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# LINK STABILITY AND OBSTACLE AVOIDANCE BASED TRAFFIC-AWARE REACTIVE ROUTING PROTOCOL FOR MOBILE AD-HOC NETWORKS

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**ABSTRACT**

A distinctive type of wireless network called an ad hoc network has several hops, no central hub, and dynamic architecture. The forwarding of intermediate nodes is required to achieve data communication. A mobile ad hoc network is made up of several wireless communication nodes, each of which serves as a router. The restrictive characteristics of this type of communication networks, such as its frequent topological changes and low battery power, have a significant impact on routing. Numerous studies have been conducted to enhance MANET routing performance. The network's performance typically suffers as a result of the unstable path caused by the high traffic load on links and the low energy of the nodes. Reactive MANET routing techniques handle link breaks caused by node mobility and energy consumption. For broad area networks, multi-hop communication may be more effective in terms of routing methods. To build a better quality route between source and destination, the research suggested the Traffic-Aware and Stable Ad hoc On-Demand Multipath Distance Vector protocol (TAS-AOMDV), which is an upgrade over AODV. By choosing the most stable neighbor concerning the transmitter of the route request message and the nodes approaching throughout the route discovery process, this method aims to forecast a stable path. To reduce lost data packets and route error messages, this minimizes the contention phase, predicts the route lifespan, and speeds up data packet transmission. The effectiveness of routine procedures in MANET is substantially hampered by the existence of obstructing obstacles. This study instead looks at the dynamic and autonomous detection of potential network barriers. A combined Lion Optimization algorithm (LOA) and Dynamic Window Approach are proposed in the article to suit the needs of global optimal and dynamic obstacle avoidance in path planning (DWA). To find the path, this optimization technique has been used. The algorithm proficiently plots a path among multiple nodes over the plot area, which results in perceiving the shortest path that is optimal without obstacles. The performance analysis was carried out in Network Simulator 3.36 software. It took into account various aspects like packet delivery ratio end-to-end delay for differing traffic loads, throughput and in the proposed scheme via existing schemes.

**Keywords:** *MANET, Routing Protocol, Traffic Loads, AOMDV, Obstacle Avoidance, Lion Optimization Algorithm, Dynamic-Window Approach, Network Simulator.*

## 1. INTRODUCTION

With the security protocols and new technologies, wireless networks have become more secure and popular [1]. The MANET is an autonomous group of mobile users that communicates over unstable wireless links. Infrastructure less networks and infrastructure-based networks are the two types of wireless networks. In an infrastructure-based network, all wireless devices exchange data and connect via infrastructure components like computers, routers, or access points with access point software. Direct connections between wireless devices that lack infrastructure components like an access point or router are known as ad-hoc networks or infrastructure-less. Ad-hoc networks don't require the support of infrastructure components like access points to be set up. Ad-hoc networks are receiving greater attention today because of their capacity for self-healing, self-organization and self-configuration. Wireless Mesh Networks (WMNs), Wireless Sensor Networks (WSNs), and Mobile Ad-hoc Networks (MANETs) [2] are the three categories into which ad-hoc networks can be divided. Numerous optimization-based MANET routing protocols have been put forth in the literature, and each of them takes into account various metrics and makes an effort to address a particular issue. Due to the mobility of the hosts, MANETs also have a dynamic topology. This unpredictable topology frequently causes link failures [3]. When a node leaves its neighbor's transmission range, a link breaks. As a result, numerous routing protocols were put forth to create and maintain routes for mobile ad-hoc networks; these protocols may all be broadly divided into three categories proactive, reactive and hybrid. MANETs rely on a selected, consistent path with a long duration and the adaptability of the battery power stored in seeking end nodes, which frequently results in link failures. Hence, it is important to perform a problem-free communication process in a network system [4]. Routing is the method of choosing routes between sources and nodes along which packets can be transferred from sources to final destinations by passing through chosen intermediate nodes while adhering to a certain routing protocol. To determine the best route between the source and the destination in MANETs, routing protocols are crucial. In networks with a stable infrastructure and dependable high-capacity links, conventional routing protocols were created to support user communication. Data packets are typically transmitted along an ideal primary path, or optimal path, with backup paths that are less optimal, kept ready for the worst-case scenarios [5]. Because some nodes may be outside the transmission range in some circumstances, the routing protocol may face considerable difficulty. This will need the discovery of an alternate route to the target [6]. The routing paths are created during the path discovery phase by comparing the mobility and reliability values to the thresholds set by a trust management module. The limited battery of the mobile node only transmits the limited data packet to the target node. Since each node in a real network has a certain amount of battery life, power restrictions have an impact on how long they can operate [7].

When considering network operations, it is impossible to provide an accurate picture of traffic demand in many networks due to a lack of the necessary infrastructure for measuring traffic and the statistical characteristics of communication channels [8]. The network is distributed, and the nodes are responsible for handling message delivery and organizing. In a decentralized network where the topology is constantly changing, routing is problematic [9]. For routing protocols to be designed in an energy-conscious manner, it is crucial to understand the mobile radio's power characteristics. Therefore, the link stability model which is based on node energy and traffic on the link seeks a stable route for data transmission in a congestion-free environment. There are three possible operating modes for a standard mobile radio: send, standby and receive. Reactive, and proactive routing protocols are the basic categories of MANET routing protocols. The reactive protocols are based on route discoveries, whereas the proactive protocols are based on periodical exchange [10]. Proactive protocols recommend keeping the routing table in every node's memory to reduce transmission time because the path is already known, but this uses up storage space on mobile devices. The absence of huge routing databases gives reactive protocols additional advantages over other protocols, including lower routing overhead and resource consumption.

Numerous optimization-based MANET routing protocols have been studied in the literature, and each of them takes into account various metrics and makes an effort to address a particular issue. While there is a lag in the process of looking for a stable route, in which reactive protocols provide greater storage usage [11]. On-demand and bandwidth-efficient reactive routing protocols are the two most used varieties. The location of the node is used to alter the packet transmission rate utilizing the available energy and bandwidth, preventing network congestion. Various researchers utilized the location, energy, and bandwidth-aware routing algorithm. This protocol's primary functions include route maintenance and route discovery for fixing existing routes and identifying broken links [12]. The wireless and dispersed architecture of the MANET can be used by intruders to reduce its functionality. The majority of MANET routing protocols are susceptible to several attacks at different layers since they are designed with the premise that there isn't a hostile intruder in the network. Therefore, it is essential to recognize these threats and come up with plans for fending them off [13]. Obstacles limit the strength of the signal that is received at the destination node, which lowers the network's efficiency. Accordingly, the nodes must use their mobility to their advantage and keep transmitting the messages until forwarding chances present themselves to get around this challenge [14-

15]. As a result, routing methods for traffic-aware routing are more effective when the possible next-hop nodes are evaluated based on factors.

## 2. LITERATURE REVIEW

An effective routing scheme of Enhanced AODV (E-AODV) is suggested in [16] to improve the Ad Hoc On-Demand Distance Vector (AODV) routing protocol performance by creating the most stable and dependable route from the source to the destination node. The suggested technique reduced average routing overhead by 47.76%, increased average end-to-end time by 0.04 seconds, increased average network throughput by 0.23 kbps, and increased average packet delivery ratio by 0.75%.

The stable Ad hoc On-Demand Distance Vector was proposed by Priyanka Pandey *et al* [17] to enhance AODV's routing performance by increasing route stability. To select the next hop, the residual energy of each node and the link's quality, which is determined by the received signal strength, are measured throughout the route discovery procedure. The proposed algorithm outperforms the competition in terms of packet delivery ratio, throughput, delay, control message overhead, and normalised routing load, according to simulation results.

To improve the path reliability and stability for data transmission, Binuja Philomina Marydasan *et al* [18] develop a reliable and stable TA-AOMDV (RSTA-AOMDV) routing protocol. In comparison to the current protocols, the RSTA-AOMDV protocol achieves a 66.5% PDR, 1485.74ms mean E2E-D, 639.7Kbps throughput, 15% NRO, and 22.7J MEC.

The authors in [19] suggest a routing protocol called Cross-Layer Design and Fuzzy Logic based Stability Oriented (CLDFL-SO), which provides a method for stable route building by removing unstable linkages and low-quality nodes. The stability of the link is evaluated using a cross-layer interaction parameter-based link residual lifespan estimate. By supplying node parameters like residual energy, speed of node, and degree of a node, fuzzy logic is being used to assess the node quality. Link residual lifespan estimation using a cross-layer design is used to assess the link stability status (LSS). The suggested routing protocol is simulated and its performance is compared to that of the AODV routing protocol.

In the study [20], a novel statistical method for calculating link failure time based on least-square quadratic polynomial regression is proposed. A respected mathematical strategy for anticipating the characteristics of the variable is regression. The received data packets' signal strength is inversely related to the separation between the reception and transmitter nodes. Any node that consistently receives packets of data with the strength of signal below a threshold value is far away from the transceiver node pair. Nodes are still drifting apart if the receiving node continues to notice a reducing strength of the signal pattern.

For improving MANET networks, Petal Spider-Ant Routing (PSAR) Protocol based on the Proactive Energy-Aware Stabilized Path Routing (PEASPR) scheme is suggested in [21]. Each node on the routing path has its energy level analysed by the Time Stamp Duty Cycle (TSDC) based on relevance and transmission support weight (CH-RTSW). Stability is carried out with the assistance of RTSW-Link and is based on route cluster propagation using Droptail Queue Management. By reducing congestion, these techniques improve the QoS and route selection performance.

Using Garson's pruning-based recurrent neural network, Hemalatha *et al* [22] elucidate four steps, including stable node prediction, stability determination, route discovery, and packet dissemination. Modified seagull optimization (RMSG) algorithm is used in conjunction with this. The experimental study demonstrated that the proposed strategy outperformed other approaches that were compared. The challenges of obstacle and mobility-aware multipath transmission in MANET have been taken into account in [23]. AIFSORP, an Ambient Intelligence-based Fish Swarm Optimization Routing Protocol, finds the fastest and least energy-intensive way to a destination. During the simulation, AIFSORP used 29.669% of the available energy, while APDRP and MARP used 61.969% and 53.277%, respectively.

The LEACH with fuzzy logic and genetic algorithms was recommended by [24] to guarantee an efficient design model and to enhance energy efficiency. Additionally, a hybrid link state prediction analysis using the DEEC and OLS algorithms was given. Current features show a 10% improvement in energy efficacy for each set of algorithms after the model was improved.

Dalal *et al* [25] coupled the discovery of numerous alternative routes between two nodes with calculations of the link's cost, stability, and traffic load. This is based on the participating nodes' available power and intelligent traffic routing using threshold values. The results of the simulations made it clear that the proposed approach, which combined load balancing and congestion control with energy-efficient algorithms, increased the network lifespan.

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As a result, it significantly decreased the likelihood of packet dropping, decreased node-to-node delay, and increased system lifetime.

## 3. RESEARCH PROBLEM DEFINITION AND MOTIVATION

A Mobile Ad-hoc Network can be represented as graph G (V, E) where V represents the number of nodes and E represents the unidirectional links. A mobile ad-hoc network is the most uncertain network because of its dynamic topology. As the nodes are mobile in nature, links or paths among nodes are unstable so to ensure reliability now a day's research mainly focuses on multi-path routing. In this uncertain and dynamic environment, deciding on the selection of optimal paths among several available paths is the problem to be addressed. The primary goal of routing protocols is to successfully route a packet from the source node to the destination node. Routing protocols outline specific guidelines for promoting safe communication between network nodes. A unique type of wireless network called an ad hoc network has several hops, no central hub, and dynamic architecture. The forwarding of intermediate nodes is required to achieve data communication. A mobile ad hoc network is made up of several wireless communication nodes, each of which serves as a router. The restrictive characteristics of this type of communication networks, such as its frequent topological changes and low battery power, have a significant impact on routing. Numerous studies have been conducted to enhance MANET's routing performance. The improvement in overall performance in terms of packet delivery, latency, and control message overhead has not yet been completed. The source will start when the path is found and withstand the total disconnect. The network's performance typically suffers as a result of the unstable path caused by the high traffic load on links and the low energy of the nodes. Reactive MANET routing techniques handle link breaks caused by node mobility and energy consumption. When it comes to routing methods for large-area networks, multi-hop communication can be more effective in overcoming link stability and obstruction issues.

## 4. RESEARCH PROPOSED METHODOLOGY

A Mobile Ad Hoc Network (MANET) is an autonomous ad hoc wireless network that consists of many nodes, in which the nodes dynamically move so that the topology changes. The routing protocols play an important role in ensuring reliable communication among nodes in MANET. Routing is the process of transmitting packets from one network to another. Routing protocols in MANET must also be able to adjust the changes in the changing network topology. Therefore, a reliable routing protocol is needed with a low overhead in managing MANET. Other than that, routing parameter values play an important role in providing stable routing in a dynamic environment, where the network topology changes continuously and quickly. A reactive routing protocol is compatible with stable networks which use maximum link stability-based routing. Consequently, the research proposed the Traffic-Aware and Stable Ad hoc On-Demand Multipath Distance Vector protocol (TAS-AOMDV) which is an improvement over AODV to establish a better quality route between source and destination.

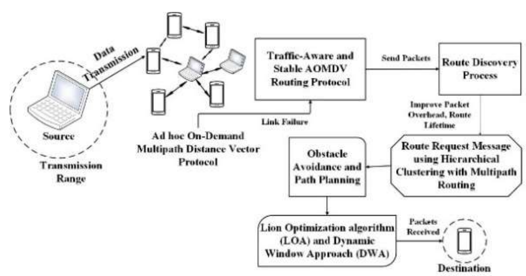


*Figure 1: Flow Diagram of the Proposed Work*

Figure 1 illustrates the flow diagram of the proposed work. In this method, selecting the most stable neighbour relative to the transmitter of the route request message and nodes impending during the route discovery process. Further, predict the route lifetime and the transmission time of the data packet to reduce lost data packets and route error messages. A link failure between two neighbouring nodes does occur not only when these nodes leave the range of each other but also when the line of sight between them is obstructed by an obstacle. The presence of obstructing obstacles severely degrades the efficiency of routing protocols in MANETs. This study instead focuses on the dynamic and autonomous detection of potential network barriers. The use of improved cartography is used to achieve this. A combined Lion Optimization algorithm (LOA) and dynamic window technique were proposed in the research to suit the needs of global optimal and dynamic obstacle avoidance in path planning (DWA). To find the path, this optimization technique has been used. The algorithm successfully plots a path between various nodes throughout the plot area, which yields the perception of the shortest path that is ideal and free of obstructions. The cartographic approach, which provides information on the barriers, pruning, filtering, and concave hull construction, forms the basis for obstacle determination. The proposed technique can accurately delimit the obstacle region with high coverage and effective precision ratios, according to the results. Additionally, the proposed system was included in TAS-AOMDV to enable autonomous obstacle detection and avoidance. As a result, it decreased the likelihood of packet loss, decreased node-to-node delay, and increased system longevity.

### 4.1 Adhoc On-demand Multipath Distance Vector Protocol

The major theme of the routing protocol in ad hoc networks is to create an effective and exact path between the nodes and delivers the messages in time. As there is a restricted number of resources in MANETs, the protocols adjust themselves according to the alterations that happen in the network status i.e., network size, and traffic density, and the resources are utilized efficiently. AODV combines the use of destination sequence numbers in DSDV with the on-demand route discovery technique in DSR to formulate a loop-free, on-demand, single-path, distance vector protocol. Unlike DSR, which uses source routing, AODV is based on a hop-by-hop routing approach. For computing, the link disjoint paths and multi-loop free routes, an extension of AODV known as AOMDV has been used. AOMDV's primary concept is to compute numerous pathways while doing route discovery. It is particularly intended for use in extremely dynamic ad hoc networks with the frequent link and route failures. Every time a route breaks in a network like this, new route discovery is required when using a single path on-demand routing protocol like AODV. Every route discovery comes with significant overhead and latency. The presence of numerous redundant pathways allows for the avoidance of this inefficiency.

Although AOMDV saves multiple paths for data transmission it uses only one path till it is valid and keeps others as a backup. This can lead to high overhead on a single path and a waste of resources in case the primary path does not break and the other paths will never be used if the primary path stays valid. To overcome this problem, the article proposes an approach to Traffic-ware and Stable Ad hoc On-Demand Multipath Distance Vector protocol (TAS-AOMDV). In this method, a scheme strives to predict a stable route by selecting the most stable neighbour relative to the transmitter of the route request message and nodes impending during the route discovery process. This minimizes the contention phase, to predict the route lifetime and the transmission time of the data packet to reduce lost data packets and route error messages. This method provides a stable route for data transmission in a congestion-free environment.

#### *4.1.1 System Model*

MANETs are made up of nodes, which are moveable platforms that can be anywhere and at any time. Through the cable network, network-related information is sent from one node to another. The bandwidth of the link is represented by the directed graph G = (V, L), where V indicates the set of nodes and L is the set of edges connecting the nodes. This relationship is illustrated in Equation 1.

$$Link\ B(I,J) = freeslot(I) \cap freeslot(J) \quad (1)$$

In this equation, $Link\ B(I,J)$ refers to the accessible bandwidth from the link between nodes $I$ and $J$. $freeslot(x)$ is defined as the time slot which has not been used by any of the neighbouring nodes of $x$. The transmission of packets from a node $x$ is carried out by that time slot. The obtained bandwidth for the link can be used for measuring the bandwidth of the route. This information enables us to answer the question of whether it is appropriate and enough bandwidth in the route between the source and destination. Like the following route given as an example, a route from the source node $A$ towards the destination node $J$ might include several intermediate nodes as $Path(A,J) = \{A,B,C,\ldots,J\}$. The available bandwidth to the path, path-BW (A, J) is defined as

$$Path - B(A,J) = \min\{Link - B(A,B), Link - B(B,C), \ldots, Link - B(I,J)\} \quad (2)$$

As shown in Equation 3, the bandwidth of a route is the minimal amount of the bandwidth of the route links.

#### *4.1.2 Routing Discovery Process*

There are no entirely stable nodes in MANETs, and all of the nodes are capable of random movement at any time. The mobility of the accessible nodes in the route, the routing overhead, and the remaining energy of the nodes that create the route can all affect how stable the path is. The idea of stability that is presented in this study is based on RREP, which is information that one node learns about its neighbours. This process is carried out to determine the link connection's strength and length in response to node movement. The route discovery phase of the proposed TAS-AOMDV routing protocol begins when the sender node determines all potential paths to the destination node. To reduce packet overhead and extend the lifetime of a route, hierarchical clustering with multipath routing is essential. Table 1 displays the cluster creation process with route discovery taking the definitions into account.

*Table 1: Algorithm of Route Discovery Hierarchical Clustering Formation*

| **Algorithm: Route Discovery Hierarchical Cluster Formation** |
|---|
| **If** (path exists for destination)<br>{distribute data amongst multiple paths}<br>**Else**<br>{initiate route discovery}<br>**Route discovery process**<br>Send RREQ (), //RREQ→neighbour node is initiated 0<br>MN sends RReq with the Link and<br>Packet reception routine<br>**If** (packet type is RREQ)<br>//For node N and RRPE h<br>**if** has processed(sequence(h)) then<br>drop(h)<br>**end if**<br>// Cluster formation and change of cluster<br>**If** $(ClusterHeadOf(N) == NULL) \vee (D_{ch}(N) > D_{ch}(h)+1)$<br>**then**<br>$ClusterHeadOf(N) \leftarrow ClusterHeadOf(h)$<br>$(D_{ch}(N) \leftarrow D_{ch}(h)+1)$<br>$R_{deafult}(N) \leftarrow Last\_Hop(h)$<br>Update_rtable ()<br>Increment hop distance(h)<br>Re-broadcast(h)<br>**end if**<br>**if** (Size Path > 1)<br>Selected Route = Route_Selection_Algorithm<br>**End** |

According to the proposed routing protocol, a node must find every path there is to the destination node before it can deliver packets to any other node in the network. To all of its 1-hop neighbours, the sender, therefore, broadcasts a route request message. Instead of broadcasting the route request message, the sender node sends a route request to its CH if it is a CM. The route request message is afterwards transmitted by CH to its 1-hop neighbour. Finally, the cluster head sends a REP (responding) message back along the found path, including the destination. Keep in mind that the cluster head will transfer the REP along the nearest, shortest route in the detected path. The source will therefore receive the shortest path to the destination. A neighbour node determines whether an RREQ packet it has received is a duplicate or not. If it is a duplicate, the node instantly drops or discards the RREQ packet. If not, it looks for an alternative path back to the original node. If a route already exists, it modifies it; if not, a reverse route is created. It determines whether its speed is below a certain threshold speed if the receiving neighbour node is not the destination node and there is no feasible path. The neighbouring or intermediate node then determines if the direction value of the two nodes is equal to one. Additionally, confirm that the remaining energy value of the neighbour node exceeds the energy threshold. Additionally, distributing the traffic load evenly while clustering can help the cluster last longer because each cluster head can evenly dissipate the battery energy.

**Traffic-Aware Clustering**

Data traffic in a cluster-based network travels through intermediary CHs and FNs, where neighbourhood density affects traffic flow significantly. This is due to the possibility that the message may need to wait in the queue for a longer time if it goes through a populated location. As a result, queuing latency is described in terms of neighbourhood density, where neighbourhood density is the quantity of a node's 1-hop neighbours. Let, $N_i$ be the number of neighbouring nodes of $MN_i$ where the data rate of $MN_i$ is $DR_i$ and packet size is $P$. Then, Queuing Delay of upcoming packets (δ Q) for $MN_i$ can be determined by the following equation.

$$\delta_i^Q = \frac{PN_i}{DR_i}$$

Equation enables the calculation of the Traffic Load (TL) of the node $n$ at the current time $t$ by using the average interface queue length of $K$ samples measured over some time (3)

$$TL_n(t) = \sum_{i=1}^{K} \frac{queue(i)}{K} \tag{3}$$

Where, $queue(i)$ is the i-th sample of the queue length. A more accurate estimate of the node's traffic load is provided by the higher value of $K$. Ad hoc networks might include a variety of terminal types, and we might encounter a wide range of heterogeneity among these end nodes. Node degree is one of the metrics used by the majority of current clustering techniques to frame the clusters (see Figure 1-a). As CH nodes, they selected nodes 4, node 6, and node 11. According to these clustering techniques, the cluster-head load will be balanced by allowing an equal number of cluster members in each cluster. However, they neglected to take into account the real traffic that each member node generates and accumulates in the cluster head while planning further routing. There will be greater traffic on CH node 4 with the three CM nodes [1, 2, 3]. In addition, since nodes 5 and 12 are not producing any traffic, CH node 6 with the members "5, 7, 12" has to cope with less traffic. In this scenario, CH node 4 will lose energy far faster than CH node 6 will. As a result, this strategy of clustering is unfair. This issue was addressed by the study by taking into account the real traffic generated at each node before clustering.

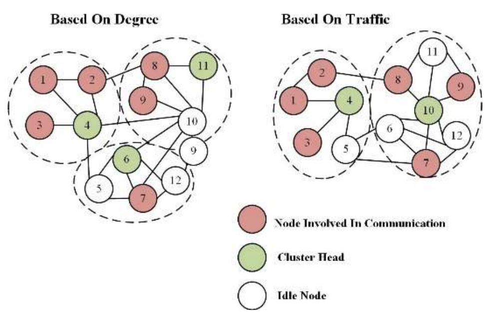


*Figure 2: Network Model Representing CH Selection*

Figure 2 illustrates how clusters are established by calculating the volume of traffic generated at each node and the total traffic load to be handled by the cluster head. If the condition is met, the node broadcasts the RREQ, updates the route to the originator, and increases the hop count by one. The node drops or discards the RREQ packet if it is not. Until the RREQ packet reaches the target or an intermediary node with a viable route there, each node will proceed according to this procedure.

#### *4.1.3 Contention Phase Minimization with Route Lifetime Estimation*

The cumulative time of these activities across all participating nodes in the route increases significantly if each mobile node has a route request message and executes operations to choose the destination node that will receive and retransmit the message. As a result, these processes lengthen the time required to request a route between sources and destinations. As a result, a fresh route request message may be sent throughout the entire network when a data packet is transmitted, decreasing the route lifetime. Each node regularly identifies the most stable neighbour forward and the most stable neighbour back, while also determining the time of stability of each of these neighbours, to avoid this contention phase. Each cluster searches for its most stable neighbours among those moving in the same direction, both forward and backward. If no neighbours are nearby who are travelling in the same direction as it, it searches in the other way. As a result, we give the route request message precedence to be received and forwarded by neighbours who travel in the same direction as the transmitter path.

Each source adds the stability time to estimate the route's lifetime between sources and destinations. The stability time of the next hop is compared to the one in the route request packet by each cluster when it receives it. The route request packet will include the shortest stability time over the other.

$$TS = \min\left(E,\left(STj,i\right)\right) \tag{4}$$

Where, $E$ is the set of links between multiple nodes that build the route between source and destination. $E,\left(STj,i\right)$ is the set of lifetimes of these links between $j$ and $i$ mobile nodes that build the route between source and destination. When the destination receives the route discovery packet, it replicates the information $ST$ into the route reply packet and sends it back upstream to the source. The route reply packet also includes the destination's current position, speed, and time. The average time is included in the route reply message that is delivered back downstream to the source when a route request reaches the destination. Additionally, determines the amount of time the route will take to reach the destination for each data packet transmission. When a data packet is being transmitted incorrectly, the sender will generate an error message and send it to the source to let them know there has been a route break. The source will then search for a new route. The source will be aware of when the route will be severed based on the routing lifespan. Where the error notice in this instance has no meaning, it must be eliminated. As a result, the network will be less overloaded.

### 4.2 Obstacle Avoidance in Path Planning

In addition to when two neighbouring nodes are out of range of one another, a link failure can also happen when an obstruction blocks the line of sight between them. The effectiveness of routine procedures in MANETs is substantially hampered by the existence of obstructing obstacles. A combined Lion Optimization algorithm (LOA) and Dynamic Window Approach are proposed in the research to suit the needs of global optimal and dynamic obstacle avoidance in path planning (DWA). To find the path, this optimization technique has been used. The algorithm successfully plots a path between various nodes throughout the plot area, which yields the perception of the shortest path that is ideal and free of obstructions. The suggested work's flowchart is shown in Figure 3.

#### *4.2.1 Lion Optimization Algorithm*

The article provides an enhanced Lion Optimization Algorithm approach to plan pathways for the pursuers to capture the evaders and avoid collision in a complicated environment. Based on the lion swarm optimization (LSO) algorithm, the optical path is chosen from among all feasible paths. The LSO algorithm was created using traits from the lion's kingdom, making it one of the bio-inspired algorithms. The group of lions $N$ that live together is called a pride. This pride consists of two categories of lions called resident lions $R_L$ and nomadic lions $N_L$ such that

$$N = R_L + N_L \tag{5}$$

Pride is a collection of five to six lions, lionesses, and their cubs $C_L$. When the cubs mature into lions, they must demonstrate their power to other animals. If it doesn't work, that specific lion will be expelled from the pride and is referred to as a nomadic lion. The nomadic lions will return to the pride after training to demonstrate their might and take over its pride. The LSO algorithm uses this tactic to locate the network's ideal path. The population of lions is created at the beginning state and consists of both the pride and the migratory lions. The lioness mostly focused on hunting and teaching the pups to hunt, while the lion pride controlled the entire area. The nomadic lions are placed in the algorithm for the fitness values. The lion with the best fitness value is chosen to form a pride, followed by lions with lower fitness values who are chosen to be resident lions and lions who have the lowest fitness values who are expelled from the pride. Up until the best fitness values are reached, the process is continued. The proposed work's fitness calculation is mathematically provided below.

$$F_{value} = \sum_{i=1}^{N} \frac{(L\max_1, L\max_1, \ldots, L\max_n)}{N} \tag{6}$$

The best fitness value can be calculated using equation (7) and here the optimal path is chosen by using the LSO algorithm. Like this, the optimal path is selected from the possible path which helps to reach the highest level of reliability which leads to improving the overall performance of the network. This algorithm selects the best possible shortest path.

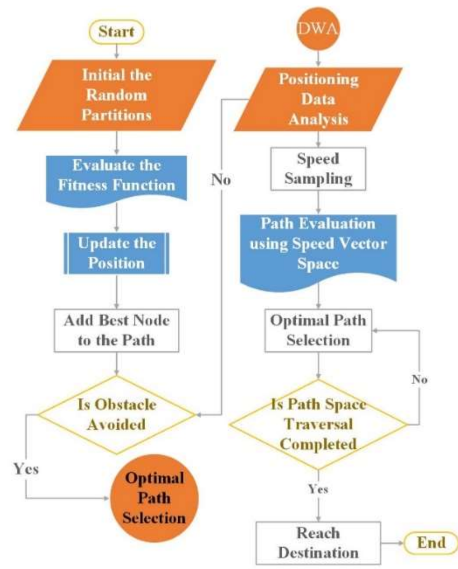


*Figure 3: Flowchart of the Hybrid Optimal Path Planning Strategy*

#### *4.2.2 Dynamic Window Approach (DWA)*

Planning a local path mostly involves avoiding potential local impediments and then resuming the predicted global path after avoiding obstacles. The local path planning issue is resolved in this article using the DWA algorithm. The DWA, also known as the dynamic window approach, works by turning the problem of path planning into an optimization problem with constraints in the velocity vector space. Multiple sets of velocities in the velocity space $(v, u)$ are formed by the linear velocity $v$ and then, the path is simulated. Multiple sets of pathways are obtained, these are evaluated, and the best path is chosen to be the destination's actual trajectory. However, when sampling in velocity space, there are some limitations. The possibility that the car's contour might collide with the impediment also needs to be taken into account since the obstacle cannot simply be seen as a particle. As a result, the dynamic window approach is included in the computation of the obstacle's expansion radius. The distance between the edge of the obstacle outline and the furthest length of the source node's contour particle is the expansion radius.

Meanwhile, there are theoretically an endless number of speeds $(v, u)$, the speed sampling range must be constrained. The maximum and minimum speeds of the cellphone vary.

$$V_m = \{v \in [v_{\min}, v_{\max}], u \in [u_{\min}, u_{\max}]\} \tag{7}$$

Based on the routing load and connectivity of three typical ad-hoc network routing protocols

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with different simulation models, the article develops a dynamic network size with a variable number of movement speeds at an invariable pause time that, in the weakest case, should be zero because a longer pause time of the node may be insignificant for mobile ad-hoc networks with frequently and rapidly moving nodes. As a result, the mobile node can travel at the pace shown in the dynamic window:

$$V_d = \{(v,u) \mid v \in [V_c - V_b\Delta t, V_c + V_a\Delta t] \wedge u \in [u_c - u_b\Delta t, u_c + u_a\Delta t]\} \quad (8)$$

There are several viable trajectories in the speed group that was sampled. To determine the best value for the mobile node $k+1$ at a given time in the speed vector space, each trajectory must be assessed in the form of an evaluation function.

The DWA's typical objective function is

$$G(v,u) = \gamma \cdot velocity(v,u) + \alpha \cdot heading(v,u) + \beta \cdot distant(v,u) \quad (9)$$

The $heading(v,u)$ represents a measure of movement toward the destination. If the node travels directly to the desired location, it is maximum. The greatest value is when the angle between the sender node and the receiver point is 0 degrees.

$$heading(v,u) = 1 - \frac{\theta}{\pi} \quad (10)$$

Among them, $\theta$ represents the position between the sender node and the target point. The $distant(v,u)$ is the distance to the closest obstacle on the route. $L$ denotes the distance between the sender position and the target point at that moment. The function's larger value indicates a greater distance from the target point and a lower likelihood of collision; the function's smaller value indicates greater proximity to the obstacle and a higher likelihood of a collision, which also indicates a greater desire on the part of the nodes to avoid it.

$$distant(v,u) = \begin{cases} 1/L, & 0 \le l \le L \\ 1, & L < l \end{cases} \quad (11)$$

The $velocity(v,u)$ is the forward velocity of the car and supports fast actions.

$$velocity(v,u) = \frac{v}{v_{\max}} \quad (12)$$

Where, $v$ is the average speed of mobile nodes and $v_{\max}$ is the maximum speed of the mobile node in the problem space. The results of the actual testing show that the mobile node can successfully avoid obstacles from the intended initial place and travel to the intended position along the intended path. Both the algorithm and the system are efficient and reliable.

## 5. EXPERIMENTATION AND RESULTS DISCUSSION

The simulation is conducted on NS-3.36 run on the Ubuntu platform with system configuration of intel core i5 @ 2.4 GHz with 6GB of DDR3 RAM. Experiments are conducted with 200 to 1000 nodes, and each node's transmit power is 0.005 watts. Total simulation inputs are displayed in below table 2 respectively. The suggested technique is assessed for the packet delivery speed obtained and the end-to-end delay using a simulated network. The results are shown in figures 4 to 12. Performance analysis was done along with the implementation of obstacle-aware MANET routing. It considered some factors, including packet delivery ratio versus data rate, end-to-end latency comparison for varying traffic loads, and throughput of various data rates in the proposed scheme via existing methods.

*Table 2: Simulation Parameters*

| | |
|---|---|
| Simulator | Network Simulator 3.36 |
| Simulation Time | 600 sec |
| Bandwidth | 25 Mb |
| Number of nodes | 50 |
| Area Size | 1000m×1000m |
| Transmission Range | 250m |
| Maximum Speed | 5 m/s |
| Maximum Number of Connection | 20 |
| Application Traffic | CBR |
| Packet Size | 512 bytes |
| Traffic Rate | 4 packets/sec |
| Node Mobility Mode | Random Way-point Model |

### 5.1 Performance Metrics

To examine the simulation's results, the study includes two possibilities. To study the impact of mobility, the first scenario's pause period is changed from 0 seconds to 600 seconds. Each node remains stationary for the amount of time equal to the pause time seconds before shifting to a random location. Mobility is high when the pause time is 0. Every node keeps moving. There is no motion when there is a pause for as long as the simulation lasts (in this case, 600 seconds). For a pause time of 0 seconds, some malicious nodes are varied in the second scenario. To assess the effectiveness of the suggested strategy, Table 2 takes the following simulation parameter into account. The simulated MANET area is equal to 500 m by 500 m.

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### 5.1.1 Packet Delivery Ratio

The proportion of data packets that were successfully delivered to their intended locations to those that were produced by CBR sources. When there are no malicious nodes in the network, Figure 4 illustrates the effect of node mobility on the packet delivery ratio.

$$Packet\ Delivery\ Ratio = \frac{Total\ Packets\ Received}{Total\ Packets\ Sent} \quad (13)$$

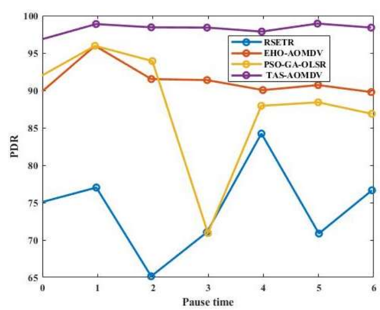



*Figure 4: Packet Delivery Ratio Vs Pause Time*

Figure 4 revealed that compared to the other three protocols, the suggested TAS-AOMDV achieved a greater packet delivery ratio rising rate, whereas the AOMDV achieved the lowest packet delivery ratio increasing rate for all experiment-related pause duration values and the two distinct packet sizes. Additionally, it can be shown that the packet delivery ratio decreases as packet size increases. For instance, the RSETR, EHO-AOMDV, PSO-GA-OLSR, and TAS-AOMDV packet delivery ratios are shown, respectively, during 1 second of pause duration and 512 bytes of packet size. As the packet loss rate is particularly high at such a drastic change in network architecture, the packet delivery ratio rises with an increase in stop time.

### 5.1.2 Throughput

The effective data transfer rate is known as throughput, and in this study, it is expressed as bytes per second (Bps). Throughput is calculated as the sum of all successful packet arrivals recorded on the destination device during a certain period divided by the length of the period. Knowing whether there is sufficient bandwidth available for the application is the key component of throughput. This establishes how much traffic an application can travel via the network. Equation (14) can be used to determine this throughput once the data transfer has taken place.

$$Throughput = \frac{Total\ Packet\ Sent}{Total\ Data\ Sending\ Time} \quad (14)$$

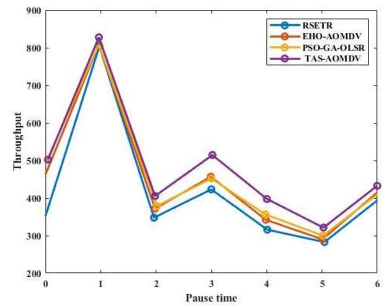



*Figure 5: Throughput Vs Pause Time*

Figure 5 illustrates the throughput as a result of RSETR, EHO-AOMDV, PSO-GA-OLSR, and TAS-AOMDV. It is discovered that AODVLRT has a typically 4.3% higher throughput than the AODV routing protocol, which is a slight improvement. The throughput is impacted by the number of packets discarded or kept waiting for a route because a higher quantity will result in lower throughput. The success of local repair in fixing a failed route had an impact on the number of packets dropped or left waiting for a route; as the success rate of local repair attempts rose, the quantity of dropped or left waiting packets decreased.

### 5.1.3 Routing Overhead

Routing overhead displays how many routing packets were sent throughout a simulation. According to Equation, the three routing packages in the AODV protocol are Route Request (RREQ), Route Reply (RREP), and Route Error (RRER) (15).

$$Routing\ Overhead = RREQ + RREP + RRER \quad (15)$$

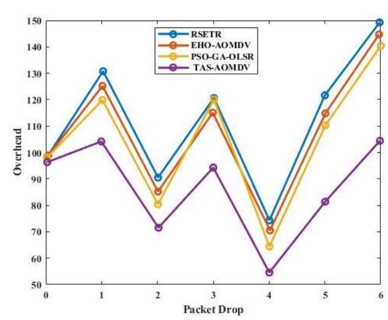
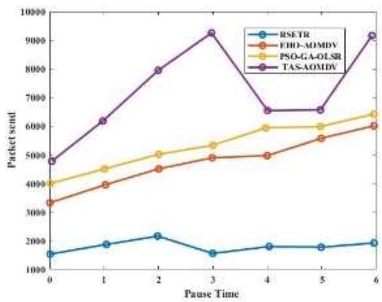
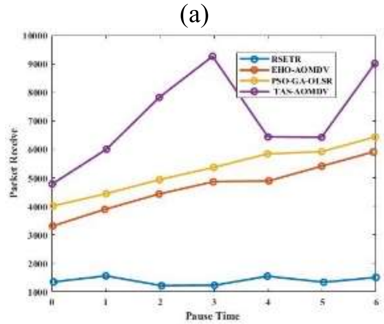



*Figure 6: Routing Overhead Vs Packet Drop*

Figure 6 displays the routing overhead for three alternative routing techniques. The TAS-AOMDV routing protocol is seen to have less routing overhead than other protocols like RSETR, EHO-AOMDV, and PSO-GA-OLSR in the small network, but this difference started to grow in the large network toward the conclusion of the simulation period. In comparison to the other routing protocol, TAS-AOMDV has more packets discarded or left waiting for a route by an average of 13.7 % respectively.




(a)




(b)

*Figure 7: Number of Packets Receive and Send Vs Pause Time*

The data packets sent and received for the three distinct routing methods are shown in Figures 7(a) and (b). Figure 7 illustrates how the TAS-AOMDV protocol outperforms the other three protocols. At the beginning of the experiment, the value of the data packets sent by the routing protocols remains constant and drops to zero at pause time 100. During the range pause time of 1000, there is an increase in the number of data packets delivered utilizing three separate protocols. However, using third nodes and the AODV protocol, the data packets supplied are first raised and subsequently lowered. All of the protocols' data packets hold the same value and grow until pause time 3 of the initial simulation period. On the other hand, during the range gap between 3 and 5, the number of data packets received via each of the three routing protocols decreases.

### *5.1.4 End-to-End Delay*

End-to-End (E2E) latency is the amount of time it takes data packets to transport messages from the source to the destination node through the network. This includes a variety of delays, including waits at the interface queue, delivery and conveyance periods, MAC retransmission delays, and buffering during pathfinding latency.

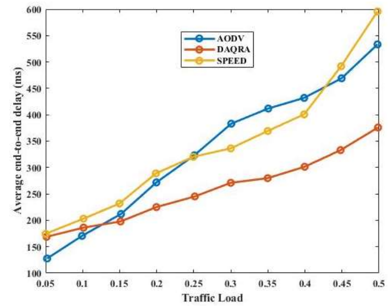



*Figure 8: Average End-to-End Delay Vs Traffic Load*

The effects of the intended load on the average delay are depicted in Figure 8. All procedures produce results that are equivalent as offered load increases. TAS-AOMDV, however, demonstrates that it can produce better delay even with a large offered load. As illustrated in Figure 8, faster nodes have a considerable impact on the TAS-AOMDV protocol's average end-to-end packet delivery delay. This is because a node will reply with the route when it receives a route request for which it has the response stored in its routing table rather than sending it on to the destination. Now that the source and destination are in contact, communication may begin. The average delay for TAS-AOMDV will be longer than both AODV and DAQRA, which have the longest delays among AODV routing protocols when node movement speed increases. In dense networks, the large reduction in routing overhead results in better end-to-end latency.

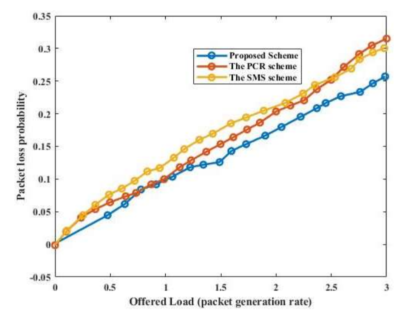



*Figure 9: Packet Loss Probability Vs Offered Load (Packet Generation Rate)*

Figure 9 depicts the performance of packet loss under very heavy loads. According to the suggested method, policies without deflection outperform those with deflection at extremely high loads. Deflection may increase the load at high loads,

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which raises the likelihood of conflict and other problems. Figure 9 shows that, in comparison to other current methods, the proposed multipath routing packet loss probability generally exhibits greater performance. The load balancing approach enables adaptive balancing of the network resource usage. The study's simulations show that the proposed system can balance acceptable network performance, whereas other schemes are unable to provide such a desirable network performance.

**5.2 Obstacle Detection Metrics Analysis**

Utilizing specific metrics (precision ratio and coverage ratio), which we describe in the following section, the effectiveness of obstacle detection is evaluated. The reduced range parameter is the only one that is exempt from parameter optimization. Each node in the simulations conducts the obstacle detection process every 50 s to measure the impact of time on our method.

***5.2.1 Coverage Ratio***

The coverage ratio measure emphasizes how thoroughly obstacles were found. It gauges how well our method for detecting obstacles can cover the actual obstacle space. The coverage ratio is outlined in (16) as the proportion of the accurately identified obstacle area (CDOA) to the actual obstacle area (ROA).

$$Coverage\ Ratio = \frac{CDOA}{ROA} \qquad (16)$$

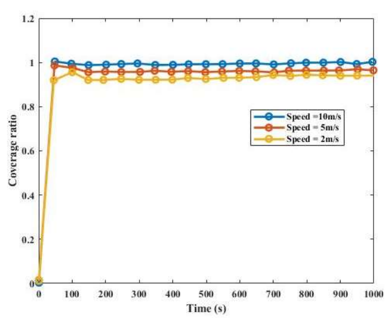


*Figure 10: Speed Effect of Converge Ratio*

The coverage ratio measure is impacted by the decline in node speed, as seen in Figure 10. The probability of detecting non-communicating positions that are closer to the barrier boundary is higher for low speeds, which could account for this behaviour. As opposed to when travelling at fast speeds, there is a greater chance of digging into the actual obstruction region. The periodicity of RRPE messages, which is set to 2s, also plays a role in delaying the perception of changes in node location.

***5.2.2 Precision Ratio***

An obstacle detection strategy's precision is measured by the precision ratio. The precision ratio is computed by deducting the detection error from one, as illustrated in (18). By dividing the total of the detected area outside the obstacle (DAOO) and the non-detected area of the real obstruction (NDA) by the union of the TADO and ROA areas, the detection error is calculated. From 0 to 1, the precision ratio is available. Weak obstacle detection is indicated by values around 0, whilst high obstacle detection is indicated by values near 1:

$$\Pr ecision\ Ratio = 1 - \frac{DAOO + NDA}{\bigcup(TADO, ROA)} \qquad (17)$$

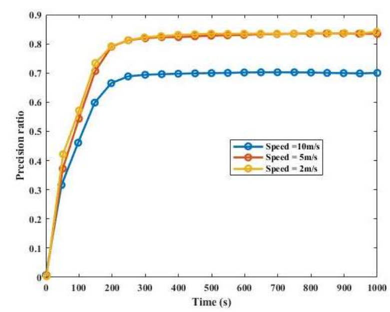


*Figure 11: Speed Effect of Precision Ratio*

The likelihood that the obstacle detection system may overestimate the obstruction area increases with speed. The outcomes shown in Figure 11 support this observation. The precision ratio metric suffers as node speed rises. The precision ratio measure rises gradually over time for a low speed of 2 m/s, reaching 0.85 within a 1000 s simulation time. However, for a high speed of 10 m/s, the precision ratio only just manages to reach 0.71 for the same 1000 s of simulation. The study gets an average precision ratio performance at a medium speed of 5 m/s which is comparable to 2 m/s.

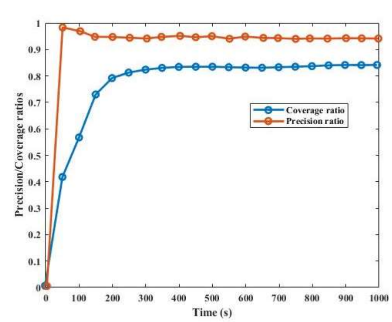


*Figure 12: Precision/Converge Ratio*

Figure 12 illustrates how the coverage and precision ratios have changed over time in a MANET that has a medium-sized obstruction in the middle of the network. This node has a 5 m/s node speed set. The obtained results demonstrate that the metrics for both the coverage ratio and the precision ratio steadily rise with time. Although the precision ratio measure converges more quickly than the coverage ratio.

## 6. RESEARCH CONCLUSION

A MANET is composed of nodes that speak to one another directly or through intermediaries. In MANET, nodes can be freely moved. Numerous difficulties arise from the network's dynamic nature. Data transfer from the start node (source) to the end node is one of the obstacles in routing (destination). Numerous criteria, including power consumption, delay, packet delivery ratio, etc., are problematic for routing. The network's performance typically suffers as a result of the unstable path caused by the high traffic load on links and low energy of the nodes. To build a better quality route between source and destination, the research suggested the Traffic-Aware and Stable Ad hoc On-Demand Multipath Distance Vector protocol (TAS-AOMDV), which is an upgrade over AODV. This technique offers a steady path for data transfer in an uncongested setting. The effectiveness of routing procedures in MANETs is substantially hampered by the existence of obstructing obstacles. A combined Lion Optimization algorithm (LOA) and dynamic window technique were proposed in the research to suit the needs of global optimal and dynamic obstacle avoidance in path planning (DWA).

The proposed technique can accurately delimit the obstacle region with high coverage and effective precision ratios, according to the results. To successfully achieve our goal of autonomously avoiding broken links created by the obstructing barrier without "a priori" knowledge of the obstacle map, the proposed detection system offers an adequate precision ratio. Additionally, the proposed system was included in TAS-AOMDV to enable autonomous obstacle detection and avoidance. As a result, it decreased the likelihood of packet loss, decreased node-to-node delay, and increased system longevity. The results demonstrate that the suggested protocol performs significantly better when the node speed is higher than 30 m/s, however, it also performs marginally better when the node speed is lower than 30 m/s in terms of packet delivery rate, end-to-end delay, and throughput. The MANET functionality provided by the Adhoc on-demand multipath distance vector routing protocol is highly effective.

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