to 0.2 Joules (j)
TR (Transmission range)	5 m
The range of Sensing	3 m
Radio-Energy-Dissipation	50 nj/bit
The length of Data Packets	5000 bits
The speed of Transmission	100 bit/s
Bandwidth	10000 bit/s
Data processing-delay	0.1 s
Idle Energy-Consumption (Eelec)	50 nj/bit
Amplification-Energy (Emp)	100/bit/m2

3.1. The evaluation of Lifetime performance evaluation considering total sensor device death, first sensor device death and loss of connectivity

This section describes performance attained by proposed EECRO over LEACH considering the total sensor device death, LoC, first sensor device death. Firstly, considering the case of total sensor device death. Here the sensor device is varied from 500, 1000, 1500, and 2000 and the experiment is conducted to evaluate the lifetime performance and the result is graphically shown in Figure 2. The outcome represented EECRO that enhances the lifetime performance by 69.09%, 76.22%, 82.96%, and 83.83% over LEACH protocol considering 500, 1000, 1500, and 2000, sensor device respectively. An average improvement of lifetime performance is attained by 78.02% , which is introduced EECRO over the LEACH considering the total sensor device death. Similarly, an experiment is conducted to evaluate the lifetime performance considering 1st sensor device death. Here, the sensor device can be varied from 500, 1000, 1500, and 2000 and the experiment is conducted to estimate the lifetime performance and the outcome is graphically shown in Figure 3. The result represents the EECRO that enhances the lifetime performance by 82.44%, 77.67%, 88.41%, and 92.57% over the LEACH protocol that considering 500, 1000, 1500, and 2000, sensor device respectively. The average improvement of lifetime performance is attained 85.27% by the help of introduced EECRO over the LEACH that considering 1st sensor device death. Furthermore, the experiment is conducted to estimate lifetime performance considering LoC. Here, a sensor device is varied from 500, 1000, 1500, and 2000 and the experiment is conducted to estimate the lifetime performance and the outcome is graphically shown in Figure 4. The outcome represents EECRO develops the lifetime performance by 81.46%, 78.52%, 85.27%, and 86.74% over the LEACH protocol considering 500, 1000, 1500, and 2000, sensor device respectively. An average lifetime performance improvement of 86.73% is attained by introduced EECRO over LEACH considering LoC. The overall improvement of average performance is attained by 83.35%, which is introduced by the EECRO model over LEACH considering total sensor device death, LoC, first sensor device death. The overall attained outcome represents the scalable lifetime performance considering the varied network density.

3.2. Communication overhead and Routing/transmission overhead performance evaluation considering varied sensor device

This section defines the communication and routing overhead performance attained by the help of EECRO over LEACH. For the experiment analysis, the sensor device is varied from 500, 100, 1500, and 2000 and the experiment is conducted and the outcome is graphically shown in Figure 5. The outcome shows, EECRO minimizes the CO (Computation overhead) by 32.74%, 26.25%, 48.644%, and 41.88% over LEACH considering 500, 1000, 1500, and 2000 the sensor device, respectively. An average communication overhead reduction of 37.37% is attained by EECRO over LEACH. Similarly, the experiment is conducted to estimate the performance of routing overhead by varying sensor devices from 500, 100, 1500, and 2000 and the outcome is graphically represented in Figure 6. The outcome shows, EECRO minimizes routing overhead by 51.62%, 44.06, 45.08%, and 51.93% over LEACH considering 500, 1000, 1500, and 2000 sensor devices, respectively. The average routing of overhead reduction of 48.17% is achieved by EECRO over the LEACH.

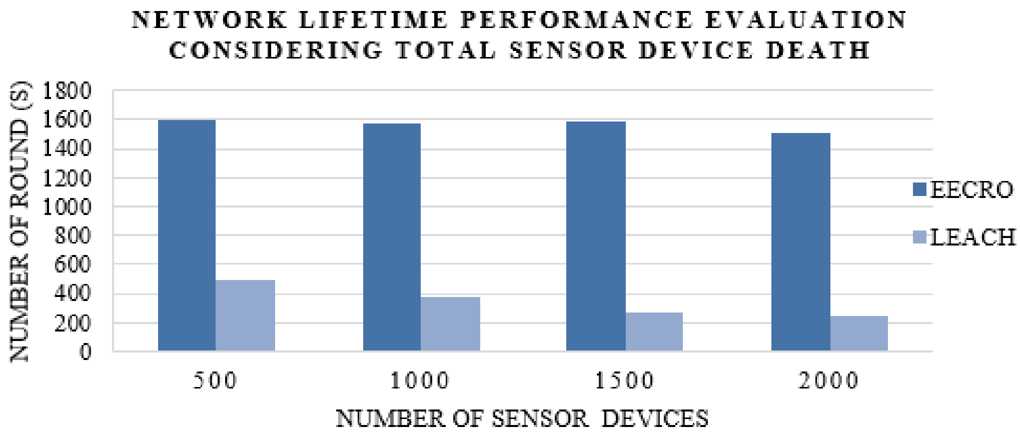

Figure 2. Network lifetime performance evaluation considering total sensor device death

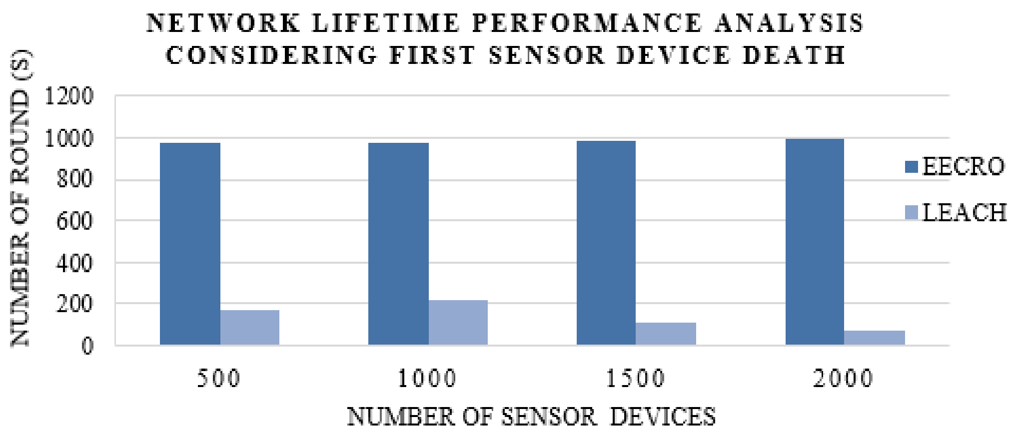

Figure 3. Network lifetime performance evaluation considering first sensor device death

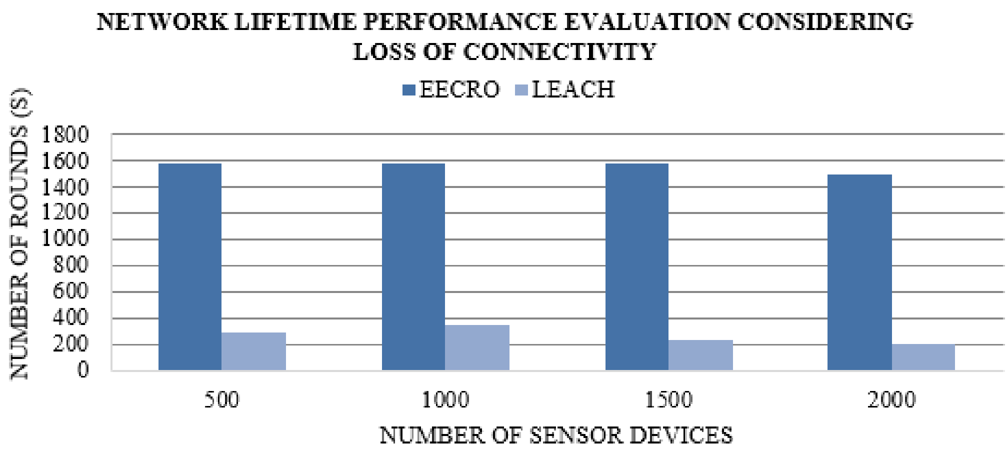

Figure 4. Network lifetime performance evaluation considering loss of connectivity

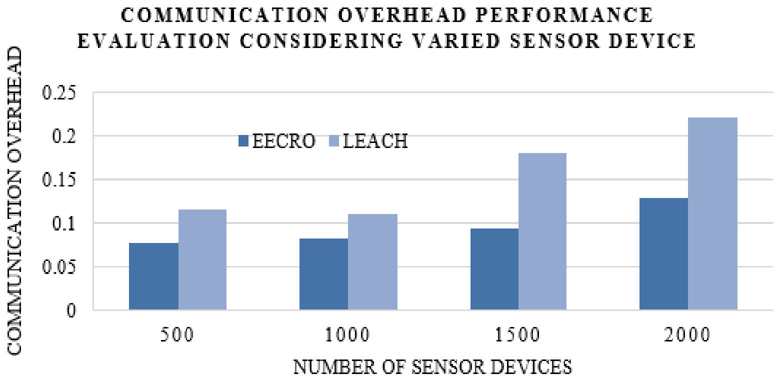

Figure 5. Communication overhead performance evaluation considering varied sensor device

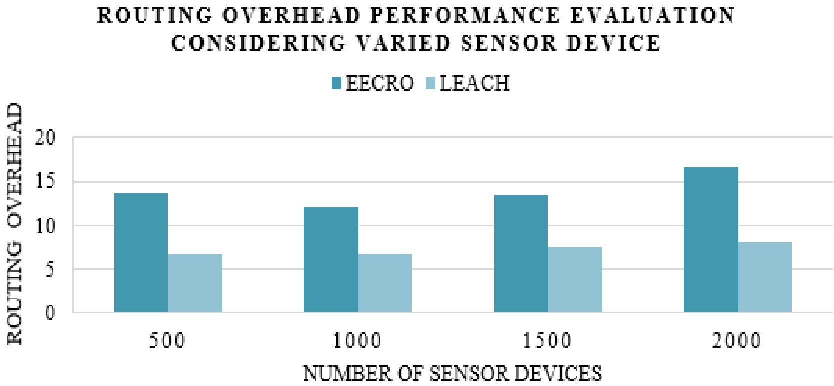

Figure 6. Routing overhead performance evaluation considering varied sensor device

3.3. Result and discussion over state-of-art technique

This work carried out the experiment evaluation considering different performance parameters like CO, network lifetime and routing overhead considering first sensor device death, LoC and total sensor device death. This section particularly estimates the evaluation of lifetime performance over the state-of-art method. Several existing methods assume the evaluation of lifetime performance considering the total sensor device death. However, the evaluation considering 1st sensor device death is also the most eminent performance parameter. As this outcome in LoC affecting the lifetime performance of WSN. As an outcome, this paper considers the evaluation of lifetime performance considering first sensor device death, total sensor device death, and LoC. Below in Table 2, the performance comparison of introduced EECRO and existing protocols of lifetime achievement over the LEACH protocol is tabulated. The overall outcome represents the EECRO model that attained better performance improvement of network lifetime over state-of-art model [18, 19, 29, 31, 33] considering total sensor device death, 1st sensor device death, and LoC. The most important outcome is achieved in this work due to routing and cluster optimization adopting the design of cross-layer. Our model reduces the energy consumption of CH, improving coverage time aiding in lifetime performance improvement of WSNs. Thus, it will aid in provisioning the application of real-time service that needs the design of energy-efficient.

Table 2. Performance comparison of network lifetime achievement over LEACH

Algorithm	Lifetime improvement achieved over LEACH considering total sensor device death	Lifetime improvement achieved over LEACH considering first sensor device death	Lifetime improvement achieved over LEACH considering loss of connectivity
[18]	25.0%	56.7%	-
[19]	50.0%	-	-
[29]	55.0%	-	-
[31]	44.0%	-	-
[33]	15.0%	-	-
LLEER	78.02%	85.27%	86.73%

4. CONCLUSION

Building energy-efficient design for provisioning non-real and real-time application services in the WSN, which is very challenging. An extensive survey carried out shows a number of approaches have been represented lately to improve the energy efficiency of SN. Among them, clustering adopting cross-layer play an important role in enhancing the performance of the sensor network. However, the design of cross-layer architecture with minimal communication and routing overhead is challenging. The existing model did not consider coverage time for cluster optimization considering heterogeneous networks. As a result, incurs energy overhead among cluster head. Affecting lifetime performance. To overcome research challenges, this manuscript presented an Energy Efficient Clustering and Routing Optimization model adopting cross-layer design. The EECRO use physical layer information to obtain channel gain information for obtaining link quality parameter. Then, in data link or MAC layer TDMA based communication is adopted for communication among inter and intracluster communication. In the network layer, clustering-based transmission or routing is considered. Further, clustering and routing optimization are carried out and the shortest path based routing is considered for attaining good trade-off between minimizing the energy of cluster head, enhancing coverage time and maximizing the lifetime of a sensor network. The experiment is conducted to estimate the performance of EECRO over the existing model. The outcome represents EECRO improves lifetime performance of 78.02%, 85.27%, and 86.73% considering total sensor device death, first sensor device death, and loss of connectivity respectively. The overall average performance development of 83.35% is attained by the proposed EECRO model over LEACH considering all the cases. Further, the EECRO model reduces communication overhead and routing overhead over the existing model by 37.37%, and 48.17% respectively. The overall result attained shows scalable lifetime, communication overhead and routing overhead performance considering varied network density. The future work we would consider energy consumption evaluation of cluster head at a different level and design an optimal cluster and hop selection design for further enhancing the lifetime performance of WSN.

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