An Energy Efficient Clustering Protocol using Enhanced Rain Optimization Algorithm in Mobile Adhoc Networks

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Abstract

Energy efficiency is a significant challenge in mobile ad hoc networks (MANETs) design where the nodes move randomly with limited energy, leading to acceptable topology modifications. Clustering is a widely applied technique to accomplish energy efficiency in MANET. Therefore, this paper designs a new energy-efficient clustering protocol using an enhanced rain optimization algorithm (EECP-EROA) for MANET. The EROA technique is derived by integrating the Levy flight concept to the ROA to enhance global exploration abilities. In addition, the EECP-EROA technique intends to proficiently select CHs and the nearby nodes linked to the CH to generate clusters. Moreover, the EECP-EROA technique has derived an objective function with different input parameters. To showcase the superior performance of the EECP-EROA technique, a brief set of simulations takes place, and the results are inspected under varying aspects. The experimental values pointed out the betterment of the EECP-EROA technique over the other methods.

Keywords: MANET, Energy efficiency, Clustering, Rain optimization algorithm, Network lifetime

1. Introduction

By the development of several natural stimulated methods to dissimilar optimization issues, researcher is inspired for developing solutions for two significant optimization issues, i.e., clustering and routing [1, 2]. It has various applications of bioinspired calculating and the requirement of each algorithm is for optimization problems. All potential solutions in optimization algorithms are resulting in 2 methods, viz., stochastic and deterministic. Each deterministic algorithm is usually enclosed through a particular arithmetical formula and the searching proceed in single direction; i.e., this is unidirectional search guide through specific rule [3, 4]. The stochastic algorithm is non-traditional algorithm for solving multilayer problem have numerous optimal. A MANET [3] is an independent scheme where many hosts are interconnected to one another with multihop wireless links (Fig. 1). It is a network scheme which doesn't based on an everlasting backbone or set architecture and includes devices on fly which is placed to certain application. This network is appropriate in situations in which infrastructures aren't deployed/available of infrastructures aren't cost effective such as disaster recovery, search and rescue operation, communication between vehicles, and roadside equipment and military services as VANET [5]. But, the managing of this network is challenging as a result of its self-configuring nature and nonexistence of other fundamental authorities [6]. Likewise, scalability is another problem in previous years become the most concentrated area of transmission study fields.

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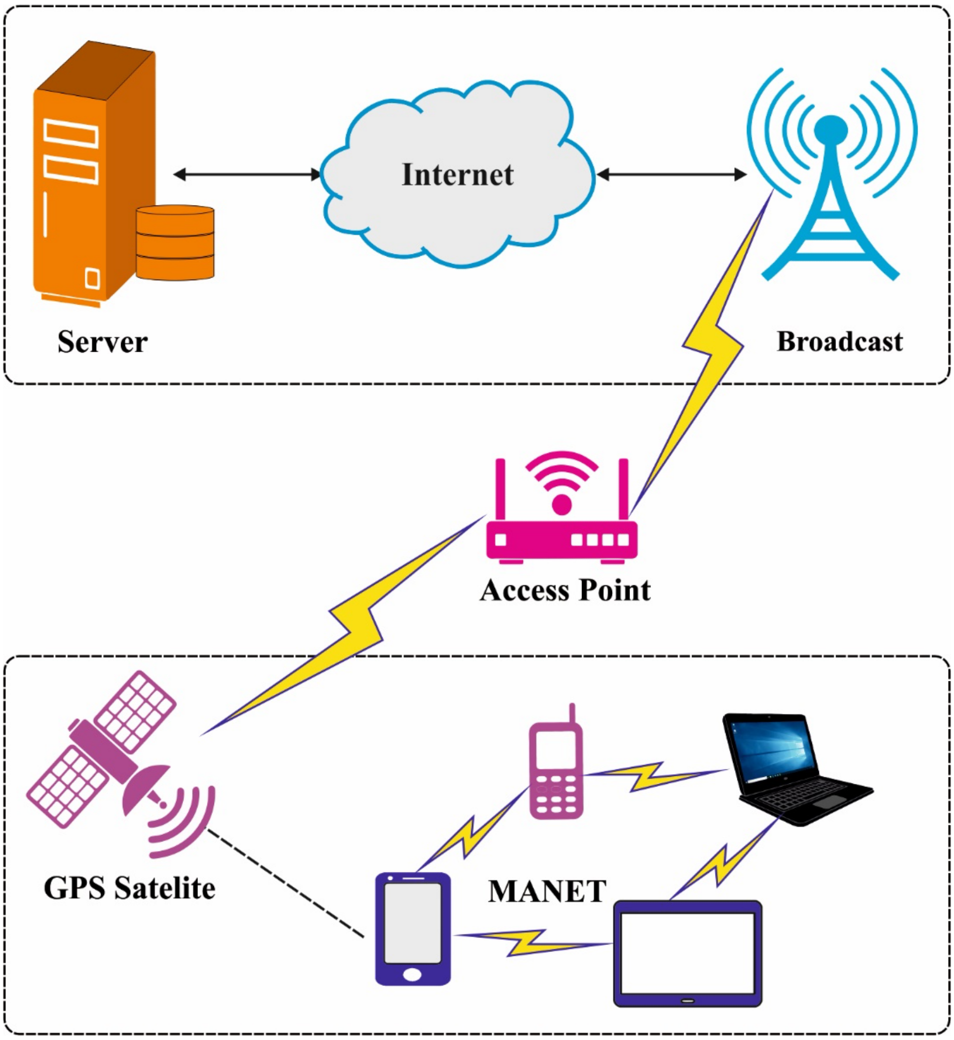

Fig. 1. Structure of MANET

Clustering in MANET is determined as the natural procedure of mobile nodes in many distinct collections [7]. Clustering is employed for improving the energy consumption, networks efficacy, stability, extending capability, and ease of navigation [8, 9]. A disadvantage of clustering is the higher power utilization in the course of re-clustering operations. The main component in MANET is the power utilization of all nodes [6]. While the power of a nodes end, the nodes fail. When the failed nodes are a CH, the nodes fail however each of its clusters fail. Afterward a failure, there are few steps to construct novel clusters to the residual node, named re-clustering. Re-clustering entails higher power utilization, however, the node has constrained power resources. Therefore, several re-clustering operations direct the entire network to rapidly collapsing [10, 11]. The steadiness of the generated cluster in MANET is the main challenge which clustering algorithm tries to solve. In addition, the mobility of nodes is the main reason for connection failures, hence, in a clustering system, mainly the state while an elected CHs are moderately high mobile compared to another node, it can often dissolved well-made clusters and requires a novel inter-cluster path set up from source to end or in worsening situations, it is necessary to re-cluster [12, 13]. These repeated connection failures because of the movements of CH accelerate the routing overhead and degrade the consistency of transmission information since there is an increase in control messages overhead result in decrease in the efficacy and whole networks lifetime. For that reason, developing actual clustering algorithms using minimal overheads becomes a better method to increase the network's lifespan of MANETs [14, 15].

A novel system [16] is presented such as SCCM for MANET. It includes the succeeding phases: encryption, secure routing, signature verification, decryption, and signature generation. Afterward making the networks, the connections among the mobile nodes have been made. Next, secure routing has been made among the source and destination through executing the AOMDV routing protocols. In [17],

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proposed an effective RRCST method. This technique starts by clustering the node in an area whereas the election of CHs is executed based on the prior broadcast behaviour and node statistics. The node is clustered according to geographic feature, and the CHs are selected from all clusters according to many supports measure calculated on geographic, energy, and transmission feature.

Sudhakar et al. [18] present a novel structure named MO–MMC–HAWGA. The presented method leads to optimum clustering of mobile nodes in many objectives such as energy, distance, stability, and bandwidth. Firstly it chooses an optimum CHs according to an optimum clustering will be made. Selvakumar et al. [19] introduce an EECSRP by means of hybrid EA for MANET. The aim is to clusters the node and select optimum route for energy effective and consistent broadcast information. The EECSRP method includes 2 main phases. Initially, the CH election and cluster creation procedure occur by the niche method using monarch butterfly optimization method. Then, β-hill clustering using GOA method is used to optimum election of route in MANET. In [20], the novel EBDC method is proposed for predicting connection failures and increase the node lifespan. Now, the presented method is used to cluster and route preservation in MANET to create the node with the star topology.

This paper designs a new energy efficient clustering protocol using enhanced rain optimization algorithm (EECP-EROA) for MANET. The EROA technique is derived by the integration of Levy flight concept to the ROA for enhancing the global exploration abilities. In addition, the EECP-EROA technique intends to the proficient selection of CHs and the nearby nodes linked to the CH to generate clusters. Moreover, the EECP-EROA technique has derived an objective function with different input parameters. In order to showcase the superior performance of the EECP-EROA technique, a brief set of simulations take place and the results are inspected under varying aspects.

2. Design of EECP-EROA Technique

In ROA, the rain behaviours are inspired and all the solutions to problems are represented as a raindrop. According to this issue, some points in the solution spaces are determined in an arbitrary manner when raindrop falls on the ground. The main feature of rain drops is the radius [21]. The radius of each raindrop is constrained when time passed and is improved by raindrops are connected to alternative drops. When the early solution populations are produced, the radius of all droplets is assigned in a random fashion for a constrained range. Furthermore, all droplets validate the neighbourhood according to the size. Individual droplet isn't still connected only verify the termination limits of the location i.e., enclosed. For resolving the problems in dimension spaces, all droplets are made up of n variables. Therefore, initially, the minimum and maximum limits of variables are authenticated when the limit is calculated through a radius. Then, two end points of the variables are tested and it is repetitive until reaching the concluding variables. Next, the costs of initial droplets are updated by shifting in a downward direction. It is executed to all the droplets, and the costs, and location of each droplet, can be allocated. The droplet radius is adapted in 2 ways:

While 2 droplets using radius r_1 & r_2, are close to each other using usual areas and connect to develop large droplets of radius R:

$$R = (r_1^n + r_2^n)^{1/n} \tag{1}$$

Whereas n suggests the amount of variable to each droplet. While droplets using radius r1 isn't moved, according to the soil feature, which is given as α.

$$R = (\alpha r_1^n)^{1/n} \tag{2}$$

Apparently, α exemplifies the amount of droplets are absorbed in each iteration from zero to hundred percent. Furthermore, it describes the smallest value to droplet radius r_{min}, whereas droplet using the least radius of r_{min} is reduced.

As abovementioned, the population values are decreased afterward few iterations, and maximal droplet is positioned using a large area of analysis. Through improving the analyses procedure, the local search possible of drop is increased proportionately to the diameters of droplet. Therefore, maximize the amount of round, weak droplet gets disappeared or connects to strong drop through the maximal area of investigation, and the early populations are decreased and discover the accurate solution(s). It is expected

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that there is some variation amongst the recently proposed optimization method in ROA and the presently meant search method positioned RFA that can be given below:

In ROA, the early population numbers are adapted afterward each iteration due to the connections of neighbouring drops. It leads to enhance the search ability of the method and reduce the optimization costs considerably.

When the droplet size is altered, the connecting of neighbouring droplets or absorption of soils are executed. These performances modify the search possible of all droplets and classify the droplet.

In RFA, and alternative search methods, all the populations are made up of neighbour points and the droplets are improved each phase in an arbitrary manner. Also, all populations identify an optimum route to the low points. When the paths are established, it is moved in down directions with steps and costs functions are decreased in an individual iteration.

Based on the approximation and idealization of the models, the rain methods are represented. Comprehensive, tuning parameters of these methods such as early raindrop numbers (population's amount), fundamental raindrop radius, etc. Next, the values are assigned to each droplet based on the objective function. Later, all droplets are shifted downwards. Therefore, nearer droplet is integrated to each other, that results in improving result. When droplets are ended at smallest points, the radius begins to reduce gradually create the accurateness of the solution to be improved. Later, it is appropriate for identifying extremal point of the cost functions.

Algorithm I: Pseudo code of ROA

Objective functions f(X), $X = (x_1, x_2, \dots, x_n)$
Input: Parameter Initialization namely population number (nPop), maximum iteration (MaxIt), variable count (nVar), domain of variables ([VarMin, VarMax]), initial radius of the droplet (InitR) and jointed droplet count (size), rain speed (Speed) and Soil adsorption Constant (α).
Initialization of the location, radius, and size of the droplets.
Determine every droplet with an objective function for obtaining the type of every droplet and arrange population with respect to cost.
Main loop:
While (iteration number <MaxIt)
For (every droplet)
Modify every parameter x_i to $x_i + R_i$ and $x_i - R_i$ and determine the new location using the objective function.
If (new cost< previous cost), accept a new position for x_i.
While (cost minimizes)
Shift the droplets in the same direction with the identical velocity,
Minimize the droplet based on the characteristics of soil adsorption
Join closer droplets to one another, modify the size of new droplet
End while
End for
Discard weaker droplets based on the soil adsorption
Produce new droplets based on the speed of the rain
End while
Sort population with respect to cost.
Display outcome.

The EROA technique is derived by the integration of Levy flight concept to the ROA for enhancing the global exploration abilities. LF is an effective type of stochastic non-Gaussian walk where the step length value needs to be dispersed based on Levy stable distribution [21]. It can be represented by

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$$Levy(\beta) \sim u = t^{-1-\beta}, 0 < \beta \leq 2 \tag{3}$$

β means important Levy index to adjust the stability. The Levy arbitrary number can be determined as follows.

$$Levy(\beta) \sim \frac{\varphi \times \mu}{|v|^{1/\beta}} \tag{4}$$

Here, μ & v represents regular distribution, Γ signifies normal Gamma function, $\beta = 1.5$, & φ can be provided as

$$\varphi = \left[\frac{\Gamma(1+\beta) \times \sin\left(\pi \times \frac{\beta}{2}\right)}{\Gamma\left(\left(\frac{1+\beta}{2}\right) \times \beta \times 2^{\frac{\beta-1}{2}}\right)} \right]^{\frac{1}{\beta}}. \tag{5}$$

To obtain effective tradeoff between exploitation and exploration ability of the ROA, the LF concept is employed to update the search agent position which can be represented as follows:

$$X_i^{levy} = X_i + r \oplus levy(\beta) \tag{6}$$

where X_i^{levy} means novel location of ith search agent X_i and r denotes arbitrary vector.

The EECP-EROA technique derived a fitness function with an aim of reducing the communication distance. When the fitness value is high, the clusters will be highly compact with optimum CHs [22].

$$Avg_{Distance} = \frac{Dist(v_i, CH)}{|n|} \tag{7}$$

3. Results and Discussion

The PDR analysis of the EECP-EROA technique takes place under distinct packet sizes in Table 1 and Fig. 2. The results highlighted the betterment of the EECP-EROA technique with the higher PDR. For instance, with packet size 10, the EECP-EROA technique has gained a higher PDR of 85% whereas the CLPSO, ME-PSO, and ME-AFS techniques have attained a lower PDR of 38%, 55%, and 78% respectively. In addition, with packet size 30, the EECP-EROA approach has reached an improved PDR of 92% whereas the CLPSO, ME-PSO, and ME-AFS techniques have attained a decreased PDR of 60%, 62%, and 84% correspondingly. Followed by, with packet size 50, the EECP-EROA technique has attained a higher PDR of 95% whereas the CLPSO, ME-PSO, and ME-AFS techniques have gained a reduced PDR of 71%, 73%, and 88% correspondingly.

Table 1 PDR Analysis of EECP-EROA Technique

Packet Delivery Ratio (%)				
Packet Size	**CLPSO**	**ME-PSO**	**ME-AFS**	**EECP-EROA**
10	38	55	78	85
20	53	60	81	91
30	60	62	84	92
40	64	62	84	93
50	71	73	88	95

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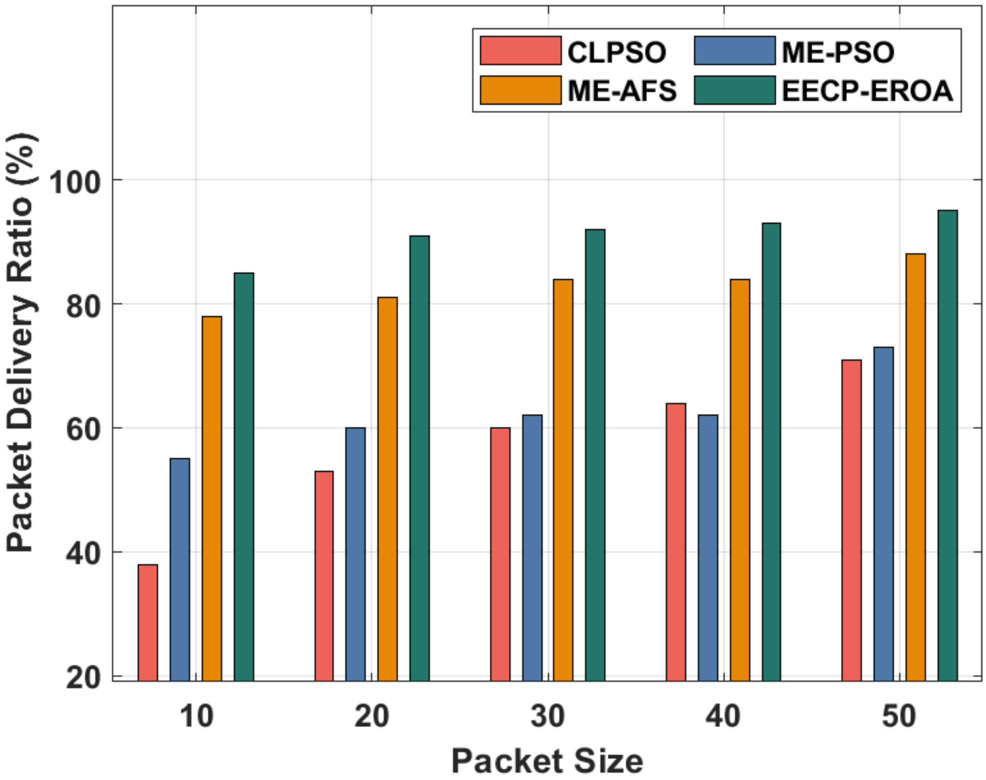

Fig. 2. Comparative analysis of EECP-EROA technique interms of PDR

The EC analysis of the EECP-EROA technique takes place under distinct count of nodes in Table 2 and Fig. 3. The results emphasized the improvement of the EECP-EROA technique with the minimal EC. For instance, with 20 nodes, the EECP-EROA technique has resulted in a lower EC of 85mJ whereas the CLPSO, ME-PSO, and ME-AFS techniques have attained a higher PDR of 124mJ, 148mJ, and 101mJ respectively. Moreover, with 60 nodes, the EECP-EROA manner has resulted in a lesser EC of 113mJ whereas the CLPSO, ME-PSO, and ME-AFS approaches have gained an increased PDR of 215mJ, 154mJ, and 127mJ correspondingly. Furthermore, with 100 nodes, the EECP-EROA approach has resulted in a minimum EC of 108mJ whereas the CLPSO, ME-PSO, and ME-AFS methodologies have attained a higher PDR of 217mJ, 182mJ, and 129mJ correspondingly.

Table 2 EC Analysis of EECP-EROA Technique

Energy Consumption (mJ)				
No. of Nodes	**CLPSO**	**ME-PSO**	**ME-AFS**	**EECP-EROA**
20	124	148	101	85
40	158	152	132	120
60	215	154	127	113
80	216	164	128	107
100	217	182	129	108

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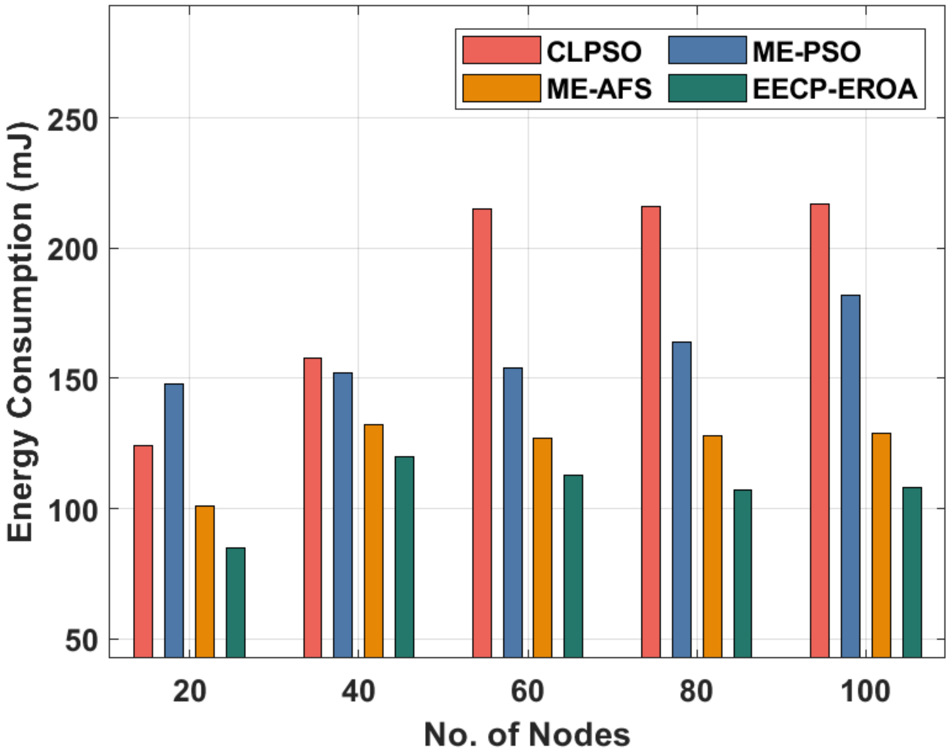

Fig. 2. Comparative analysis of EECP-EROA technique interms of EC

Table 3 Delay Analysis of EECP-EROA Technique

Delay				
No. of Nodes	**CLPSO**	**ME-PSO**	**ME-AFS**	**EECP-EROA**
20	20	18	16	13
40	29	26	22	19
60	39	35	29	23
80	40	36	31	28
100	42	40	34	30

The delay analysis of the EECP-EROA manner takes place under varying count of nodes in Table 3 and Fig. 4. The results emphasized the improvement of the EECP-EROA manner with minimal delay. For sample, with 20 nodes, the EECP-EROA algorithm has resulted in a minimal EC of 13 whereas the CLPSO, ME-PSO, and ME-AFS approaches have reached a superior PDR of 20, 18, and 16 correspondingly. Similarly, with 60 nodes, the EECP-EROA manner has resulted in a lower EC of 23 whereas the CLPSO, ME-PSO, and ME-AFS techniques have attained a higher PDR of 39, 35, and 29 correspondingly. Also, with 100 nodes, the EECP-EROA methodology has resulted in a lower EC of 30 whereas the CLPSO, ME-PSO, and ME-AFS algorithms have obtained a superior PDR of 42, 40, and 34 correspondingly.

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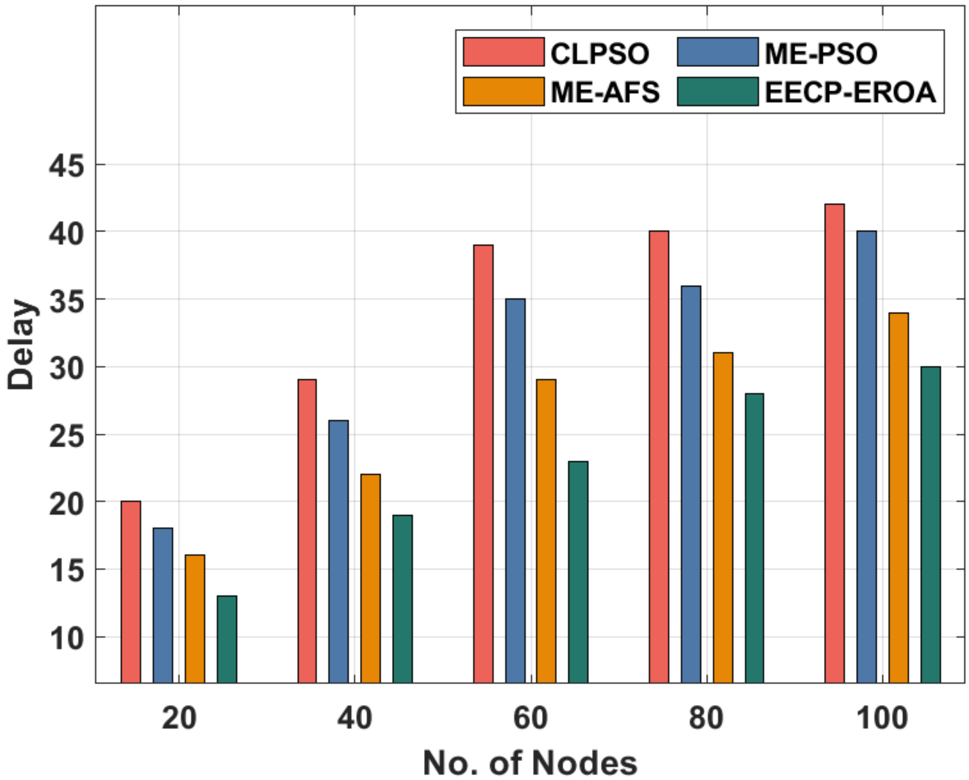

Fig. 2. Comparative analysis of EECP-EROA technique interms of delay

Table 4 NLT Analysis of EECP-EROA Technique

Network Life Time (hrs)				
No. of Nodes	**CLPSO**	**ME-PSO**	**ME-AFS**	**EECP-EROA**
20	101	122	141	144
40	88	112	100	117
60	51	80	101	109
80	37	73	81	93
100	30	73	86	102

The NLT analysis of the EECP-EROA approach takes place under different number of nodes in Table 4 and Fig. 5. The outcomes demonstrated the betterment of the EECP-EROA manner with the maximum NLT. For instance, with 20 nodes, the EECP-EROA approach has achieved a superior NLT of 144hrs whereas the CLPSO, ME-PSO, and ME-AFS techniques have attained a lesser NLT of 101hrs, 122hrs, and 141hrs correspondingly. Likewise, with 60 nodes, the EECP-EROA methodology has gained a higher NLT of 109hrs whereas the CLPSO, ME-PSO, and ME-AFS techniques have attained a lower NLT of 51hrs, 80hrs, and 101hrs correspondingly. Finally, with 100 nodes, the EECP-EROA technique has obtained an increased NLT of 102hrs whereas the CLPSO, ME-PSO, and ME-AFS techniques have gained a decreased NLT of 30hrs, 73hrs, and 86hrs correspondingly.

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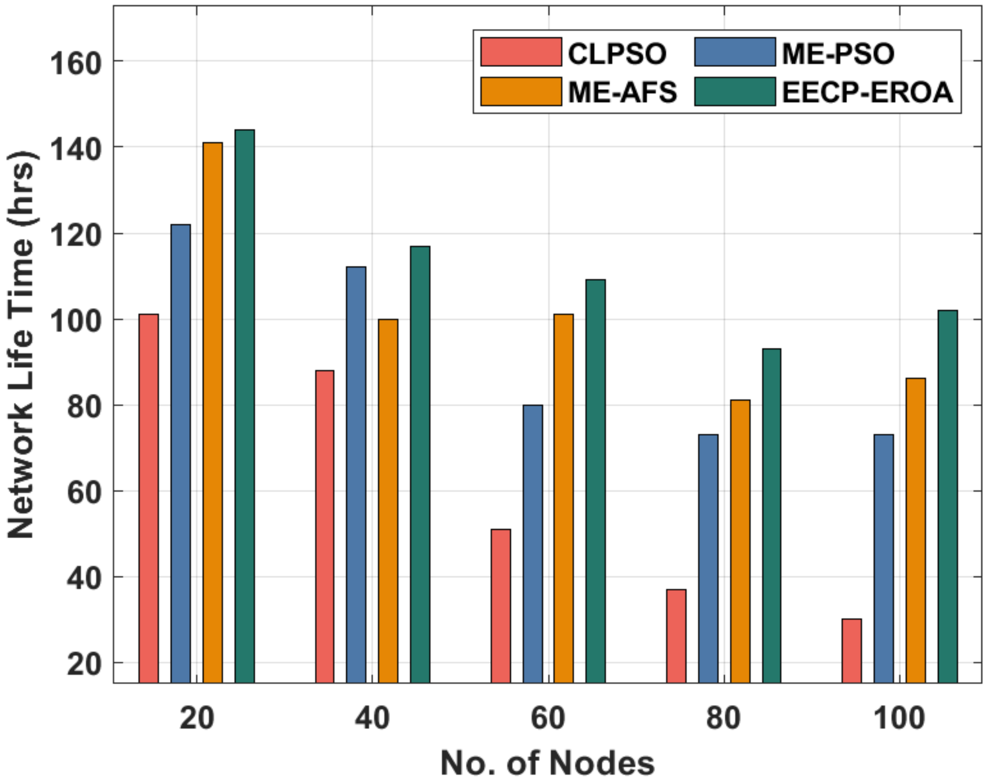

Fig. 2. Comparative analysis of EECP-EROA technique interms of NLT

4. Conclusion

This paper has designed an intelligent EECP-EROA for MANET. The EROA technique is derived by the integration of Levy flight concept to the ROA for enhancing the global exploration abilities. In addition, the EECP-EROA technique intends to the proficient selection of CHs and the nearby nodes linked to the CH to generate clusters. Moreover, the EECP-EROA technique has derived an objective function with different input parameters. In order to showcase the superior performance of the EECP-EROA technique, a brief set of simulations take place and the results are inspected under varying aspects. The experimental values pointed out the betterment of the EECP-EROA technique over the other techniques. In future, unequal clustering approaches can be designed to enhance the outcome of the EECP-EROA technique.

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