Wireless Personal Communications (2024) 137:909–929
https://doi.org/10.1007/s11277-024-11406-7

Cluster-Based Hybrid Routing Technique for Wireless Sensor Networks

Y. Harold Robinson[1] · B. Valarmathi[2] · P. Srinivasan[3] · Hanen Karamti[4]

Accepted: 20 June 2024 / Published online: 10 July 2024

Abstract
While deploying wireless sensor networks (WSNs), the cluster heads need huge amount of energy according to the unbalanced routing of the Sensor nodes to the base station as the result, which has produced minimized network lifetime and unbalanced energy utilization. The proposed cluster-based hybrid routing technique (CHRT) contains the cluster head selection with effective energy utilization procedure which extends the network lifetime and enhanced packet routing technique is used to reduce the energy of the sensor node with the Euclidean distance metric, base station location identification and residual energy. The fitness function is used for selecting the cluster heads for enhancing the selection of the cluster head in efficient way. The modified fitness function has been introduced for relaying the remaining cluster heads through enhanced routing functionality. The simulation results of the proposed technique suggested that it enhances the network lifetime, improves the residual energy and coverage area as compared to the relevant methodologies.

Keywords Wireless sensor networks · Cluster head selection · Fitness function · Network lifetime · Energy consumption

✉ Y. Harold Robinson
yhrobinphd@gmail.com

B. Valarmathi
valargovindan@gmail.com

P. Srinivasan
srinivasan.suriya@vit.ac.in

Hanen Karamti
HMKaramti@pnu.edu.sa

1 Department of Computer Science and Engineering, Francis Xavier Engineering College, Tirunelveli, India

2 Department of Software and Systems Engineering, School of Computer Science Engineering and Information Systems, Vellore Institute of Technology, Vellore, India

3 School of Computer Science Engineering and Information Systems, Vellore Institute of Technology, Vellore, India

4 Department of Computer Sciences, College of Computer and Information Sciences, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia

1 Introduction

The prime aim of the sensor node in WSN is to gather data from common climate as several electronic factories are developing minimum power with small size advanced sensor nodes for observing environmental changes like pressure and temperature [1]. The sensor nodes gather the data and deliver into the specific recipient, the sensor nodes are randomly deployed in the communication area for measuring the environmental data as the self-organized monitoring system into huge geographical regions such as industry, vehicle monitoring [2]. Every sensor node is constructed through several components like memory, processing, sensing, energy management. Every sensor node has the restricted energy level and the battery replacement is very hard in several applications so the effective energy consumption is very much required in WSNs [3].

The sensor node requires more energy for delivering the data into the base station, so the cluster related routing methodology is required for effective energy utilization while the improved approach is required to the sensor nodes for delivering the data into the base station [4]. The clustering functionality is required for distributing the nodes into the clusters as every cluster contains members and cluster heads. Additionally, every member delivers the data packets to the particular cluster head, the data aggregation for the delivered data packets to the base station. The cluster heads need high energy for evaluating the operations with effective energy utilization [5].

Every round of routing process consumes unwanted energy consumption and it could be optimized through the centralized approach. The energy of each cluster members diminish due to the transmission to the recipient and maintains the low energy level, after the specific amount of rounds, the energy metric maintains minimum values then other metrics of cluster head selection and produces ineffective utilization of energy; hence the enhanced cluster head selection procedure is required [6]. The ineffective inter-cluster transmission routing requires large amount of energy so the multihop transmission is not useful in huge area networks. The relay nodes are transmitted through the base station for active routing to produce the energy dissipation that identifies the ineffective routing [7].

The effective utilization of energy is having the fitness function for every cluster which has to be selected through energy consumption and the distributed routing is used to save the energy [8]. The clustering process is implemented in every round by base station with the enhanced optimization procedure in an effective manner and the base station operation requires the data about the location [9]. Hence, the sensor nodes deliver the control packet into the base station that involves unwanted energy utilization. The clustering process could be implemented in small rounds and the enhanced approach for observing residual energy of the rotation cluster head identification approach [10].

Every cluster head consumes the energy through the specific functions as the fitness function that needs the node's residual energy. The inter-cluster transmission has the cluster heads nearer to the base station died suddenly as the extra data packets are received from another cluster heads for distance from the base station. The balanced energy utilization has been confirmed through the node distance from the base station. Cluster members and cluster heads consume huge energy through unbalanced approach according to the ineffective routing and it reaches the reduced network lifetime. The improved packet routing approach for effective utilization of energy through effective cluster head for saving energy of the cluster heads. The main contribution of the paper is.

- The cluster head selection process contains the distance-based cluster members with the modified fitness function.
- The cluster head collects and performs data aggregation operation of the data packets from one cluster head to another cluster head.
- The packet routing methodology has the energy consumption strategy for cluster head selection through the base station.
- The optimum value is used to measure the distance with the performance metrics like network lifetime and energy consumption.

2 Related Works

The clustering techniques have the important role in enhancing the network lifetime as the LEACH protocol [11] has been used to minimize the global transmissions within the WSN using the nodes grouping into tiny sized clusters. The random selection of cluster heads needs enhanced functionalities to reduce the energy consumption. The enhanced technique HEED [12] has been used to identify the high residual energy nodes as the cluster heads with the level of the battery. Another technique of FLEC [13] has been implemented for increasing the energy efficiency through the high energy nodes which have been selected as the cluster head and maintains the data in cluster features and deliver it to the base station.

The improved LEACH approach [14] has been used to reduce the computational time and identifying the cluster head whenever it has some issues, an enhanced approach is used to assign every cluster through cluster head. The elaborated LEACH approach called as LEACH-F [15] has been maintained through a fixed amount of clusters in a centralized framework. The main drawback of this approach is no flexibility for cluster update whenever the clusters are constructed, the nodes should not modify the details while the damage of nodes also. Additionally, the clustering approach with energy balancing [16] has the reliability of the residual energy and distance parameters that enhances the identification of cluster head. The K-LEACH [17] approach has been used to select the cluster head randomly. The fuzzy decision making technique (MADM) [18] has been implemented for selecting cluster heads through the metrics of adjacent nodes, distance and residual energy.

The cluster enabled energy optimization methodology (CEOMS) [19] has the energy density procedure for the sensor nodes initially and the maximum residual energy nodes are assigned as the cluster heads. The sink node has been framed for enhancing the probability of nodes is high for selected as the cluster head. The enhanced adjustment procedure has been used to enhance the adaptability for density of several active nodes in the network. The Grid head based cluster head formation in optimized way with energy efficiency (EOCGS) [20] has been implemented using dynamic approach that the fitness function utilizes the Euclidean distance and position of the grid based cluster heads. The centralized cluster head selection approach (C3HA) [21] has been determined to identify the cluster head that minimizes the energy consumption and enhance the network lifetime.

The network bandwidth has been increased with the enhanced clustering approach [22] that the transmission cost directly suffers the energy utilization for environmental monitoring of the WSNs. The enhanced clustering approach has been involved for achieving energy efficiency while data communication. The energy distribution functionality is used for conserving the residual energy and extending the network lifetime. The Differential Evolution functionality has been intended for solving the energy utilization problem while cluster head selection [23]. The energy related problem and the network lifetime are the common problems and the effective clustering process has the solution for these problems. The energy enabled minimum spanning tree approach (EEMST) [24] has been used to identify the optimized cluster head and active routing through graph theory. The weighted tree has been involved to find the optimal cluster head through the shortest path for data communication within the cluster head and the sensor nodes.

The data redundancy, scalability and end-to-end delay are the common problems of deploying WSNs, the effective cluster head election procedure (LEDCHE) [25] has been used to solve these problems. The dynamic re-clustering procedure and optimum cluster head head selection are the main functionalities with the random function in every node. The residual energy could minimize the dead nodes in the network while implementing the re-clustering procedure for addressing the black holes and end-to-end delay issues. The multi-objective genetic procedure [26] has been established to minimize the intra-cluster distance and diminishing the energy utilization of the cluster head while selecting the optimal cluster head, the optimum routing methodology is used to transmit the data packets within the sink node and the cluster head in efficient way. An artificial neural network technique [27] has been established for minimizing the energy consumption while the group of routes are identified through the sink node using the genetic algorithm. The data collection procedure for every cluster is initiated by the sink node to the clusters.

The non-uniform signals into the sensor nodes manage to extra battery utilization that reduces the network performance and this issue could be solved through the ant colony optimization methodology is utilized for identifying the optimal energy proficient route for improving the network lifetime [28]. The congestion control in WSN could produce the low throughput while the RACC technique improves the network lifetime and reduces the congestion control which increases the overall performance than the related techniques [29]. The 2-step Congestion control technique is used to increase the network performance and it solves the path loss issue to enhance the network throughput. The constant bit ratio in user datagram protocol for reducing the congestion [30]. The congestion control technique within the data communication, Congestion occurs while network resources are overloaded and leaded to packet loss, network delay, and minimized the overall performance. The congestion could be avoided through the efficient quality of Services, improved load balancing, buffer management, traffic management, and network optimization.

3 Proposed Framework

The proposed technique (CHRT) is constructed to enhance the network lifetime by balancing energy consumption with improved residual energy of the sensor nodes as the rotational cluster head discovery through base station. The centralized clustering concept in every round eliminates the unwanted energy consumption according to the transmissions within the base station and the sensor nodes. The total amount of clustering rounds is dynamically reduced by eliminating the unnecessary energy utilization. The fitness function is used to select the cluster heads through the residual energy of the cluster members as every cluster head's energy has to be minimized according to the data exchange within the recipient and the entire routing process is demonstrated in Fig. 1.

The network contains huge number of nodes which are randomly deployed in static and has the similar level of energy that every member delivers its data packets to the particular destination that every cluster head computes its functionality as gathering and data aggregation process on the data packets which are communicated through its

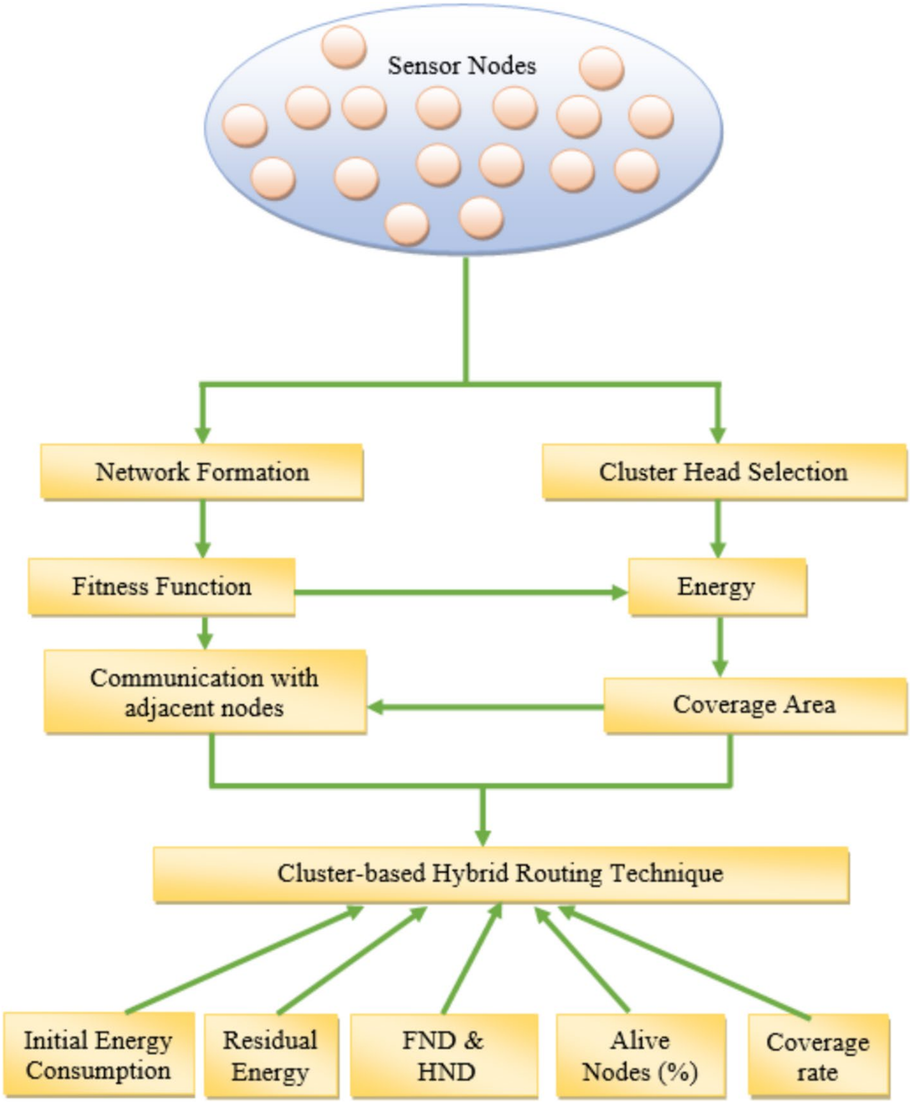

Fig. 1 Routing process of proposed technique

cluster members and deliver it into the base station through multi-hop transmission. The cluster head maintains the data aggregation and data gathering functionality for other cluster heads due to enhanced routing strategy. The centralized clustering procedure utilizes the location data of the nodes for delivering into the specific clusters. The nodes need to deliver a data packet to the base station that involves the location data which performs the convergence centroid values for performing cluster construction which is demonstrated in Eq. (1).

$$Cen_{xy} = \frac{1}{\sum_{z=1}^{c} \left(\frac{dis_{xy}^2}{dis_{yz}^2} \right)} \tag{1}$$

where Cen_{xy} demonstrates the centroid value, x denotes the total amount of nodes in active routing, y illustrates the total clusters, c demonstrates the total amount of clusters and dis_{xy} denotes the distance within the centroid and the sensor node. The distance within the nodes is computed in Eq. (2).

$$dis_{\alpha\beta} = \sqrt{\left(p_\alpha - p_\beta\right)^2 + \left(q_\alpha - q_\beta\right)^2} \tag{2}$$

where p_α, q_β is the node coordinates and the cluster centroid value is computed in Eqs. (3), (4) and (5).

$$cc_{y_p} = \frac{\sum_{x=1}^{N_p} p_x Cen_{xy}^m}{\sum_{x=1}^{N_p} Cen_{xy}^m} \tag{3}$$

$$cc_{y_q} = \frac{\sum_{x=1}^{N_p} q_x Cen_{xy}^m}{\sum_{x=1}^{N_p} Cen_{xy}^m} \tag{4}$$

$$cc_y = \left(cc_{y_p}, cc_{y_q}\right) \tag{5}$$

where $cc_{y_p} andcc_{y_q}$ are the cluster centroid coordinates and m is the parameter value within the actual value of two has been used for completing the performance.

The enhanced routing technique for effective energy utilization according to the residual energy through cluster based centroid approach from the base station which enabled inter-cluster transmission. The distributed approach has several rounds as the cluster head selection and routing in every round with packet-based routing approach. The deployment procedure has been completed as the cluster procedure which begins every node transmits to the base station and consumes energy consumption. The cluster round is expressed in Eq. (6).

$$Clu_R = \begin{cases} 1, & r_d = 1 \\ 1, & dead_n > 0 \\ 0, & Otherwise \end{cases} \tag{6}$$

where Clu_R demonstrates cluster round, r_d is the particular round of simulation, the minimized amount of cluster round improves the network energy. The nodes are divided into 2 groups as the shortest distance and the long distance. The optimum value is used to discover the distance and it could be measured with the performance parameters of energy utilization and network lifetime. The smaller distance cluster needs to satisfy the expression in Eq. (7).

$$dis_0 = \begin{cases} dis^{th}_{SN\ \ BS}, & dis^{th}_{SN\ \ BS} \leq dis_{th} \\ dis_{th}, & otherwise \end{cases} \tag{7}$$

where dis^{th}_{SNBS} is the distance from the sensor node to the base station as the maximum limit of threshold value, the optimum value for the distance cluster is described in Eq. (8).

$$Opt_{DC} = \frac{R}{dis^2_{CH}} \tag{8}$$

where R is the communication area, dis_{CH} demonstrates the distance to the cluster head and other clusters in the network has been used for generating the optimum values. Whenever the clustering process is completed, the base station transmits a control packet in the network that confirms every node to identify the position into the clusters with centroid. The enhancement of the cluster head procedure needs to discover the cluster head for every cluster of long distance and smallest distance with the fitness function that modifies the residual energy of the members. The cluster head directly transmits the message through the base station for active communication, the distance within the base station and the cluster member utilize the fitness function for cluster head selection through the residual energy. The fitness value is computed in Eq. (9).

$$FV_{CH} = \gamma p_1 + (1 - \gamma)p_2 \tag{9}$$

The value of p_1 is computed in Eq. (10).

$$p_1 = \frac{Energy_{Res}}{Energy_i} \tag{10}$$

where p_1 is the parameter for the residual energy to beginning energy of the cluster member, p_2 is expressed as the distance within the base station and the cluster member in Eq. (11).

$$p_2 = \frac{\left(dis_{th} - dis_{SN \rightarrow BS}\right)}{dis_{th}} \tag{11}$$

The energy for every member diminishes regularly due to the active transmission with cluster head so that the value of γ needs to be modified in every round according to the residual energy and the threshold energy of the specific cluster while selecting the cluster head. Every cluster head has huge number of members in smallest distance to the cluster centroid according to the proposed technique; hence the cluster head must be near to the centroid and maintains maximized residual energy. The fitness functions of the proposed technique despites distance metric for the cluster head selection in a largest distance cluster also modifies through residual energy and energy related operations. Every member maintains the fitness value and the highest valued member is discovered as the cluster head. The modified fitness function is computed in Eq. (12).

$$FV^{mod}_{CH} = \gamma p_1 + (1 - \gamma)p_3 \tag{12}$$

The value of p_3 is computed in Eq. (13).

$$p_3 = \frac{(dis^{LD}_{max} - dis_{SN \to CH})}{dis^{LD}_{max}} \tag{13}$$

The largest distance value is computed in Eq. (14).

$$dis^{LD}_{max} = 1 + \max\left\{dis_{SN \to Cen}\right\} \tag{14}$$

The mean distance within the centroid and the cluster member is computed in Eq. (15).

$$dis^{LD}_{mean} = mean \sum_{i=1}^{n} dis_{SN_i \to Cen} \tag{15}$$

The cluster head selection procedure has the selection of cluster members of smallest distance then the cluster heads of long distance has been selected with the modified fitness value. After successfully selecting the cluster heads, it delivers the acknowledgement message to all the members of long distance for providing active routing process. The response message has been delivered by the members to the cluster head for active transmission. The cluster heads with members deliver the data packets within the specified time periods. The inter-cluster transmission utilizes the cluster heads for delivering the data packets to the base station according to the proposed routing functionality which is demonstrated in Algorithm 1.

Algorithm 1 Cluster head selection with Effective Energy utilization

```
Begin Procedure
    For every cluster head do
        modify γ value
    For number of smallest distance clusters do
        cluster member obtains fitness value
    End For
        The cluster with highest fitness value is assigned as cluster head
    End for
    For selecting long distance cluster head do
        modify γ value
    For number of long distance clusters do
        cluster member obtains modified fitness value
    End For
        The cluster with highest modified fitness value is assigned as cluster head
    End for
End Procedure
```

The packet routing methodology has the effective utilization of the network energy with the functionality of cluster head selection process within the base station and the cluster head. The intra-cluster transmission is the smallest distance cluster which is used for effective utilization of energy in cluster members according to the distance to the base station. Whenever the sensor node satisfies the condition, it broadcasts the data packets to the cluster head else it delivers to the base station and the destination is expressed in Eq. (16).

$$SN_{dest} = \begin{cases} CH & dis_{SN \to CH} > dis_{CH \to BS} \\ BS & otherwise \end{cases} \tag{16}$$

where the cluster head gathers and data aggregation of the data packets from the cluster head to other cluster heads of long distance delivers it to the base station which is used to avoid the unwanted communication from the sensor nodes to the base station. In every long distance clusters, every sensor node delivers the data packets to the specific cluster head and the cluster heads deliver the data packets through multi-hop routing with fitness value as the distance with the base station and cluster head. Every cluster head gathers the fitness value with residual energy and the centroid value is computed in Eq. (17).

$$FV_{Routing} = \delta p_4 + (1 - \delta) p_5 \tag{17}$$

where p_4 is identified as the rate of residual energy for the cluster head and it is computed in Eq. (18).

$$p_4 = \frac{Energy_{Res}^{CH}}{Energy_i} \tag{18}$$

The value of p_5 is computed as the rate of distance for the cluster heads through the centroid in Eq. (19).

$$p_5 = \frac{(dis_{CH \to Cen}^{max} - dis_{CH \to Cen})}{dis_{CH \to Cen}^{max}} \tag{19}$$

The value of $dis_{CH \to Cen}^{max}$ is computed in Eq. (20).

$$dis_{CH \to Cen}^{max} = 1 + \max_{\mathrm{i}} \left\{ dis_{CH \to Cen_i} \right\} \tag{20}$$

The energy based dependency and the distance metric has been maintained by identifying the value of $\delta, Cen\prime$ is the value of centroid to the cluster heads with highest value into the centroid values. The value of p_5 becomes zero despite $(dis_{CH \to Cen}^{max} = dis_{CH \to Cen})$, so that the value of 1 should be included for avoiding 0. The cluster heads satisfy the condition of delivering the data packets through the active cluster head which directly transmits to the base station. Moreover, every sensor node of long-distance clusters delivers the packets to the cluster head through multi-hop transmission is illustrated in Algorithm 2.

Algorithm 2 Enhanced packet routing technique

```
Begin Procedure
    For the entire WSN do
        Compute the value of dis_{CH→BS}
    For all smallest distance clusters do
        Compute the value of dis_{SN→BS}
    if dis_{SN→BS} > dis_{CH→BS} then
        Sensor node delivers the data packets to the cluster head
    else
        Sensor node delivers the data packets to the base station
    end if
    End For
    For all long-distance clusters do
        Compute the value of dis_{CH→BS}
        Compute the value of dis_{CH→Cen}
    if dis_{CH→Cen} ≤ dis_{CH→BS} then
        Cluster head delivers the data packets through centroid
    else
        Cluster head delivers the data packets through the base station
    end if
    End For
        Cluster head directly delivers the data packets to the base station
    End For
End Procedure
```

4 Performance Analysis

The proposed technique is simulated using MATLAB through 2 environments through several performance metrics of network coverage, residual energy and network lifetime. The proposed CHRT methodology is compared with the related methodologies of CEOMS [19], EOCGS [20], C3HA [21], EEMST [24], and LEDCHE [25] through the performance metrics of energy consumption, active nodes, residual energy, and

Table 1 Simulation metrics

Metrics	Value
Simulation environment	MATLAB
Coverage is for environment 1	100m × 100m
Coverage is for environment 2	200m × 200m
Base station initial for environment 1	(150m, 100m)
Base station initial for environment 1	(200m, 100m)
Number of rounds	2000
Number of nodes	1000
initial energy	$50 \frac{nJ}{bit}$
Size of the data packet	4000 bits
Transmit energy	0.5 J
size of control packet	200 bits
distance	90 m

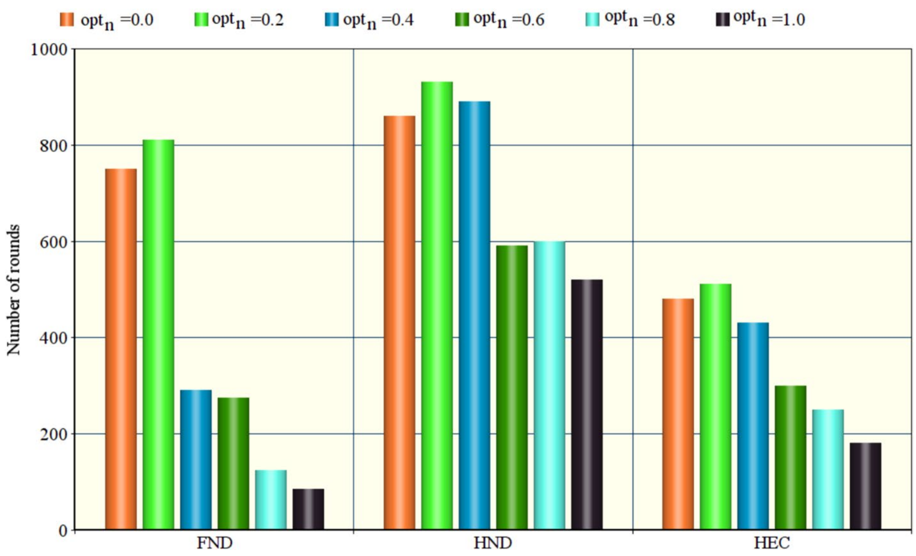

Fig. 2 Different optimum values for the proposed technique

coverage rate for the 2 environments. The simulation metrics are illustrated in Table 1 that the base station is initially originated as $(0m, 0m)$. The Coverage area in WSN is affected by the physical environment, signal refraction, interferences, antenna and environmental factors with constraints. The frequency band is involved to affect the coverage in Indoor environment which leads to tiny coverage range compared with outdoor environments that signals could travel with longer distances.

The total amount of sensor node in the smallest distance cluster using the optimum value opt_n with the performance parameter of total amount of rounds for FND, HND and HEC. Figure 2 demonstrates the simulation of the different optimum values in

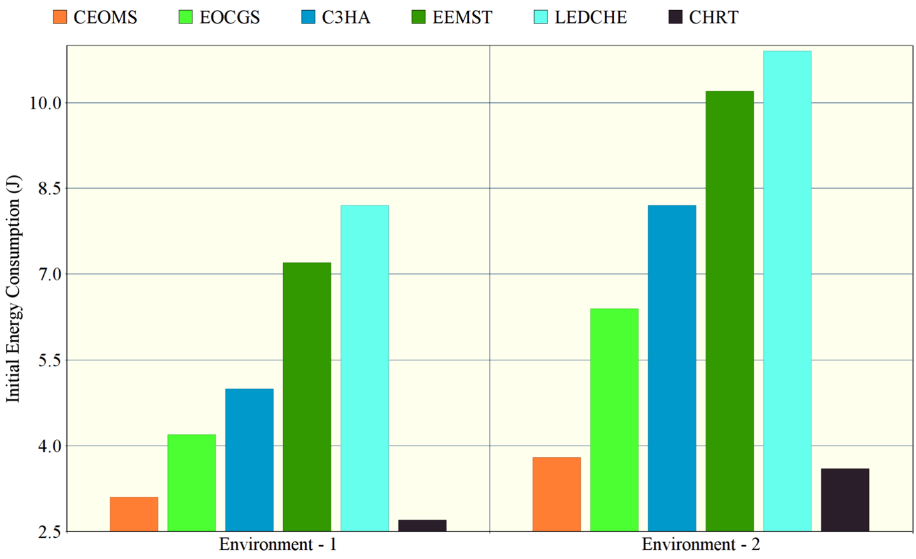

Fig. 3 Initial energy consumption

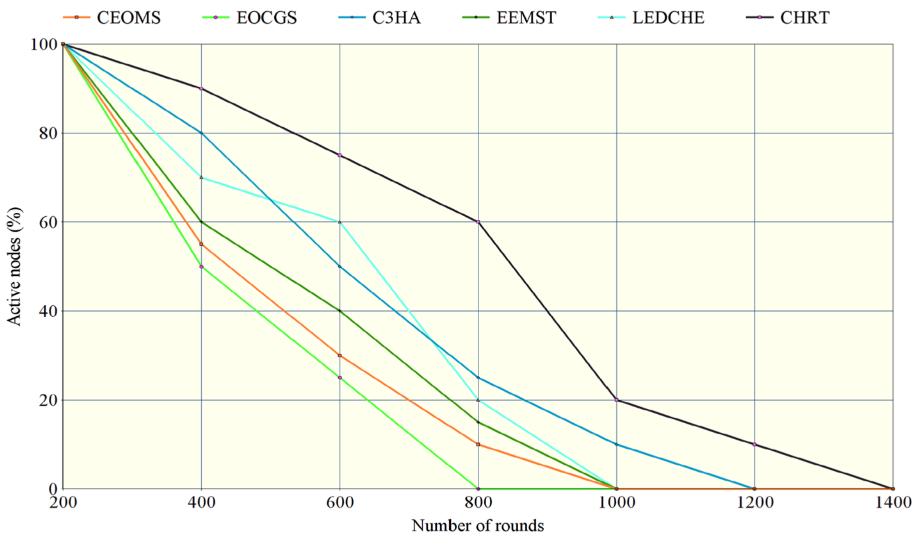

Fig. 4 Alive nodes (%) for environment–1

the network and whenever the optimum value is 0.2, the total amount of rounds are increased and this value is identified as the optimum value of the proposed technique.

The initial energy utilization in each environment is demonstrated in Fig. 3 that the relevant methodologies have highest amount of energy consumption due to the centralized clustering approach in every round, but in the proposed methodology the enhanced clustering approach has been utilized to minimize the energy consumption.

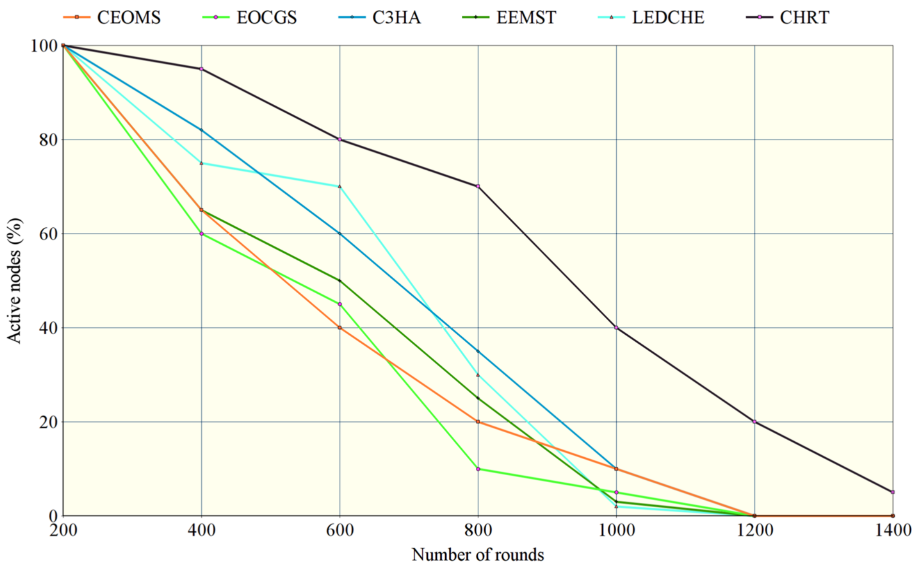

Fig. 5 Alive nodes (%) for environment–2

The alive nodes have been evaluated through the network environment 1 in Fig. 4 and environment 2 in Fig. 5 that the simulation result shows about the proposed technique is compared with other techniques which have produced the extended network lifetime due to the energy proficient cluster head selection and enhanced routing approach. The simulation results show that the network lifetime suddenly diminished after some rounds due to energy consumption.

The proposed technique has improved rounds than the relevant methodologies due to the base station and it is kept at the initial period through the sensing area which is higher in Environment–1 than Environment–2, the enhanced clustering through the improved rounds periodical extends the network lifetime as the proposed technique holds the unwanted energy utilization through the clustering procedure and the overall simulation results are better for the proposed technique which is demonstrated in Figs. 6 and 7.

The proposed technique is simulated to evaluate the residual energy of the network for Environment–1 in Fig. 8 and Environment–2 in Fig. 9 that the results have been compared with the relevant methodologies. The optimal energy utilization is identified for the proposed technique due to enhanced clustering and routing approach that minimizes the unwanted energy utilization into the initial procedure.

The coverage rate is the important performance metric for evaluating the network coverage that the rate of the amount of completed grids to the total amount of grids in the network. Basically the whole sensing area has been segregated into same sized squares while the completed squares are the smallest alive nodes. The proposed technique is simulated for computing the coverage rate in 2 Environments, the simulation results are compared with the related methodologies and (Figs. 10, 11) demonstrate that the proposed technique is having better result in network coverage.

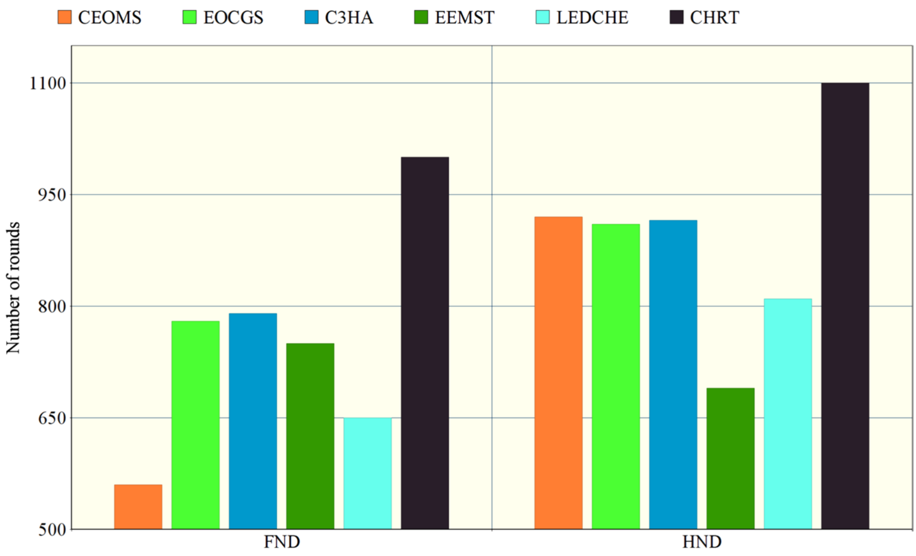

Fig. 6 FND and HND for environment–1

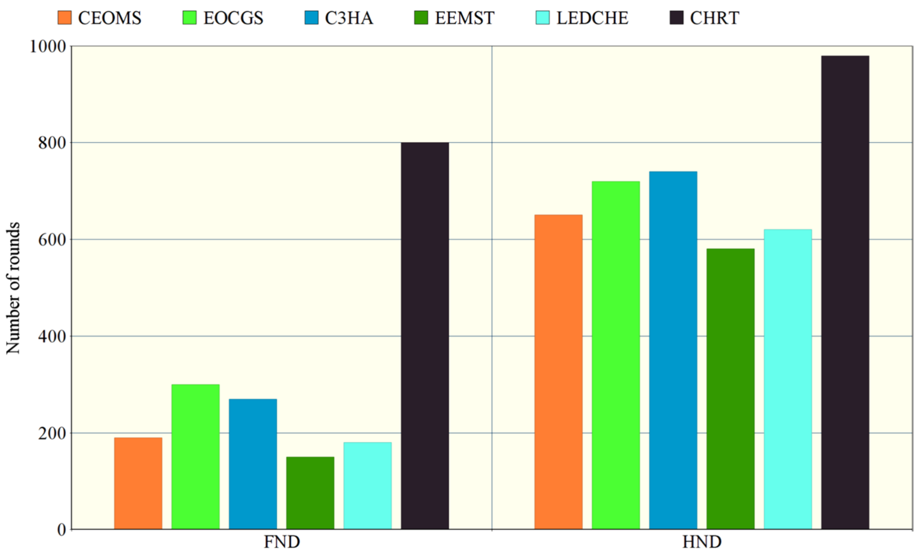

Fig. 7 FND and HND for environment–2

Figures 12 and 13 demonstrate the performance analysis for the proposed technique with the relevant methodologies in terms of clustering metrics and the results proved that the proposed technique has the improved performances.

The increasing the packet size will affect the efficacy of data communication, network congestion, error rate, fragmentation, latency, jitter, buffer requirement, throughput. While increasing the packet size could enhance the efficiency and throughput in

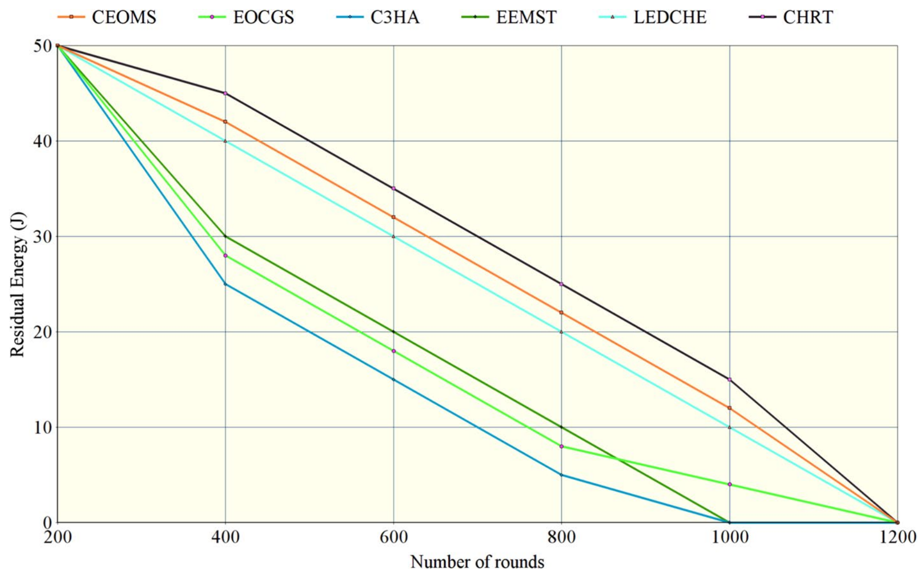

Fig. 8 Residual energy for environment–1

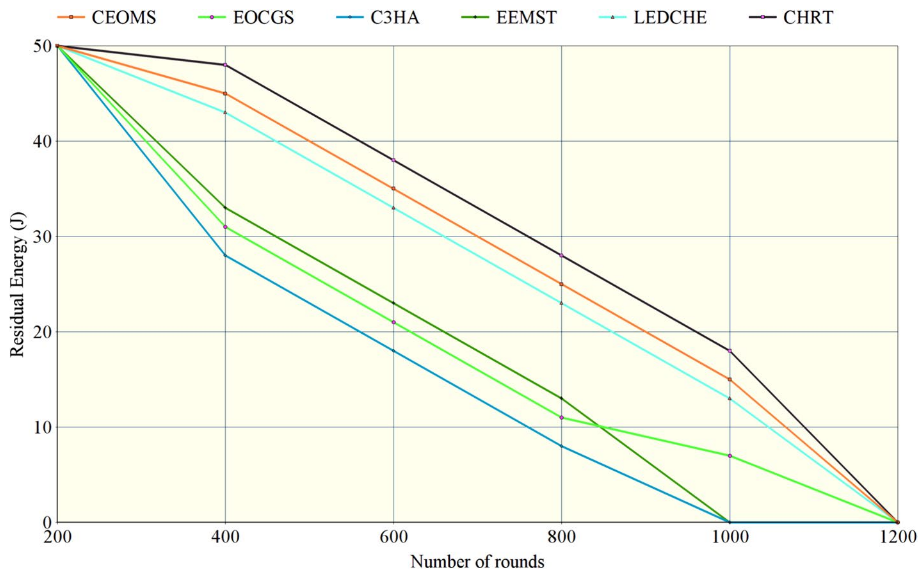

Fig. 9 Residual energy for environment–2

particular environments, it can also lead to enhance the congestion, latency, and retransmission costs in difference environments. The decision of enhancing the packet size should be executed according to the particular network constraints, balancing of the trade-offs for achieving the optimized network performance and the proposed technique is developed to overcome the above-mentioned issues.

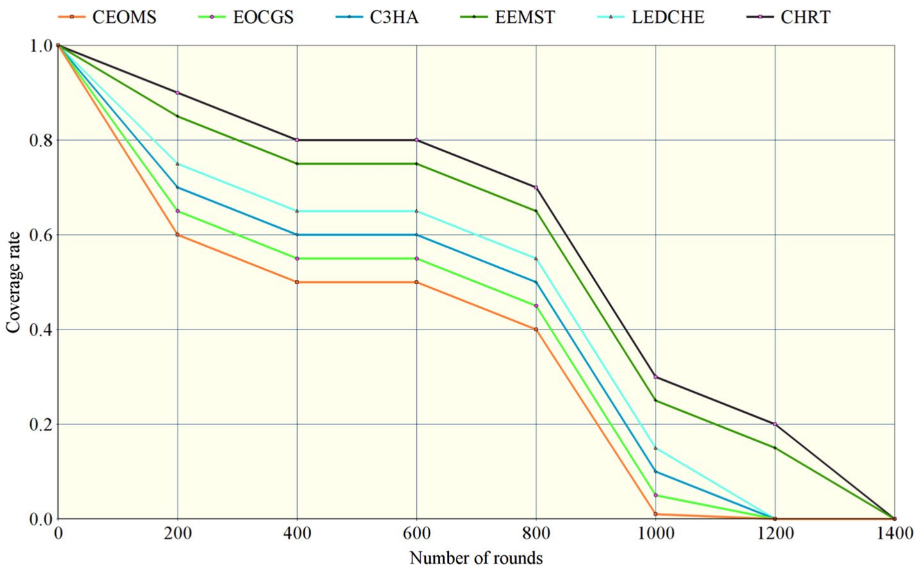

Fig. 10 Coverage rate for environment–1

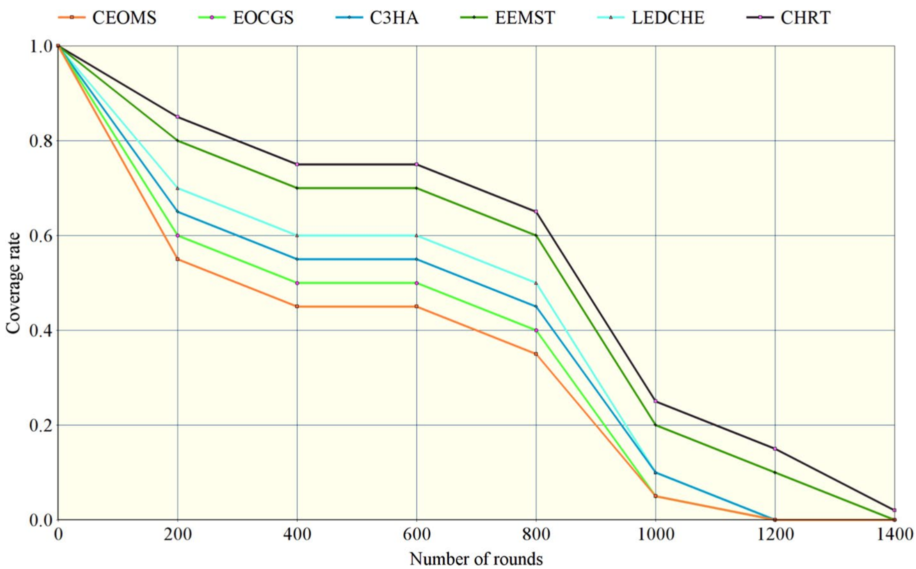

Fig. 11 Coverage rate for environment–2

5 Conclusion

In this paper, Effective Energy utilization for cluster head selection process and an enhanced packet routing technique has been proposed for enhancing the network

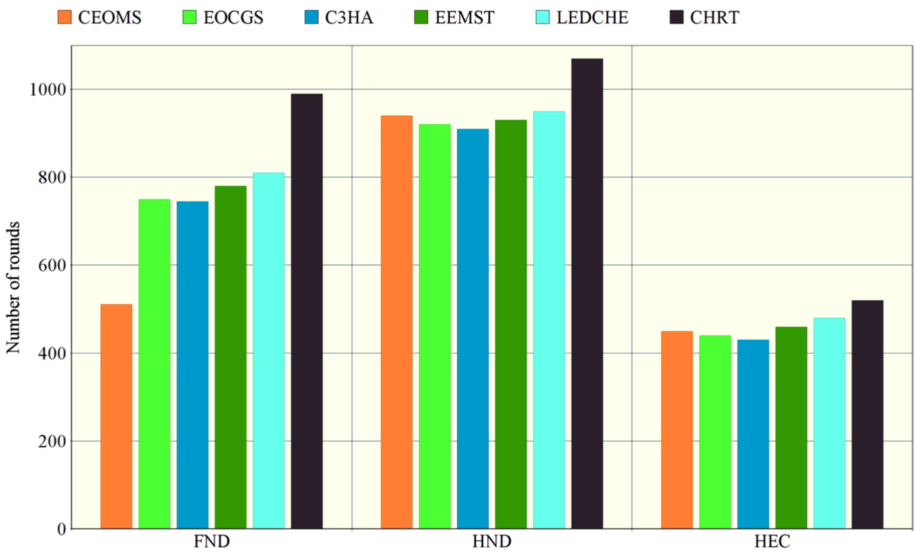

Fig. 12 Performance analysis for environment–1

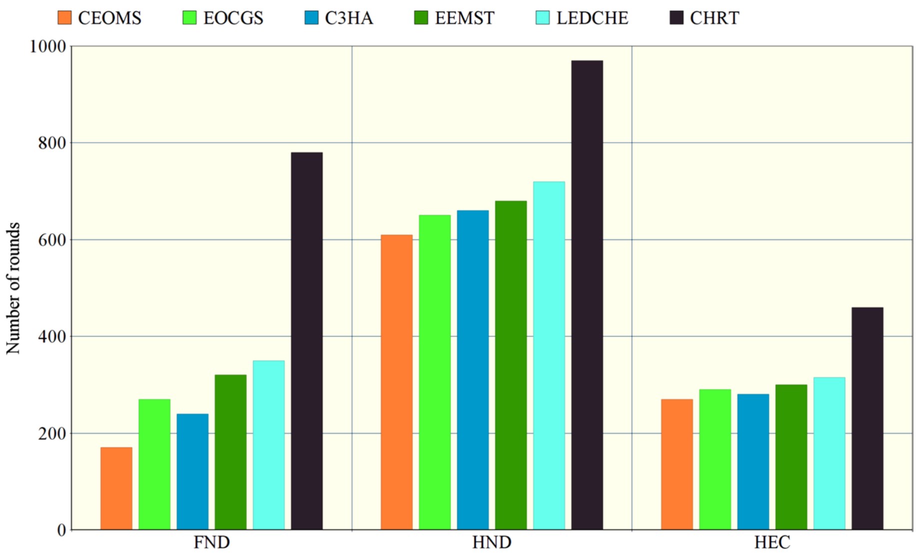

Fig. 13 Performance analysis for environment–2

lifetime. The proposed cluster procedure has been used for producing the optimized energy utilization that reduces the unwanted energy consumption. Every cluster head is selected with the fitness function that holds the residual energy and the modified fitness function have relayed the remaining cluster heads to save the energy in effective way. The Experimental results proved that the proposed technique has produced enhanced results such as residual energy, network lifetime and coverage rate than the related techniques. In Future, the analytical-enabled Optimization technique could be implemented to integrate the performance metrics of congestion, network Lifetime, coverage in dynamic environment of WSN. The congestion control technique will be tested in real-time integrated IoT applications like smart city and automation of Agriculture-enabled application.

Acknowledgements Princess Nourah bint Abdulrahman University Researchers Supporting Project number (PNURSP2022R192), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

Author Contributions Y. Harold Robinson: Writing—original draft, Writing—review & editing, Conceptualization, Data curation. B. Valarmathi: Writing—original draft Conceptualization, Data curation. P. Srinivasan: Validation, Formal analysis, Supervision. Hanen Karamti: Conceptualization, Data curation.

Funding This work has not supported by any funding agency/institution.

Data Availability Not applicable.

Code Availability Not applicable.

Declarations

Conflict of interest The authors declare that they do not have any conflict of interest. This research does not involve any human or animal participation. All authors have checked and agreed the submission.

References

1. A, Raychaudhuri, D, De, (2020). "Bio-inspired algorithm for multi-objective optimization in wireless sensor network," In in Nature Inspired Computing for Wireless Sensor Networks, (pp. 279–301), Springer.
2. Sun, Z., Wei, M., Zhang, Z., & Qu, G. (2019). Secure routing protocol based on multi-objective ant-colony-optimization for wireless sensor networks. *Applied Soft Computing, 77*, 366–375.
3. J, Lou, (2019). "Location-based multi-objective optimization routing algorithm for WSN," in In Recent developments in intelligent computing, communication and devices, (pp. 523–529), Springer
4. Liu, J., Shen, H., Yu, L., et al. (2017). Characterizing data deliverability of greedy routing in wireless sensor networks. *IEEE Transactions on Mobile Computing, 17*(3), 543–559.
5. Singh, S., & Kumar, P. (2020). MH-CACA: Multi-objective harmony search-based coverage aware clustering algorithm in WSNs. *Enterprise Information Systems, 14*(9–10), 1325–1353.
6. Wang, J., Ju, C., Gao, Y., Sangaiah, A. K., Kim, G., et al. (2018). A PSO based energy efficient coverage control algorithm for wireless sensor networks. *Computers, Materials & Continua, 56*(3), 433–446.
7. Wang, J., Gao, Y., Zhou, C., Simon Sherratt, R., & Wang, L. (2020). Optimal coverage multi-path scheduling scheme with multiple mobile sinks for WSNs. *Computers, Materials & Continua, 62*(2), 695–711.
8. Guruprakash, B., Balasubramanian, C., & Sukumar, R. (2020). An approach by adopting multi-objective clustering and data collection along with node sleep scheduling for energy efficient and delay aware WSN. *Peer-to-Peer Networking and Applications, 13*(1), 304–319.
9. J, Kumari, (2015). "A comprehensive survey of routing protocols in wireless sensor networks," In 2015 2nd International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India
10. M, Malakar, (2020). "TLBO based cluster-head selection for multi-objective optimization in wireless sensor networks," In in Nature Inspired Computing for Wireless Sensor Networks, pp. 303–319, Springer
11. Heinzelman WR, Chandrakasan A, Balakrishnan H, (2000). "Energy-efficient communication protocol for wireless microsensor networks," Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, (vol.2, pp. 10). Maui, HI, USA.

12. Younis, O., & Fahmy, S. (2004). HEED: A hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks. *IEEE Transactions on Mobile Computing, 3*(4), 366–379.
13. Verma, A., Kumar, S., Gautam, P., Rashid, T., & Kumar, A. (2020). Fuzzy logic based effective clustering of homogeneous wireless sensor networks for mobile sink. *IEEE Sensors Journal, 20*(10), 5615–5623.
14. I. Daanoune, A. Baghdad and A. Balllouk, (2019). "BRE-LEACH: A new approach to extend the lifetime of wireless sensor network," 2019 Third International Conference on Intelligent Computing in Data Sciences (ICDS), (pp. 1–6). Marrakech, Morocco.
15. Nayak, P., & Devulapalli, A. (2016). A Fuzzy logic-based clustering algorithm for wsn to extend the network lifetime. *IEEE Sensors Journal, 16*(1), 137–144.
16. Liao Q, Zhu, (2013). "An energy-balanced clustering algorithm based on LEACH protocol", In ICSEM-13–2nd International Conference on Systems Engineering and Modeling, (vol. 5, no. 3, pp. 90–95).
17. Rajpoot P, Dwivedi P, Dubey K, (2019). "Power balanced efficient clustering algorithm for WSN," 2019 International Conference on Communication and Electronics Systems (ICCES), (pp. 585–589). Coimbatore, India.
18. Azad, P., & Sharma, V. (2013). Cluster head selection in wireless sensor networks under fuzzy environment. *International Scholarly Research Notices, 2013*(909086), 8.
19. Wei, Q., Bai, K., Zhou, L., Hu, Z., Jin, Y., & Li, J. (2021). A cluster-based energy optimization algorithm in wireless sensor networks with mobile sink. *Sensors, 21*, 2523.
20. Panchal, A. (2021). Rajat Kumar Singh, "EOCGS: Energy efficient optimum number of cluster head and grid head selection in wireless sensor networks." *Telecommunication Systems, 78*, 1–13.
21. Muhammed Tay, Arafat Senturk, (2021). "A new energy-aware cluster head selection algorithm for wireless sensor networks", Wireless Personal Communications.
22. Saleh, S. S., Mabrouk, T. F., & Tarabishi, R. A. (2021). An improved energy-efficient head election protocol for clustering techniques of wireless sensor network (June 2020). *Egyptian Informatics Journal, 22*(4), 439–445.
23. Kathiroli, P., & Selvadurai, K. (2021). Energy efficient cluster head selection using improved sparrow search algorithm in wireless sensor networks. *Journal of King Saud University-Computer and Information Sciences, 34*, 8564–8575.
24. Doryanizadeh, V., Keshavarzi, A., Derikvand, T., & Bohlouli, M. (2021). Energy efficient cluster head selection in internet of things using minimum spanning tree (EEMST). *Applied Artificial Intelligence, 35*, 1777–1802.
25. Yagoub, M. F. S., Khalifa, O. O., Abdelmaboud, A., Korotaev, V., Kozlov, S. A., & Rodrigues, J. P. C. J. (2021). "Lightweight and efficient dynamic cluster head election routing protocol for wireless sensor networks." *Sensors, 21*(15), 5206.
26. Nabavi, S. R., Ostovari Moghadam, V., Yahyaei Feriz Hendi, M., & Ghasemi, A. (2021). Optimal selection of the cluster head in wireless sensor networks by combining the multiobjective genetic algorithm and the gravitational search algorithm. *Journal of Sensors, 2021*(2292580), 16.
27. Aydin, M. A., Karabekir, B., & Zaim, A. H. (2021). Energy efficient clustering-based mobile routing algorithm on WSNs. *IEEE Access, 9*, 89593–89601.
28. Sharma, V., & Grover, A. (2016). A modified ant colony optimization algorithm (mACO) for energy efficient wireless sensor networks. *Optik, 127*(4), 2169–2172.
29. Grover, A., Kumar, R. M., Angurala, M., Singh, M., Sheetal, A., & Maheswar, R. (2022). Rate aware congestion control mechanism for wireless sensor networks. *Alexandria Engineering Journal, 61*(6), 4765–4777.
30. Grover, A., Singh, H., Chhabra, N., et al. (2022). Finding an appropriate radio propagation model for rate aware congestion control mechanism in wireless sensor networks. *Wireless Networks, 28*, 3045–3057.

Y. Harold Robinson is currently working in Francis Xavier Engineering College, Tirunelveli, India. He has received Ph.D degree in Information and Communication Engineering from Anna University, Chennai in the year 2016. He is having more than 15 years of experience in teaching. He has published more than 50 papers in various International Journals and presented more than 70 papers in both national and International Conferences. He has written 4 book chapters by Springer,IGI global Publication. He is acting as an editor for a book Title as "Successful Implementation and Deployment of IoT Projects in Smart Cities ". IGI Global in the The Advances in Environmental Engineering and Green Technologies (AEEGT) book series. He is one of the editor for the book "Handbook of Research on Blockchain Technology: Trend and Technologies" publish by Elsevier .He is acting as a Reviewer of many journals like Multimedia Tools and Applications, Wireless Personal Communication by Springer Publication. He has given many Guest Lecturer in various subjects such as pointer, operating system, compiler design in Premier Institutions. He has also given an invited talk in technical symposium He has acted as a Convenor, coordinator and jury in National level and international IEEE Conferences, project fair and Symposium. He has attended various Seminars Workshops, and Faculty Development Programmes to enhance the knowledge of student's community. His research area includes Wireless Sensor Adhoc Networks ,Soft computing, blockchain, IoT and Image Processing. He has published research papers in various SCI journals like wireless personal communication, IEEE access, Ad-hoc networks, Mobile networks and application, Journal of Ambient Intelligence and Humanized Computing, Peer-to-Peer Networking and Applications, Journal of Intelligent & Fuzzy Systems, Computer Standards & Interfaces and Earth Science Informatics. He is also an active life time member in Indian Society of Technical Education.

B. Valarmathi holds M. Tech degree in computer science and engineering from IIT Madras and PhD degree in computer science and engineering from Anna University, India. Prof. B. Valarmathi, an accomplished faculty with 29 years of teaching experience with achievements ranging from teaching, administration, research and industrial consultancy has 44 publications in the peer reviewed international journals in the field of Machine learning, Internet of things, Text mining, Opinion mining, and heuristics. She has developed a quick and accurate heuristic for document level sentiment analysis method using Mahalanobis distance and also worked extensively on developing clustering algorithms using correlation analysis. She has co-authored a textbook Total Quality Management published by Tata McGraw Hill publications and developed computer based training materials (CBT) for various subjects. She published 4 book chapters in CRC press, Springer and IGI Global publishers. She has a mastery over the quality management systems (QMS) implementation and successfully implemented ISO 9000 QMS at TANMAG industries a 300 crore company located in Salem, Tamilnadu. She received a Project Grant 3 times from Tamil Nadu State Council for Science and Technology under Student Project Scheme during 2007-2010. She coordinated Anna University Sponsored Faculty Development Programme and AICTE Sponsored Staff Development Programme for a five times. She organized various state and national level workshops and conferences. Also she organized various Training Programme to Tamilnadu Government Judicial Officers, Treasury employees and Higher Secondary School Headmasters. Three scholars have completed Ph.D under her guidance and she is currently guiding three Ph.D scholars in the field of sentiment mining and heuristics. Her current areas of interest include data mining, deep learning, IoT, opinion mining, clustering algorithms for categorical data and Software Quality assessment.

P. Srinivasan is working in the School of Information Technology and Engineering, Vellore Institute of Technology, Vellore. He has 16 years of teaching experience and published more than 25 research papers in international journals and presented several papers in National/International conferences.

Hanen Karamti received the bachelor's degree in computer science and multimedia from the Higher Institute of Computer Science and Multimedia, Sfax University, Tunisia, the Master of Computer Science and Multimedia degree from Sfax University, in 2011, and the Ph.D. degree in computer science from the National Engineering School of Sfax, Tunisia, in 2017, in cooperation with the University of La Rochelle, France, and the University of Hanoi, Vietnam. She is currently an Assistant Professor with Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia. Her research interests include information retrieval, multimedia systems, image retrieval, health informatics, big data, and data analytics.