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(Research Article)

# End to end delay distribution analysis and interference aware high throughput for Wireless Mesh Networks

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## Abstract

The wireless mesh network is an innovative and efficient wireless communication approach with immense potential to transform future wireless networks. This cutting-edge wireless technology provides a wide range of wireless services for personal, local, campus, and metropolitan environments. The wireless mesh network consists of a cluster of mobile wireless nodes that can dynamically and instantaneously create random and temporary network topologies, forming a wireless ad-hoc network. Ad hoc wireless networks are particularly advantageous due to their cost-effectiveness and ease of deployment. In order to further optimize the performance of ad-hoc networks, different routing algorithms such as Ad-hoc On-Demand Distance Vector Routing (AODV), Dynamic Source Routing Algorithm (DSR) and Destination Sequenced Distance Vector (DSDV) have been thoroughly researched via simulation.

**Keywords:** AODV; DSR; DSDV; Wireless Mesh Network

## 1. Introduction

Ad hoc networks are made up of a collection of mobile nodes that collaborate to build a temporary network without the aid of centralized management or the typical network support tools. These nodes depend on the nodes next to them to help them forward packets because their transmission ranges are often limited. Because of this, nodes in an ad hoc network can serve as both hosts and routers. As a result, in addition to passing packets between nodes, a node can also run user applications. These networks are appropriate for situations in which there is either no established infrastructure or where network deployment is inherently impractical. Military, first aid, conferencing, sensor networks, and other sectors all make extensive use of ad hoc mobile networks.

Routing protocols must fulfill specific requirements for each application area. In ad hoc networks, the dynamic topology, caused by mobile nodes, significantly affects the network's performance. Nevertheless, ad hoc networks' decentralized architecture makes them ideal for various applications where relying on central nodes is not practical. These networks have the potential to be more scalable than managed wireless networks.

A wireless mesh network's main objective is to ensure accurate packet delivery while also providing an efficient path between nodes. Routing techniques are used when a packet must traverse multiple nodes to reach its destination. Routing protocols are responsible for tracking the route and delivering packets to their destination by selecting the best path[1].

Mobile wireless networks can be classified into two types: infrastructure networks with fixed and wired gateways, and self-organized networks with no infrastructure, consisting of mobile radio nodes that don't require centralized system administration. The latter is well-suited for scenarios where immediate infrastructure is necessary[2].

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AODV is a widely used routing protocol in wireless networks due to its ability to converge quickly, have low computational cost, and self-repair capability. It utilizes a destination sequence number to facilitate communication between inquiring nodes. However, AODV only considers the number of hops, and the destination node responds to the routing request packet (RREQ) only when it first arrives. While it is an efficient protocol, it does not support quality of service (QoS) routing, and it lacks features such as delay, bandwidth, congestion, and high QoS that may not meet the needs of certain services that require dynamic multi-target performance.

The routing protocol determines the transmission path of messages in a Mobile Ad-hoc Network (MANET) or Wireless Mesh Network (WMN) and is mainly defined at the network layer. Routing protocols can be categorised into three groups based on their routing strategies: reactive, proactive, and hybrid. Hybrid protocols consist of both proactive and reactive modes. The routing policies, which can also be impacted by the topology of the network, have a significant impact on the network's performance and energy consumption (whether it is dynamic or not) [3].

### 1.1. Challenges in Wireless Mesh networks

- The issues like limited energy supply and impractical situation where battery of the nodes cannot be replaced. The energy consumption of the network could be minimized through efficient routing protocol design.
- The size of the network may not be same all the time when the size varies the performance of the network should not degrade.
- The coverage area of the network can be increased by conserving the energy of the nodes present in the network.
- The traffic load of the network can be managed by creating multihop multipath network.
- Scalability and performance of the overall network can be improved by combining the functions of different layers.

### 1.2. Related work

In wireless mesh networks, there are several types of routing protocols that fall into three categories: reactive, proactive, and hybrid protocols. Reactive protocols do not require nodes to have knowledge of the network topology and instead construct routing tables on an as-needed basis. Proactive protocols maintain a routing table for each node, representing the entire network topology, and frequently update it to ensure that routing information is up to date. Hybrid protocols typically adopt a proactive approach to maintain routes to nearby nodes but function like reactive protocols for nodes located further away.

In WMNs, routing systems can be categorized into these three basic types, each with its own advantages and limitations. Reactive routing protocols are demand-based and provide a routing channel for data delivery when a node in the network wants to send data to another node. On the other hand, proactive routing protocols maintain the most recent location of a node within the network. Hybrid routing techniques mix reactive and proactive strategies [4].

The routing protocol provides guidelines for routers to communicate, transfer data, and select routes between nodes in a computer network. Different routing methods have been proposed for wireless mesh networks that offer varying levels of QoS support.

Vector routing is a popular on-demand technique used in mobile ad hoc networks. It establishes unicast routes to destinations within the network and offers benefits such as quick response to changing connection conditions, low network usage, and minimal processing and memory costs. The DSDV routing protocol, based on the Bellman-Ford algorithm, was widely used before AODV. It employs a table-driven routing approach and stores predefined communication pathways. However, DSDV needs to regularly update its routing tables even when the network is not in use, which can consume battery life and a small amount of bandwidth.

Compared to AODV, DSR has access to a larger amount of routing information. It is a source routing protocol that uses the addresses of all devices between the source and destination to identify the source routes during route discovery. The nodes processing the route discovery packets cache the path information, and the learned paths are used for packet routing. This approach reduces the overhead for long paths or large addresses such as IPv6 [2].

#### *1.2.1. AODV (Ad-Hoc On-Demand Distance Vector)*

The AODV routing protocol is a type of reactive protocol that incorporates some proactive protocol features. This protocol only establishes a route when necessary and keeps it available for as long as needed. Reactive protocols reduce routing overhead, but they may introduce significant delays between when a route is required and when it is obtained.

AODV is an efficient and dynamic on-demand routing protocol designed for mobile wireless ad hoc networks. This protocol uses a reactive approach, meaning nodes remain silent until a connection is needed, at which point a node sends a connection request. Other nodes receiving the request forward it and maintain a temporary route to the destination node. If a node already has a route to the destination, it responds with a message through the temporary route to the requesting node. AODV selects the route with the least number of hops and eliminates obsolete entries from routing tables over time[5].

The AODV protocol efficiently discovers routes without source routing and maintains a route cache table to reduce the number of route requests needed. It also regularly removes stale routes and only keeps active routes active while they are being used. The AODV protocol is a type of reactive routing protocol that begins the route discovery process by broadcasting the Route Request (RREQ) packet across the network from the source node.

Overall, AODV is a dynamic and efficient on-demand routing protocol specifically designed for mobile wireless ad hoc networks. It selects the optimal route with the least number of hops and efficiently manages routing tables and cache to provide seamless and reliable connectivity in wireless networks.

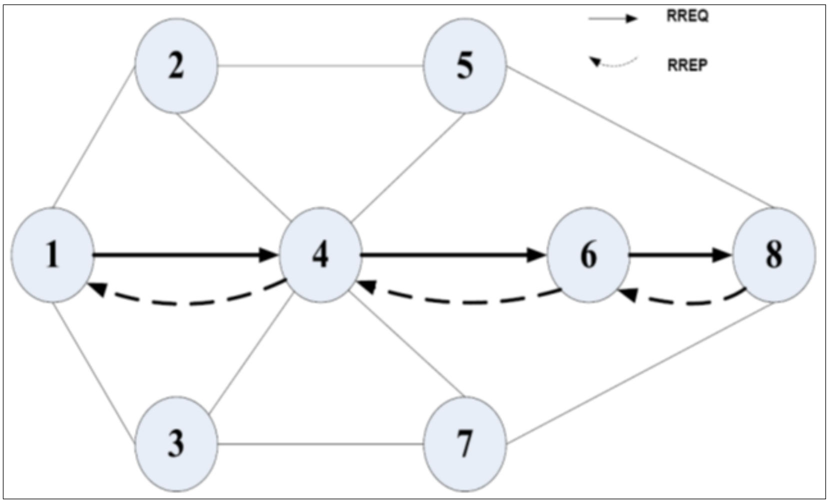


**Figure 1** Route Establishment in AODV Routing Protocol

Fig.1 shows the route establishment in AODV routing protocol. To find and keep routes, AODV uses three control messages. Route Mistake, A node generates an error message, if it is unable to forward a packet. The originator node starts a fresh route discovery for the specified route as soon as it receives the error message.

*1.2.2. Dynamic Source Routing Algorithm (DSR)*

Johnson, D. B. et al. proposed [11] DSR (Dynamic Source Routing), which requires every node to maintain a route cache. If a node is having a packet to transmits, the source will examine their routes available in cache for the valid route till destination. Here nodes can have multiple paths to the destination. When destination doesn't occur in the cache, a route discovery process comes in place and a route request is generated by the source to transmit packets till destination. Whereas if the path already exist in the cache, a packet which is to be sent, is having a copy of route and packet follows that route to reach the destination. If route cache is having route information, but that route is no longer valid, the process of route maintenances comes in place [7]. Nodes will process the route-request packet when it does not process the packet in past as well cache doesn't have its address

On Demand Reactive routing is referred to as DSR. DSR differs from other routing protocols in that it does not call for the transmission of recurrent HELLO messages to maintain nearby nodes. In wireless mesh networks, DSR is a routing protocol that establishes a route in response to a transmitting node's request by using a source routing approach. Unlike AODV, which depends on routing databases at intermediate nodes, DSR discovers the route by broadcasting a Route Request (RREQ) message that includes a unique RREQ ID and a list of intermediate nodes. The RREQ packets are processed by the nodes that store path information in their cache, and the learned paths are used to route packets.

Source routing is employed by DSR to establish a route, whereby packets contain the addresses of all devices between the source and destination. This approach can result in a high overhead for long paths or large addresses like IPv6.

However, it enables DSR to establish routes with fewer messages, and it reduces the control overhead of maintaining routing information in intermediate nodes. A flow id option is defined by DSR as an optional means of avoiding source routing[1].

Fig.2 shows the route establishment in DSR protocol.Where thick lines indicates route request and dotted lines shows the route reply packet communication.

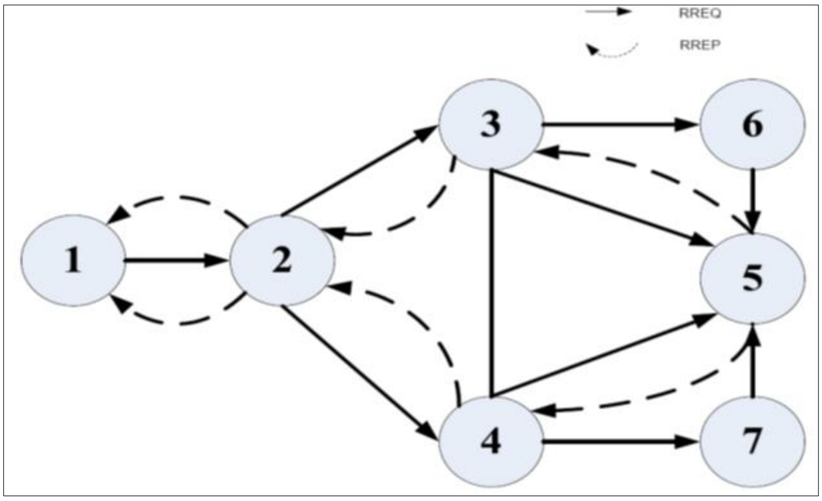


**Figure 2** Route Establishment in DSR Routing Protocol

*1.2.3. Destination Sequence Distance Vector Routing Algorithm (DSDV)*

DSDV is a routing algorithm that was designed to cater to the unique challenges of mobile ad hoc networks. This algorithm was first proposed in 1994 by C. Perkins and P. Bhagwat[8]. Its primary objective is to prevent routing loops while ensuring that data packets are delivered efficiently.

In DSDV, every node in the network maintains a routing table that contains information about available destination nodes and the number of hops required to reach them. The routing tables are updated periodically with information gathered from neighboring nodes. This approach helps ensure that each node has access to up-to-date routing information.

A key feature of DSDV is the use of sequence numbers. These numbers are generated by destination nodes and paired with corresponding routing table entries. Typically, even numbers are used when a link is present, and odd numbers are used otherwise. This approach ensures that the most recent routing information is used and eliminates the possibility of routing loops.

In short, DSDV is a routing algorithm that was designed specifically for mobile ad hoc networks. It utilizes the Bellman-Ford algorithm to avoid routing loops and employs sequence numbers to ensure that the most recent routing information is used. Its periodic update mechanism ensures that routing tables remain up-to-date, making it an efficient and reliable algorithm for ad hoc networks.

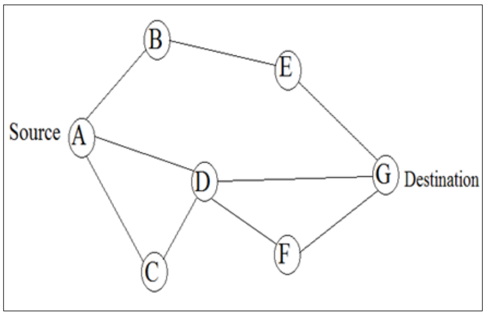


**Figure 3** Route Establishment in DSDV Routing Protocol

## 2. Material and method

The Network Simulator 2 version 2.35 (NS2.35) is a widely used tool for simulating and analyzing network protocols and algorithms. One of the applications utilized in NS2.35 is the Constant Bit Rate (CBR) application, which generates a steady stream of traffic. The packet size for this application is fixed at 512 bytes.

In our experiment, we used a flat grid topology model with a size of 1000 x 1000 x 1000 m. We designed the topology to range from 25 to 200 nodes, with a fixed base station located at coordinates (500,500) in a network of 25 nodes. This design allows us to analyze the behavior of the network under different conditions, including varying node densities.

To simulate the wireless communication in the network, we employed the Two Ray Ground Reflection Model. This model accounts for the loss of signal strength due to attenuation and reflection from the ground. It considers both direct and reflected paths, making it a suitable model for flat terrain. The experiment aimed to investigate the performance of the network under different node densities and wireless communication conditions. By utilizing NS2.35 and the CBR application, we were able to generate a steady stream of traffic and by employing the Two Ray Ground Reflection Model, we were able to simulate wireless communication accurately.

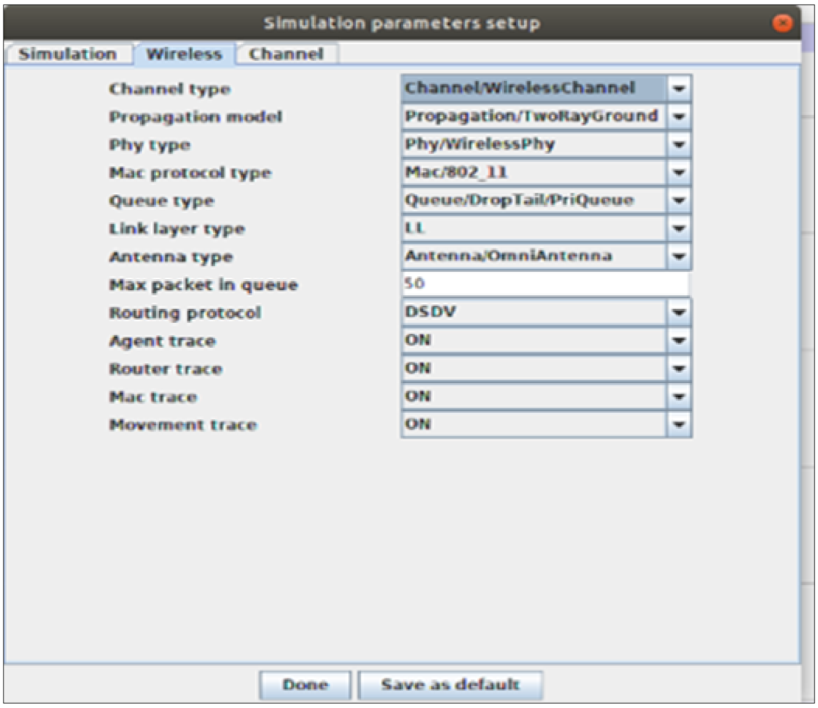


**Figure 4** Scenario creation for routing protocols

## 3. Result

The following performance parameters were studied for Wireless Mesh networks.

- End to End Delay
- Packet Delivery Ratio
- Throughput

### 3.1. Simulation setup

Traffic sources are Constant Bitrate Rate(CBR). Source Destination Pairs are spread Randomly over the network and the Calculations were done from output trace file.

**Table 1** Simulation setup Parameters

| **Parameter Type** | **Value** |
|---|---|
| Routing Protocols | AODV, DSDV, DSR |
| No. of nodes | 25,50,75,100,125,150,175,200 |
| Simulation Area | 1000x1000 |
| Link Layer | Logical Link Control ( LLC) |
| Simulation Time | 400 ms |
| Packet size | 512 bytes |
| Antenna type | Omni Antenna |
| Mac type | 802.11 |
| Type of Traffic | CBR |
| Channel type | Wireless Channel |

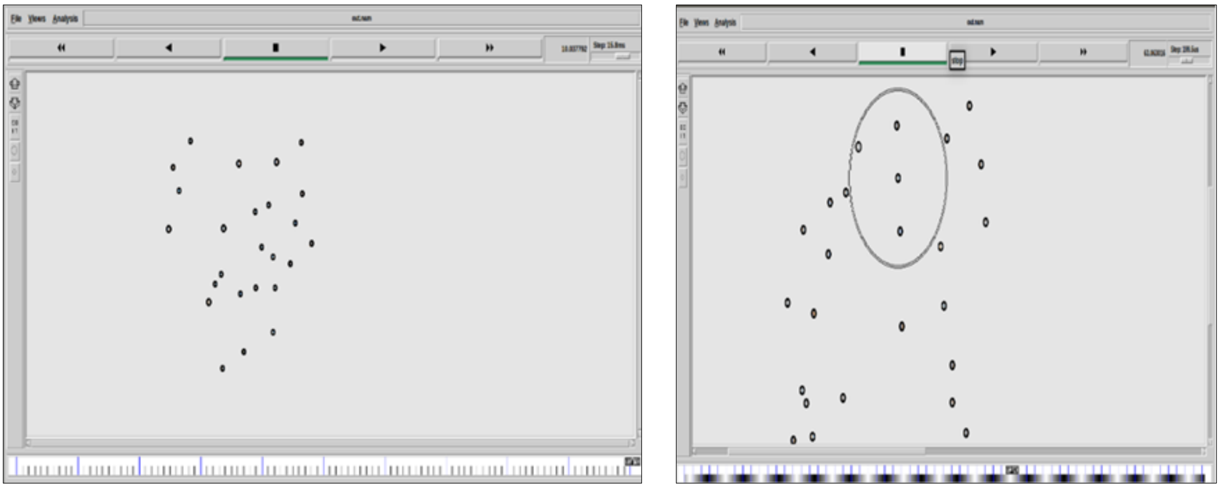

**Figure 5** Network Animator (NAM) Window

There are different parameters to analyze the routing protocols in that End to End delay, Throughput and Packet Delivery Ratio. In this paper by considering these parameters the routing protocol performance has been evaluated.

### 3.2. End to End delay

End-to-end delay, also known as one-way delay (OWD), is the time required for a packet to travel from its origin to its destination across a network. The OWD is a crucial metric in measuring network performance, as it directly affects the QoS experienced by users. Figure 6 represents a plot of the end-to-end delay against the number of nodes in the network. This plot provides insight into how the OWD changes as the number of nodes in the network increases. It allows us to analyze the behavior of the network under different conditions and helps us identify potential bottlenecks or issues that may arise.

By measuring the OWD in this manner, we can determine the overall latency of the network and assess its ability to handle different traffic loads. This information can be used to optimize network performance and improve the QoS experienced by users.

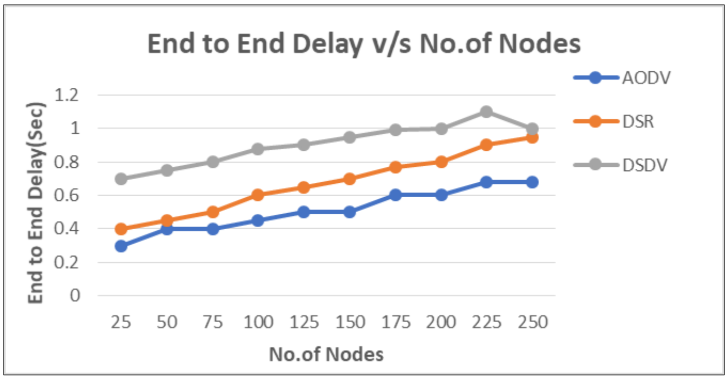


**Figure 6** End to End delay v/s No of Nodes

Overall, the OWD is a critical metric in assessing network performance, and Figure 6 provides valuable insight into its behavior under different network conditions. It is a useful tool for network administrators and researchers alike, as it allows us to identify potential issues and optimize network performance to improve the user experience.

### 3.3. Packet delivery ratio

Packet delivery ratio (PDR) is a metric used to measure the percentage of delivered packets in a network. It can be calculated using the formula: No. of packets received / Total sent packets. As shown in Figure 7, the AODV routing protocol has a higher PDR compared to DSR and DSDV protocols.

Packet Delivery Ratio = No. of packets received / Total sent packets

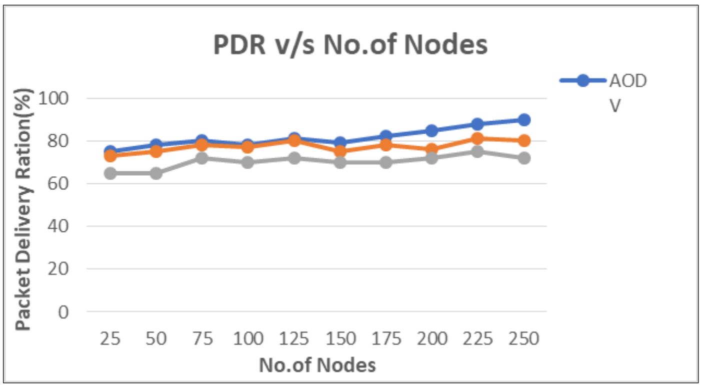


**Figure 7** Packet Delivery Ratio v/s No.of Nodes

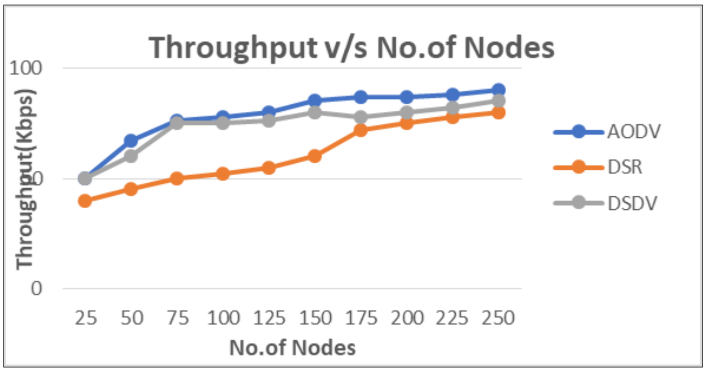


**Figure 8** Throughput v/s No. of Nodes

## 4. Conclusion and future scope

This paper provides an overview of the routing protocols used in WMNs and their functioning. A comparison between AODV, DSR, and DSDV routing protocols for WMNs is presented. To improve the efficiency and cost-effectiveness of existing protocols, future work could incorporate and apply new metrics, particularly for hybrid protocols. The study reveals that the AODV routing protocol outperforms the other two protocols. These metrics can also be used to assess the challenges encountered by WMNs and develop solutions. Here it is observed that though these algorithms works well in certain conditions they do not have learning strategy to perform multiple iterations on the algorithm. So can use any optimization algorithms for improvement of performance of routing in Wireless mesh networks.

## Compliance with ethical standards

*Disclosure of conflict of interest*

No conflict of interest to be disclosed.

## References

[1] Tai, Md Palash. Performance Comparison of different routing protocols for Wireless Mesh Networks, Journal of Multidisciplinary Engineering Science and Technology (JMEST) ISSN: 2458-9403 Vol. 9 Issue 1, January – 2022.

[2] Suryawanshi, Mr Rahul, and Mr Ravindra Kale. Improved Aodv Routing Protocol with Efficient Qos for Wireless Mesh Network, Int. Journal of Engineering Research and Application www.ijera.com ISSN : 2248-9622, Vol. 8, Issue 4, ( Part -I) April 2018, pp.73-78.

[3] Fendji, Jean Louis Ebongue Kedieng, and Sidoine Djuissi Samo. Energy and performance evaluation of reactive,proactive, and hybrid routing protocols in wireless mesh network. *arXiv preprint arXiv:1903.06875* (2019).

[4] Hassan, M. Abul, et al. Energy efficient hierarchical based fish eye state routing protocol for flying ad-hoc networks. *Indonesian Journal of Electrical Engineering and Computer Science* 21.1 (2021): 465-471.

[5] PRIYANKA M S,et al. A Study on Security Attacks And Key solutions for MANETs by Onion Routing, International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 5, May 2015.

[6] Johnson, David B., David A. Maltz and Josh Broch, DSR: The dynamic source routing protocol for multi-hop wireless ad hoc networks, Ad hoc networking 5 (2001), 139-172.

[7] Hu, Yih-Chun and David B. Johnson, Implicit source routes for on-demand ad hoc network routing, In Proceedings of the 2nd ACM international symposium on Mobile ad hoc networking & computing, pp. 1-10. ACM, 2001.

[8] Perkins, Charles E. and Pravin Bhagwat. Highly dynamic Destination-Sequenced Distance-Vector routing (DSDV) for mobile computers. Proceedings of the conference on Communications architectures, protocols and applications (1994): n. page.