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A Meta-Heuristic Particle Swarm Optimization-Based Energy Efficient Routing Protocol for MANET

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Abstract: Various techniques have been used in MANET for improving the energy efficiency of routing between the mobile nodes. But, each mobile node is driven by a battery with an inadequate capacity. Due to this reason, the nodes fail to transfer data packets to the destination node which leads to the major drawback of link failure. Furthermore, this results in some problems such as high energy consumption and retransmission process. To overcome these problems, a Proficient Energy Saving Routing (PESR) protocol is proposed to obtain an unchanging energy-efficient routing with energy awareness knowledge. The Enriched Neighbor Discovery (END) mechanism and the Meta-Heuristic Particle Swarm Optimization (MHPSO) techniques are mainly used in this proposed protocol. The END mechanism is used to collect the nodes within a specified range to provide the shortest route for transmission. Whereas the Meta-Heuristic Particle Swarm Optimization (MHPSO) rule is used to discover the efficient route. In addition, a number of node parameters is initiated to evaluate the node stability and to save the energy of the network. The PESR protocol with an effective data communication route selection is finally calculated based on these estimated node parameters. From the results, this protocol achieved the maximum network lifetime, increased throughput and end-to-end delay with less energy consumption which reduce the packet loss rate and overhead. Thus the devised PESR protocol enriches its capability and outperforms other prevailing methodologies in terms of energy consumption, network lifetime, and throughput. Therefore, the proposed PESR protocol minimizes its energy consumption and improves the network lifetime.

Keywords: Infrastructure-less, Neighbor Discovery, Route Selection, Energy, Saving, Stability, Proficient, Routing.

1 Introduction

A Mobile Ad-hoc Network (MANET) [1] is a self-designing infrastructure-less system in which the mobile nodes are associated with the wireless connections. It utilizes a distributed multi-hop routing rather than a static system framework in which the path cannot be determined. Each device in MANET is allowed to move freely towards any path, and commonly changes its links to other devices. Specially, MANET needs to meet some difficulties, for example, dynamic topology, real-time correspondence, transmission capacity administration, resource constraint and packet communication overhead. Primarily, AODV [2] routing protocol in MANET consumes significant constrained measure of battery control, and it does not require the centralized control administration in the intermediate nodes. The AODV offers fast adjustment to the conditions of dynamic connection, low handling and memory overhead, low system use, and decision of unicast routes for the destination in the network. These issues complicate the system thus result in introducing effective routing protocols. Recently, there are numerous routing protocols such as AODV, DSR, and OLSR which are utilized in MANET. But, the mobility of nodes can degrade the complete presentation of the network. A link failure in the network drives a path as an invalid route for encouraging the data packet transmission. Based on the route discovery, it starts again and cause more control packets flooding all over the network. It consumes more energy at flexible nodes and also drops more data packets. This results a raise in the overhead and reduction in the effectiveness of the system.

At that point, a high recommended link stability route discovery technique is preferred to build an effective transmission [3]. Therefore, the energy efficient stable

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routing protocol with Quality of Service (QoS) monitoring agents is presented. This produces a reliable route with continuous communication network. The Ad-hoc On-demand Multipath Distance Vector (AOMDV) routing protocol utilizes the QoS agents. The Link Expiration Time (LET), Probabilistic Link Reliable Time (PLRT), Link Received Signal Strength (LRSS), and Link Packet Error Rate (LPER) are the various reliability metrics which are collected and calculated by using QoS. Based on these link metrics, the maximum reliable link is identified and also the process of retransmission is reduced. The network performance is maintained with Residual Battery Power (RBP) technique. Finally, the fuzzy logic approach utilizes the QoS parameters for estimating the Route Selection Probability (RSP). But, the memory utilization, computing, bandwidth, and battery lifetime are not sufficiently satisfied which causes the major limitation of this research. Now, the route selection process in MANET includes the continuous communication for the packet request from neighbor nodes. Consequently, the comparison resulting from protocol energy consumption [4] in the MANET has been studied. There are different kinds of flexible nodes, e.g. source node, destination node, and transitional nodes. In spite of the fact that it is essential to obtain the data packet from the forwarder or sender to a destination node, these transitional nodes act as a source or as a destination node. Thus, energy utilization for the intermediate node can be higher when compared to that of the source node and destination node. This results in the limited battery power which is drained and stopped either by sending or receiving the packets. So, the vague set measurement technique [5] is issued to produce the energy efficient routing protocol in MANET. The energy consumption, draining of battery power and mobility are the different uncertainties which are to be considered for evaluating the vagueness of data.

Furthermore, it improves the performance by using a fitness threshold value for the selection of an energy efficient route. Hereafter, an Efficient Power Aware AODV (EPAAODV) routing protocol [6] is introduced for selecting the route and also it helps to increase the network lifetime and reduce the energy consumption. Here, the AODV and the Power Aware AODV (PAAODV) routing protocol are incorporated for refining the network presentation and minimizing the delay. But, it causes some major problems such as bandwidth optimization, power control and transmission quality enhancement. Therefore, the PS-ROGR [9] technique has been suggested for improving the network lifetime and resource optimization in the MANET. Particle Swarm Optimization (PSO) is one of machine learning techniques [7,8]. The total amount of particles in the population is used to improve the geographic routing based on the PSO. But, the optimization results in poor performance of PSO and it needs to improve in the upcoming research areas. Therefore, an energy efficient multipath routing protocol [10] based on the fitness function (FF-AOMDV) is developed in MANET. The FF-AOMDV protocol is used to extend the network lifetime based on the evaluation of three metrics such as simulation speed, varying node speed, and packet size. In this case, the bandwidth, energy and distance are also major metrics to be considered in the upcoming research to satisfy the best route selection.

The main contribution of the proposed work is expressed as follows: a Proficient Energy Saving Routing (PESR) protocol is introduced for achieving better link stability with minimum energy consumption in MANET. The enriched neighbor discovery scheme is applied to select the best nodes within the limit range for the effective transmission of data packets. Then, the position and speed of the nodes are restructured and the finest recognized positions are known in this rule. From that, the fitness value of the nodes is estimated based on various parameters and produces the highest best route. If any failure is presented in the intermediate nodes, it checks for an alternate best node for transmitting the data packets. It also reduces the process of retransmission due to the interrupted nodes. Thus the proposed technique improves the performance by reducing the energy and increasing the network lifetime.

This paper is organized as follows: The detailed description of the related works regarding route selection from source to destination node is explained in Section 2. The execution procedure of Proficient Energy Saving Routing (PESR) protocol mechanism is portrayed in Section 3. The simulation parameters are used for evaluating the proposed protocol is described in Section 4. The performance results of both the proposed and existing techniques are illustrated in Section 5. Lastly, the performance of this proposed protocol that is concluded in Section 6.

2 Related Works

In this section, a review of previously covered energy efficient routing protocols, data optimization, and the communication strategy schemes in the MANET is presented with their merits and demerits. Mahajan and Jagtap [11] offered an energy efficient routing protocol for the MANET. The Expanding Ring Search (ERS) technique is employed in this work based on the AODV protocol for discovering the route. Here the redundant rebroadcasting of the RREQ packets is avoided to save the nodes energy. They established the communication network owing to RREQ packets and its adjacent nodes decided the forwarding status of the node. The poor network performance due to link failure and high energy cost became the major limitation of this work. Narasimhan and Balakrishnan [12] developed an Energy Efficient AODV (Ee-AODV) routing protocol for MANET. Additionally, they required a centralized controller for controlling all the intermediate mobile nodes and finding the optimum active intermediate nodes among the switching on/off combination. The unused mobile nodes were evaluated and they neglected the energy utilization.

The user privacy was considered as the major parameters against the inside and outside attackers. Talwar, et al. [13] surveyed the different routing protocols in MANET. In this work, three routing protocols such as Optimized Link State Routing Protocol (OLSR), AODV, and Dynamic Source Routing Protocol (DSR) along with different algorithms were investigated. Lastly, the performance resulting from the reactive, proactive and hybrid routing protocols are compared. The results of this survey showed various difficulties that were extensive in the research. Arya and Rajput [14] developed a secured version of AODV to prevent the routing attacks in MANET. This method utilized the Nested Message Authentication Code (NMAC) key pre-distribution to reduce the overheads caused by distributing and sharing keys at the runtime. A technique called Hop Count Based Key Selection (HBKS) was used in this method for authentication. Though this method prevented few attacks, the network was still vulnerable to some routing attacks.

Ravi and Kashwan [15] suggested the new routing protocol for saving the energy in MANET. Here the Energy-Aware Span Routing Protocol (EASRP) utilized the energy-saving methodologies such as span and Adaptive Fidelity Energy Conservation Algorithm (AFECA). Then, a Remote Activated Switch (RAS) called hardware circuit was employed to awaken the sleeping nodes for optimizing the energy utilization. These energy-saving methodologies were established in reactive protocols. This provided low power in the hazardous environment where the replacement of fault evaluation was impossible. Kodole and Agarkar [16] presented an Efficient Routing Protocol (ERP) model for creating the communication network in MANET. The redundant retransmission and congestion were considered as the main problems. These were resolved by utilizing the rebroadcast probability, average active path count, and the neighbor knowledge method. The battery power consumption was considered as the major issue.

Basurra, et al. [17] proposed an energy efficient zone-based routing protocol for MANET. They discussed the zone-based routing with Parallel Collision Guided Broadcasting Protocol (PCGBP) for accelerating the route detection scheme and reduced the redundant broadcast. It used the parallel and distributed broadcasting technique. Additionally, single-node grouping algorithm was used for partitioning the communication network into zones. The static and abundant battery resources were controlled the reliable leaders of the zones. The cost of the network that depends on the energy consumption of each mobile node was considered as the major drawback in this research. Nayak and Gupta [18] analyzed the different presentation of routing protocols such as AODV, DSR, and ZRP in MANET. They addressed the energy consumption issue in MANET. However, these simulation results directed that the DSR protocol provided mobility robustness and high protocol performance. This work compared DSR with AODV in terms of various parameters such as throughput, packet delivery ratio and low energy cost per packet.

Chatterjee and Das [19] presented an enhanced dynamic source routing-based Ant Colony Optimization (ACO) that produced high packet delivery ratio, less overhead, energy consumption, etc. Before data transmission, it verified the cache as in DSR. If there was no route, then the sender transmitted the route request packet to find the route similar to the ant finding for food. After that, the packets propagated through the network and gathered all the information about the route using the proposed novel routing scheme. With the ACO technique, the best route was selected. Also the route was maintained by a pheromone decay technique. Bheemalingaiah, et al. [20] recommended the Energy Aware On-demand Multipath Routing (EAOMR) protocol for reducing the energy consumption in MANET. The standard AOMDV protocol was modified and formed the recommended EAOMR protocol. The energy aware node-disjoint multipath amongst source-destination pairs based on the two new power aware metrics and the AOMDV protocol was successfully determined.

In this context, the energy efficient routing becomes an ever demanding task since it has many issues like scalability, security, network lifetime, link stability, and energy consumption.

3 Proficient Energy Saving Routing Protocol

This section deliberates the implementation details of an innovative multipath routing protocol called as PESR, which is an integration of multi-attribute-based optimization and the AODV routing protocol. The chief goal of PESR protocol is to improve the link stability and also to reduce the energy consumption. Fig. 1 shows the overall proposed framework.

In this proposed PESR system, the MANET architecture is initially formed. Then neighboring nodes are identified in the neighbor discovery and forms the neighboring table with that identified neighbor nodes. With this neighboring table, a Route Request (RREQ) packet is transmitted to the neighboring nodes for node selection. After that, the acknowledgement (ACK) message is received from the neighboring table. Then, the neighboring node distance is calculated by applying some distance-based conditions. If the ACK receives, it will remove the data packets from the queue list and transmits the next packet. Otherwise, it changes the next node for transmission.

If the above condition is satisfied, then the multi-attribute parameters for the neighboring nodes are evaluated. By evaluating these node parameters, the route for transmission of data is discovered. Then these evaluated parameters are updated in the link routing table for choosing the best route among the neighboring nodes. In our proposed MHPSO mechanism, the optimized routing can be achieved. After that, the link route further checks for any link failures. If there occurs a link failure then the process of node parameters evaluation is repeated until no link failure condition is attained. Once the route does not contain any link failure, the communication for data transmission takes place.

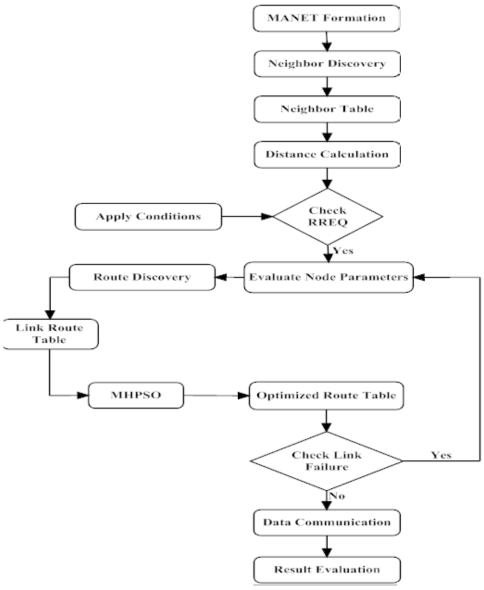

Fig. 1: Work Flow of Proposed PESR Protocol

3.1 MANET Formation

The MANET architecture is comprised with a number of movable nodes to formulate the networking infrastructure. This network arrangement contains mobile nodes with limited energy and link. In order to accomplish the overall networking scenario, the basic criteria to be served is to select a suitable node for communication. To each and every mobile node, the data packets are forwarded based on RREQ message from the source node. The number of mobile nodes is given as,

$$MN = \{m_1, m_2, m_3, ...m_n\} \qquad (1)$$

Where 'n ' represents the number of mobility nodes.

Due to the continuous movement of nodes, the topology of the MANET formation deviates constantly and the nodes can endlessly move in and out of the ranges. Then, the routing information will be changed continually because of the movement of the nodes. Hence, the adjacent nodes are derived effectively for transmitting the data packets.

3.2 Neighbor Estimation

After the formation of MANET architecture, each node communicates with END scheme by transmitting RREQ through broadcasting which has hello messages. The nodes that receive RREP validate the signature and recollect the information in a memory-less manner. The adjacent node estimation is performed based on the distance measurement under two conditions:

$$Dis < 100m;$$

Which increases the number of hops

$$Dis > 200m;$$

Which increases the link fault due to the mobility Numerous mobile nodes can be accommodated in the network. Among these mobile nodes, the distance between the nodes which satisfies the above criteria can be considered as the neighbor nodes and makes communication between them. This END scheme derive perfect nodes given as,

1. Initially selecting the robust nodes.
2. Next forwarding the data packets from the source to the destination node through the intermediate nodes.

The neighboring nodes are derived and update the information in the neighboring table for route discovery process.

4 Meta-Heuristic Particle Swarm Optimization technique

In the proposed MHPSO technique, every node is deliberated as a possible determination to the optimization issue in an infrastructure-less area. The results of END nodes will be analyzed by using the MHPSO, to check their fitness value. This helps in predicting better route for effective transmission of data packets without any failure. This proposed MHPSO technique is a modified optimization technique which is employed to discover the better link stability in a route selection and also resolve the optimization issues in the dynamic topology. This rule is used to determine the best nodes that is derived from the route discovery. Also it selects the best nodes based on the link stability in order to transmit data packets from the source to destination. If a node with better link stability is not found, then the process of MHPSO is performed repeatedly until it reaches the global best solution. This technique reduces the traffic and routing overhead of the optimization process and saves the energy as well. In a D-dimensional space, each particle node comprises its allocated position and velocity.

Additionally, each node comprises a local energy saving node that are used to store the best position experienced by the particle node at that point. Every hop contains a global energy saving hop for selecting the best global position experienced from the node. Based on this, the speed of the hop can be assessed by,

$$N_v + 1 = N_v + \varepsilon_1 \times r_1 \left(N_{les} - N_p\right) + \varepsilon_2 \times r_2 \left(N_{ges} - N_p\right) \quad (2)$$

Where N_p represents the node position, N_v represents the node velocity, N_{les} denotes the local energy saving node and N_{ges} denotes the global energy saving node.

Then, the position of the mobility nodes is updated and it can be expressed as,

$$N_p = N_p + N_v, \quad (3)$$

where ε_1 and ε_2 represent the constant terms (qualified power) derived from the social and personal experiences, r_1 and r_2 represent equally-distributed arbitrary number in the range of [0, 1]. A latency factor φ that standardizes

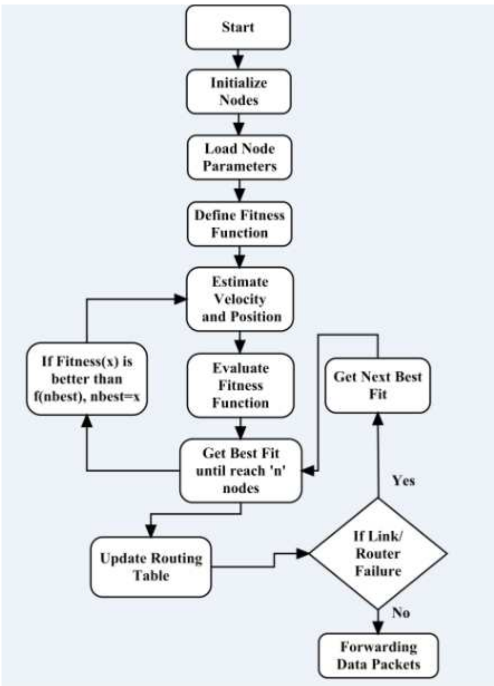

Fig. 2: Work Flow of Proposed MHPSO Technique.

the speed and enhances the look at precision of the hop after some time and that is expressed in equation (2) as,

$$N_v + 1 = \left(N_{gesp} - N_p\right) \varphi \times N_v + \varepsilon_1 \times r_1 \left(N_{les} - N_p\right) + \varepsilon_2 \times r_2 \quad (4)$$

Then, introducing a confidence factor is represented in terms of σ based on the velocity constraint and the efficient control as shown in equation (4) as,

$$N_v = \sigma \times r_1 \times \left(N_{gesp} - N_p\right) \varphi \times N_v + \varepsilon_1 \times r_2 \left(N_{les} - N_p\right) + \varepsilon_2 \quad (5)$$

Where confidence factor is denoted as,

$$\sigma = \frac{2}{\left|2 - \varepsilon - \sqrt{\varepsilon^2 - 4\varepsilon}\right|} \in = \varepsilon_1 + \varepsilon_2$$

The above mentioned equations (2) to (4) are used to evaluate the fitness value of each node presented in the neighboring table. The fitness evaluation is derived mainly to support the data packet transmission. Before performing the fitness calculation process, various node parameters in the MHPSO scheme are initialized and these parameters are explained as follows,

1. Link stability.
2. Average Link bandwidth.
3. Queue rate.

4.1 Link Stability

The link stability estimation is well-defined as the process of calculating the strength of a connection that will be persistently accessible for a predefined time period. The link stability can be anticipated precisely within a short range of time, by evaluating the separation between two nodes. The link life time $Link_{lt}$ is calculated using the equation as,

$$Lk_{lt} = \frac{ON_{lt}}{\text{Total number of selecting path}} \quad (6)$$

Where ON_{lt} represents overall node stability. The connection strength determination is derived mainly by a node. So, the node lifetime is estimated preferably by using the equation as,

$$N_{lt} = \frac{\text{Res}_{\text{engy}}}{Engy_{dept \in dt}} \quad (7)$$

Where Res_{engy} represents residual energy of the node, $Engy_{dept \in dt}$ represents energy depletion rate with respect to the distance estimation-based neighboring nodes. This estimation shows the available energy resource of the individual node. The Overall Node efficiency is calculate as,

$$ON_{lt} \frac{N_{lt1} + N_{lt2} + \ldots + N_{ltn}}{\text{Total number of nodes in neighboring table}} \quad (8)$$

Where $N_{lt1} + N_{lt2} + \ldots + N_{ltn}$ represents the overall presence of the node in the neighboring table, which can be calculated from the distance-based adjacent node evaluation. The stability estimation is characterized with the connection between associated nodes. Thus,

$$Avg_{Lk_{lt}} = \frac{ON_{ltn}}{\text{Total number of paths}} \quad (9)$$

From the above equation, it is clearly noted that the link stability decreases with an increase in the node mobility. And this can be calculated as follows, $Avg_{Lk_{lt}}-$ Mobility range of the nodes.

The link capacity is defined as the total amount of energy resources that are available for an efficient transmission of data packets. It is the sum of the arriving and leaving data rates of the packets and accessible data transfer capacity on the connection should be equivalent to the connection limit. Therefore, the link capacity is calculated using the following equation,

$$Lk_c = FR_{a+l} + Av_{nbw} \quad (10)$$

Where FR_{a+l} represents the flow rates of the data packets from arriving and leaving and Av_{nbw} represents the available bandwidth.

4.2 Average Link Bandwidth

Every hop is in-charge for measuring the accessible transmission capacity on its connection. For a given node, the available bandwidth Av_{nbw} estimation of individual node is performed.

The average link bandwidth is calculated with respect to node availability and the overall nodes. The average link bandwidth is estimated using the equation as,

$$Avg_{Lkbw} = \frac{\sum_{i=1}^{i=n} Av_{nbw}}{\text{Total number of nodes in particular path}} \quad (11)$$

Where Av_{nbw} represents the available individual node bandwidth.

4.3 Queue Rate

The queue rate is defined as the overall waiting time for the data transmission. The data traffic of the packet transmission is calculated mainly for reducing energy consumption of nodes. The availability of queue rate is estimated as, Av_{QR} = Queue availability depends upon time

These different estimation metrics are used to show the routing effectiveness. Based on these parameters, the fitness evaluation process is performed and also predicts the best link and efficient energy saving node for data transmission.

4.4 Effective Data Communication

The PESR protocol is proposed to deliver the data packets effectively without any link failure, energy drain, or traffic. Based on the END and MHPSO process the transmission rate can be improved. First of all, the nodes which are arranged in the network are incorporated and the swarm nodes SN_i are arranged in a distributed manure and are represented based on the END procedure. Each node represents its position and velocity (N_p, N_v) The arrival of new node is represented in between source and destination pairs. It is estimated by using the equation as,

$$NN_v = N_v + \sigma_1 (IPb_i - X_i) + \sigma_1 (GPb_i - X_i) \quad (12)$$

Where NN_v represents the new node velocity, σ_1 represents the individual router confidence factor, σ_2 represents the swarm confidence factor, X_i represents the current node position, IPb_i denotes the individual local best position and GPb_i denotes the global best position of all nodes. $\sigma_1, \sigma_2 > 0$; which are positive constants. Then, the node position can beestimated based on the local best and global best which can be expressed as,

$$IPb_i^n = Null(Possition \text{ of } particle\ with\ best\ fitness)$$
$$GPb_i^n = Null(Global\ best\ fitness)$$

For individual swarm, the current position and velocity of the node are initialized. Then, assigning the individual position of the node as,

$$IPb_i^n = X_i \quad (13)$$

Some conditions are applied to evaluate the swarm fitness value of each router. Then, the evaluation of individual router is performed based on the equation as, For individual swarm, the current position and velocity of the node are initialized. Then, assigning the individual position of the node as,

$$F(i) = \left[\gamma * \frac{(\max L(s,d) - L(s,d))}{\max L(s,d)}\right] + \left[(1-\gamma) * \left(1 - \frac{A\beta_{total} - \beta(s,d)}{A\beta(s,d)}\right)\right] \quad (14)$$

Where γ represents the design parameter. After that, we apply the above equation (14) in all the routing to reach the destination node unless it continues the process. Then we calculate the swarm velocity using the equation as,

$$N_v = N_v + \sigma_1 (IPbi - X_i) + \sigma_2 (GPbi - X_i) \quad (15)$$

After predicting velocity value of the node, the adjacent current position of the swarm can be updated as,

$$X_i + 1 = X_i + N_v \quad (16)$$

Then update all the information that is derived from the equations (15) and (16). This updated information is used to evaluate the individual node fitness value by using an equation (17). This process is continued till it reaches the overall node in the route discovery path. If any failure exists, it can drop the node and select another best node. Then the failure estimation process is carried out using mean function to derive the delay factor in a data packet.

$$pkt_i^k = \frac{\sum_{t=1}^{k}\sum_{j=1}^{n}\left(d_j^{t+i}(i) - d_j^t(i)\right)}{k*n} \quad (17)$$

Where pkt_i^k represents the packet delay factor. After predicting the delay factor nodes, the delay covariance between the two routers r_i and r_j can be derived using the equation,

$$\rho\left(r_i, r_j\right) = \frac{1}{K-1}\left(\sum_{k=1}^{K} pkt_i^k \cdot pkt_j^k - \frac{1}{k}\sum_{k=1,k'=1}^{K} pkt_i^k \cdot pkt_j^{k'}\right) \quad (18)$$

Where $\rho(r_i, r_j)$ represents the delay covariance. Then, the overall procedure of the proposed PESR framework algorithm is described below.

Therfore, the PESR protocol efficiently predicts the best route for the transmission of data packets. Once the routing path is initiated, the node transfers the data packets and linking variables parallelly calculates the traffic overhead. It keeps the forwarded packets until receiving the ACK from the destination node. If the ACK is received, it removes the packet from the source and transmit the next packet. Otherwise, it selects another best node to transfer the same packets and this reduces the packets re-transmission from the source node. This will save the energy and also increase the network efficiency of the nodes.

MHPSO-based PESR Protocol

Input: Mobile Node Set
Output: Energy efficient data transmission

Step-1: Extract adjacent list of nodes using equation (12)
Step-2: Initialize IPb_i^n and GPb_i^n for calculating the fitness value of swarm.
Step-3: Check the condition as for each swarm i in G
Initialize X_i , N_v randomly; Assign equation (13);
Estimate the swarm fitness values $\{F(i)\}$
If $\{GPb_i^n < F(i)\}$
$\{GPb_i^n = F(i)\}$
$IPb_i^n = X_i$
Else If
End for
*Step-4:*Calculate the fitness values of each router using equation (14)
Step-5: Initialize the number of iterations $cnt = 0$;
While {count is less than maximum iteration}
In each swarm i in global GPb_i^n
Compute the swarm velocity using equation (15)
Update the next current position of swarm using equation (16)
Evaluate the particles fitness values $F(i)$
Update IPb_i^n
If $GPb_i^n < F(i)$
$GPb_i^n = F(i)$
$IPb_i^n = X_i$;
End If
Increment the iteration $cnt++$
End While
*Step-6:*for each j in light path lp
calculate the delay factor using mean function based on equation (17)
Step-7: Compute delay covariance between two routers using equation (18)
Step-8: Evaluate the energy efficient route based on the route Metrics Evaluation for detecting the fault using equation (6),(7),(8),(9),(10),(11).

5 Simulation Model and Parameters

The proposed PESR protocol efficiency is derived with the help of NS2 simulation tool. In this simulation model, the nodes are distributed in a free space and are arranged in a random order. The following parameters are used to simulate the MANET for an efficient network communication as shown in Table 1.

In this scenario, IEEE 802.11 is used as the MAC protocol for the wireless LANs. The link stability is measured based on the functionality of the network layer. Then the various execution attributes are as follows.

Table 1: Simulation Setup

Attribute	Description
Number of nodes	50, 100, 150, 200, ..., 500
MAC	EEE 802.11
Radio range	100-200 m
Routing protocol	PESR protocol
Number of connections	8
Traffic source	CBR, video and TCP
Packet size	512 bytes
Rate	250 kb
Mobility model	Random way point
Area size	1,000 x1,000
Simulation time	200 s

5.1 Performance Parameters

The accompanying parameters are utilized to assess the execution of the proposed PESR protocol are:

5.1.1 PDR

The Packet Delivery Ratio (PDR) is defined as the proportion of total data packets received in the destination node to the total number of data packets transmitted from the source. It is estimated by using the equation as,

$$PDR = \frac{Total\ no.\ of\ data\ packets\ received}{Total\ no.\ of\ data\ packets\ transmitted} * 100 \quad (19)$$

5.1.2 End-to-End Delay

The E2E delay is characterized as the normal time taken for transmitting the message packets effectively over the system from the source to destination. This E2E delay involves all kinds of delay such as propagation, buffering due to the path detection latency, MAC retransmission delays, queuing, and transfer times. This can be determined by,

$$E2Edelay = \frac{\sum_{i=1}^{n} (R_i - T_i)}{n} \quad (20)$$

5.1.3 Throughput

Throughput is defined as the process of calculating the total amount of bits received in the destination node effectively. It can be conveyed in terms of kilobits per second (Kbps). It is calculated as,

$$Thrp = (total\ no.\ of\ bytes\ received * 8/sim\ time) * 1000kbps \quad (21)$$

5.1.4 Average Message Overhead

The AMO is characterized as the proportion of the total number of data packets that are isolated by a number of data packets to be transmitted. The message overhead is an effect on the system's strength as far as the utilization of transmission capacity and battery control of the nodes. The formula for the AMO as,

$$AMO = \frac{Total\ no.\ of\ routing\ packets}{No.\ of\ routing\ packets + No. of\ data\ packets\ tansmitted} * 100 \quad (22)$$

5.1.5 Energy Consumption

The EC is well-defined as the measure of energy that is consumed by the system nodes in the retransmission time. This can be acquired by computing every hop's energy level towards the simulation end time, and initial energy of each node. It is calculated as,

$$EC = No.of nodes * Time * power \quad (23)$$

5.1.6 Average Network Lifetime

The ANL is defined as the essential time designed for shattering the battery of n mobile nodes. It is considered as follows,

$$ANL = \frac{Energy\ consumption\ of\ nodes}{Total\ no.\ of\ nodes} * 100 \quad (24)$$

6 Results and Discussions

The proposed PESR protocol performance results are compared with the existing techniques [9] such as TIGHT, APU-strategy, and the PS-ROGR. The comparison results of PDR, E-E delay, network lifetime, throughput, message overhead, and the energy consumption are presented in this section.

6.1 PDR-Performance Analysis

The PDR metric expresses the strength of a routing protocol for the data transmission from the source to destination. The higher the proportion, the better is the execution of the routing protocol. Fig. 3 represents the variation of simulation time with respect to the PDR metrics. The PDR of the proposed protocol varies with the variation in the simulation time. The proposed PESR technique accomplishes preferred execution over both the existing TIGHT, and PSROGR techniques. The PESR technique achieves 99.3% of PDR in 20 seconds and 80% in 200 seconds of simulation, whereas in existing TIGHT and PSROGR protocol 85.6%, 99.1% in 20 seconds and 20.6%, 75.5% in 200 seconds of simulation time, respectively. Hence, the PESR protocol attains better performance than existing due to short and strong routes to transmit the data packets. This result shows an effective reduction of packet loss rate.

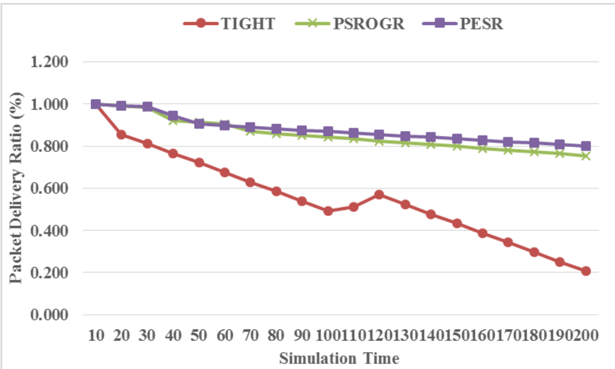

Fig. 3: PDR Metric

6.2 Throughput-Performance Analysis

This measure is used to recognize the protocol's efficiency through the transmission. Fig. 4 clearly demonstrates the impact of varying simulation time with respect to the throughput of the TIGHT, PS-ROGR, and PESR protocol.

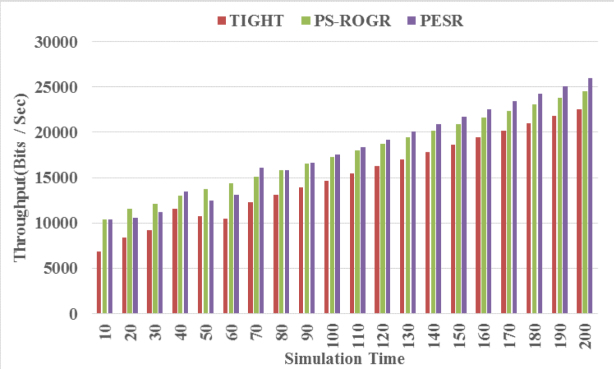

Fig. 4: Throughput metric

The simulation time differs from 10, 20, 30? 200 seconds. When the simulation time increases, the throughput also gets increased. The performance of the proposed PESR protocol is compared with the existing TIGHT, and PS-ROGR protocol. Hence, the proposed PESR protocol achieves greater performance than the existing protocol.

6.3 E2E Delay-Performance Analysis

Fig. 5 represents the E-E delay time for the routing protocol such as PESR, PS-ROGR, and TIGHT. In this figure, it is observed that as the simulation time 10, 20, ...200 sec increases, the E-E delay also increases. The proposed PESR protocol achieves 0.0342 ms in 10 seconds, 0.042 ms in 20 sec, to 0.15 ms in 200 sec of simulation time. The existing TIGHT, PS-ROGR protocol produces 0.0496 ms , 0.0468 ms in 10 sec of simulation and 0.16365 ms, 0.14495 ms in 200 sec of simulation time respectively. Hence, the proposed PESR protocol attains greater performance than the existing protocol.

6.4 Energy Consumption-Performance Analysis

The energy utilization value of the proposed PESR protocol is compared with the existing TIGHT and PS-ROGR protocol. Table-3 represents the energy consumption with varying simulation time. For instance, the proposed PESR protocol consumes 0.07 J in 10 sec and for 200 seconds it utilizes 0.37 joules. The existing

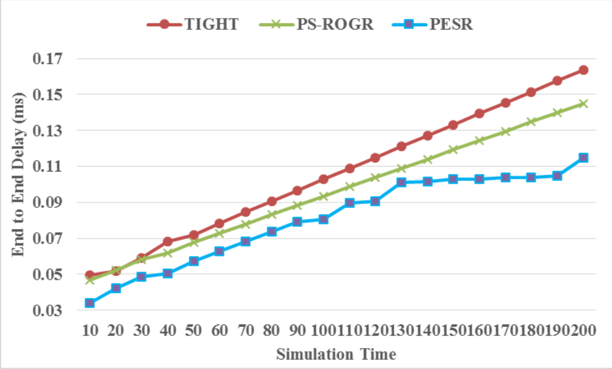

Fig. 5: End to end delay metric

Table 2: Energy Consumption

Sim. Time	TIGHT	PS-ROGR	PESR
10	0.18	0.18	0.07
20	0.47	0.37	0.22
30	0.55	0.44	0.23
40	0.24	0.05	0.03
50	0.41	0.29	0.08
60	0.21	0.21	0.18
70	0.35	0.20	0.10
80	0.59	0.05	0.02
90	0.16	0.18	0.01
100	0.79	0.12	0.05
110	0.40	0.76	0.18
120	0.75	0.16	0.14
130	0.51	0.66	0.15
140	0.30	0.47	0.42
150	0.48	0.35	0.14
160	0.43	0.48	0.20
170	0.56	0.39	0.08
180	0.55	0.33	0.06
190	0.20	0.14	0.01
200	0.92	0.46	0.37

TIGHT, PS-ROGR consumes 0.07 J, 0.18 J for 10 seconds and 0.92 J, 0.46 J for the 200 seconds of simulation time respectively. Hence, the proposed PESR protocol attains less energy consumption than existing protocols.

Fig.6 represents the energy consumption with the various amounts of nodes. For an instances, the number of nodes can be varied such as 50, 100, 150,... 500 respectively. The proposed PESR protocol increases the energy consumption from 741 J to 1035 J while the existing TIGHT, APU strategy and PS-ROGR protocol are utilized from 950 J to 1352 J, 820 J to 1280 J, and 753 J to 1073 J respectively. Hence, the PESR protocol utilizes less energy than the existing protocols.

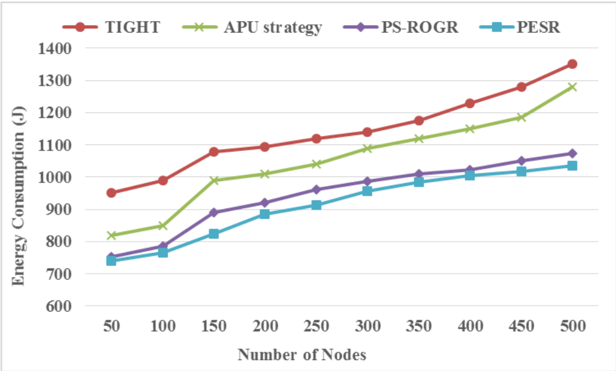

Fig. 6: Energy consumption

6.5 Average Message Overhead-Performance Analysis

The AMO analysis is used to derive the data traffic and also known about the consumed bandwidth that causes overhead issue.

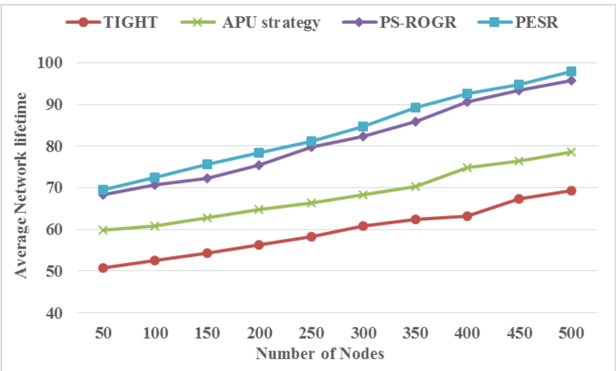

Fig. 7: AMO metric

Fig.7 represents the comparison results of overhead issues of the proposed with existing protocols. The AMO is analysed with the simulation time of 10, 20, 30,... 200 seconds respectively. The PESR protocol achieves less overhead issues than the TIGHT, and PS-ROGR protocol. Hence, the proposed PESR protocol outperforms well than the existing methods.

6.6 Average Network Lifetime-Performance Analysis

The ANL is measured with the help of the varying number of nodes for the TIGHT, APU-strategy, PS-ROGR, and PESR. If the number of nodes increases then the network lifetime also increases. Fig. 8 represents the average network lifetime. Here the number of nodes increases as 50, 100, 150, 200 and 500 respectively. For an instance, the PESR protocol network lifetime increases from 69.45 to 97.84, while existing TIGHT, APU-strategy, and PS-ROGR protocol increase from 50.78 to 69.36, 59.78 to 78.54, and 68.34 to 95.65 respectively. Due to the best route selection, the network lifetime achieves greater than the existing protocol. Hence, the proposed PESR protocol attains maximum lifetime of 97.84% for 500 nodes.

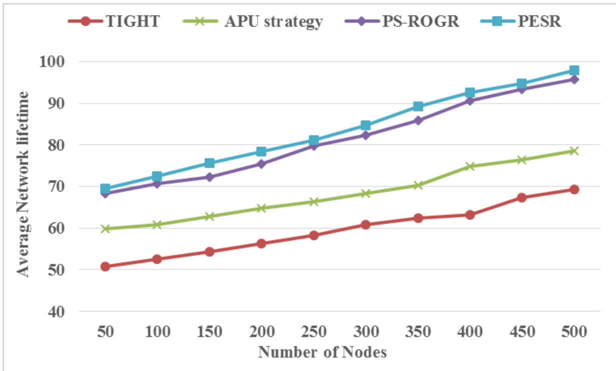

Fig. 8: ANL metric

7 Conclusion

In this research article, the PESR protocol technique is introduced to enhance the network performance with a minimized energy utilization in MANET. The proposed protocol uses an Enriched Neighbor Discovery (END) mechanism, Meta-Heuristic Particle Swarm Optimization (MHPSO) rule for selecting the best route. The END is used to determine the neighbors within the range of a specified distance. The position and velocity of the nodes are identified by a MHPSO technique which provides the energy efficient route. After that, the fitness value of the nodes is evaluated by using the different node parameters such as node lifetime, link lifetime, link bandwidth and queue rate. These parameters are significantly used to identify the proficient energy saving nodes and calculate the route traffic effectively. If there occurs any link failure in the routes, there is no need to re-transmit the data packets. Alternatively it can select another best node and transmits the same packets without any interruption. By this technique, the issues due to transmission overhead can be reduced and it can also increase the network lifetime. Various simulation parameters are considered for overcoming the existing issues. The results of the proposed PESR protocol is compared with the existing protocols such as TIGHT, APU-strategy, and the

PS-ROGR techniques in terms of PDR, network lifetime, overhead, end-to-end delay, throughput, and energy consumption. From the comparative analysis it is observed that the proposed PESR protocol achieves greater PDR and network lifetime with a minimized energy utilization and end-to-end delay performance. Therefore, the proposed PESR protocol efficiently selects the better route for transmitting the data packets.

In this work, the energy saving in terms of routing issue is implemented and it improves the network performance. Further, the energy will be drained due to the attacks and miscommunications. In the future, the energy draining issues due to attacks and miscommunications will be avoided by updating the information about malicious users and attackers to improve the network performance.

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