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SOPHISTICATED LION OPTIMIZATION BASED ROUTING PROTOCOL (SLORP) FOR CONGESTION AVOIDANCE IN MOBILE AD-HOC NETWORK

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ABSTRACT

The network that does not require infrastructure or central access is called Mobile Ad-hoc Networks (MANET). MANET has a wide range of applications because of its quick and flexible networking style. Routing protocols for MANETs are often developed on the premise that all participating nodes are completely cooperative. Developing effective routing protocols for MANETs is a difficult endeavor. There has been great interest in algorithms inspired by swarm intelligence because they can provide optimal solutions with cheap cost, flexibility and high resilience. Furthermore, MANETs can deal with complex, large-scale issues without the aid of a centralized authority. A bad route in MANET can fail at any time, causing retransmissions and congestion on the network, significantly impacting performance. Sophisticated Lion Optimization-based Routing Protocol (SLORP) is a new bio-inspired routing protocol proposed in this paper for avoiding congestion in MANET by finding a stable route. The natural characteristics of the lion inspire SLORP. The five different stages of SLORP are (i) Pride Generation, (ii) Reproduction, (iii) Bonding, (iv) Handling, and (v) Termination. The delay and energy consumption are minimized in SLORP via improved routing synchronization with the network's nodes. An evaluation of SLORP is performed using common metrics in NS3. SLORP outperforms existing routing protocols in terms of performance.

Keywords: *MANET, Routing, PSO, Optimization, Energy, Swarming.*

1. INTRODUCTION

MANET is a network of nodes/stations that communicate via wireless links. There is no restriction when connecting and disconnecting nodes, so nodes connect and disconnect as they please. The topology of a MANET is dynamic and changes quickly because the nodes are free to move and can organize themselves however they want and the topology of MANETs is unpredictable because of this node characteristic [1]. In a MANET, mobile phone devices are connected via Wi-Fi to form a self-configuring network that reduces implementation time and costs. Ad hoc is a Latin phrase meaning "for this." Each node in MANET is free to follow any path, which means its links to other devices constantly change [2]. A wireless router is also required to handle traffic unrelated to their use. To build a MANET, it is essential to equip each network with the equipment necessary to maintain the information needed to efficiently route traffic. These networks can work independently or in conjunction with others that are further out in cyberspace. MANETs became a popular study area in the mid-1990s when notebook computers and Wi-Fi social media became more common [3].

Interaction's success is heavily reliant on the cooperation of other nodes. As a result, MANET can be used to connect people and cars to the Internet even when there aren't any preexisting interactivity facilities or additional Wi-Fi coverage. Ad hoc networks make multi-hop routing possible by increasing the mobile nodes they serve. Customer focus is critical to Wi-range [4]. Ad hoc Wi-Fi networks, or MANETs, allow nodes to move

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freely and mobile nodes to exchange and receive traffic. On the other hand, wireless routers are multiple-hop devices, so mobile nodes can act like routers by forwarding traffic to their location node. MANET does not necessitate wired platform channels. Because the Wi-Fi network client is self-organized, mobile nodes can connect [5].

The mobile nodes instantly form networks without a fixed infrastructure or central control. The mobile nodes are equipped with transceivers and devices with smart antennas that let them connect. Every time a mobile node enters or exits the network, the structure of the network changes. In its early days, MANET was designed for the military, but it is now used in various settings, including disaster zones, information selection, and private meetings [6]. The real identity of this ad hoc network is MANET. As the network and its nodes become more flexible, it becomes clearer how hard it is for them to set up their connections. Some of the network's mobile nodes can serve as wireless routers and clients, allowing it to quickly build a powerful topology [7]. The administrator can add and remove nodes from the network at any given moment with minimal effort. They are linked if the receivers on two nodes can immediately establish a connection. Nodes outside the immediate reach of the platform can still interact. Inside the interaction client, mobile nodes work as advanced nodes, successfully passing information through a series of local trips. This keeps mobile nodes connected beyond the platform's immediate safe zone [8].

The unique features of MANET add intrigue to the prospect of a network with so many potential advantages. MANET is currently investigating a wide range of topics [9]. V2V communication is an important part of the system because it allows vehicles to communicate while maintaining a safe distance from one another and alerting drivers to impending collisions [10]. Automation of battlefields and war games can also be done with MANET technology if desired. In addition, MANETs are most commonly used in emergency and relief efforts, where wired ethernet networks are already damaged and cannot be repaired [11]. MANETs can be used for a lot more than just business. They can also be used for fun and learning, among other things.

MANETs rely on routing to provide users with more track options. As its name suggests, routing is figuring out which paths through a network should be used to send traffic from one resource to another. Official instructions or guidelines dictate how MANET nodes determine which route to follow while transmitting and receiving packets in an ad hoc routing mechanism. Nodes in an ad hoc network don't know how the network is set up [12]. To find it, they will be on their own, searching for it in the wild. In a computer network, the nodes may select the pathways they wish to take between one other by using routing mechanisms. Routing methods provide the specifications for how routers should communicate with one another. Only networks directly linked to a wireless router have a priori information stored on the router. To begin with, the routing method disseminates this information to those in the immediate vicinity and the rest of the network. As a result, routers become aware of the network's topology. Such a routing method is designed to ensure that information is delivered to and from a limited number of nodes efficiently and promptly [13].

1.1 Problem Statement

Nodes in MANETs have a great deal of freedom in terms of joining and leaving the network. There isn't a central control point for managing the flow of nodes in and out of the network. Wires are used to connect all of the devices in a traditional network. When the network was designed, its topology and scale were predetermined, and they won't change much over time. As such, designers can say that the network's scalability is established early in the design process. Nodes in MANETs are stationary, but in this situation, they are movable, and the size of MANETs changes as a result. The number of nodes in MANETs in the coming years is extremely difficult to predict. Because the nodes may move freely across the network, the MANET is flexible and scalable. MANET protocols and services must be able to react to such changes because of this aspect.

1.2 Objectives

A bio-inspired strategy-based routing protocol, namely "Sophisticated Lion Optimization Based Routing Protocol", has been proposed in this research to reduce network congestion and energy consumption in MANETs, which is the primary objective.

1.3 Organization of the Paper

This section has provided a quick introduction to MANET and its routing mechanisms. In addition, this problem statement and research objective have been explored. The associated literature is discussed in detail in Section 2. Addressing the mentioned problems is the goal of Section 3, which proposes a novel routing protocol. Section 4 examines the results and describes the simulation settings and metrics used to assess the protocol's performance. The paper's last section, Section 5, discusses possible future directions.

2. LITERATURE REVIEW

Routes in Delay-Tolerant Networks can be found using a method called "Routing under Uncertain Contact Plans" [14]. Before delivering any data, it determines whether or not a priori accessible probabilistic schedules to optimize data delivery in various real-world scenarios. Multiple-copy Markov Decision Process routing with uncertain contact plans is built and exported as local knowledge. Contact Graph Routing extensions are applied to the DTN protocol stack for node identification. "Hybrid Secure Routing and Monitoring" [15] is designed to cope with dynamic wireless sensor webs and maintain constancy while identifying destination routes. Multi-variant tuples, utilizing the Two-Fish symmetric key technique, are designed to find and deter attackers in the global sensor network. The Authentication and Encryption Model informs the quality of routes. The sensor guard nodes are picked using the Eligibility Weight Function, and the complicated symmetric key technique is used to hide it. OLSR and AOMDV protocols are combined to create a hybrid routing protocol that is safe, secure, and scalable. "Multi-metric Geographical Routing Protocol" [16] is proposed to quickly deal with topology changes in ad-hoc vehicle networks. Smart cities will be able to get video reports through this platform. Digital communication resource allocation problems are studied and optimized using the game theory paradigm. "Delay Aware, and Energy Efficient Node Selection" [17] is proposed to utilize anchor nodes in routing. It employs opportunistic random graphs in ring routing to select the next hop with the greatest link and path connectivity achievable in a confined search region due to sensor nodes having an asynchronous working-sleeping cycle.

"Geographic Position Based Hopless Opportunistic Routing" [18] is proposed to deal with the issues with UAV network topology, and link quality between UAVs varies greatly across time and space. Combining the advantages of hopless and position-based protocols provides the best of both. Hopless routing allows this protocol to fully use all links, independent of their hop lengths or the link quality, compared to hop-by-hop routing techniques. This protocol, which differs from other hopless protocols in that it picks relays based on the geographic position of each node rather than the topology, is well-suited to the frequent changes in topology. This protocol allows each node to compute its forwarding priority in a distributed way based on its location information. Protocol overhead minimizes by eliminating the need for regular network information measurement and communication. "Jamming-Aware Routing" [19] is proposed to deal with the difficulties of routing in MANET. There are MAC protocols for friendly jamming, in which only the favourable mobile nodes are aware of the jamming schedule, but the schedule is kept secret from all hostile ones. These protocols stop working when the network is jammed but restart functioning when the network isn't jammed. For non-jamming, the routing protocol relies on TDMA, whereas the OLSR sub-protocol is used for jamming. "Multi-Watchdog Routing" [20] is proposed as part of the 5G WSN for the Internet of things. It monitors each sensor node's transmission to ensure its safety. It includes procedures for evaluating the safety of 5G-based IoTs through secure data-centric and node-centric evaluations. DL-based network assessment techniques are applied in deploying on-demand active monitoring IDS agents in dense IoT-WSN networks. Currently, the routing protocols [21]–[31] for ad-hoc networks are designed using various bio-inspired optimization algorithms, which ends with better results.

"Joint Service Placement and Request Routing" [32] is proposed to assign edge cloud resources to meet user demands. Service placement and request processing in the network is optimized for data analysis techniques within computing and storage resource restrictions. When implementing load balancing between edge clouds, the Cloud Radio Access Network topology is specifically used. The two-timescale system reduces the high operational costs generated by service duplication and replica destruction. A greedy-based approximation and relaxation-based heuristic approach were devised for the service placement subproblem. "Geocast Routing Protocol" [33] intends to transfer signals to a specified set of mobile drones determined by their geographic position. Their geographic location for data delivery will target a specific set of mobile UAVs.

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Adaptability, dynamic topological changes with 3D movements and dependability are all considered. "Link Utility Aware Geographic Routing" [34] is suggested to improve routing performance in VANET by expanding the local based on the network topologies at the present forwarder to include information about two-hop neighbors. The link utility measure is also used. Consider the minimal remaining bandwidth on that connection and the packet loss rate when evaluating a two-hop neighbor link's utility. It responds adequately to the growing network traffic and the frequent topological disconnection by adding two-hop neighbor information. "Location-based Opportunistic Geographic Routing Protocol" [35] is proposed to identify network topology and often update node positions for improved routing. If the sender node doesn't know the next hop, it cannot send. The transmitting node uses the broadcast aspect of wireless transmission to broadcast both the routing tables and the data packet. It will then be up to the individual nodes to determine whether or not they are allowed to forward a packet based on the established rules. Absolute priority is used so that each candidate receiving the packet may establish its priority based on its location and forwarding rules, as well as the sending yime, while providing timely information about other candidates. Rather than doing a pair-wise comparison of the nodes to determine priority, it may simply use the current network architecture instead.

"Distributed priority tree-based routing protocol" [36] is proposed for network fragmentation and relaying difficulties that arise when many networks operate together. Ad hoc networks on the ground and in the air have different challenges regarding network splitting. Mutually coordinated systems may transmit and resolve issues related to topology construction and routing across concurrently functioning nodes of two separate ad-hoc formations simultaneously. It creates a priority network that makes it possible to pick a suitable relay node and channel. "Imperialist Competitive Algorithm" [37] has been proposed to improve MANET routing and increase the network's lifetime and stability. When it comes to routing algorithms, it takes into account the great efficiency of clustering approaches. Reducing the overburden is made possible by preventing further re-clustering from occurring. "Predictive Geographic Routing Protocol" [38] is proposed to increase connection to deal with the difficulty of quickly changing topology and high-speed mobility of the nodes. Nodes in this protocol provide weight to their neighbors based on their position concerning other nodes. It uses a vehicle's acceleration to anticipate the position of every network at the duration of a hello packet and then sends packets depending on the vehicle's location after a brief delay. "Stochastic Geometry Graphs-based Routing" [39] aims to enable safe connection in ad-hoc wireless networks. While stochastic geometry is employed for modelling, simulation-based analysis is offered to explore the properties of ad hoc networks with eavesdroppers. The shortest path's hop count is returned from all secure communication channels between two valid users designated as source and destination. There are three input variables: user location, wireless channel state, and eavesdropper mode of operation.

To construct a virtual coordinate system for routing, the "Gradient Assisted Routing (GAR) [40]" idea has been proposed for MANET. Instead of using external location data like in standard routing, the two-hop neighbors' information is used instead, which is then shared in beacons. Better routing may be achieved by creating a VCS approximating the real network node coordinates. In contrast to conventional routing methods, which rely on external location data, this one relies on data sent between two-hop neighbors using beacons. "Energy-Efficient Multipath Routing Algorithm (EEMRA)" [41] is a routing algorithm based on the ant's foraging behavior. EEMRA is an extension of the classic ant colony-based routing algorithm that tries to increase the lifetime of the network by considering several impact variables while making routing decisions. Meta-heuristic impact variables are used to deliver dependable routes while also preserving battery life for the user's device. The importance of individual impact factors in determining routing efficiency may be demonstrated by an examination of their individual impact factors. Multipath routing is backed up by energy and statistical analyses.

3. SOPHISTICATED LION OPTIMIZATION-BASED ROUTING PROTOCOL (SLORP)

3.1 AODV Routing Protocol

The AODV (Ad-hoc On-Demand Distance Vector) routing protocol is developed for MANET. When new routes are required, they are generated dynamically using the AODV reactive protocol. Traditional routing tables, one record for each destination, and sequence numbers are used to establish whether routing information is current and

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to prevent routing loops. AODV maintains time-based states in each node, which means that a routing item that hasn't been utilized in the last period is expired. In the event of a route breakdown, the affected neighbors can be aware of the problem. Queries and replies are used to find routes and intermediate nodes along a path and record information about a route in a database. RREQ is broadcasted as a message by a node that needs a route to another node. RREP is unicasted as a message back to the source of RREQ. RERR is transmitted to inform other nodes of the connection failure. Hello messages are used to identify and track connections to other neighbors.

3.2 Natural Characteristics of Lion

A unique social structure, known as "pride," is used by lions to ensure the long-term survival of their species through each successive generation, which sets them apart from other felids. There are usually 1 to 3 lion pairings in pride, and the females follow the males to give birth. Territories are areas where living beings together live in harmony. A territorial lion rules an area and defends it against invading animals, including other territorial and migratory lions. Until the cubs reach sexual maturity, the territorial defense will likely continue for two to four years. Nomadic lions attempt to infiltrate the pleasure throughout this two to four-year period. When defending the territory, there are frequent battles for survival between migratory lions and the pride. The wandering lion has finally been put down for the support of the pride of lions united in the coalition. However, it is possible for the nomadic lion's pride to kill or expel the territorial lion. Taking command of pride, a lion will become the territorial leader of the pride. It kills the lioness' cubs and makes her enter estrus. An attempt at mating takes place to give birth to the cubs of the newly established territory. A territory's cubs will continue to act this way until they are fully grown.

When the cubs are old and powerful enough, they take over the territory from the territorial lion. There are two ways to deal with territorial laziness, i.e., expulsion from the pride of mature cubs. Stronger lions in the pride hunt down and kill the weaker ones, then breed with the pride's females to have new cubs.

3.3 Lion Optimization Framework

In 2012, the lion algorithm's fundamental architecture was proposed as a search algorithm. It has since been reorganized and updated, and provided in a new format. The five steps of this algorithm are (i) Pride Generation, (ii) Reproduction, (iii) Bonding, (iv) Handling, and (v) Termination.

Pride generation is an evolutionary cum swarm-based optimization algorithm-like procedure for getting things going in lion algorithms. Lion cubs are born after the parent lions are evaluated for fertility, and coupling is the most important step in this process. The lion's social behavior is modelled after territorial defense and takeover, which makes these processes superior to others in the optimization field. These two processes are critical to find the best possible answer from an enormous search area. In the lion optimization algorithm, the termination procedure is problem-dependent; therefore, it may either be based on the number of extensions or the optimality of the generated solutions.

3.4 SLORP Strategies

When the solution variable's dimension is one, the binary-lion algorithm is a particular instance of the real-lion algorithm. Let's think about the objective function in Eq (1)

$$p^{optimal} = \underset{p_s\,\omega(p_s^{min},\,p_s^{max})}{\arg\min}\; g(p_1, p_2, \ldots, t \qquad (1)$$

B^t is the solution area's dimensions for the constant dynamic modal function g(.) in Eq.(1), where B stands for real numbers, $p_s : s = 1,2,\ldots,t$ is the s^{th} solution variable, t is the dimension of the set of vectors, and, p_s^{min} and p_s^{max} are the limit ranges, i.e., maximum and minimum of the s-th variable, respectively. $p^{optimal}$ is the best outcome of the optimization procedure, shown in Eq (3). Eq.(2) and Eq.(3) are applied to measure the area of solution space, i.e., g(.).

$$B^t = \prod_{s=1}^{t} (p_s^{max} - p_s^{min}) + S \qquad (2)$$

$$p^{optimal} = P : g(P) < g\left(P' \mid P' \neq 1\right. \qquad (3)$$

$P = [p_1, p_2 \ldots, p_t]$ represents the solution vector, P indicates the minimization of the objective function concerning Eq.(1). When it acts as a maximizing function, a suitable selection method must be employed in the optimization technique.

3.5 Pride Generation Stage

Based on the definition of pride and Eq.(1), pride starts with P^{male} (i.e., territorial lion), its lioness P^{female}, and a nomadic lion P^{nomad}. Even though its generation talks about the pride process of creation, the nomadic lion is not part of the pride. The way the lions represent the solution vectors that are identified. When $t > 1$, then $l = 1,2,\ldots,Z$ are the elements of P^{male}, P^{female} and P^{normal}, i.e., p_l^{male}, p_l^{female}, and p_l^{nomad}, are integers, and can be any number between 0 and 1. Here, Z is the size of the lion, which can be figured out Eq.(4).

$$Z = \begin{cases} t; & t > 1 \ (normal\ case \\ c; & otherwise\ (unique\ case \end{cases} \quad (4)$$

where the length of a lion is determined by the numbers c and t. $t = 1$ means that the method needs to seek a binary-lion strategy so that the vector elements can only be created as 1 or 0 if the requirements stated in Eq.(5) and Eq.(6) are met.

$$(p_1^{min}, p_1^{max}) \supseteq j(p_1) \quad (5)$$

$$\sum \|c\%2\| \gg 0 \quad (6)$$

where $j(p_1)$ is defined in Eq.(7)

$$j(p_1) = \sum_{z=1}^{Z} p_z 2^{\left(\frac{Z}{2}-z\right)} \quad (7)$$

No matter how many binary bits are created in this process, they must be identical to the number of binary bits between the decimal point for the resulting binary lion to be inside solution space. This P^{nomad} fills one of several two nomadic-lion posts since SLORP presume two nomadic lions attempt to conquer the land. After a territorial dispute, the other lion will be activated. As a result, the position will be shown as P_1^{nomad} for the moment being while P^{nomad} stays empty.

3.6 Reproduction Stage

Every territorial lion starts to age or becomes sterile as part of the SLORP sequential procedure. In general, the lion is not the fastest in hunting. It is possible that the fitness of P^{male} and P^{female} may become saturated, which would mean they could not lead to identifying better alternatives. Examining reproduction can assist in skipping over less than the local optimum solutions. If $g(P^{male})$ is larger than g^{ref}, then the P^{male} is deemed to be having drawbacks, and its laggingness rate Z_b is raised by one. Protection of territory begins when Z_b crosses L_r^{max}(i.e., maximum number). Following the crossover, the sterility rate E_b of P^{female} is incremented by one. If E_b is greater than E_b^{max}, then P^{female} is updated according to Eq (8). When the improvement is progressed, then the female lion $P^{female+}$ is taken as P^{female} results in the happening of mating. On the other hand, updating keeps going until the number of female generations f_u, reaches g_c^{max}. The P^{female} can still produce new cubs if there is no $P^{female+}$ to replace P^{female} during the upgrading procedure, it is expressed in Eq.(9) and Eq.(10).

$$p_l^{female+} = \begin{cases} p_a^{female+}; & if\ z = \\ p_z^{female}; & otherwis \end{cases} \quad (8)$$

$$p_a^{female+} = min[p_a^{max}, \max(p_a^{min}, \quad (9)$$

$$\nabla_a = [p_a^{female} + (0.1b_2 - 0.05)(p_a^n \quad (10)$$

where $p_z^{female+}$ and $p_a^{female+}$ are the z^{th} and a^{th} vector elements of $P^{female+}$, respectively. a is an unspecified integer where the values lie in $[1, Z]$, ∇ is the function of female-lion notification, and b_1 and b_2 are random integers lies in $[0,1]$.

3.7 Bonding Stage

In SLORP, there are two basic processes and one additional step in mating. Gender clustering is referred to as a supplemental phase following crossover and mutation. The crossover and mutation processes and the requirement for bio-inspired algorithms have been extensively studied in the related works section. P^{male} and P^{female} undertake crossover and mutation to produce cubs, which are the solutions generated from both P^{male} and P^{female} components. The number of cubs produced by the SLORP crossover procedure equals the maximum birth rate for lionesses, i.e., four. Each cub is generated using a different crossover mask V. The first four are exposed to additional mutation to create another set of four cubs. Hereafter, SLORP will use the labels 'P^{cubs}' and 'P^{new}', respectively, for cubs that are derived through crossover and mutation, respectively. P^{m_cub} and P^{f_cub} are finalized for these eight cubs

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in the cub pool. The resulting P^{m_cub} and P^{f_cub} are self-updating since they follow the cub growth strategies.

3.8 Handling Stage

A large area of the solution space must be explored better to go around the local optimum point and find different solutions with equivalent fitness. Nomad coalition generation is followed. pride gets upgraded to the Nomad Coalition to defend the territory. To quickly identify P^{e_nomad}, the winner taking all is strategy is applied. After meeting the conditions in Eq.(11), Eq.(12) and Eq.(13), P^{e_nomad} is chosen as the next step of optimization.

$$g(P^{male}) \gg g(P^{e\_nomad}) \quad (11)$$

$$g(P^{m\_cub}) \gg g(P^{e\_nomad}) \quad (12)$$

$$g(P^{g\_cub}) \gg g(P^{e\_nomad}) \quad (13)$$

Pride doesn't get updated until P^{male} is defeated, while the nomad coalition doesn't get updated until P^{e_nomad} is also defeated. So, the update of pride is done by replacing P^{male} with P^{e_nomad}, however, upgrading a nomad coalition involves selecting a P^{nomad}, which has an H^{nomad} larger than or similar to the exponential of the unit, the other slot will be filled at the moment of the next stages of territorial defence. The algorithm updates P^{male} and P^{female} when P^{m_cub} and P^{g_cub} reach maturity, i.e., when the cub's ages surpass the maximum maturity age D_{max}, as a result of the territorial takeover.

3.9 Termination Stage

A few of the two additional requirements must be satisfied for SLORP to be terminated, as expressed in Eq.(14) and Eq.(15).

$$T_j^{max} \ll T_j \quad (14)$$

$$h_b \geq \left| g(P^{male}) - g(P^{optimal}) \right| \quad (15)$$

Eq.(15) can only be employed only if the target is minimum or maximum, i.e., $g(P^{optimal})$ and recognized.

Algorithm 1: Pseudocode of SLORP

i. Begin
ii. Using P^{male}, P^{female} and P_1^{nomad} perform initialization
iii. Compute $g(P^{male}), g(P^{female})$ amd $g(P_1^{nomad})$
iv. Set $g^{ref} = g(P^{male})$ and $T_j = 0$
v. P^{male} and $g(P^{male})$ are saved
vi. Assessment for reproduction
vii. Mating and gathering of cubs
viii. Using the gender clustering method, calculate P^{m_cub} and P^{f_cub}
ix. With $D_{cub} = 0$ perform initialization
x. Function of cub growth is applied and followed
xi. If the result obtained is 0, then go to step iv.
xii. If $D_{max} \gg D_{cub}$ then go to step ix
xiii. Improved P^{male} and P^{female} are obtained by taking over the territorial
xiv. Increment the value of T_j with one
xv. Endif
xvi. Endif
xvii. If the conditions for ending the procedure are not met, go to step iv, or the process is terminated.
xviii. End

4. SIMULATION RESULTS

Measures of SLORP's performance in comparison to the current routing protocols include (i) throughput, (ii) energy consumption, (iii) packet delivery ratio, (iv) packet drop ratio, and (v) delay. Details regarding the settings used to conduct the simulation are provided in Table 1.

Table 1. Simulation Specification and its values

Simulation Specification	Value
Simulator Name	Network Simulator 3
Version	NS-3.36
Distribution of Node	Random
MAC	802.11
Node Count	200
Simulation Duration (in seconds)	300
Size of data packet (in bytes)	1475
Type of traffic	UDP
Simulation Size	1200m × 1500m

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Mobility Model	Randomway Point
Total Number of Packets	1300

4.3 Discussion of Results

4.3.1 Throughput

Throughput depicts the quantity of data transmitted at a particular time inside the network. Figure 1 discusses the throughput attained by SLORP against the existing routing protocols. From Figure 1, it is clear that SLORP has achieved better throughput than the existing routing protocols. Optimization performed by SLORP during the route selection assists SLORP in achieving more throughput than the existing routing protocols. During the route selection process, the existing routing protocols do not give more importance to optimization, making them achieve poor throughput in simulation. Throughput values achieved by routing protocols during simulation are provided in Table 2.

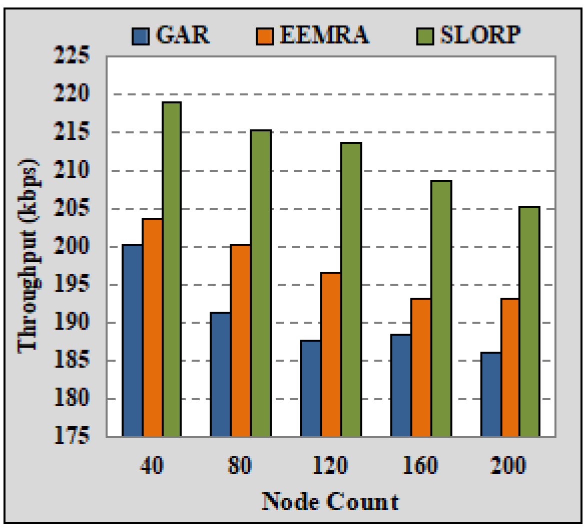

Fig. 1. Throughput

Table 2. Throughput Results

No of Packets	GAR	EEMRA	SLORP
40	200.25	203.62	218.96
80	191.34	200.36	215.32
120	187.71	196.65	213.63
160	188.42	193.29	208.83

200	186.05	193.30	205.36

4.3.2 Energy Consumption

Energy Consumption indicates the amount of energy utilized to transport a data packet from the source node to the destination node. Figure 2 compares the energy consumed by SLORP and existing routing protocols during the simulation. It is be noted that when the count of nodes is 40, the protocols have consumed minimum energy only, but when the count of nodes gets increased, the consumption of energy drastically increases in all routing protocols. But while comparing, it is found that SLORP has consumed minimum energy even though nodes get increased. The crossover and mutation strategy in SLORP help identify a better optimum quality route that mostly avoids route failure and minimizes energy consumption. Due to giving more priority to the shortest path, the existing routing protocols face more route failure and retransmission, which consumes more energy. Energy Consumption values achieved by routing protocols during simulation are provided in Table 3.

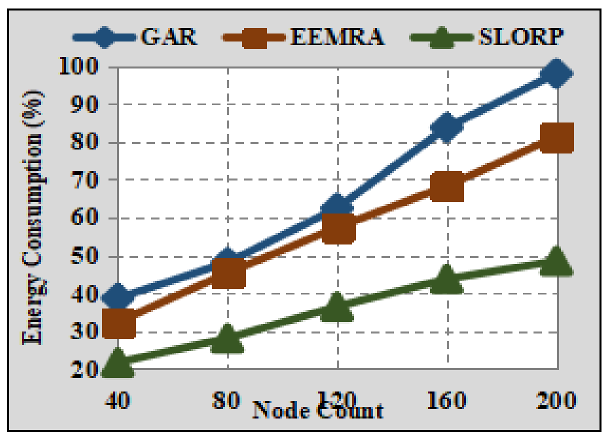

Fig. 2. Energy Consumption

Table 3. Energy Consumption Results

No of Packets	GAR	EEMRA	SLORP
40	38.63	32.32	21.63
80	48.07	45.26	28.05
120	62.41	57.33	36.43
160	83.75	68.27	43.70
200	98.02	81.28	48.47

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4.3.3 Packet Delivery and Drop Ratio

The packet delivery ratio is the ratio of packets received at the destination in contradiction of packets transmitted from the source, whereas the Packet Loss Ratio measures how many packets are lost compared to packets transmitted from the source. Figure 3 and Figure 4 show that SLORP has delivered a greater number of data packets and dropped the minimum number of data packets during the entire simulation. The bonding and handling stages in SLORP assist the routing process and face maximum delivery of packets and minimum dropping of packets. Identifying and utilizing non-optimum routes by the existing routing protocols lead to facing minimum delivery and maximum dropping of packets. The shortest path is not best at all times in MANET. Hence, SLORP gives priority to distance as well as quality. The result values of Figure 3 and Figure 4 are provided in Table 4.

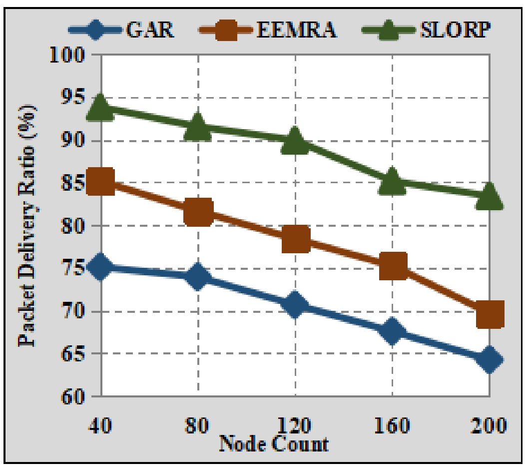

Fig. 3. Packet Delivery Ratio

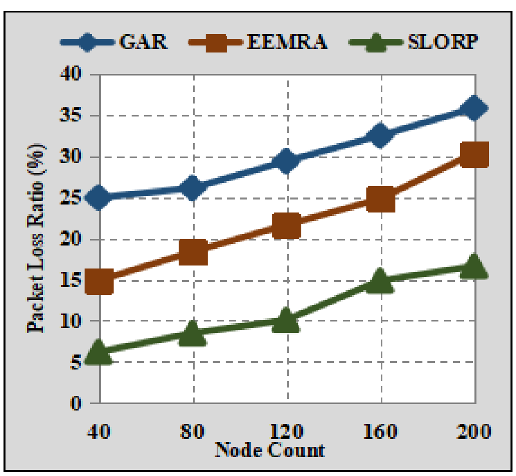

Fig. 4. Packet Drop Ratio

Table 4. Packet Delivery and Drop Ratio Results

No of Packets	Packet Delivery Ratio			Packet Drop Ratio		
	GAR	EEMRA	SLORP	GAR	EEMRA	SLORP
40	75.08	85.14	93.80	24.92	14.86	6.20
80	73.92	81.66	91.53	26.08	18.34	8.47
120	70.66	78.38	89.92	29.34	21.62	10.08
160	67.55	75.23	85.14	32.45	24.77	14.86
200	64.21	69.69	83.39	35.79	30.31	16.61

4.3.4 Delay

Delay is the consumption of time to move data packets from the source node to the destination node. Figure 5 highlights the delay faced by routing protocols during the simulation, and it is found that SLORP has faced minimum delay than other routing protocols. Synchronization of routing information in SLORP assists nodes in getting aware of the faulty and failed routes. SLORP analyze the node's energy level before utilizing them in routing. When the energy level is less than the threshold level, then it is not utilized. But the current routing protocols never check for available energy levels at the node before using them in routing, and it will end in route failure. The current routing protocols make the nodes spend more energy finding alternate routes to the destination. Table 5 provides the result outcome values of Figure 5.

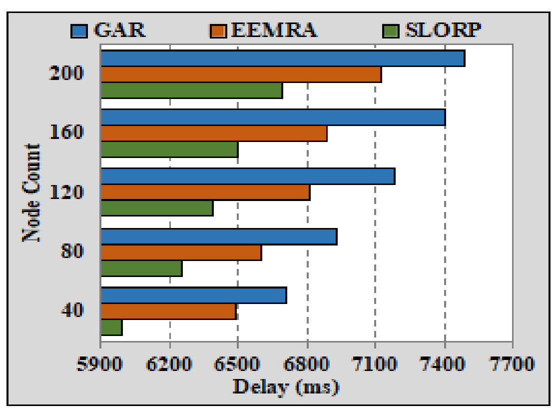

Fig. 5. Delay

Table 5. Delay Results

No of Packets	SLORP	EEMRA	GAR
40	5989	6488	6711
80	6256	6597	6932
120	6386	6810	7188
160	6501	6889	7403
200	6694	7125	7489

5. CONCLUSION

MANET faces major congestion issues, and it is because nodes change a position dynamically that results in causing the routes to fail. When a route gets failed, nodes instantly expend their energy consumption to route the data packets, causing congestion in the network. Sophisticated Lion Optimization-based Routing Protocol (SLORP) is a routing protocol designed for MANET biologically inspired by the characteristics of the lion. SLORP focuses on avoiding congestion concerns when nodes are scaled in MANET. At each level of SLORP, the emphasis is on maintaining synchronicity with other network nodes regarding routing information. Using this SLORP, network nodes can determine the faulty routes and failed nodes. When tested in NS3, SLORP significantly reduced delay and energy consumption, opening the door to higher throughput and a higher packet delivery ratio. Future research might adopt bio-inspired strategies to improve the performance of MANET even more.

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