Vol.66: e23220866, 2023
https://doi.org/10.1590/1678-4324-2023220866
ISSN 1678-4324 Online Edition

Article - Engineering, Technology and Techniques

Multi-objective Sand Piper Optimization Based Clustering with Multihop Routing Technique for IoT Assisted WSN

Vinoth Kumar Kalimuthu[1*]
https://orcid.org/0000-0002-8920-4936

Balakrishnan Srinivasan[2]
https://orcid.org/0000-0002-3836-2926

[1]SSM Institute of Engineering and Technology Department of ECE, Dindigul, India; [2]Vivekanandha College of Engineering for Women, Department of ECE, Tiruchengode, India.

Editor-in-Chief: Alexandre Rasi Aoki
Associate Editor: Alexandre Rasi Aoki

Received: 05-Nov-2022; Accepted: 05-Jun-2023

*Correspondence: vinodkumaran87@gmail.com; Tel.: +91-9787367067 (V.K.K.)

HIGHLIGHTS

- MOSPO-CMR technique intends to effectively choose cluster heads (CHs) and derive optimal routes to BS. The MOSPO-CMR technique initially performs cluster constructionprocess by the election of CHs using three variables namely Residual energy (RES), distance to BS (DIST), and Node Degree (NDEG). Besides, the MOSPO-CMR technique derives an objective function involving two variables such as RES and DIST to determine optimal routes to destination.
- In order to demonstrate the enhanced outcomes of the MOSPO-CMR approach, a series of simulations were carried out and the outcomes highlighted the enhanced outcomes of the MOSPO-CMR technique over the other recent approaches.
- In this view, this study develops a novel multi-objective sand piper optimization based clustering with multi-hop routing (MOSPO-CMR) technique to IoT assisted WSN.

Abstract: Internet of Things (IoT) can be considered as one of the emergent research topics, which linked several sensor enabled devices. Wireless sensor networks (WSNs) remains a key enabling technology for IoT environment due to their possibility in placing different types of essential smart city applications, like healthcare, smart cities, environment monitoring, etc. At the same time, effectual utilization of energy is required for the design of energy-efficient data transmission strategy in the IoT environment. In this view, this study develops a novel multi-objective sand piper optimization based clustering with multi-hop routing (MOSPO-CMR) technique to IoT assisted WSN. The proposed MOSPO-CMR technique intends to effectively choose cluster heads (CHs) and derive optimal routes to BS. The MOSPO-CMR technique initially performs cluster construction process by the election of CHs using three variables namely Residual energy (RES), distance to BS (DIST), and Node Degree (NDEG). Besides, the MOSPO-CMR technique derives an objective function involving two variables such as RES and DIST to determine optimal routes to destination. In order to demonstrate the enhanced outcomes of the MOSPO-CMR approach, a series of simulations were carried out and the outcomes highlighted the enhanced outcomes of the MOSPO-CMR technique over the other recent approaches.

Keywords: Internet of Things, WSN, Clustering, Routing, Multi-objective optimization, Metaheuristic.

1. INTRODUCTION

Internet of Things (IoT) is considered as newer technologies intending to link multiple sensor devices and it is significant to consider the challenges and issues in the execution of IoT based networks in smart cities [1]. Recently, it has witnessed sensors with improved smartness and the capacity to collect information without human interference [2]. Wireless sensor network (WSN) is a well-known key enabler for the IoT system since its inception and became an environment to deploy different types of smart city applications including, roadside applications, automated control systems, transportation, smart parking, monitoring air pollution, etc [3]. WSN is the traditional technology utilized within an IoT paradigm that permits a wide variety of sensors to independently collect information and effectively route the packet towards the Base station (BS) [4]. The IoT sensors connected to form WSN enabled IoT and additionally implement data sensing in its target region for forwarding the sensed data to the destination. This routing process data sensing and requires a significant data transmission amongst the node, which results in high depletion of energy. Therefore, proficient energy consumption technique is highly required to perform powerful data communication strategy in IoT networks [5]. Figure 1 depicts the overview of IoT assisted WSN. The clustering method is viewed as an optimum method to preserve energy balance in sensors. All the clusters consist of single cluster head (CH) and cluster member (CM) node. CM transmits the data to their corresponding CH in the cluster that is accountable for data aggregation and moreover transmits that aggregated information to the BS [6]. When the node is facing inadequate energy to survive in the network, then it is stated as dead, and when each node runs out of energy in all the rounds, it represents the end of the network. A WSN protocol's aim is to send the fused information from each CH to the BS for detailed analysis, thus routing becomes very essential for effective communication of packets from one node to other nodes, and finally to the BS. This routing experiences sudden node death and higher energy that might stop the network from working and therefore it is significant to effectively expand lifetime of the network [7]. WSN routing system is accountable to form a transmission of data for all the independent nodes. Because of the resource-constrained and application-related features of WSN routing method, it is essential to develop the present routing system based on the situation of switching and charging services and the functions of smart battery pack, for designing a WSN routing system applicable for smart battery pack application [8].

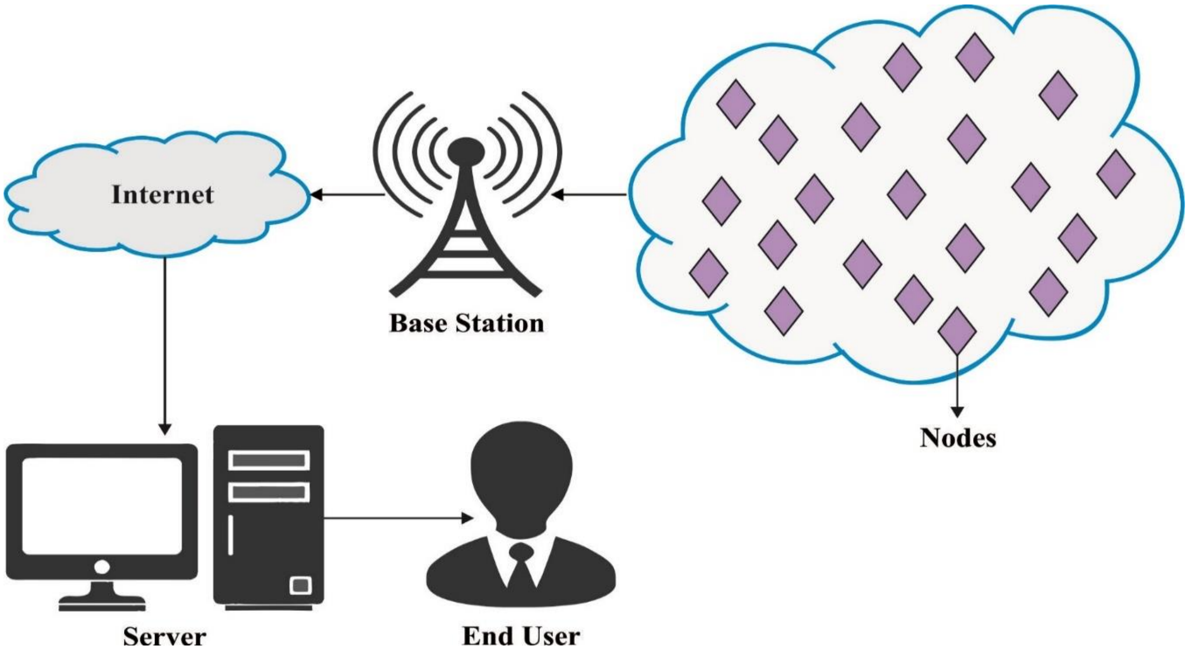

Figure 1. Overview of IoT assisted WSN

By analyzing the implementation technique of panoramic data acquisition for battery, it is shown that WSN networking mode is largely employed in the storage link of battery and the charging mode of sub-compartment, and the features of WSN node distribution based smart battery can be attained [9, 10].
Research Contribution

1. To develop a novel multi-objective sand piper optimization based clustering with multihop routing (MOSPO-CMR) technique for IoT supported WSN.

2. Incorporate cluster construction process by the choice of CHs using three variables namely Residual energy (RES), distance to BS (DIST), and Node Degree (NDEG).

3. To develop an objective function involving two variables such as RES and DIST to decide optimal routes to destination.

MATERIAL AND METHODS

In this study, a new MOSPO-CMR technique has been developed for clustering and routing in the IoT supported WSN. The presented MOSPO-CMR approach encompasses two major phases such as cluster construction and optimal route selection. At the initial stage, the MOSPO-CMR technique derives a fitness function by the use of three parameters namely RES, DIST, and NDEG. In the next stage, the MOSPO-CMR technique determines an objective function involving two variables namely RES and DIST. Figure 2 demonstrates the block diagram of MOSPO-CMR method

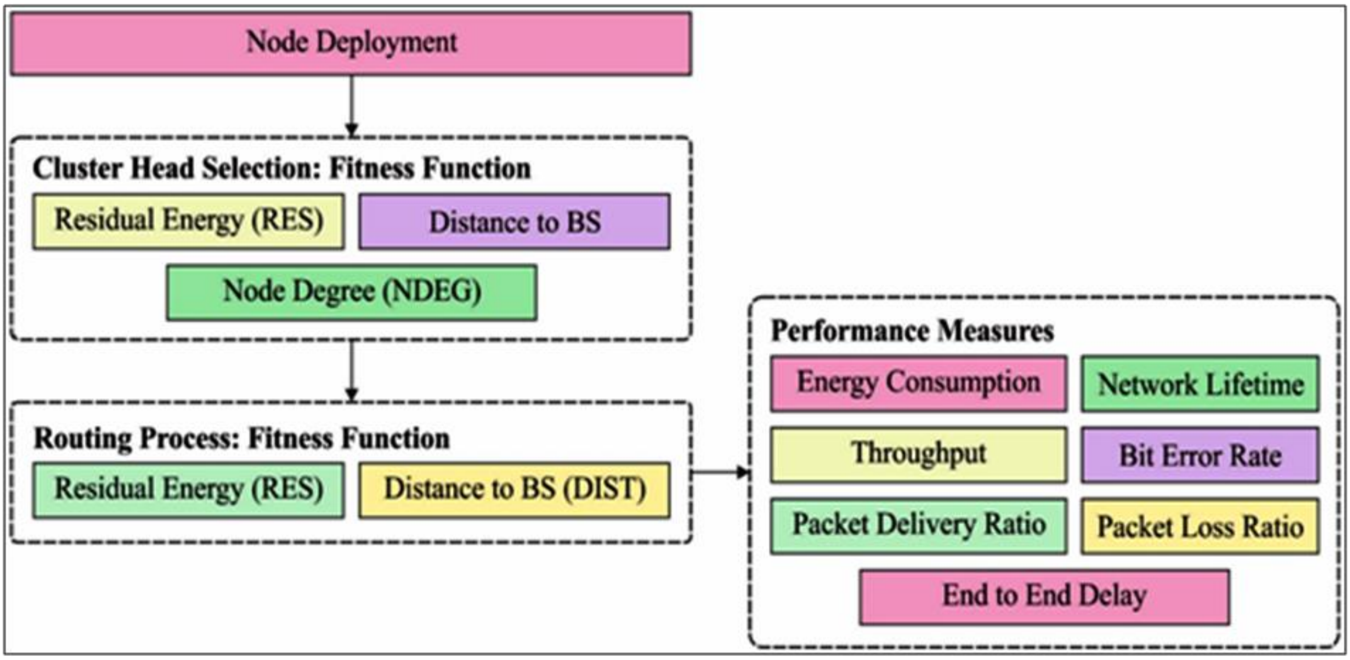

Figure 2. Workflow of MOSPO-CMR method

Overview of SPO Algorithm:

The sandpipers are seabird that is established around the planet. Usually, sandpipers live in colonies. It can be utilized its intelligence for finding and attacking the prey. One of the essential things about the sandpiper is its migration and attack performance. The migration was determined as seasonal movement of sandpipers from one place to another for locating the food-rich and abundant source which offers needed energy. The sandpipers often attack migrate birds on the sea if they can be migrating from one place to another. It can generate its spiral natural shape process under the attack. These performances are expressed like they could be connected with objective functions that optimize. It can be generated its feasible for formulating a novel optimized technique. This work concentrates on 2 natural performances of sandpipers. The mathematical processes of migration and attack performances are discussed as follows [17-21].

Exploration Process

The technique examines the set of sandpipers that move from one place to another under the migration. During this phase, the sandpiper must fulfill the subsequent 3 criteria:

- Collision avoidance: A further variable C_A was applied to compute of novel search agent place for avoiding the collision avoidance amongst its neighbouring sandpipers.

$$\overrightarrow{C_{sp}} = C_A \times \overrightarrow{P_{sp}}(z) \quad (1)$$

where $\overrightarrow{C_{sp}}$ refers the place of search agents that don't collide with other search agents, $\overrightarrow{P_{sp}}$ signifies the existing place of search agents, z implies the existing iteration, and C_A indicates the movement of search agents from the search space.

$$C_A = C_f - \left(z \times \left(\frac{C_f}{Max_{iterations}}\right)\right) \quad (2)$$

where,

$$z = 0,1,2, \ldots, Max_{iterations} \quad (3)$$

where C_f represents the control frequency for adjusting the variable C_A that is linearly lower in C_f to 0. For sample, once the parameter C_f is fixed to 2, the variable C_A has continuously reduced in two to zero. The value of C_f is fixed to 2 from this case.

- Converge from the direction of optimum neighbor: Afterward the collision avoidance, the search agent converges (that is, move) near the direction of optimum neighbor's

$$\overrightarrow{M_{sp}} = C_B \times \left(\overrightarrow{P_{bst}}(z) - \overrightarrow{P_{sp}}(z)\right) \quad (4)$$

where, $\overrightarrow{M_{sp}}$ states the places of search agents $\overrightarrow{P_{sp}}$ near the optimum fittest search agents $\overrightarrow{P_{bst}}$ (for instance, whose fitness value has lesser). C_B Implies the arbitrary variable that was responsible for an optimally exploration. The C_B was calculated as:

$$C_B = 0.5 \times R_{and} \quad (5)$$

whereR_{and} demonstrates the arbitrary number lies from the range of zero and one.

- Updating in terms of optimum search agents: At last, the search agents or sandpipers are updated their place equivalent to an optimum search agent.

$$\overrightarrow{D_{sp}} = \overrightarrow{C_{sp}} + \overrightarrow{M_{sp}} \quad (6)$$

where $\overrightarrow{D_{sp}}$ signifies the gap amongst the search agents as well as optimum fittest search agents.

Algorithm 1: Pseudocode of SPO Algorithm

Input: Population Size initialized
Output: Optimum solution
Parameter initialized
Define fitness value too every search agent
Xa=Primary optimum solutions from the search agent
Xb=Secondary optimum solutions from search agent
Xc=Tertriay optimum solutiosn from the search agenst
T=0
While (t<max_number_iterations)
For every search agent
Upgraded optimally solutions
Define the fitness of searching agent
Upgraded palce of Xa, Xb, and Xc
Increment T
End while

Exploitation Process

In the migration, sandpiper is modifying its speed as well as angle of attack continuously. It can be utilized its wings for increasing its altitude. The sandpipers create the spiral performance, but attack the prey from the air. This performance in 3D plane was explained as:

$$x' = R_{adius} \times \sin(i) \quad (7)$$

$$y' = R_{adius} \times \cos(i) \quad (8)$$

$$z' = R_{adius} \times i \quad (9)$$

$$r = u \times e^{kv} \quad (10)$$

where R_{adius} refers the radius of all turns of spirals, i indicates the variable lies from the range of $[0 \leq k \leq 2\pi]$. u and v imply the constants for defining the spiral shapes, and e denotes the base of natural logarithm. It can be considered that the value of constants u and v is 1. Once the value of this constant is one or more and the shapes of spirals are very difficult. So, the update place of search agents is calculated as follows.

$$\overrightarrow{P_{sp}}(z) = \left(\overrightarrow{D_{sp}} \times (x' + y' + z')\right) \times \overrightarrow{P_{bst}}(z) \quad (11)$$

where $\overrightarrow{P_{sp}}(z)$ implies the upgrades the places of other search agents and stores optimum solutions.

3.2. Design of SPO Algorithm for Clustering Process

Primarily, the nodes in the IoT assisted WSN are placed arbitrarily in the target region. Then, the initiation of the nodes in the IoT assisted WSN takes place, and then nearby nodes communicate with one other. Followed by, the SPO algorithm is executed at the BS to pick optimal set of CHs. To accomplish this, the SPO algorithm computes an objective function as follows.

$$F(i) = \alpha \times RES + \beta \times DIST + \gamma \times NDEG \quad (12)$$

where $\alpha + \beta + \gamma = 1$. Mainly, the RES of $SN(x)$ for transmitting k bit data to the receiver at distance d, can be determined as follows.

$$RES = E - \left(E_T(k, d) + E_{R(k)}\right) \quad (13)$$

where E and E_T denotes present energy level of SN and energy consumed on data broadcasting.

$$E_T(k, d) = kE_e + KE_a d^2 \quad (14)$$

where E_e represents electron's energy and E_a implies energy spent for amplication, $E_{R(k)}$ designates the energy transmitted on receiving data, as given below.

$$E_{R(k)} = kE_e \quad (15)$$

Moreover, the DIST denotes the mean value of the distance to nearby nodes that exist as single hop neighbors. It can be defined as follows.

$$DIST = \frac{\sum_{j=1}^{NB_i} dist(i, nb_j)}{NB_i} \quad (16)$$

where $dist(i, nb_j)$ indicates distance of the SN to closer jth SN. Finally, the NDEG denotes the amount of neighboring node that exists from the transmission radius and is defined as follows.

$$DEG = |N(x)| \quad (17)$$

where $N(x) = \{n_y / dist(x, y) < trans_{range}\} x \neq y$, and $dist(x, y)$ demonstrates the distance among 2 Nodes n_x and n_y, $trans_{range}$ implies the broadcast range of Nodes.

3.3. Design of SPO Algorithm for Routing Process

At this stage, the existing paths amongst CH and sink nodes are initialized as primary population to the optimized by the SPO algorithm. Primarily, most CH was regarded as the sender and each other CH is assumed that intermediate path or sinks. Therefore, during this initialized stage each feasible path amongst CH as well as sink that is expressed in (18).

$$Sol = P_i, i = 1,2, \ldots N. \quad (18)$$

where 'Sol' implies the primary set of populations, P_i' refers the i^{th} path amongst CH and sink, and 'N' stands for the entire amount of paths. The path contains distance and entire energy.

$$P = \{RES, DIST\} \quad (19)$$

where RE' refers the remaining energy of nodes from the path, 'DIST' signifies the entire distance of paths. The standard deviation (SD) to RES σ_{RES} was utilized to the measurement of the amount of uniform load distributions amongst sensor nodes and is provided in Eq. (20).

$$RES = f_1 = \sigma_{RES} = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left\{\mu_{RES} - e(node_j)\right\}^2} \quad (20)$$

Here,

$$\mu_{RE} = \frac{1}{n}\sum_{i=1}^{n} E\,(node_i) \quad (21)$$

where 'n' implies the entire amount of nodes which exists from the paths and $E(node_j)$' defines the RES of i^{th} node from the paths. Afterward, the distance amongst the sender CH to sink was computed as the sum of Euclidean distance amongst all CHs from the path that is provided in Eq. (22).

$$DIST = \sum_{i}^{n-1} \sqrt{(CH_i(x) - CH_{i+1}(x)) + (CH_i(y) - CH_{i+1}(y))} \qquad (22)$$

where $CH_i(x)$ and $CH_i(y)$ implies the x and y co-ordinates of i^{th} CH from the paths correspondingly. So, a primary objective of presented optimization was energy reduction as expressed in Eq. (21). The secondary objective is for reducing the path distance that is written in Eq. (22). Therefore, these 2 parameters of all paths were initialization as primary population.

Here, the fitness of all solutions or paths amongst the CH and sink are computed using the SPO algorithm. An important objective of optimized is for finding the path with lesser energy utilization and short distances. Therefore, the expressed main function contains both energy as well as distance of all the paths. The FF was expressed as the minimized function and it can be product of energy and distance that is provided in Eq. (23).

$$F_i = \min\{RES_i \times DIST\} \qquad (23)$$

where, 'F_i' signifies the fitness of i^{th} populations, 'RE_i' denotes the energy needed from the i^{th} population and '$DIST_i$' indicates the entire distance of i^{th} paths or populations.

SIMULATION RESULTS AND ANALYSIS

The proposed research work implemented in MATLAB tool, with wireless toolkit. This section inspects the result analysis of the MOSPO-CMR techniques with recent approaches [11-16] under several aspects are discussed here. Table 1 inspects the result analysis of the MOSPO-CMR technique in terms of energy consumption (ECM), network lifetime (NLFT), and throughput (THRP).

Table 1. Comparison Study of MOSPO-CMR Technique interms of ECM, NLFT, and THRP

No. of Nodes ECM (mJ)	MOSPO-CMR	BiHCLR	FEEC-IIR	NF-EPO	FRLDG	HEED
100	10	26	41	57	68	134
200	18	37	71	86	107	157
300	28	47	99	108	140	177
400	37	58	114	140	160	211
500	47	74	145	166	185	251
NLFT (Rounds)						
100	5500	5500	5500	5000	4800	4290
200	5410	5340	5200	4780	4600	4000
300	5450	5350	5010	4690	4370	3830
400	5400	5220	4900	4320	4100	3410
500	5350	5230	4700	4090	3890	3090
THRP (Mbps)						
100	0.9943	0.9863	0.9481	0.9100	0.8035	0.7574
200	0.9783	0.9642	0.8236	0.7754	0.6931	0.7092
300	0.9742	0.9501	0.7333	0.6931	0.6027	0.6288
400	0.9622	0.9280	0.6650	0.5987	0.5405	0.5204
500	0.9542	0.9200	0.6308	0.5365	0.4521	0.4782

A comprehensive ECM analysis of the MOSPO-CMR method takes place with existing techniques in Figure 3. The results reported that the MOSPO-CMR method has accomplished minimal ECM over the other approaches. For sample, with 100 nodes, the MOSPO-CMR method has attained least ECM of 10mJ whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have achieved increased ECM of 26mJ, 41mJ, 57mJ, 68mJ, and 134mJ respectively. In addition, with 500 nodes, the MOSPO-CMR method has provided lower ECM of 47mJ whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have required higher ECM of 74mJ, 145mJ, 166mJ, 185mJ, and 251mJ respectively.

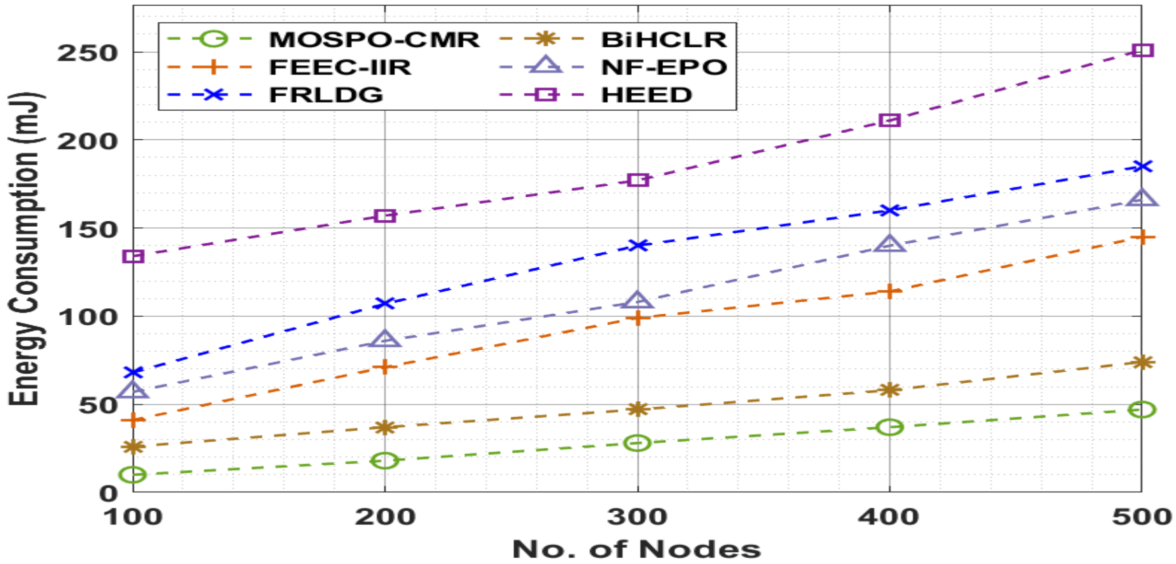

Figure 3. Comparative ECM of MOSPO-CMR with existing models

Figure 4 inspects the comparative NLFT analysis of the MOSPO-CMR method with existing techniques under various nodes. The results reported that the MOSPO-CMR method has accomplished increasing values of NLFT over the other methods. For instance, with 200 nodes, the MOSPO-CMR method has reached to improved NLFT of 5410 rounds whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have accomplished reduced NLFT of 5340, 5200, 4780, 4600, and 4000 rounds respectively. Meanwhile, with 500 nodes, the MOSPO-CMR method has attained enhanced NLFT of 5350 rounds whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have demonstrated decreased NLFT of 5230, 4700, 4090, 3890, and 3090 respectively.

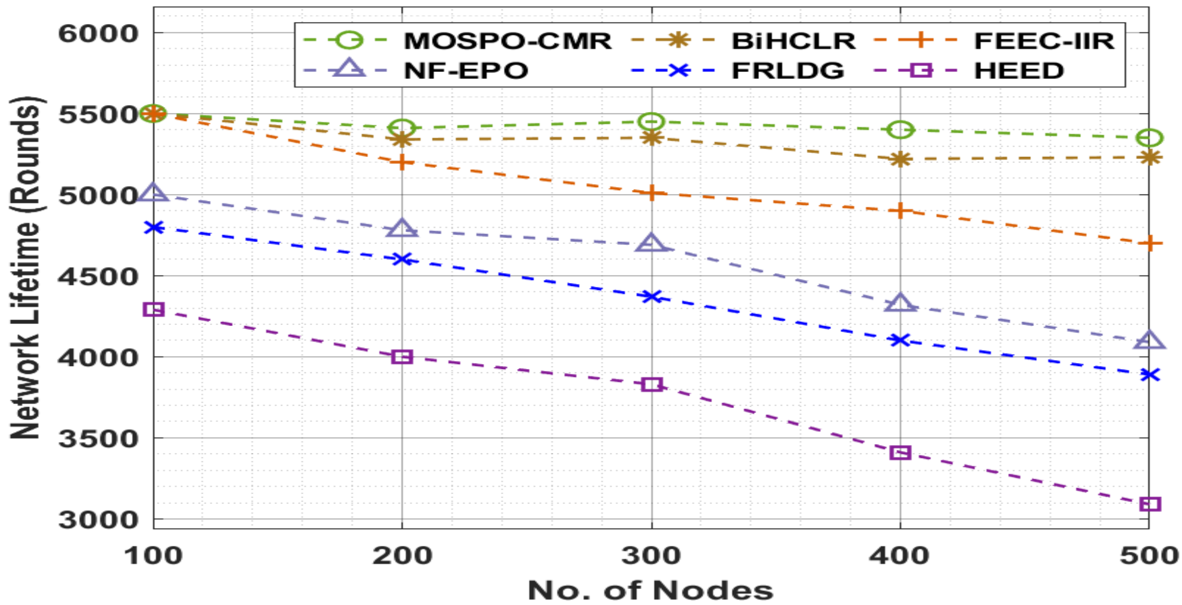

Figure 4. Comparative NLFT of MOSPO-CMR with existing models

Figure 5 examines the comparative THRP analysis of the MOSPO-CMR method with recent ones under distinct nodes. The figure portrayed that the MOSPO-CMR method has resulted in better values of THRP over the other approaches. For instance, with 100 nodes, the MOSPO-CMR method has obtained increased THRP of 0.9943Mbps whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have obtained decreased THRP of 0.9863, 0.9481, 0.9100, 0.8035, and 0.7574 respectively. Similarly, with 500 nodes, the MOSPO-CMR method has reached higher THRP of 0.9542Mbps whereas BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have depicted reduced THRP of 0.9200, 0.6308, 0.5365, 0.4521, and 0.4782 respectively.

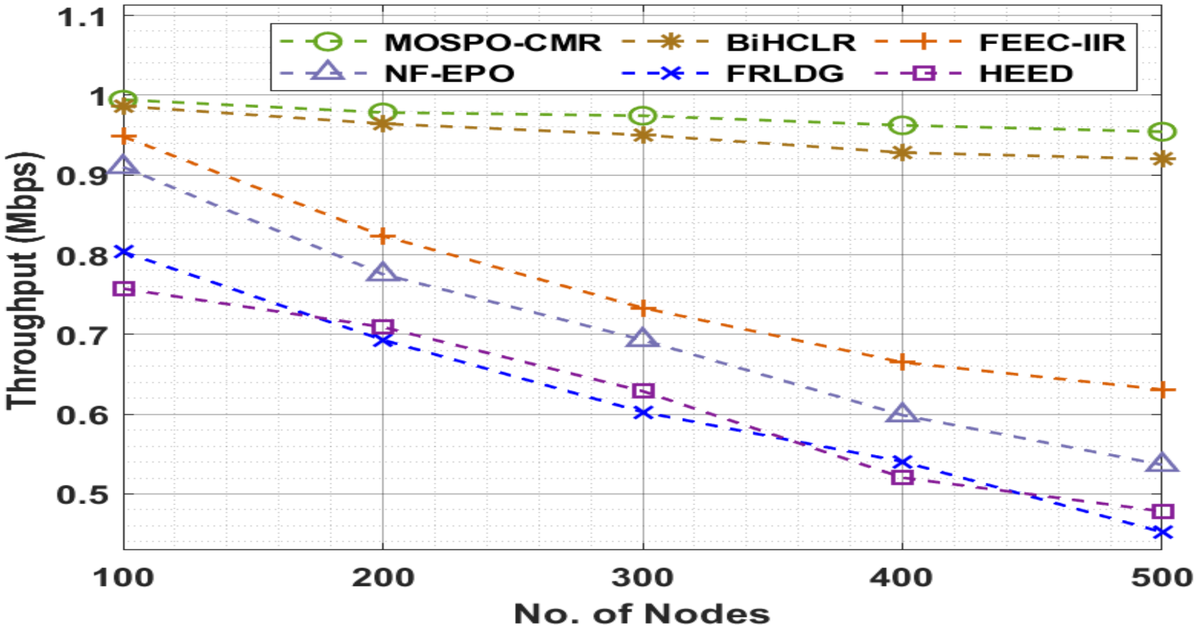

Figure 5. Comparative THRP of MOSPO-CMR with existing models

Table 2 inspects the result analysis of the MOSPO-CMR technique interms of packet delivery ratio (PDR), packet loss ratio (PLR), and end to end delay (ETED). Figure 6 inspects the comparative PDR examination of the MOSPO-CMR method with recent ones under distinct nodes. The figure depicted that the MOSPO-CMR method has led to improved values of PDR over the other methods. For instance, with 200 nodes, the MOSPO-CMR method has got improved PDR of 99.57% whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have gained reduced PDR of 98.96%, 98.04%, 97.12%, 96.04%, and 93.97% respectively. Likewise, with 500 nodes, the MOSPO-CMR method has achieved increased PDR of 97.31% whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have exhibited decreased PDR of 96.08%, 94.97%, 94.09%, 92.05%, and 88.06% respectively.

Table 2. Comparison Study of MOSPO-CMR Technique interms of PLR, PDR, and ETED

No. of Nodes	MOSPO-CMR	BiHCLR	FEEC-IIR	NF-EPO	FRLDG	HEED
			PDR (%)			
100	100.00	100.00	99.08	98.08	97.04	95.08
200	99.57	98.96	98.04	97.12	96.04	93.97
300	98.81	98.12	97.08	96.04	94.09	92.05
400	97.77	96.93	96.08	95.08	93.09	89.98
500	97.31	96.08	94.97	94.09	92.05	88.06
			PLR (%)			
100	0.00	0.00	0.92	1.92	2.96	4.92
200	0.43	1.04	1.96	2.88	3.96	6.03
300	1.19	1.88	2.92	3.96	5.91	7.95
400	2.23	3.07	3.92	4.92	6.91	10.02
500	2.69	3.92	5.03	5.91	7.95	11.94
			ETED (sec)			
100	2.53	3.10	3.92	4.13	4.61	5.75
200	2.62	3.40	3.98	4.88	5.54	6.45
300	3.13	3.95	4.85	6.02	6.51	7.26
400	3.49	3.95	5.60	7.68	8.10	8.46
500	3.68	4.61	6.20	8.76	9.19	9.49

A wide-ranging PLR study of the MOSPO-CMR method with existing algorithms is performed in Figure 7. The results stated that the MOSPO-CMR method has demonstrated least PLR over the existing approaches. For instance, with 200 nodes, the MOSPO-CMR method has been found to be ineffective with the minimum PLR of 0.43% whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have depicted maximum PLR of 1.04%, 1.96%, 2.88%, 3.96%, and 6.03% respectively. Moreover, with 500 nodes, the MOSPO-CMR method has reached to lesser PLR of 2.69% whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have attained increased PLR of 3.92%, 5.03%, 5.91%, 7.95%, and 11.94% respectively.

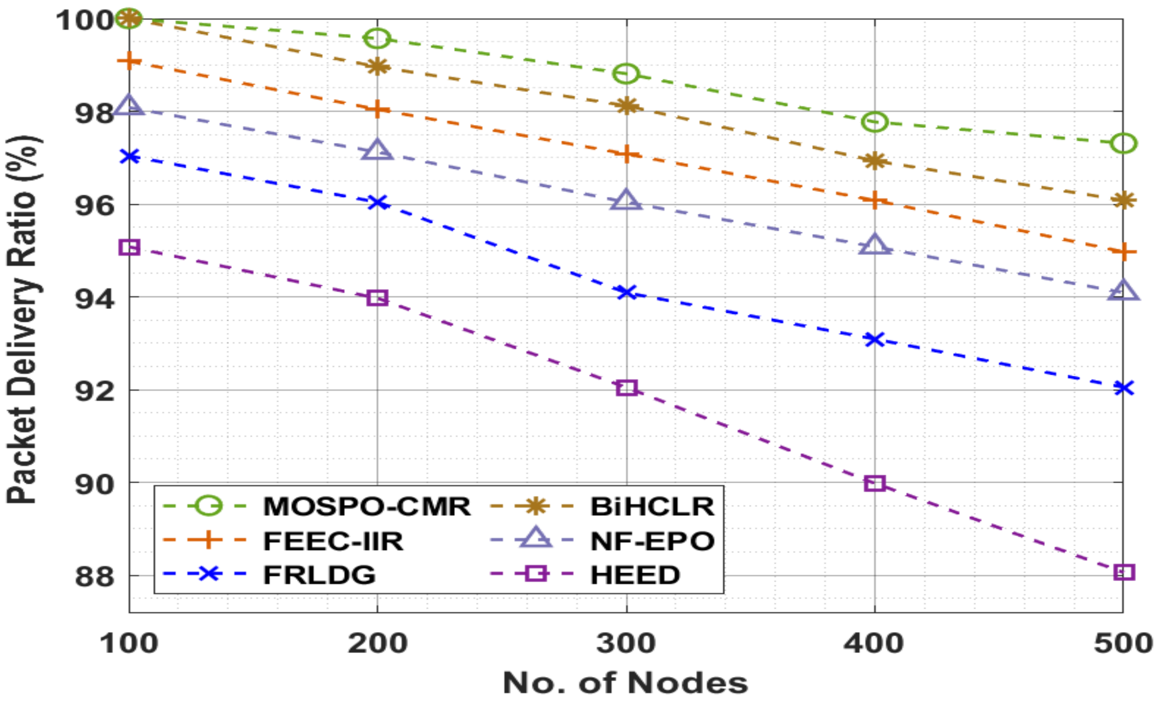

Figure 6. Comparative PDR of MOSPO-CMR with existing models

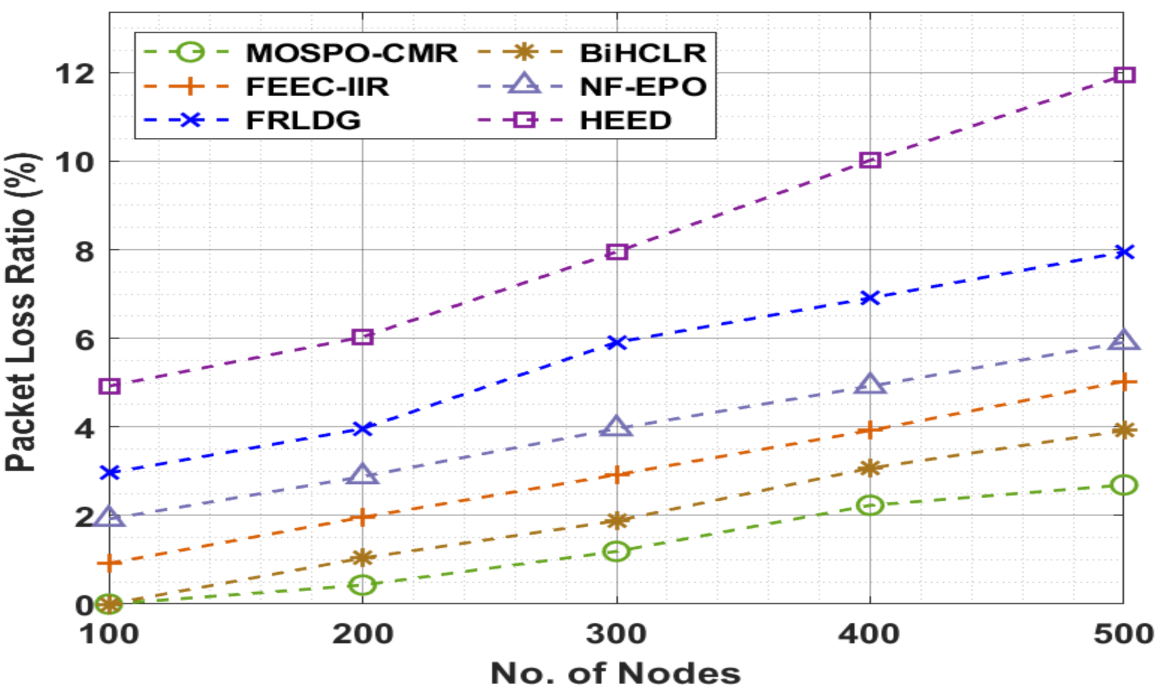

Figure 7. Comparative PLR of MOSPO-CMR with existing models

Finally, a brief ETED investigation of the MOSPO-CMR method is offered with compared models in Figure 8. The figure implied that the MOSPO-CMR method has resulted in the least ETED over the other methods. For instance, with 200 nodes, the MOSPO-CMR method has gained minimal ETED of 2.62s whereas the B BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have achieved somewhat enhanced ETED of 3.40s, 3.98s, 4.88s, 5.54s, and 6.45s respectively. Furthermore, with 500 nodes, the MOSPO-CMR method has accomplished decreased ETED of 2.69s whereas the BiHCLR approach, FEEC-IIR method, NF-EPO system, FRLDG algorithm, and HEED methodologies have resulted in maximum ETED of 34.61s, 6.20s, 8.76s, 9.19s, and 9.49s respectively.

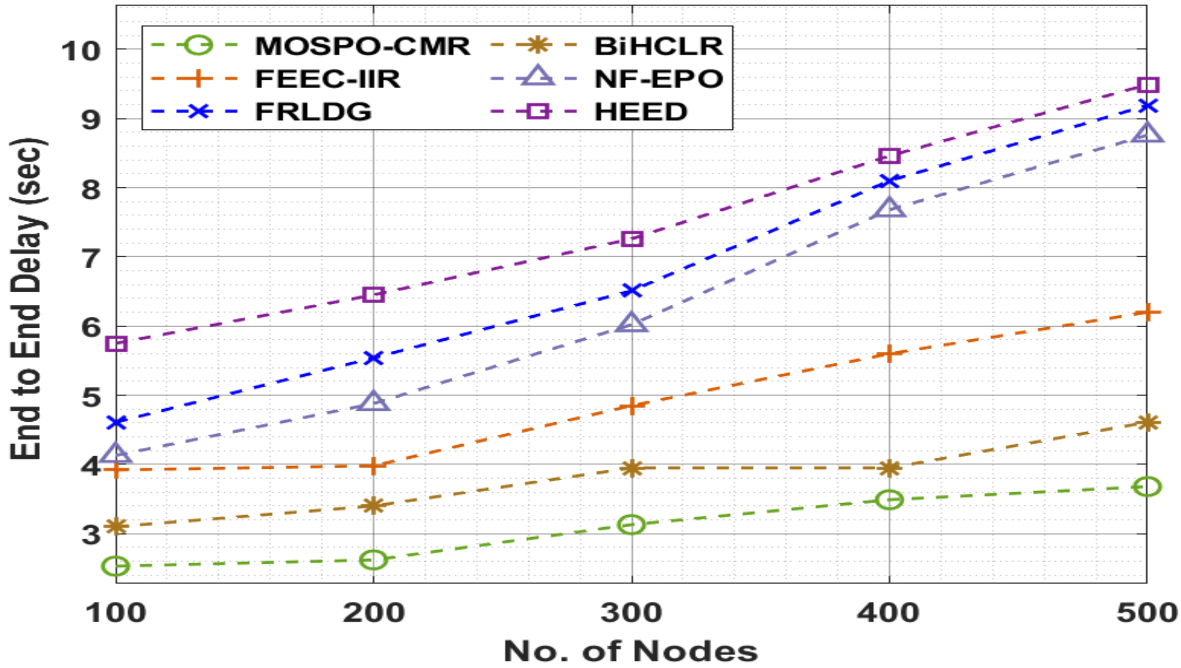

Figure 8. Comparative ETED of MOSPO-CMR with existing models

From the above mentioned results, it can be confirmed that the MOSPO-CMR model can be utilized as a proficient tool to accomplish energy efficiency in IoT assisted WSN.

CONCLUSION

In this study, a new MOSPO-CMR approach has been developed for clustering and routing in the IoT assisted WSN. The presented MOSPO-CMR approach encompasses two major phases such as cluster construction and optimal route selection. For CH selection, the MOSPO-CMR technique derives a fitness function by the use of three parameters namely RES, DIST, and NDEG. In addition, the MOSPO-CMR technique determines an objective function involving two variables namely RES and DIST. For determining the improved outcomes of the MOSPO-CMR approach, a sequence of simulations was carried out under several aspects. The comparative results highlighted the enhanced outcomes of the MOSPO-CMR technique over the other recent approaches interms of several evaluation measures. In future, hybrid metaheuristic techniques can be presented for improving the efficacy of the IoT assisted WSN.

Funding: This research received no external funding.
Acknowledgments: We wish to thank our parents in all the directions. We immense pleasure and privilege to thank my Research Institute Principal, HoD/ECE and Research and Development team of SSM Institute of Engineering and Technology, Dindigul, India for their kind support and guidance in completion of our Project report writing successfully. Additionally, we would like to express our deep gratitude and thanks to the Principal, HoD/ECE and Research and Development team of Vivekanandha College of Engineering for Women, Tiruchengode, India.Finally I would like to thank to all who are inspiration and always motivate us towards our academic development.
Conflicts of Interest: No conflict of interest.

REFERENCES

1. Gupta V, De S. Energy-efficient Edge Computing Framework for Decentralized Sensing in WSN-assisted IoT. IEEE Trans Wirel Commun. 2021 Aug; 20(8):4811-4827.
2. Chouhan N, Jain SC. Tunicate swarm Grey Wolf optimization for multi-path routing protocol in IoT assisted WSN networks. J Ambient Intell Humaniz Comput. 2020. 1-17.
3. Mamdiwar SD, Akshit R, Shakruwala Z, Chadha U, Srinivasan K, Chang CY. Recent Advances on IoT-Assisted Wearable Sensor Systems for Healthcare Monitoring. Biosensors (Basel). 2021 Oct 4; 11(10):372.
4. Eswaramoorthy V, Vinoth Kumar K, Gopinath S. Fuzzy Logic Based DSR Trust Estimation Routing Protocol for MANET Using Evolutionary Algorithms. Technical Gazette. 2021; 28(6):2006-2014.

5. Jabbar WA, Saad WK, Ismail M. MEQSA-OLSRv2: a multicriteria-based hybrid multipath protocol for energy-efcient and QoS-aware data routing in MANET-WSN convergence scenarios of IoT. IEEE Access. 2018 Nov; 99:1-1.
6. Abazeed M, Faisal N, Ali A. Cross-layer multipath routing scheme for wireless multimedia sensor network. Wirel Netw. 2018; 25(8):4887-4901.
7. Jaiswal K, Anand V. EOMR: an energy-efcient optimal multipath routing protocol to improve QoS in wireless sensor network for IoT applications. Wirel Pers Commun. 2019; 111(2):1-23.
8. Preeth SSL, Dhanalakshmi R, Kumar R, Shakeel PM. An adaptive fuzzy rule based energy efficient clustering and immune-inspired routing protocol for WSN-assisted IoT system. J Ambient Intell Humaniz Comput.2018;1-13.
9. Sundhari RM, Jaikumar K. IoT assisted Hierarchical Computation Strategic Making (HCSM) and Dynamic Stochastic Optimization Technique (DSOT) for energy optimization in wireless sensor networks for smart city monitoring. Comput Commun. 2019;
10. Se-Jung LIM. A Chain-Based Wireless Sensor Network Model Using the Douglas-Peucker Algorithm in the IoT Environment. Technical Gazette. 2021; 28(6):1825-32.
11. Sadrishojaei M, Navimipour NJ, Reshadi M. Hosseinzadeh, M. A new clustering-based routing method in the mobile internet of things using a krill herd algorithm. Cluster Computing. 2021 Sep; 25(6):351–361.
12. Nasri M, Lamiri A, Maaref H, Mghaieth, R. Adaptive dynamic multi-hop technique for clustering protocol in wireless sensor networks assisted Internet of Things applications. IET Networks. 2022 Nov; 11(1):27-41.
13. Tandon A, Kumar P, Rishiwal V, Yadav M, Yadav P. A Bio-inspired Hybrid Cross-Layer Routing Protocol for Energy Preservation in WSN-Assisted IoT. KSII Transactions on Internet and Information Systems. 2021 Apr; 15(4):1317-1341.
14. Yarinezhad R, Azizi S. An energy-efficient routing protocol for the Internet of Things networks based on geographical location and link quality. Comput Netw. 2021. 193:108116.
15. Ajmi N, Msolli A, Helali A, Lorenz P, Mghaieth R. Cross-layered energy optimization with MAC protocol based routing protocol in clustered wireless sensor network in internet of things applications. Int J Commun Syst. 2021; e5045p.
16. Kaur A, Jain S,Goel S. Sandpiper optimization algorithm: a novel approach for solving real-life engineering problems. Appl Intell. 2020 Feb; 50(2):582-619.
17. Balakrishnan S, Vinoth Kumar K. Hybrid Sine-Cosine Black Widow Spider Optimization based Route Selection Protocol for Multihop Communication in IoT Assisted WSN. Technical Gazette. 2023; 30(4):1159-65.
18. Wang J, Gao Y, Zhou C, Simon Sherratt R, Wang L. Optimal coverage multi-path scheduling scheme with multiple mobile sinks for wsns. Computers, Materials & Continua. 2020. 62(2):695-711.
19. Tang Q, Yang K, Li P. An energy efficient MCDS construction algorithm for wireless sensor networks. J Wirel Commun Netw. 2012 Mar; 83.
20. Taskin D, Taskin C, Yazar S. Container-Based Virtualization for Bluetooth Low Energy Sensor Devices in Internet of Things Applications. Technical Gazette. 2021; 28(1):13-9.
21. Wang J, Ju C, GaoY, Sangaiah AK, Kim G. A PSO based energy efficient coverage control algorithm for wireless sensor networks. Comput, Mater Contin. 2018.56(3):433–46.