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Energy Aware Oppositional Whale Optimization Based Linear Discriminant Load Balanced Routing And Data Delivery In Manet

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ABSTRACT

MANETs are independent wireless networks that emerge often in self-organized application development, where the Mobile Nodes (MN) communicate with others through the wireless interfaces. Designing an energy efficient load balanced routing and data delivery are the major concern of MANETs due to dynamic nature with inadequate battery capability. An Energy Efficient Whale Optimized Linear Discriminant Load Balanced Routing (EEWOLDLBR) technique is presented in MANET for efficient data delivery. The EEWOLDLBR technique comprises three processes namely route path discovery, data transmission and route maintenance. In EEWOLDLBR technique, multiobjective oppositional learned whale optimization process is carried out to find the optimal mobile nodes for route establishment. With optimized energy efficient MN, Linear Discriminant Load balancing method is used to find the minimal load to deliver the Data Packets (DP). During the data packet delivery, in case of any link break, alternate energy efficient and less loaded mobile node is chosen for route maintenance in network with efficient data delivery. Simulation outcome of EEWOLDLBR technique achieves higher delivery ratio and throughput with lesser delay as well as packet loss as compared with previous routing techniques.

KEYWORDS

MANET, load balanced routing, data delivery, multiobjective oppositional learned whale optimization, Linear Discriminant Load Balancing method

1. Introduction

In MANET, the number of MN deploy with limited resources like power. Owing to random mobility of MN and wireless links, obtaining energy efficient routing and data delivery are considered to be challenging task. However, the existing methods fail to improve the delivery fraction and reduce the energy utilization during load balanced routing in MANET. Our main aim is to improve the routing as well as data delivery performance with lesser ECusing machine learning techniques.

Ant-based Efficient Energy and Balanced Load Routing (A-EEBLR) method are introduced in [1] for selecting the neighboring node. The method fails to reduce the packet loss during the data transmission. A Synchronized Fuzzy Ant System (SynFAnt) is developed [2] to perform optimal routing in the network, but the energy optimal load balanced routing is not performed. (FOLLOW THE UNIFORMITY. EITHER YOU HAVE TO USE IN BEFORE THE REFERENCE NUMBER OR REMOVE IT)

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A QoE-driven multi path data delivery method is introduced in [3]. Though the approach obtains better network traffic load balancing, the energy aware data delivery is not performed. The residual energy evaluation model is introduced in [4] for balancing the data load transmitted over the network, but the model has higher end to end delay.

A novel technique for load balancing is designed in [5] for MANETs by means of temporal load on the neighboring nodes while sending data. The designed technique fails to consider the energy metric to expand the life span of MANET. The model of endcast is presented in [6] for data delivery from a source to a destination, but the designed method fails to utilize machine learning algorithms for reliable data delivery with lesser delay. A bio-inspired hybrid trusted routing protocol is designed in [7] to improve the data transmission by means of selecting an optimal route. However, the designed routing protocol fails to consider the link status for enhancing the transmission.

To determine a best possible path, an ant colony-based energy control routing (ACECR) protocol is presented in [8]. The designed protocol minimizes the routing load but the higher throughput of data delivery is not achieved. A queue-based load balancing routing protocol is introduced in [9] to enhance data delivery and reduce delay, but it fails to dynamically balance the network load between the multiple routes. A Multipath Battery and Mobility-Aware routing method are developed in [10] to perform efficient routing by choosing stable paths. However, the method is difficult to estimate its performance with the large-scale network deployments.

An ant-based routing method is introduced in [11] for balancing the network load when the source sends data towards destination. However, the designed method fails to minimize the performance of PLR. A Least Common Multiple based Routing (LCMR) method is designed in [12] for load-balanced routing with lesser delay, but the performance of various routing metric is not calculated.

An effective load balancing AOMDV protocol is designed in [13] to improve the ability of balancing the constant load between the nodes but it fails to utilize the energy metric for data transmission to the intended destination. Dynamic genetic algorithms are introduced in [14] that lead to improve the dynamic load-balanced routing with lesser energy consumption. The algorithms fail to achieve the higher throughput for data transmission.

A novel link-disjoint multipath routing approach is introduced in [15] to choose the shortest path for data transmission. However, the optimization method is not implemented to find the optimal path. An efficient and stable multipath routing method is developed in [16]to improve the delivery and reduces the energy utilization. However, the load balanced routing remained unaddressed.

A multi path routing scheme fine-tuned with the spatio temporalis presented in [17] to increase the efficiency and reliable routing. However, the performance of this scheme is not improved with minimum delay. A dynamic energy aware AODV protocol is introduced in [18] to reduce the packet delay and extend the network lifetime, but it fails to enhance the performance of MNs in MANET.

In [19], an energy-efficient multi-constraint routing algorithm is designed to increase energy efficiency of networks and load balancing. The designed algorithm fails to apply the optimization algorithm to further increase the delivery ratio. A memetic optimization algorithm is designed in [20] to solve the routing problem, but the designed optimization fails to perform the energy aware routing in MANET.

1.1. Our contributions

The existing issues are identified from the above said literature are solved by developing a novel EEWOLDLBR technique. The key contributions of this paper are,

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- An EEWOLDLBR technique is proposed to perform the energy efficiency and load balanced routing as well as data delivery. EEWOLDLBR technique includes MultiObjective opposition Learned Whale Optimization (MOLWO) and linear discriminant load balancing strategy. The multiobjective optimization is used to find out more energy efficient mobile nodes. The opposition learned whale optimization finds the global optimum energy efficient mobile nodes for data delivery in MANET.

- For load balancing, EEWOLDLBR technique uses the linear discriminant load balancing strategy which is used to find the less loaded mobile nodes and perform route path discovery.

- To create route paths between the nodes, the two control messages are distributed. Followed by, the route maintenance carried out to improve the data delivery performance.

- The simulation tests are conducted to validate our approach with the conventional routing techniques. Simulation results prove that our EEWOLDLBR technique is feasible and effective.

1.2. Paper outline

This article is ordered into different sections. EEWOLDLBR technique is described in Section 2. Section 3 offers simulation settings and demonstrates the performance of EEWOLDLBR technique via simulations and analyzes the obtained results in detail. Finally, the conclusion of the paper is presented in section 4 followed by the references are cited.

2.Energy Efficient Whale Optimized Linear Discriminant Load Balanced Routing technique

To enhance the data delivery in MANET, EEWOLDLBR technique is introduced. The EEWOLDLBR technique uses the whale optimization technique and linear discriminant method for finding the energy efficient and load optimized mobile nodes in MANET. The proposed EEWOLDLBR technique initially finds the optimal energy efficient nodes followed by which the node with lesser load is identified. After that, the route is discovered from source to destination. After route discovery, the data delivery is said to be performed. During the data packet transmission, the link between the nodes is observed. If any cause of link failure, the

alternative mobile node is chosen for minimizing the delay of data packet transmission.

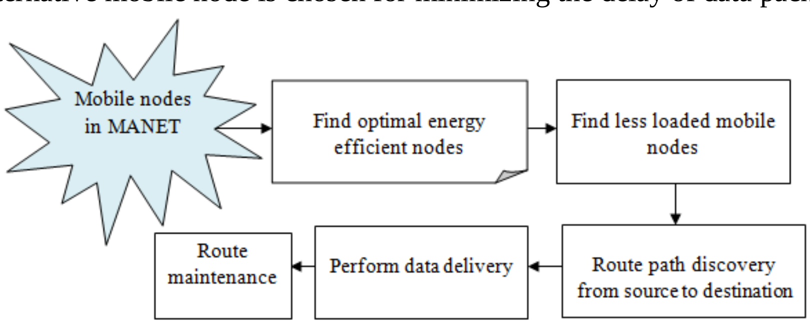

Figure 1.block diagram of EEWOLDLBR technique

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Figure 1 illustrates the block diagrams of the EEWOLDLBR technique where the mobile nodes $MN_i = MN_1, MN_2, MN_3 \dots MN_n$ are distributed in a squared area $n * n$ for performing the energy aware data delivery and load balanced routing in MANET. Among the distributed sensor nodes, energy optimized sensor nodes are identified by employing the whale optimization. Followed by, the Linear Discriminant method is applied for identifying the less loaded mobile nodes. With the selected mobile nodes, the route discovery is performed by distributing the control messages. Then the Source Node (SN)transmits data packets $dp_1, dp_2, dp_3, \dots dp_n$to destinations ($DN$) via the selected neighboring nodes $N_1, N_2, N_3, \dots . N_n$ with better link quality. Finally, the route maintenance is performed to enhance the delivery ratio and minimizes the delay of data delivery at destination end. The brief description about the EEWOLDLBR technique is presented in the following sections.

2.1. Multi objective opposition learned Whale optimization (energy efficient node selection)

In this section, EEWOLDLBR technique starts to find the energy efficient nodes using MOLWO technique. The whale is very intellectual animal and optimization is inspired by hunting behavior of humpback whales. In MOLWO technique, the whale discovers the prey location and generates bubbles along a path.

MOLWO technique is the best approaches since it has higher convergence speed, flexibility, error tolerance and higher accuracy. This improvement is achieved by applying the opposition learning method. The opposition learning concept is employed to obtain the global optimum solution to the next generation. The opposition based learning defines to consider the opposite estimates or an action performed by optimization algorithm to find the optimum solution.

The above process of the MOLWO technique is related toenergy efficient node selection in the MANET. In MOLWO technique, multi objective refers to the two objective functions such as energy and distance. The mathematical model of the MOLWO technique consists of five process namely population initialization, fitness computation, encircling the prey, hunting behavior and search the prey.

- **Population initialization**

The first process of the MOLWO technique is to initialize the whales (i.e. mobile nodes) population arbitrarily in search space.

$$D = MN_1, MN_2, MN_3 \dots MN_n \quad (1)$$

Where, Dindicates the initial population of mobile nodes $MN_1, MN_2, MN_3 \dots MN_n$. By applying the opposition learning method, the opposite population of mobile nodes is also generated to obtain global optimum. The opposite generation of mobile nodes is expressed as given below,

$$D_o = a_i + b_i - D \quad (2)$$

From (2), $D_o$represents an opposite population generation with the current population 'D', a_i and $b_i$indicates the minimum and maximum value of the dimensions in the current population 'D'.

- **Fitness computation**

Upon generating the current and opposite population, the fitness for each node is computed. The fitness is computed based on the two objective functions namely residual energy and distance.

Initially, each MN has equal energy level. Due to the mobility nature of the nodes, the energy level gets degraded. Therefore, energy is the major parameters for achieving the stable routing in

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MANET. Let us consider the initial energy of the mobile node is ‘$E_{(t)}$’ and the mobile node consumed energy is denoted by ‘$E_{(c)}$’. Therefore, the remaining energy of node is given as below,

$$E_r = E_{(t)} - E_{(c)} \quad (3)$$

After the energy calculation, the distance between the nodes is determined. Let us consider the current coordinate for the mobile node'MN_1' is (x_1, y_1) and the coordinates of another mobile node 'MN_2' is (x_2, y_2). Therefore, the distance between the mobile nodes is calculated for finding a nearest mobile node. The distance is measured as follows

$$d = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \quad (4)$$

Where, ‘d’ indicates a distance between the two nodes. Based on above calculation, the fitness is calculated as follows,

$$\delta = E_r > th \ \&\& \min d \quad (5)$$

Where, δ indicates a fitness, E_r denotes a residual energy and $\min d$ represents a minimum distance. After calculating the fitness of each individual, the current and the opposite populations are combined and sorting the whales based on their fitness. Finally, select ‘m’ best whales from the group for further processing.

- **encircling prey phase**

In this phase, the whale discovers prey location and surrounds them. The optimization algorithm considers current best solution is intention prey. Then the position is performed by comparing current best solution with other solution (i.e. whale). Therefore, the behavior is expressed as given below,

$$p_{i+1}(w) = p_i(r) - g.q \quad (6)$$

$$q = |\alpha.p_i(r) - p_i(w)| \ (7)$$

Where,q signifies a distance, $p_i(r)$is a position vector of prey and $p_i(w)$is the position vector of whale, $'i'$ denotes a current iteration, $p_{i+1}(w)$ is the updated position of whale. From (6), g, αdenotes a coefficient vector and it obtained as follows,

$$g = (2wk - k) \quad (8)$$

$$\alpha = 2w \quad (9)$$

Where, ‘k’ is minimized from 2 to 0 and ‘w’ is a random vector ranges from [0, 1].

- **Hunting behavior**

The whale hunting behavior is generated based on shrinking encircling approach and spiral updating location. This behavior is also known as foraging behaviors of the whales. A spiral equation is attained among position of whale and prey to follow helix-shaped movement. Followed by, the current best solution is updated and compared to other whales to discover the global optimum as follows,

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$$p_{i+1}(w) = q' \exp(uv)\cos(2\pi v) + p_i' \qquad (10)$$

$$q' = |p_i' - p_i(w)| \qquad (11)$$

Where, $p_{i+1}(w)$ indicates the updated position of humpback whale, p_i' denotes a position of prey currently located, 'u' is a constant to describe the logarithmic curve structure whereas 'exp' denotes exponential function and 'v' is the random number and their ranges are [-1, 1]. Consider humpback whales swim around prey with shrinking circle and spiral-shaped path.

To model the nature of whale, consider there is a probability of 50% to decide between either shrinking encircling or spiral behavior. The whales updating behavior as follows,

$$p_{i+1}(w) = \begin{cases} p_i' - g.q & ; \quad pr < 0.5 \\ q' \exp(uv)\cos(2\pi v) + p_i' & ; \quad pr \geq 0.5 \end{cases} \qquad (12)$$

From (21), 'pr' is a probability varied from [0, 1].

- **Search the prey**

At last, the global optimum solution is obtained. Therefore, the final updating performance is expressed as given below,

$$p_{i+1}(w) = p_R(w) - g.q \qquad (13)$$

$$q = |\alpha.p_R(w) - p_i(w)| \quad (14)$$

From (13), (14) '$p_R(w)$' signifies a random location vector of a random whale. As a result, the global optimum node is selected for route path discovery. The step by step process of the MOLWO technique is described in the algorithm 1. Initially, the population and opposite populations are generated. For each whale in current and opposite population, the fitness is evaluated and finds the best solution. With the selected population, the three different behaviors are humpback whales which are discussed. Based on these behaviors, the positions of the different whales are updated and find the global best solution.

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Algorithm 1 Multi objective opposition learned Whale optimization

Input: **number of mobile nodes** $MN_1, MN_2, MN_3 \dots MN_n$

Output: **select energy efficient nodes**

Begin

Initialize the whale's current populations $D = MN_1, MN_2, MN_3 \dots MN_n$

Initialize the opposite populations 'D_o'

For each whale in D **and** D_o

Compute the fitness 'δ'

Combine two populations D **and** D_o

Sort the mobile nodes

Select current best 'm' mobile nodes

If (pr<0.5)

If ($|g|$<1) **then**

Update the whale position using **(6)**

Else if ($|g|$ >1)

Select a random position of whale ' $p_R(w)$

Update the location of the current best whale using **(13)**

End if

Else if ($pr \geq 0.5$) **then**

Update the whales position using ((**10**)

End if

Reiterate process until it reaches the maximum iteration

End for

return (optimal solution)

End

2.2. Linear discriminant method based node classification

After finding the energy efficient mobile nodes, the proposed EEWOLDLBR technique finds the node with minimal load. In order to enhance the performance of routing, load balancing is required between the energy optimized mobile nodes. The linear discriminant method is applied for finding the node with lesser load or heavy loaded nodes. The linear discriminant is used to split the mobile nodes into two subsets namely less loaded and heavy loaded. The separation function describes the ratio of the divergence between the two subsets to the divergence within the subsets. It is expressed as follows,

$$F = \frac{dif\ (b)}{dif\ (t)} = \frac{L\, M_b\, D}{L\, M_t\, D} \quad (15)$$

Where, F indicates the separation function, $dif\ (b)$ denotes a divergence between the two subsets, $dif\ (t)$ indicates a divergence within the subsets, L indicates a linear discriminant vector to project the mobile nodes into the subsets, D is the optimal projection direction of the linear discriminant vector. M_b and M_t are the scatter matrix between subset and within the subset to find the similar

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characteristics of mobile nodes. For each energy efficient MN, the load is calculated depends on number of DP received by that mobile node at a given time period which is calculated as follows,

$$L = \frac{N_{dp}}{t} \quad (\mathbf{16})$$

Where, L indicates load of mobile nodes, N_{dp} is number of DP received by MN, $t$is the time in seconds (S). The linear discriminant vector sets threshold value for the load of the mobile node to project the mobile nodes into subsets. The estimated load is minimum than the threshold and then the discriminant vector classifies the mobile node as lesser loaded. Otherwise the node is classified as a heavy loaded.

$$Y = \begin{cases} L > L_t \ \ , MN\ classifed\ as\ less\ loaded\ (\boldsymbol{L_{MN}}) \\ otherwise, MN\ classifed\ as\ heavy\ loaded\ (H_{MN}) \end{cases} \quad (17)$$

From (17), Y is the output of the linear discriminant function, L indicates the load, L_t is the threshold is set to the load of the mobile node, $\boldsymbol{L_{MN}}$refers to the less loaded mobile node, H_{MN} denotes a heavy loaded mobile node. The mobile node heavy loaded causes the packet drop and it reduces the packet delivery from source to destination. Therefore, the EEWOLDLBR technique chooses the mobile node with less loaded to perform the data transmission. The minimum loaded mobile node receives the incoming packets from other mobile nodes and it effectively transmits the DP to the destination with minimum packet drop and higher delivery ratio.

2.3. Route path discovery and route maintenance

After finding the less loaded MN, the route path is identified via control messages namely $RREQ$ and $RREP$. Initially, the source node starts to identify the route by transmitting the request messages ($RREQ$) to the less loaded mobile nodes.

$$SN \xRightarrow{(RREQ)} \boldsymbol{L_{MN}}_i \xRightarrow{(RREQ)} DN \quad (18)$$

From (18), SNindicates a source node, $\boldsymbol{L_{MN}}_i$is the less loaded mobile node, $DN$is the destination mobile node

$$SN \xLeftarrow{RREP} \boldsymbol{L_{MN}}_i \xLeftarrow{RREP} DN \quad (19)$$

Where, $RREP$ indicates the respond sent from the destination node (DN)to source node(SN).In this way, route path from source to destination is identified for data delivery.

Due to a dynamic topology of the mobile network, the link breakages between the mobile nodes may possibly occur during the data transmission. Therefore, the route maintenance is essential for

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improving the data delivery. In case of any link failure, alternate energy efficient and minimal loaded nodes are chosen for enhancing the data delivery and minimizing the end to end delay. The lesser loaded node is selected for minimizing the network traffic and packet loss. The algorithm of node classification based data delivery is described as follows,

Algorithm 2 Linear discriminant method based node classification

Input: number of energy efficient mobile nodes $MN_1, MN_2, MN_3 \dots MN_n$, number of data packets $dp_1, dp_2, dp_3, \dots dp_n$

Output: Improve data delivery

Begin
  Initialize the two subsets
  For each energy efficient mobile node MN_i
    Measure the load 'L'
      If $(L > L_t)$ **then**
        Node is classified as lesser loaded
      else
      Node is classified as heavy loaded
    End if
  End for
 Select less loaded mobile node (L_{MN})
 SN sends $RREQ$ to destination via L_{MN}
 DN sends $RREP$ to source node via L_{MN}
 Construct route between SN and DN
SN sends dp_i to DN
If link failure between the node then
 Select alternative L_{MN}
 Send data packets to destination DN
End if
End

The above algorithmic process clearly describes the mobile node classification and data delivery between the nodes. For each energy efficient node, the load of the mobile nodes is calculated to classify the nodes. The load which is lesser than the threshold is categorized as a minimum load. Otherwise, the node is classified as a heavy loaded. In other words, the nodes which receive minimum DP is known as lesser loaded MN. Then the source node finds the route by the means of distributing the control messages. After finding the route path, the DP are transmitted to the destination. Finally, the route maintenance is performed in case of link failure, the alternative energy efficient and minimal loaded mobile node is selected resulting it increases the data delivery and minimizes the delay.

3. Simulation setup and results discussion

Simulation of EEWOLDLBR technique and conventional routing methods namely [1] and [2] are performed in NS2.34 simulator. For the simulation environment, totally 500 nodes are dispensed in the squared area of A^2 (1500 m * 1500 m) with Random Waypoint. The DSR routing protocol is used for the implementation to perform the load balanced routing and data delivery in MANET. The simulation time is set as 300 seconds. The nodes speed is 0-20 m/sec. Number of DP is varied from 15 to 150. For the fair

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comparison, totally ten runs are considered. To evaluate the EEWOLDLBR technique against the existing methods, various routing parameters are employed as given below,

- Energy consumption
- Packet delivery ratio
- Packet loss rate
- End to end delay
- Throughput

Energy consumption (EC): It is the significant metric in MANET used to enhance the routing performance. This metric is used to calculate the amount of energy utilized by the nodes in MANET to perform load balanced routing and data delivery. EC is calculated in joule (J) and computed as given below,

$$EC = n * E\ (single\ MN) \quad (20)$$

Where, EC denotes an Energy Consumption, 'n' signifies the number of mobile nodes,$E\ (single\ MN)$ denotes an EC of single mobile node (MN).

Packet delivery ratio: It is another important routing metrics in MANET for measuring the successful DP received to destination and it is measured in percentage (%). The following equation is used to compute the packet delivery ratio.

$$Packet\ delivery\ ratio = \left\{\frac{No.of datapacketsreceived}{No.of packetsent}\right\} * 100 \quad (21)$$

Packet loss rate (PLR): PLR is major metric for load balanced routing in MANET. During the data transmission, the number of packets gets lost, is identified using following formula,

$$PLR = \left\{\frac{No.of datapackets\ lost}{No.of packetsent}\right\} * 100 \quad (22)$$

PLR is calculated in percentage (%).

End-to-End Delay (EED): EED is an amount of time taken by the algorithm for delivering the packets. The delay measurement is done in terms of milliseconds (ms).

$$EED = (DP_{ar} - DP_{sd}) \quad (23)$$

Where,$DP_{ar}$is a data packet arrival time, $DP_{sd}$is a data packet sending time.

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Throughput (TH): It is measured as a number of packets delivered at the destination in a specific time. The throughput is determined in terms of bits/sec

$$TH = \left(\frac{AD_{dp}(bits)}{t\,(sec)}\right) \qquad (24)$$

Where, 'AD_{dp}' symbolizes the amount of DP successfully delivered in terms of bits at destination, time (t) in second (sec).

Table I comparative analysis of energy consumption

Mobile nodes (numbers)	Energy consumption (J)		
	A-EEBLR	SynFAnt	EEWOLDLBR
50	35	38	30
100	37	39	32
150	39	42	36
200	44	48	40
250	46	50	43
300	48	51	45
350	53	55	49
400	54	56	51
450	57	59	54
500	60	63	56

In order to perform the experiments, 10 times with the various counts of the mobile nodes to compare the EC performances of EEWOLDLBR technique and conventional routing methods A-EEBLR [1] and SynFAnt [2]. The simulation outcomes are reported in table I. For the fair comparison, the mobile nodes are taken in the counts from the 50, 100, 150….500. From table I, the EEWOLDLBR techniques considerably lessen the EC. The performance results are illustrated in figure 2.

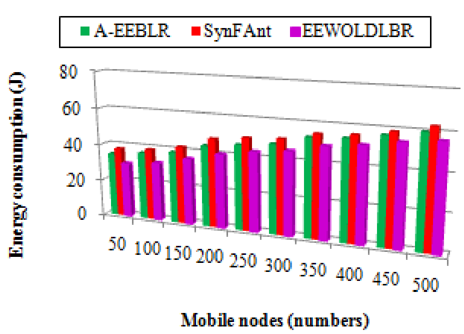

Figure 2 graphical results of energy consumption

To better perceive the efficacy of the proposed EEWOLDLBR technique, considerable experimental results are demonstrated in Figure 2. The EEWOLDLBR technique is compared against the two existing A-EEBLR [1] and SynFAnt [2]. As depicted in figure 2, the proposed EEWOLDLBR

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technique performs comparatively well than the other two routing methods [1] and [2]. The EEWOLDLBR technique has better changes using the energy efficient multiobjective optimization technique. In order to obtain the efficient routing, the MOLWO technique through which the optimized energy efficient nodes are selected based on fitness evaluation. The nodes with higher residual energy are taken for load balanced routing in MANET. EC of EEWOLDLBR technique is reduced by 8% and 14% as compared to conventional routing methods [1] [2].

Table II comparative analysis of packet delivery ratio

Data Packets (numbers)	Packet delivery ratio (%)		
	A-EEBLR	SynFAnt	EEWOLDLBR
15	87	80	93
30	83	77	97
45	89	82	96
60	87	78	93
75	85	83	95
90	90	86	96
105	89	85	93
120	85	83	92
135	88	85	94
150	89	87	95

The simulation results of EEWOLDLBR technique over A-EEBLR [1] and SynFAnt [2] are recorded in Table II as mentioned above. The performance results of EEWOLDLBR technique are compared on two methods by varying data packets i.e., number of data packets. Totally ten results are obtained for three methods. The EEWOLDLBR technique out performs than the other two methods. This improvement is obtained by performing the load balanced routing. The Linear discriminant method is applied to find the mobile node with minimal load. Besides, with the energy optimized and load balanced nodes, the source node performs the data transmission. This helps to enhance the data delivery. The EEWOLDLBR technique also performs the route maintenance, in case of any link failure. The alternative less loaded node is chosen for efficient data transmission. As a result, the successful data delivery is obtained. The EEWOLDLBR technique demonstrates an improvement of upto 8% over A-EEBLR [1] and an improvement of 14% over SynFAnt [2] in terms of average packet delivery ratio. The various results of delivery ratio are demonstrated in figure 3.

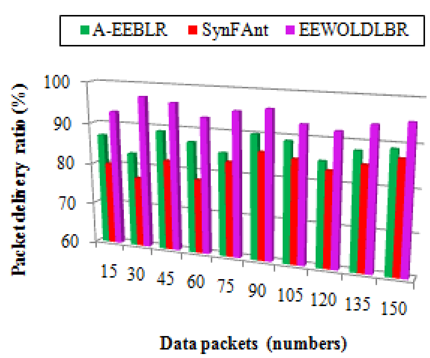

Figure 3 graphical results of packet delivery ratio

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As shown in the figure 3, the proposed EEWOLDLBR technique offers comparatively increased delivery rate than the state-of-the-art methods. Our EEWOLDLBR technique differs from the A-EEBLR [1] and SynFAnt [2]. As shown in the plot, the performance of packet delivery ratio is represented by the three different colors. From figure 3, the packet delivery ratio of EEWOLDLBR technique is higher.

Table III comparative analysis of packet loss rate

Data Packets (numbers)	Packet loss rate (%)		
	A-EEBLR	SynFAnt	EEWOLDLBR
15	13	20	7
30	17	23	3
45	11	18	4
60	13	22	7
75	15	17	5
90	10	14	4
105	11	15	7
120	15	18	8
135	12	15	6
150	11	13	5

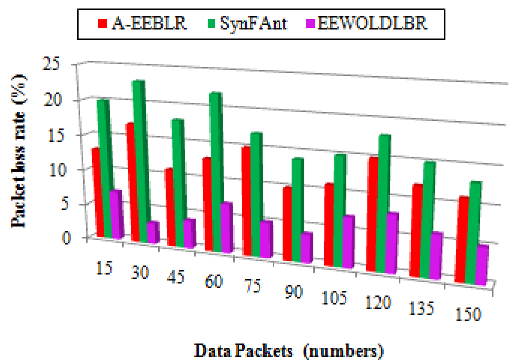

Figure 4 graphical results of packet loss rate

Table III and figure 4 illustrate the results of PLR with number of DP ranges from 15 to 150. The results notice that the EEWOLDLBR technique achieves minimum PLR than the conventional methods. This is due to the linear discriminant method discovers the mobile node with minimum load. The less loaded mobile nodes increase the data transmission resulting it reduces the packet loss. In addition, route path is established among the energy efficient and less loaded mobile nodes. As a result, efficient data delivery is attained with minimum loss of DP at destination end. The obtained results of EEWOLDLBR technique is compared to the other two existing methods. Then, the average of ten results of PLR is minimized by 55% and 67% than the other two methods [1] [2].

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Table IV comparative analysis of end to end delay

Data Packets (numbers)	End to end delay (ms)		
	A-EEBLR	SynFAnt	EEWOLDLBR
15	16	18	13
30	18	22	15
45	22	25	19
60	25	27	21
75	27	30	24
90	29	32	27
105	33	36	30
120	35	37	31
135	37	40	33
150	39	42	36

In table IV, the simulation result of EED is illustrated. The simulations are conducted by using ten test cases in the range of 15 to 150 that measures the analysis of EED

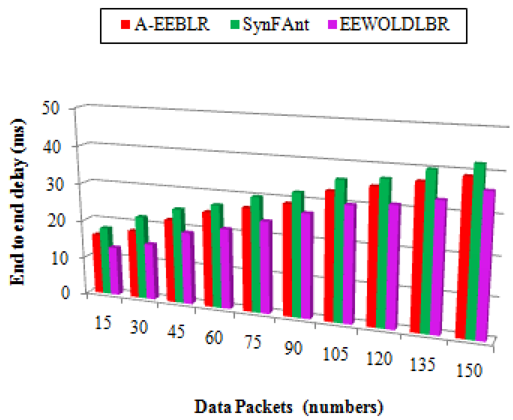

Figure 5 graphical results of end to end delay

Figure 5 depicts the EED using three methods with number of DP ranges from 15 to 150. From the figure, the EED of EEWOLDLBR technique is minimal as compared to existing methods. Considered number of DP is 15, the EED of EEWOLDLBR technique is $13ms$ whereas EED of existing methods [1] and [2] are $16ms$and$18ms$. The above statistical result evidently proves that the proposed technique outperforms well. The EEWOLDLBR technique performs the route maintenance by selecting the alternative mobile nodes with stable link. As a result, the higher energy nodes and the stable link between the nodes capably deliver the DP to a destination. Therefore, the EED of EEWOLDLBR technique is reduced by 12% compared to A-EEBLR [1] and 21% compared to SynFAnt [2] respectively.

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Table V comparative analysis of throughput

Size of Data Packets (KB)	Throughput (bits/sec)		
	A-EEBLR	SynFAnt	EEWOLDLBR
10	140	134	168
20	295	260	325
30	410	380	436
40	505	460	552
50	570	520	610
60	690	643	736
70	780	720	835
80	850	812	950
90	930	910	1026
100	1130	1045	1250

Table V lists out the throughput provided by EEWOLDLBR technique and the two state-of-the-art methods [1] and [2].The simulation is conducted using ten assessment using data packet sizes 10 to 100KB that measures the throughput. The comparisons of the ten resultant outcomes are illustrated in figure 6.

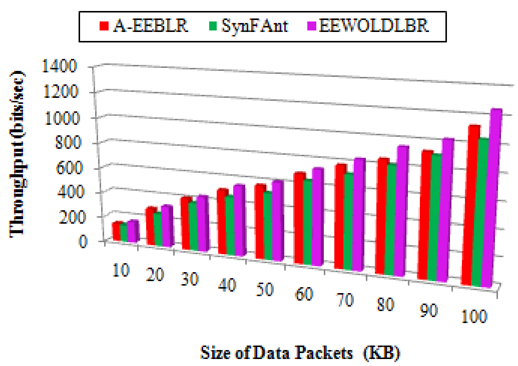

Figure 6 graphical results of throughput

Figure 6 demonstrates the throughput versus the DP sizes. Throughput of EEWOLDLBR technique is comparatively higher than the A-EEBLR [1] and SynFAnt [2]. The node with higher residual energy and minimum distance is chosen to send the DP. Average of ten results evidently proves that the proposed technique achieves higher throughput. Let us consider 10Kb of the data packet being sent from the source node, the EEWOLDLBR technique receives the 168bits of data per second. The A-EEBLR [1] and SynFAnt [2] receive 140 and 134bits per second with similar input size. The evaluation of ten simulation results proves that the throughput of the EEWOLDLBR technique is increased by 10% and 18% as compared existing methods.

4. Conclusion

The EEWOLDLBR technique is developed to raise the energy efficiency of networks, which also takes into account load balanced routing in MANET. The EEWOLDLBR technique uses multiobjective optimization technique considers the operational parameters such as residual energy and distance. Moreover, a whale optimization also considers oppositional learning concept to find the global optimum based on fitness evaluation. Followed by, the linear discriminant load balancing method is introduced. With the selected energy efficient well-organized mobile nodes, route path is established to increase data

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delivery. Different routing metrics are discussed in this article with various routing techniques. The proposed EEWOLDLBR technique provides better performance in terms of PLR, packet delivery and throughput, EC, and EED.

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