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Performance improvements for MANET routing protocols using a combination of cat and particle swarm optimization (CPSO)

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Abstract

Mobile networking refers to the technology utilized to transmit speech and data between specific mobile network nodes across wireless channels. In general, "mobile" refers to the purposeful, lightweight, and portable technologies that moviegoers may carry. To enhance the MANET routing protocols, a hybrid swarm optimization model has been suggested in this study. The suggested optimization establishes the MANET network as the ideal setting. The suggested approach combines cat swarm optimization (CSO) with particle swarm optimization (PSO). MANT network also called mobile sensor network and utilizing the research's technique, the improvement mechanism (s) that could be employed to end degraded routing concerns and enhance act may be identified. Compared to both PSO and CSO, the results produced by the suggested model are the best.

Keywords: Cat swarm optimization, DSR routing protocol, AODV, MANT, Particle swarm optimization, ad-hoc network
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1 Introduction

Mobile ad hoc network also called wireless ad hoc network (WANET), are wireless network that join groups of mobile devices spontaneously and without any previous design [22]. There are various applications for it, including [6, 22]: Smartphone ad hoc network (SPANs), Vehicular ad hoc network, and wireless sensor network (VANETs). MANT and WANET are called "ad hoc network" since they do not rely on preset pathways and network (unfixed infrastructure).

Given that each node contributes to routing by interacting with other nodes, the decision of which nodes send messages is dynamic and dependent on network availability and the steering computation utilized. A group of mobile devices that can communicate and interact with one another without relying on any predetermined structure constitutes an ad hoc mobile network (MANET). In a MANET, essential criteria are the total nodes' number, the total connections' number, and the mobility rate [4]. MANET has a less uniform and centralized organization [15]. Instead of employing permanent infrastructure, they link via self-organizing, self-managing, and self-creating network [1]. Because each node's wireless transmission range is restricted, every node functions as both a host and a router. Figure 1 is a diagram illustrating the MANET architecture.

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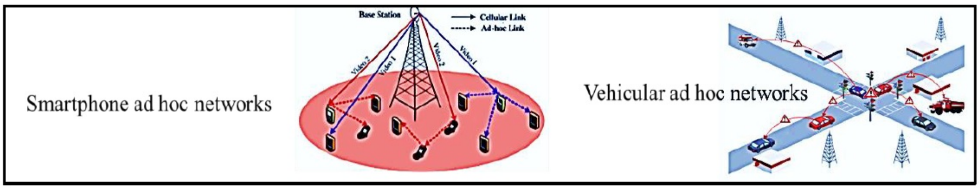

Figure 1: Example of MANET

MANETs have a specific advantage that allows them to react to circumstances. That advantage is that they could be deployed to any location quickly and immediately. As a direct result of these significant advantages, the military, police, and emergency services have demonstrated a rapid interest in MANETs, especially in settings that are either chaotic or dangerous [17, 22]. Enterprise applications have been present for some time, and ever since their beginnings, they have depended on constantly increasing standards like IEEE 802.11 as their primary support mechanism. The protocol suite that underpins MANET provides support for both static and dynamic routing [4]. The static routing protocol is implemented into the fixed network architecture. A LAN network's physical connection between its two fixed end nodes is an excellent illustration of a static routing method, which occurs when both of the network's end nodes are permanently installed [12]. A network is said to be ad hoc and utilizes a dynamic routing system if its node and link topologies can be moved. The exchange of data between devices linked to the same network is governed by a set of predetermined guidelines that make up what is called a network protocol [19].

On network, routing, data transfer, communication, and the sharing of resources are not possible without the use of protocols. Both reactive and proactive routing protocols govern the routing on the MANET network. Reactive routing protocols are the more traditional form [22]. The two reactive routing algorithms that are utilized the most often are called Dynamic Source Routing (DSR) and Ad Hoc On-Demand Distance Vector (ADOV) [3, 20, 22]. The family of proactive routing protocols called ADOV includes the Ad Hoc On-Demand Distance Vector. The many topology-based routing approaches are demonstrated here in Figure 2.

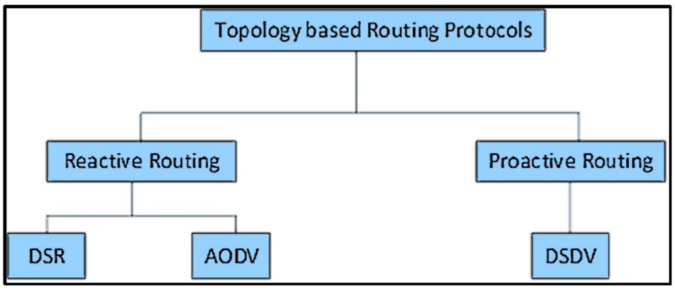

Figure 2: Routing protocols depending on the topology

Reactive routing group techniques are still very significant for dynamic network topologies, even though proactive routing group methods are more suited for reducing bandwidth utilization and attaining speedier convergence times [20]. Compared to the first topology-based routing protocol, the DSDV routing protocol requires a central processing unit (CPU), memory, bandwidth, and battery power (AODV and DSR).

Cat Swarm Optimization (CSO) and Particle Swarm Optimization (PSO) are common examples of metaheuristic algorithms, which demonstrated to be very effective in the resolution of a widely complex optimization issues in different sectors [2]. Because there are restrictions placed on the progression of the search (exploitation and exploration), the Metaheuristic algorithm may experience considerable setbacks if it becomes stuck at a locally optimal solution [23]. Exploitation and exploration were essential to get from one kind of toxin to the most effective treatment [7, 14]. Both exploitation and exploration were essential to get from one kind of toxin to the most effective treatment.

1.1 Motivation

Issues with the routing of ad hoc network have more than one solution, but they are all intended to be as efficient as possible. Poor choices in network design may lead to less effective routing guarantees than expected, which links between the numbers of nodes could cause stop length and link nodes. These connections could be lower than planned [22]. Many ad hoc protocols begin with the assumption that nodes are cooperative and behave appropriately. The technique makes this incorrect assumption, so it conducts performance measurements in an ever-changing environment. Since the fundamental differences between MANETS and wired network, established methods could only be transferred to MANETS by being updated to execute these protocols in various conditions. This prevents the transfer of established techniques [3]. It is essential to energy constraints, tackle multiple node functionality, absence infrastructure, erroneous link-state information, node mobility, limited bandwidth, absence centralized authority, and other MANET-specific difficulties to provide quality of service (QoS) across MANETs. To build the route, the nodes must often work closely together [14].

1.2 Contribution

- This research proposes a new hybrid swarm optimization (CPSO) strategy. This method could improve the MANET routing protocol since it speeds up the progress of the search for the suggested model. The optimization techniques called (CSO) and (PSO) have been combined in the system that has been suggested (PSO). It is suspected that CSO and PSO are searching in the same region. When the attempt to find a locally optimal solution did not succeed, the system switched to PSO and proceeded until the conditions were met. The strategy that was suggested resulted in various successful outcomes: An adaptive hybrid metaheuristic that utilizes both the Cat and PSO techniques while dealing with various MANET protocols and situations.
- Determine the optimal path for the MANET mobility environment and the protocols to follow in various scenarios.
- Be certain that other network requirements, including those for maximum bandwidth, low latency, low packet delivery proportion, and low loss of packets, are satisfied.

2 Research Review

MANET routing protocol approaches were created to manage mobile nodes in the most effective manner possible. Through a great deal of research and development, the performance of the MANET routing technology has been created and enhanced. Most research efforts are concentrated on finding ways to improve connection when moving to boost the performance of MANETs. Metaheuristic algorithms are the most effective strategies for optimizing the interactions' number between nodes while maintaining a certain pace.

Alnabhan et al. [7] is recommended that swarm ant colony optimization be utilized to locate the most effective route for the distribution of traffic between nodes in MANT (ACO). The network was managed with the help of the DSR and ADOV routing systems that are part of the MANET protocol. The essential characteristics of the routing protocols, including the mobility rate, the connections' number, and the nodes' number, should be considered in favor of optimizing only a single aspect of the routing protocols. MANET environments will not always support the deflated variables of the protocol.

To determine which location-based routing algorithms are the most effective, frameworks for performance assessment have been developed [9]. In this study, performance evaluation is focused on different criteria, including power consumption, throughput, latency, and the pace at which packets are sent, a performance assessment technique for choosing the most effective location-based routing algorithms. The investigation into the performance being carried out here emphasizes factors, including power consumption, throughput, latency, and the pace at which packets are sent.

The study's authors adjusted three characteristics of the VANET network: the transmission time, the frequency of missed packets, and the quantity of data provided [10].

A difficulty exists with the system that has been suggested, in addition to the issue of stagnation. The authors do not alter the connections' number, the mobility rate, and the node count, three of the essential components of routing protocols.

Lü et al., [16] utilized metaheuristics to enhance the routing protocol configuration before constructing a network. When utilizing AODV as a routing protocol, the authors explored how the utilization of (PSO), differential evolution (DE), and genetic algorithms impacted the efficiency of MANET (GA). They demonstrate that PSO has the most significant influence on the network's overall efficiency. The issue of leaky stagnation in swarm optimization approaches could not be solved by utilizing this strategy.

The effectiveness of AODV and DSR in different locations with the same node density was assessed by [6] as (100 nodes). The protocols' respective outcomes are equal to one another depending on how the operations of the

AODV protocol and the DSR protocol interact with one another. There is room for improvement in the variables of the routing protocol. When evaluating the routing protocol's effectiveness, the network's static magnitude should be utilized.

3 Research Technique

This section may be split down even further, into a total of four primary subsections. In Section 3.1, both the PSO algorithm and the generic steps technique are detailed for the reader. In Section 3.2, the structure of the LAR protocol as well as its guiding principles are described. In Section 3.3, the RREQ mechanism is described, and in Section 3.4, the optimization approach is described.

3.1 Particle Swarm Analysis

The PSO asserts that social animals are the source of inspiration for a portion of the P-Metaheuristic Optimization method [13]. Compared to other P-Metaheuristics, PSO has lower total optimization number formulas and is easier to implement [16]. This sets it apart from other P-Metaheuristics in a significant way. In the search technique, the location and velocity PSO variables are the two that are considered to be of the utmost importance (candidate solution). Each particle has two possibilities available to it: the best possible local solution often called p-best, and the solution that is now being utilized (location). PSO stands apart from other metaheuristic algorithms thanks to its technical process, which distinguishes it from other algorithms [5]. Two solutions inside a single particle enhance PSO's capacity for exploration. The particles work together to uncover the finest solution in the whole universe, which they call G-best. The new particle location in the PSO pool may be found by solving Formula (3.1) [18].

$$x_i^d(t+1) = V_i^d(t+1) + x_i^d(t) \tag{3.1}$$

whereas: $x_i^d(t+1)$ is the particle's new location, $x_i^d(t)$is the particle's stated current location, and $V_i^d(t+1)$ is a new functional velocity.

The Formula (3.2) determines the particle's new velocity at optimization iteration $t+1$.

$$V_i^d(t+1) = w(t) * V_i^d(t) + c_1 r_1 (pbest_i^d - x_i^d(t)) + c_2 r_2 (gbest^d - x_i^d(t)) \tag{3.2}$$

whereas: both magnitudes of (r_1, r_2) are random, and the constants magnitudes (c_1, c_2) are set to (1.25) [18]. The $V_i^d(t)$ represents the particle's velocity at iteration t, $w(t)$ weight inertia at iteration (t).

3.2 Cat swarms Optimizations (CSO)

Chu et al. [8] first presented the cat swarm optimizations (CSO) method of swarm optimization in 2006. Chu locating beats stimulates cats to go hunting. Searching and tracing are the two different technical modes in which the CSO algorithm may operate [2]. A cost magnitude, a flag, and three magnitude locations are associated with the cat in CSO. The location of the cat is often a solution that may be implemented and has a reduction that is equivalent to the optimization issue. The cat's accuracy or fitness magnitude will define how much it is worth in terms of its cost. The cat flag may mean searching or tracking [2]. Underpinning the Seeking Mode is Formula (3.3) [8].

$$P_i = \frac{|FS_i - FS_b|}{FS_{\max} - FS_{\min}}, \text{ whereas } 0 < i < j \tag{3.3}$$

While tracking, the cat updated its location and velocity. Formula (3.4) is utilized to update the velocity $(v_{k,d})$ [8].

$$v_{k,d} = v_{k,d} + r_1 \times c_1 \times (x_{best,d} - x_{k,d}), \text{ whereas } d = 1, 2, ..., M \tag{3.4}$$

$x_{best,d}$ is the spot held by the cat with the highest level of fitness in the cat population; $x_{k,d}$ is the location of cat k. c_1 is a constant, and r_1 is a random magnitude in the range of $[0, 1]$

The cat moves to a new location $(x_{k,d})$ depending on formula (3.4) [8]

$$x_{k,d} = x_{k,d} + v_{k,d} \tag{3.5}$$

Since CSO does not provide the optimum answer until after all of the iterations have been completed, the outcome will be the best location in one of the cats.

3.3 Ad Hoc Distance Vector on Demand (ADOV)

Reactive routing is possible with ADSV in MANETs and other mobile network [4, 11]. Because of its numerous beneficial characteristics, including dynamic, self-starting multi-hop routing between mobile nodes that seek to construct and sustain an ad hoc network, it is well suited for MANET network. This is one of its many applications [17]. When nodes are not actively communicating, AODV does not need the routes to be maintained, making it simpler to create routes to specified destinations [14]. Using objective sequence numbers, AODV can address the challenge of "counting to infinity." Therefore, AODV does not include any loops. The AODV routing protocol just supplies the source and the destination, not the whole network route path between the two points. Figure 3 illustrates the route request (RREQ) packet transfers inside the MANET network.

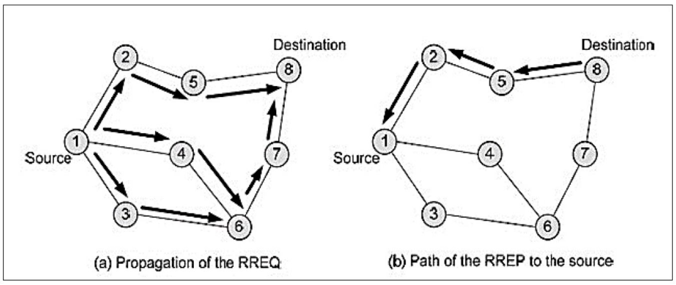

Figure 3: Broadcast of AODV

3.4 Routing Sources Dynamically (DSR)

In a MANET, the DSR routing mechanism guides packets from their origin to their final destination. It is simple for nodes to locate a source route that traverses several network hops and leads to any destination node [4]. Route maintenance and route discovery are the two most important aspects of the DSR routing system. Before mobile hosts may begin to transmit packets utilizing the DSR protocol, they must first verify their route cache to identify whether or not they have a route to the destination they plan to send the packets. If there is a path from the source to the destination on the network, a packet is sent from the source to the destination [9, 20]. If the host node have no route, if the route disappear, or if the route has not yet expired, the host node will initiate route discovery by sending a route request packet. This packet will include the destination's address, the address of the source mobile host, and a unique identification number. If the host node have no route, if the route disappear, or if the route has not yet expired, the host node will send this packet. As a consequence, the DSR routing protocol is consulted by every node in the network whenever a packet is added to the network to ascertain whether or not there is a path to the destination [4, 21].

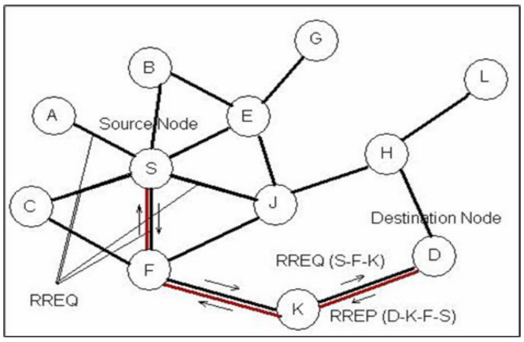

Figure 4: DSR broadcast RREQ

3.5 Cat and Particle Swarm Optimization hybrid proposed (CPSO)

The performance of the MANET routing protocol will be improved with the utilization of metaheuristic optimization strategies, which will be the focus of this study. In this investigation, the AODV and DSR routing protocols are implemented. Utilizing the offered optimization strategy allows for optimal selection and configuration of the MANT routing protocol settings. One of the most common issues with metaheuristic optimization models is the existence of a locally optimal solution. In the field of optimization, this phenomenon is referred to as stagnation. To avoid complacency in the conceptual framework that has been presented, the scope of the investigation is being expanded. Expanding the possibilities that the metaheuristic algorithm may consider is the most effective method for assisting it in breaking out of a rut it may be in the hybrid model provides populations with a selection of proposed solutions, in addition to models that have improved features compared to the methodologies utilized to develop the model. The proposed method includes the following four stages:

There is a significant correlation between the random population's size and the proposed model's initialization. The optimization issue says that a random population must begin with a size and dimension determined by the individual utilizing the system.

The COA is free to begin its first search for the local optimum utilizing the technique that has been supplied. If the first search is unsuccessful, the system is programmed to transition to the PSO search strategy immediately. The only course of action that will be successful is the PSO.

Suppose the PSO is already at the local optimum, and the candidate solution does not get any better. In that case, the system will instantly switch to COS and utilize the most recent best solution that the PSO discovered. The system preserves the population and speed characteristics of swarm optimization approaches and will only alter the optimal solution once it has switched. Providing that the best outcome is achieved by both swarm optimization strategies (COA, PSO). The algorithmic variables are going to be modified by the suggested system (population and speed). Figure 5 illustrates the processes that should be followed while implementing the suggested system.

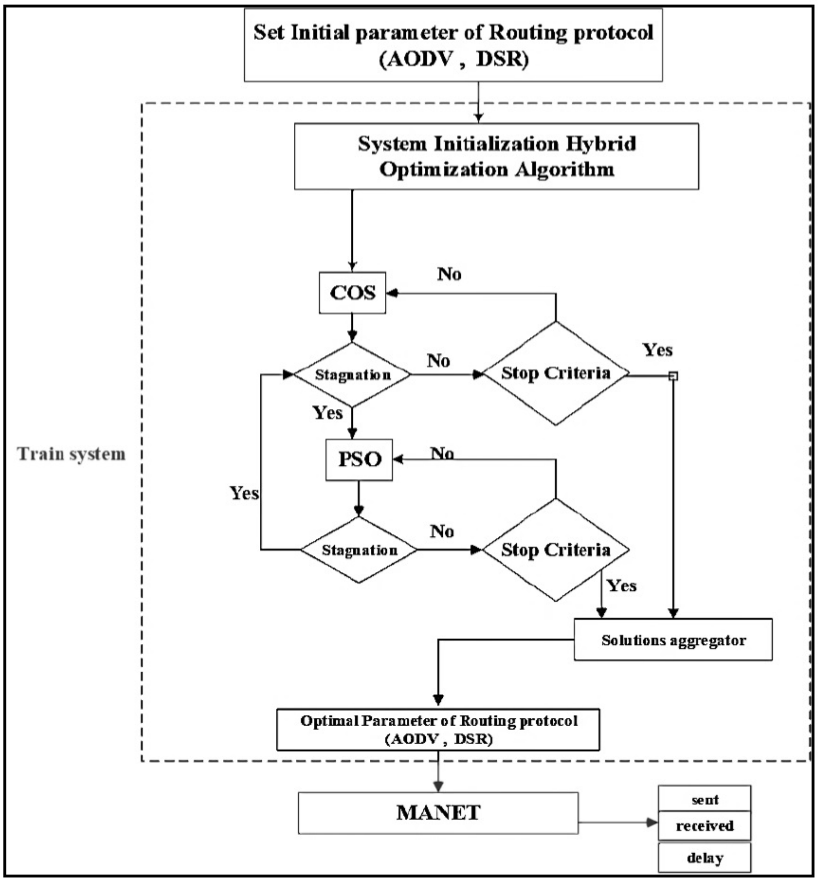

Figure 5: The Suggesting System

4 Evaluation Metric

- The recommended technique is assessed with a specialized benchmark, with the primary considerations being the total broadcasts' number, received packets, and delay packets. It consists of four primary components: latency, the packets' number lost, the proportion of lost packets to successful packets, and the proportion of sent packets to received packets.

- Exemplification of the Proportion of Items Sent to Those Received (SR) This statistic measures the proportion of successfully delivered and received packets. Formula (4.1) provides the SR since the recommended optimization model searches for the objective function that is the lowest magnitude possible.

$$SR = \frac{1}{S+R} \tag{4.1}$$

  R is the packet number that has been successfully received, whereas S is the number that has been successfully sent.

- The packet number that cannot be delivered to its intended location is the dropped packet (DP). The answer may be found by taking the packet number sent and subtracting it from the packet number received.

$$DP = S - R \tag{4.2}$$

- It is in the system's favor if it receives packets that are geographically close to the sender.

- R/S stands for the proportion of successful packets. A flawless system would have the same proportion of successfully received packets as successfully sent ones. To get the function of the smallest object possible, it has been subtracted R/R from 1. The R/S proportion is determined by applying Formula (4.3) to the data.

$$R/S = 1 - \frac{R}{S} \tag{4.3}$$

  The object function (f) is constructed by adding the SR, DP, R/S, and delay.

$$f = SR + DP + R/S + Delay \tag{4.4}$$

Table 1 displays the interval bounders for the objective function's parameters.

Table 1: demonstrates the object function's argument range bounders.

Variables	**Best**	**Worst**
SR	0	1
DP	Depending on the packets transmitted and received	
R/S	0	1

5 Observation and Discussion

The solution that has been presented makes use of different routing protocol choices for MANT to assess more than 10,000 possible results. The PSO and CSO metaheuristics, two of the most common types of metaheuristics, are compared to the model that has been developed. The default settings for the optimization variables are ten iterations, three sets of progressively simplified issues, and twenty progressively larger populations. Each particle's maximum and minimum magnitudes are 5 and -5, respectively. To apply the PSO method, one must adjust the weight inertia to 0.5 iterations and set the constant magnitudes ($c_1.,c_2.$) to 1.25. The cats' number (NUM CATS), the percentage of seeking cats (MR), the searching memory pool (SMP), and the percentage of seeking a range of the provided dimension are the critical factors for the CSO technique (SDR). PSO and CSO were given access to the variables of the hybrid model's recommended configuration (CPSO). Compared to CSO and the model that has been proposed, the optimum outcome obtained by the PSO model was the worst of the three (CPSO). The optimal solution for PSO would have the following node count (19), connection count (10), and speed rate: (10). The scenario of the PSO includes sending and receiving 162 packets (109). The decision on the matter will be delayed (6023.5 Sec). In terms of outcomes, the CSO could not match those of the CPSO. The full case study from the CSO had an average node speed rate. It consisted of 19 nodes, ten connections, and 132 packets (10). CSO acquired 13 packets after a delay of 52.36 seconds in this particular instance. Our suggested system is capable of handling the ideal MANET environment since it has (19) nodes, (4) connections, and a mobile node rate speed of (4). CPSO will take a variety of object magnitudes, including delay, received (47), transmitted (48), and received (47) packets (6.13 sec). The latency, the dropped packets (DP) number, and the proportion of successful to dropped packets (R/S) are compared in Table 2 for PSO, CSO, and the proposed CPSO.

Table 2: Compere results for PSO, CSO, and CPSO over 30 runs

Algorithm	DP	R/S	Delay (sec)
PSO	53	0.346	6023.3
CSO	1	0.0076	52.36
CPSO	1	0.0076	6.13

Since the superiority of the CSO in locating the most effective practical solution in the search area, which the proposed CPSO inherited to speed up the search process, both the CSO and the proposed CPSO perform equally in terms of packets number that are dropped. Figure 6 depicts the over scenario's effects on the dropped packets, which the PSO, CSO, and CPSO chose.

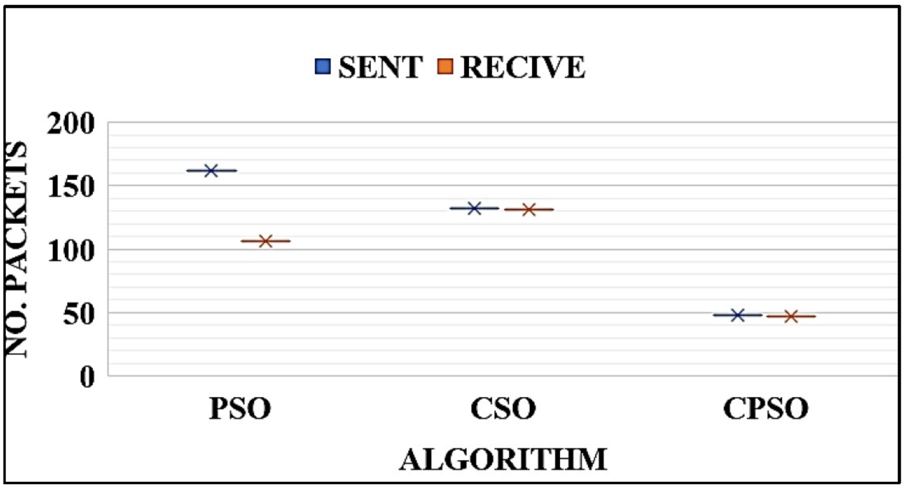

Figure 6: CPSO, CSO, and PSO compare lost packets.

6 Conclusion

The multi-objective optimization process searches for the optimal route under various conditions, including that latency, packet loss, pet, and PDR. The primary purpose is to determine the optimal routing for various protocols, including DSR, AODV, and DSDV. The findings demonstrate that the optimizer is more efficient than the traditional routing protocol. When developing apps in the future, it has been recommended dynamically implement the NS2 scenarios.

References

[1] A.M. Abdullah, E. Ozen and H. Bayramoglu, *Investigating the impact of mobility models on MANET routing protocols*, Int. J. Adv. Comput. Sci. Appl. **10** (2019), no. 2.

[2] A.M. Ahmed, T.A. Rashid and S.A.M. Saeed, *Cat swarm optimization algorithm: a survey and performance evaluation*, Comput. Intel. Neurosci. **2020** (2020).

[3] M.G.K. Alabdullah, B.M. Atiyah, K.S. Khalaf and S.H. Yadgar, *Analysis and simulation of three MANET routing protocols: a research on AODV, DSR & DSDV characteristics and their performance evaluation*, Period. Engin. Natural Sci. (PEN) **7** (2019), no. 3, 1228–1238.

[4] F.T. AL-Dhief, N. Sabri, M.S. Salim, S. Fouad and S.A. Aljunid, *MANET routing protocols evaluation: AODV, DSR and DSDV perspective*, In MATEC web of conferences, EDP Sci. **150** (2018), p. 06024.

[5] S.M. Ali, A.H. Alsaeedi, D. Al-Shammary, H.H. Alsaeedi and H.W. Abid, *Efficient intelligent system for diagnosis pneumonia (sars-covid19) in x-ray images empowered with initial clustering*, Indones. J. Electr. Eng. Comput. Sci. **22** (2021), no. 1, 241–251.

[6] S.M. Alkahtani and F. Alturki, *Performance evaluation of different mobile Ad-hoc network routing protocols in difficult situations*, Int. J. Adv. Comput. Sci. Appl. **12** (2021), no. 1.

[7] M. Alnabhan, M. Alshuqran, M. Hammad and M. Al Nawayseh, *Performance evaluation of unicast routing protocols in MANETs-current state and future prospects*, Int. J. Interact. Mobile Technol. **11** (2017), no. 1.

[8] S.C. Chu, P.W. Tsai and J.S. Pan, *Cat swarm optimization*, Q. Yang and G. Webb (eds.), PRICAI 2006: trends in artificial intelligence, PRICAI 2006, Lecture Notes in Computer Science, Springer, Berlin, Heidelberg, 2006.

[9] M.S. Daas and S. Chikhi, *Response surface methodology for performance analysis and modeling of manet routing protocols*, Int. J. Comput. Network Commun. **10** (2018), no. 1, 45–61.

[10] J. García-Nieto and E. Alba, *Automatic parameter tuning with metaheuristics of the AODV routing protocol for vehicular ad-hoc network*, Eur. Conf. Appl. Evol. Comput., Springer, 2010, pp. 21–30.

[11] A. Habboush, *Ant colony optimization (ACO) based MANET routing protocols: a comprehensive review*, Comput. Inf. Sci. **12** (2019), no. 1, 82–92.

[12] M. Ilyas, *The handbook of wireless ad hoc network*, CRC Press, 2003.

[13] J. Kennedy and R. Eberhart, *Particle swarm optimization*, Proc. ICNN'95 Int. Conf. Neural Networks, IEEE **4** (1995), 1942–1948.

[14] S. Kumar, V.S. Raghavan and J. Deng, *Medium access control protocols for ad hoc wireless network: a survey*, Ad hoc Network **4** (2006), no. 3, 326–358.

[15] J. Kuruvila, A. Nayak and I. Stojmenovic, *Progress, and location based localized aware power routing for ad hoc and sensor wireless network*, Int. J. Distrib. Sensor Network **2** (2006), no. 2, 147–159.

[16] F. Lü and C. Qin, *Particle swarm optimization-based BP neural network for UHV DC insulator pollution forecasting*, J. Eng. Sci. Tech. Rev. 7 (2014), no. 1.

[17] H. Luo, P. Zerfos, J. Kong, S. Lu and L. Zhang, *Self-securing ad hoc wireless network*, ISCC **2** (2002), 548–555.

[18] S. Mirjalili and A. Lewis, *S-shaped versus V-shaped transfer functions for binary particle swarm optimization*, Swarm Evol. Comput. **9** (2013), 1–14.

[19] A. Mishra, S. Singh and A.K. Tripathi, *Comparison of MANET routing protocols*, Int. J. Comput. Sci. Mob. Comput. **8** (2019), 67–74.

[20] A.S. Mustafa, M.M. Al-Heeti, M.M. Hamdi and A.M. Shantaf, *Performance analyzing the effect of network size on routing protocols in MANETs*, In 2020 Int. Cong. Human-Comput. Interact. Optim. Robotic Appl. (HORA), IEEE, 2020, pp. 1–5.

[21] D.T. Nghi, H.L.T. Nhan, N.T. Loi and B.T.T. Trang, *Distributed database strategies in a healthcare record systems*, Int. Nurs. Conf. Chronic Diseases Manag., 2019, pp. 7–11.

[22] P. Sarao, *Comparison of AODV, DSR, and DSDV routing protocols in a wireless network*, J. Commun. **13** (2018), no. 4, 175–181.

[23] A.O. Topal and O. Altun, *A novel meta-heuristic algorithm: dynamic virtual bats algorithm*, Inf. Sci. **354** (2016), 222–235.