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Hybrid Extend Particle Swarm Optimization (EPSO) model for Enhancing the performance of MANET Routing Protocols

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ABSTRACT

The routing protocols in MANETs are designed to provide efficient and reliable communication in a highly dynamic and resource-constrained environment. It is very efficient and requires low computational and memory resources compared to most routing protocols. Therefore, mobility and the number of nodes significantly impact the performance and reliability of routing protocols. This paper proposes a hybrid extended particle swarm optimization (EPSO) model to improve the performance of MANET routing protocols. It determines the optimal mobility and the number of hubs and nodes that satisfy the best possible version of MANET. MANET requires a robust routing algorithm that can adapt to a network that arbitrarily changes its topology at any time. The proposed model in the NS2 simulator proves the model's validity in improving the performance of MANET. The proposed model sets the general parameters of routing protocols and achieves high performance with fewer discarded packets and low delay when sending and receiving over MANET. The MANET sent 167 packets in the proposed model, and the number of discarded packets was less than 1%.

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1. Introduction

The MANETs are one of the most prominent fields for research in the modern era and the growth of the wireless network. The popularity of the mobile ad-hoc network (MANET) will increase daily. It has become a wireless network's most spirited and sporty communication field(Alkahtani and Alturki 2021a). The MANT is a self-arranged and decentralized network or infrastructure network. A Mobile network is a group of mobile devices connected

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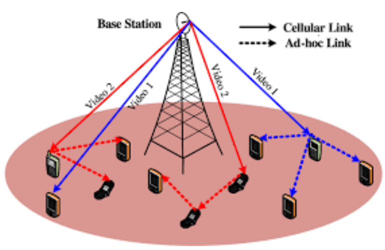
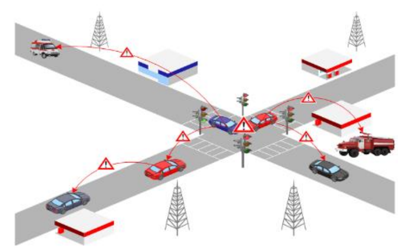
without predefinition(Abdali et al. 2020; Hadi et al. 2022; Vellingiri, Kalimuthu, and Samydurai 2021). The general types of mobile network are: Wireless Ad-hoc Network (WANET) , and Mobile Ad-hoc Network (MANET). There is a vast area where the principle of the mobile network is used in their applications(Abdullah, Ozen, and Bayramoglu 2019; Selvakumar Manickam et al. 2022; Nuiaa, Manickam, and Alsaeedi 2021). A MANET can be connected to the internet or an external network and be a standalone network. MANET is a Latin word which means "for this" or "for this purpose only". Figure(1) shows an example of a Mobile network and Vehicular Ad Hoc Network (VANET) (Yadav, M Uparosiya 2014).



a- Exmple of Mobil phone networks



b- Exmple of VANET networks

Fig1: show an example of a Mobile network

A routing algorithm is required to manage packets from MANET to exchange data between network elements. A routing protocol is essential for the network to make routing decisions, even for an immobile network(Alabdullah et al. 2019; Alfoudi et al. 2022; S. Manickam et al. 2022). All network nodes function like routers and play a role in maintaining routes to other network nodes.

1.1. Motivation

The routing protocols are used to find the path between Source and Destination(Sarkar, Choudhury, and Majumder 2021). Different reasons exist for designing and classifying routing protocols for ad-hoc wireless networks. Routing protocols provide a crucial role in modern communication networks. Each one of the routing protocols has a different structure in comparison to others. As a result, each of them demonstrates excellent performance depending on parameters related to the network(Mansour et al. 2022; Xu et al. 2019). MANET routing protocols are either Reactive or Proactive Routing Protocols[8]:

1. Reactive Routing Protocol uses for dynamic network topologies. Reactive or on-demand routing protocols route is discovered when needed[9]. Reactive protocols tend to decrease the control traffic messages overhead because of increased latency in finding new routes(Habboush 2019).

2. Proactive routing protocols: proactive protocols, also known as table-driven protocols, can find routes in all directions according to topology changes. Updates throughout the network are rerouted through the means of the nodes. The proactive routing protocols provide more straightforward implementation by reducing the risk of loops and delays in the network. However, they hold a lot of overhead and routing information, increasing the load on the nodes, which is also less likely to be used [12]. It are better adapted to extend convergence times while reducing bandwidth utilization. . For example, Destination-Sequenced Distance Vector Routing (DSDV).

Mobile Ad-hoc network is a gathering of self-configuring, multi-hop wireless networks that can change location and configure themselves on the fly. Because MANET is Mobile, they use a wireless connection to communicate with various networks. Due to the mobility and dynamic nature of MANET, it is not secure. MANET's many routing protocols assume that all the network nodes will cooperate while forwarding data packets to other nodes(Mahdi et al. 2021; Nuiaa, Manickam, and Alsaeedi 2021). Most Ad hoc protocols imply nodes' cooperation and good behavior. Such an unwarranted assumption prompts the protocol to assign various performance metrics in a changing environment. The effective routing protocol of MANETS has to solve the following:

- Dynamic Topology: The mobility of nodes causes the topology of a MANET to move very quickly, making it challenging for routing protocols to keep up-to-date routing information.

- Limited Bandwidth: MANETs often operate in situations with limited bandwidth, which makes it challenging for routing protocols to transmit routing information properly.
- Routing protocols must be energy-efficient to prolong the network's lifespan since MANET nodes are often battery-powered.
- Interference and Interruptions: Interference and interruptions may interfere with wireless communication in MANETs, making it challenging for routing systems to maintain a reliable connection.
- Security: Because MANETs lack a centralized infrastructure, they are susceptible to security risks such as network assaults, eavesdropping, and altering routing data.
- Scalability: To support the expanding number of nodes in the network, MANET routing protocols must be scalable.
- Routing Overhead: Routing protocols need to balance how much control overhead is necessary for routing with how effective the routing process is. Required extensive collaboration between the nodes to establish the route to issue in different scenarios.

1.2. Contribution

Routing protocols in MANETs are the most significant part of finding the optimal path for transmitting the information from the source node to the destination node. The Hybrid Extend Particle Swarm Optimization (EPSO) model archives the following contributions:

1. Adaptive swarm intelligent algorithm for setting optimal parameters of MANET protocols.
2. Choose the best route for the MANET mobility environment and protocols from various situations.
3. Achieve a better satisfaction rate for network criteria, including maximum bandwidth, minimal latency, low PDR, and low loss packets.

2. RELATED WORKS

In this section, we discuss several papers by researchers who have worked on using metaheuristics to optimize mobile ad hoc networks (MANETs).

In (Garca-Nieto and Alba 2010) Garca, et al., to efficiently set up routing protocols before network deployment, this study explored the optimum tuning of routing protocol parameters using metaheuristics. To demonstrate that PSO produces the greatest outcomes, they examined the impacts of PSO, DE, and GA on the AODV protocol. The writers Do not use metaheuristic optimization to resolve leaky stagnation.

In actual VANET settings, J. Garc'a-Nieto, et al. (Hernández-Garc'a et al. 2019) employ GA to optimize transmission time, packet loss rate, and volume of sent data. In addition, the suggested system still has a stagnation issue. The authors do not improve the critical components of routing protocols, such as the number of connections, mobility rate, and number of nodes.

Anuj K. Gupta and others (Jain 2022) To determine the shortest traffic route from each node in the MANT, the scientists used Ant Colony Optimization (ACO). They improved one feature of the MANET routing protocol while disregarding its primary parameter by applying the DSR and ADOV routing protocols with deflated parameters. Not all simulation scenarios can be supported by the protocol's deflate option.

Muhammad Alnabhan and others (Alnabhan et al. 2017) , the performance assessment approach in this study seeks to identify the best position-based routing methods. The performance study carried out in this work focused on several parameters, such as power consumption, throughput, latency, and packet transmission rate. The writers test a few exams for each parameter before choosing the best procedure features.

et al. Sultan Mohammed Alkahtani (Alkahtani and Alturki 2021b) In this study, DYMO was shown to be a more effective and dependable protocol than DSR and AODV in situations when the network is large and has rapid mobility.

Different regions employ the same node density (100), but AODV and DSR protocols. Depending on how these protocols' processes work, the AODV protocol's outcomes are comparable to those of the DSR protocol. The settings of the routing protocol are not optimized. When analyzing the performance of the routing protocol, static network variables are employed.

3. EXTENDED PARTICLE SWARM OPTIMISATION (EPSO)

Swarm intelligence is a type of artificial intelligence and is based on the collective behaviour of decentralized or self-organized systems(Al-Janabi and Alkaim 2022; Al-saeedi 2016). Kennedy and Eberhart first introduced the PSO algorithm as a computational method for iterative optimization of problems; the social life of birds inspired it in a swarm, where each bird is considered a particle in the hyperdimensional search space(Al-Shammary et al. 2022; Elbes et al. 2019; Hashim et al. 2022). The position of particles in the search space is flexible and changeable according to individuals' social and psychological tendencies. Particle mobility within the swarm is influenced by two aspects: knowledge and swarm experience. The consequence of shaping social behaviour is swarmed, returning to the previous successful regions in the solution space(Al-Shammary et al. 2022).

The EPSO new swarm intelligent version. It divides them into two groups(P1, P2) to promote exploration and reduce the probability of falling into stagnation. There are many advantages of EPSO, which have Low Stagnation Probability(Mehdi Ebady Manna 2020), Low Time Requirement and Unstuck with Local optimum with Persistent Results. EPSO structure consists of two parts population distribution and particle searching methodology. The Population Distribution is based on the following(Jabor and Ali 2019):

$$P_1 = P - \sim\left(\left(O_{max} - \left(\frac{\hat{I}}{I}\right)^2 \times (O_{max} - O_{min})\right) * \mathrm{P}\right) \tag{1}$$

$$P_2 = P - P1 \tag{2}$$

Where : O_{max} , O_{min} are the maximum and minimum percentages of offspring in the $EPSO_{\ G1}$ respectively. Î, I are current and maximum optimization iterations, respectively. P is population size. The Particles Searching Methodology consists of position (X) update overall based on velocity (V).

$$x_i^{t+1} = x_i^t + v_i^{t+1} \tag{3}$$

$$V_i^d(t+1) = w(t)V_i^d(t) + c_1 r_1\left(pbest_i^d - x_i^d(t)\right) + c_2 r_2(gbest^d - x_i^d(t)) \tag{4}$$

where: $r1$ and $r2$ are random variables in the range [0, 1]. $c1$ and $c2$ are positive coefficients. w is the inertia weight. $v_i^d(t)$,$x_i^d(t)$ indicates the velocity and position of i^{th}particle at iteration t in $d^{\ th}$dimension respectively.

$$V_i^d(t+1) = \alpha gbest^d + \left(1 - \beta V_i^d(t)_i\right) pbest_i^d \tag{5}$$

The Extended Particle Swarm Optimization (EPSO) Structure shows in figure(2).

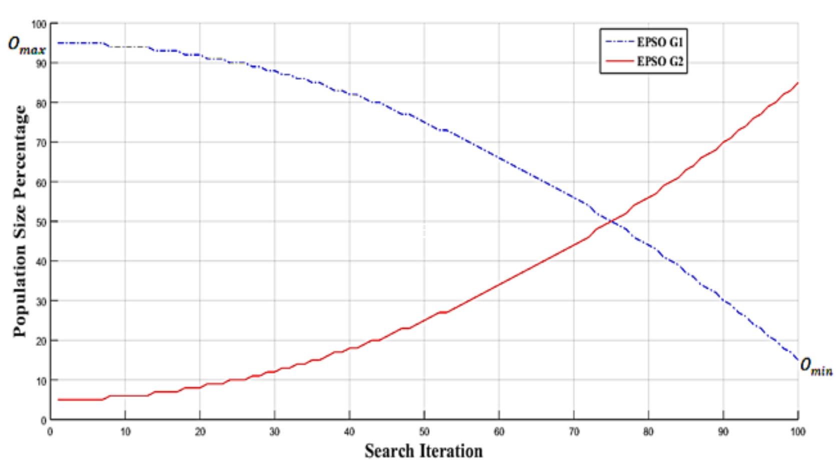


Fig2: The structure of Extended Particle Swarm Optimization (EPSO)

4. PROPOSED METHOD

The EPSO was applied and integrated into the MANET protocol to minimize the required energy consumption by applying the optimal solution for the MANET network. The methodology which will be used in this study for optimization performance of routing protocols of MANET involves the following:

1- Set initialization parameters of the hybrid optimization algorithm.

2- Searching for the best parameters for routing protocols of MANET.

3- Set the best optimal solution for the MANET network.

4- Visualize the best-performance mobile network.

After authenticating the nodes in the network, an optimal path can be selected for enabling the data transmission. For this purpose, the Extended Particle Swarm Optimization (EPSO) technique is employed in this work, which provides an optimal path based on an optimized solution. In this mechanism, two solutions, best case and worst case, are taken by updating the velocity function. During this process, the source node that contains the data to transfer can select the optimal path by using this algorithm. Moreover, an improved fitness function can be used as a best-case solution, and particle and position updating are considered in the worst case.

5. EXPERIMENTAL AND RESULT DISCUSSION

5.1. Simulation

According to the above study, the result can be concluded. Now the simulation is performed for the protocol that shows the best and worst performance. This experimental section includes a simulation environment under which scenarios need to be implemented to compare routing protocol performance for mobile nodes. In the proposed simulation environment, the results run based on 5000 scenarios for the DSR protocol with different network parameters, which were increased sequentially. Table 1 shows the setting of NS2 simulator for both EPSO and PSO.

Table 1 – Simulation setting.

Parameter	Description
Mac	802_11
Antenna	Omni Antenna
Simulation time	50 sec
Simulator	NS2
Number of nodes	15-19
Number of hub	1-10
Number of mobility rate	0.1-1

5.2. Result Discussion

Figure 3 shows the proposed Extended Particle Swarm Optimization (EPSO) technique to obtain the improved possible route. The algorithm is structured to discover the blockage node in the routing path and the optimal node for fixing the routing path. It enhances the network's lifetime and efficiency.

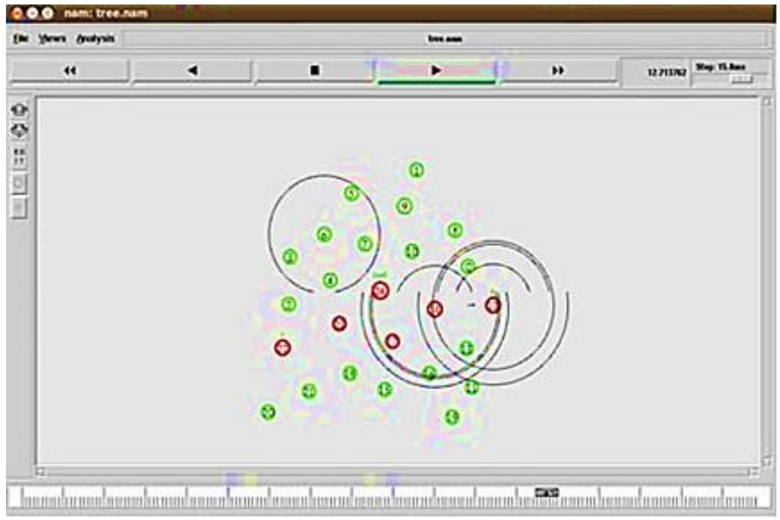


Fig3: Simulation result of proposed EPSO in NS2 stimulator

Data transmission and reception via a network are referred to as sending and receiving packets. Data in networking is broken down into tiny parts called packets, which are sent separately and put back together at the destination to create the original data. To send packets, data must be divided into tiny units, header information must be added to each packet to identify its origin and destination, and packets must then be sent through the network to the intended recipient. Receiving packets entails gathering the arriving packets, putting them together to form the original data, and sending the data to the target audience. The receiver verifies that it is the intended recipient and that the packets have arrived in the correct sequence by examining the header information of each one. All computer networks employ the basic technique of sending and receiving packets to transfer data between devices. Long-distance data transmission is made possible, and reliable, effective communication between networked devices is also ensured. Table 3 illustrates the comparison results between PSO and ESPO regarding sent and received packets. The average of 30 runs of PSO and EPSO of sent/received packets.

Table 2: Compare according low standard deviation 30 independent runs

Algorithm	Std – of Send Packets	Std- of Receive Packets
PSO	3.84	13.61
EPSO	2.89	1.99

Packet loss rate is a metric that measures the number of packets lost or discarded during data transmission over a network. It is expressed as a percentage of the total number of packets sent. A high packet loss rate indicates a problem on the network, such as congestion, insufficient bandwidth, or problems with the network hardware. The loss rate can affect the quality of data transmission and result in slow network performance or complete communication failure. Network administrators can use various techniques to minimize packet failure rate, including traffic management, quality of service (QoS) policies, and hardware component upgrades. Monitoring the packet failure rate and taking proactive measures to reduce it is important to ensure the reliability and performance of a network. Equation 6 calculates the packet dropped ratio.

$$PDR = \frac{sent\ packet - \text{received}\ packets}{total\ sent\ packet} \tag{5}$$

Table 3 shows the average drop packet rate (DPR) of the proposed EPSO method; the package delivery ratio is improved compared to the existing PSO method.

Table 3: Compare according to low standard deviation 30 independent runs of sent/received, PDR, and delay

Algorithm	Sent Packets	Receive Packets	PDR (Packet Drop Rate)	Delay(ms./Packet)
PSO	167	143	0.14	11.43
EPSO	167	150	0.09	11.17

Fig 4 and 5 represent the dropped packet ratio of the existing and proposed technique based on EPSO concerning the varying numbers of nodes in the network. These results stated that the proposed EPSO framework provides a reduced dropping ratio compared to the PSO technique

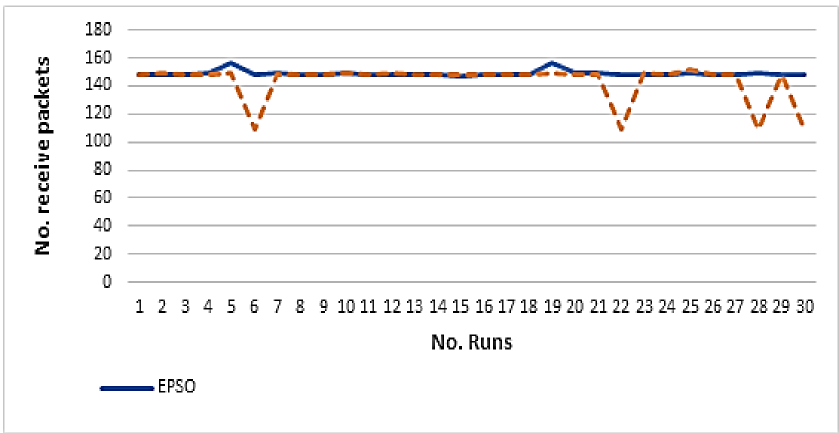


Fig4: Rate of receive packets over 30 indented runs

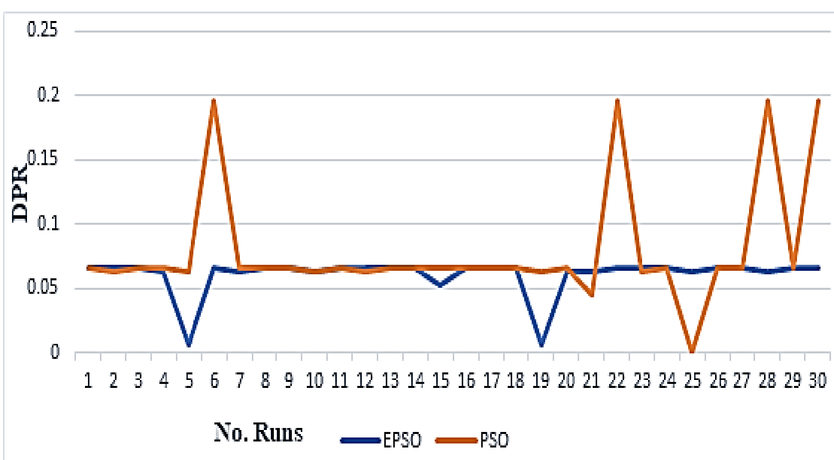


Fig5: DPR over 30 indented runs

6. CONCLUSION

MANET or mobile ad hoc network, is the abbreviation. It is a self-configuring network of mobile devices that can connect without a fixed network architecture or central infrastructure. When standard wired or wireless networks are impractical or unavailable, MANETs are often used in disaster relief, military operations, and emergency response situations. It is easily set up and provides connectivity in dynamic and rapidly changing areas. Due to their high mobility, limited bandwidth, and frequent topology changes, MANETs face unique difficulties that can lead to network splitting, congestion, and lower reliability. Various routing protocols such as AODV and DSR have been developed to discover routes dynamically and maintain connectivity in MANETs to overcome these difficulties. MANETs have been extensively researched and developed in recent years and have applications in the military, healthcare, and transportation, among others. Additionally, these networks' architecture is constantly changing due to the nodes' autonomous and haphazard mobility. The optimization multi-objective looks for the best route via pet and PDR from various delay and packet loss conditions. The primary goal is to identify the best routing for several protocols, including DSR, AODV, and DSDV. The anticipated outcomes will reveal an optimizer that is more effective than the default routing protocol.

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