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Improving Mobile Ad hoc Networks through an investigation of AODV, DSR, and MP-OLSR Routing Protocols

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Abstract

Mobile Ad Hoc Networks (MANETs) pose a dynamically organized wireless network, posing a challenge to establishing quality of service (QoS) due to limitations in bandwidth and the ever-changing network topology. These networks are created by assembling nodes systematically, lacking a central infrastructure, and dynamically linking devices such as mobile phones and tablets. Nodes employ diverse methods for service delivery, all while giving priority to network performance. The effectiveness of protocols is crucial in determining the most efficient paths between source and destination nodes, ensuring the timely delivery of messages. Collaborative agreements with MANETs improve accessibility, allow for partial packet delivery and manage network load, ultimately minimizing delays and contributing to exceptional carrier performance. This article conducts a comparative analysis of simulation parameters for AODV, DSR, and MP-OLSR protocols to explore QoS limitations associated with different routing protocols. The study primarily focuses on evaluating various quality metrics for service improvement, assessing protocol performance. Simulation results underscore the DSR protocol's 80% superior throughput compared to AODV and MP-OLSR. However, in terms of delay and packet delivery ratio, the hybrid protocol outperforms both AODV and DSR protocols. These findings provide a distinct perspective for testing the compliance services of MANETs.

Keywords: Mobile Ad Hoc Networks, Quality of Service, Routing Protocols, Performance Metrics, Simulation Parameters

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1. Introduction

Mobile Ad Hoc Networks (MANETs) face traditional challenges inherent in wireless and mobile communications, including the optimization of bandwidth, power management, and the improvement of transmission quality. Unlike conventional networks, MANETs lack a fixed infrastructure and operate in a naturally multi-hop manner. This unique characteristic has prompted research inquiries into novel aspects such as ad hoc addressing, self-routing mechanisms, configuration advertisement, discovery protocols, and network preservation. The architecture of mobile ad hoc networks is characterized by a high level of uncertainty and dynamism. The distribution of nodes and their innate self-organizing capabilities significantly impact the network's behaviour. In the dynamic realm of MANETs, nodes connect freely without a standardized architecture. Figure 1 provides a visual representation of the foundational architecture of a mobile ad-hoc network, illustrating the intricate interactions among various network elements, including servers, access points, GPS satellites, and more.

In MANETs, routing protocols play a crucial role in allowing nodes to autonomously discover, establish connections, and effectively transmit packets to other nodes [1]. These routing strategies can generally be categorized as functional or hybrid protocols. Relevant protocols maintain an equal consideration of all viable pathways between existing nodes to ensure continuous connectivity.

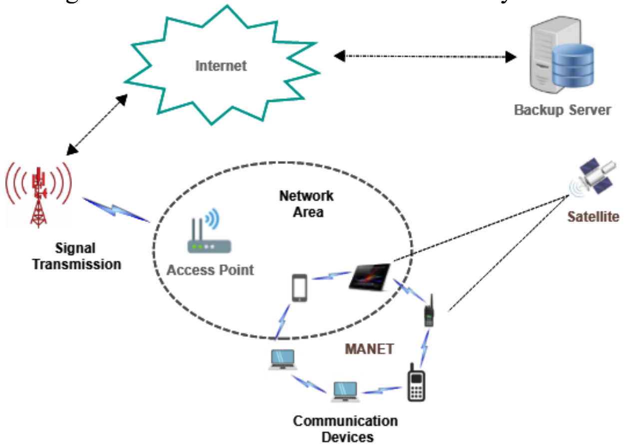

Fig. 1 Architecture of MANET

In contrast, reactive protocols involve only nodes directly linked to the destination nodes in packet forwarding. Hybrid protocols utilize a combination of negotiation strategies to optimize the transmission of packets in ad hoc cellular networks. Given the frequent changes in node positions within MANETs, establishing efficient routes becomes challenging, especially over multiple hops and while considering quality of service parameters such as throughput, delay, and partial packet delivery [3]. This complexity is further heightened by variations in network load and scale within the MANET environment. Figure 2 visually represents the essential characteristics of a mobile ad-hoc network, illustrating its dynamic and interconnected nature.

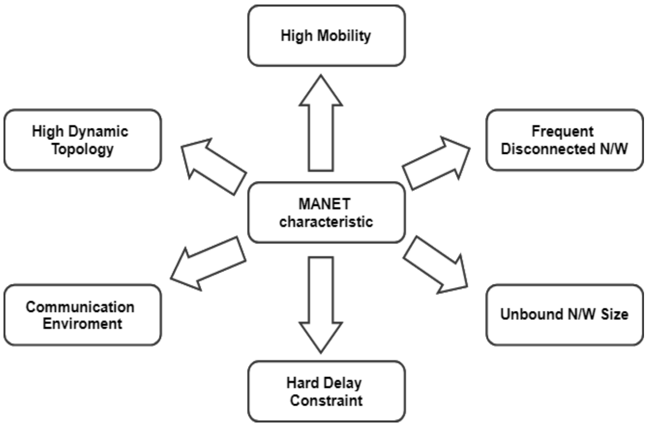

Fig. 2 Characteristics of MANET

2. Literature Survey

The Dynamic Source Routing (DSR) protocol and the Ad-hoc On-demand Distance Vector (AODV) protocol are almost as good at working well in more extensive networks, according to tests done on the Network Simulator (NS-2). However, AODV might be more susceptible to specific attacks than DSR [4]. In Vehicular Ad Hoc Networks (VANETs), DSR showcased superior performance over AODV, exhibiting lower power consumption, reduced packet loss, increased delivery rates, and decreased latency [5]. DSR was found to be more vulnerable to egocentric node attacks but outperformed AODV in scenarios involving black hole attacks [6]. The performance of these protocols varies based on parameters like packet loss and energy consumption [7]. The MP-OLSR hybrid protocol demonstrated higher performance than AODV and DSR in specific contexts, but its efficacy might vary with different network configurations and mobility patterns [8]. AODV showcased better performance under high mobility scenarios, proving advantageous for real-time applications compared to DSR [9]. Additionally, MP-OLSR's computational complexity increased with topology amendments, impacting its routing processes [10]. DSR excelled in performance, Packet Delivery Ratio (PDR), and packet loss ratio across various simulations using simulators like Netsim 10.2 and Riverbed Simulator Modeler [10, 11]. On the other hand, OLSR performed better in End-to-End (E2E) delays and specific metrics compared to AODV, DSR, and GRP protocols [11, 12]. When expanding the network size in MP-OLSR, delays increased compared to other protocols like AOMDV, which proved more suitable for more extensive networks [13]. The various studies conducted on different platforms were compared in Table 1, showcasing varied research approaches.

Table 1. Overview of Recent Studies and Applications Relevant to MANETs.

Study	**Approach and Application**	**Findings**
Parissidis, [14]	Quantitative comparison of routing protocols	Influence of Node Density on performance
Yang J, [15]	Particle swarm optimization	Impact on Energy Consumption
Alturfi, [16]	Performance of heterogeneous nodes	Optimization of Network Load
J. Deepika, [17]	Energy Efficient Routing	Focus on Power Optimization

Mohapatra, S., [18]	Routing strategic approach	Utilization of NS-2 Simulation
L, Yun-kyung, [19]	Correlation Analysis of Performance Metrics	Study conducted in NS and QualNet 5.0
Abdulleh, M., [20]	Performance Analysis of Protocol	Relationship with Network Size and Density
Sharma, A., [21]	QoS improving methods	Emphasis on Overhead Minimization
Jiazi Yi, [22]	Hybrid Protocol routing technique	Evaluation of Scalability and Security
A Mouiz [23]	Performance evaluation in MANET	Consideration of Energy Conservation

3. Methodology

This literature review explores the performance and impact of three distinct routing protocols—DSR, AODV, and MP-OLSR—within Mobile Ad Hoc Networks (MANETs) [18].

- DSR (Dynamic Source Routing): Utilizes an on-demand mechanism for routing.
- AODV (Ad-hoc On-demand Distance Vector): Efficiently finds routes as needed.
- MP-OLSR (Multipath Optimized Link State Routing): Operates as a hybrid multipath routing protocol, incorporating periodic updates to maintain network topology.

The assessment of these routing protocols focuses on evaluating their performance across evolving parameters within the network environment. The evaluation methodology employed in the proposed quality of service simulation mode encompasses a comprehensive set of parameters. This simulation, conducted through NS2, aims to demonstrate diverse behaviours exhibited by multiple protocol families rather than exclusively favouring one protocol type [19]. Classifying these protocols into efficient, effective, and hybrid categories facilitates comparative analysis, providing an overarching evaluation of their performance concerning various routing challenges. This literature aims to contribute toward developing a robust regulatory framework that enhances the quality of service in MANETs by considering multiple performance parameters [19].

4. Routing Protocol in MANET

4.1 Routing Protocol Classification

Figure 3 illustrates several routing protocols utilized in MANETs, categorized into three main types: proactive, reactive, and hybrid. These routing protocols are designed to handle numerous nodes operating in resource-constrained environments. One of the critical challenges in MANETs is the frequent appearance and disappearance of nodes in different locations. Managing message routing overhead becomes essential as the network accommodates increasing mobile nodes. Efforts to minimize routing protocol size are crucial to reducing the control packets transmitted within the network and maintaining manageable routing tables. Routing protocols are classified based on their approach to identifying routes and the timing of this process, although their primary goal remains to select the most efficient route to the destination.

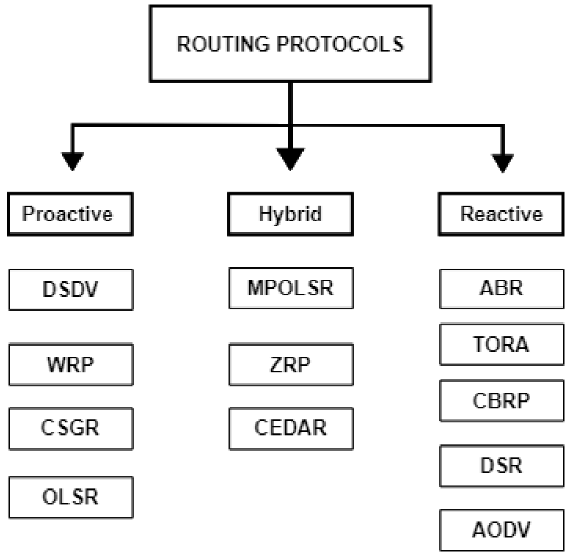

Fig. 3 Classification of routing protocol in MANET

4.2 Proactive Routing in MANETs

A proactive routing system in MANETs utilizes link-state routing algorithms, which can sometimes overwhelm nearby connections with data traffic. This system manages routing information by regularly exchanging control packets with neighbouring nodes.

Some examples of proactive routing techniques include:

- DSDV (Destination-Sequenced Distance Vector): Utilizes sequence numbers to ensure the freshness of routing information and employs periodic updates to maintain routing tables.
- WRP (Wireless Routing Protocol): A protocol that focuses on efficient routing in wireless networks, utilizing the concept of routing tables and updating routes based on link costs.
- OLSR stands for "Optimized Link State Routing." It is better than traditional link-state routing because it uses multipoint relays to send control messages with less overhead.

These proactive routing techniques aim to maintain updated routing information continuously, allowing nodes to have ready access to network routes.

4.3 Reactive Routing Protocols in MANETs

Reactive routing protocols in MANETs are designed to minimize the overheads associated with proactive routing strategies. These protocols employ a distance-vector routing method and establish a route solely upon request from a receiving node, thereby dynamically initiating the route discovery process.
Some notable reactive routing protocols used in MANETs include:

- DSR (Dynamic Source Routing): Utilizes on-demand route discovery, where a node determines routes as needed by maintaining a route cache and discovering paths based on accumulated route knowledge.
- AODV (Ad-hoc On-demand Distance Vector): Operates using on-demand route establishment, initiating route discovery upon receiving data packets requiring routing information.
- TORA (Temporally Ordered Routing Algorithm): Focuses on providing multiple routes by maintaining a directed acyclic graph and adapting to topology changes by ordering routes temporally.
- LMR (Location-Aided Multi-Hop Routing): Uses location information to make routing decisions in mobile networks, aiming to improve efficiency by incorporating node positions in routing protocols.
-

These reactive routing protocols prioritize route establishment upon explicit demand, minimizing control overhead until required.

4.4 Hybrid Routing Protocols in MANETs

Hybrid routing protocols in MANETs combine proactive and reactive routing strategies, leveraging the strengths of both approaches. These protocols aim to balance the advantages of proactively maintaining routing information and establishing routes reactively when needed.
Notable hybrid routing protocols used in MANETs include:

- ZRP (Zone Routing Protocol): Divides the network into zones and utilizes proactive routing within a zone and reactive routing between zones, optimizing routing efficiency.
- BGP (Border Gateway Protocol): Primarily used in more extensive networks, BGP employs a mix of path vector and distance vector routing strategies, ensuring scalability and stability in routing.
- EIGRP (Enhanced Interior Gateway Routing Protocol): A Cisco proprietary protocol combining distance-vector and link-state routing characteristics, providing rapid convergence and reduced bandwidth usage.

The hybrid nature of these protocols allows for adaptive routing strategies, optimizing routing efficiency based on the dynamic network conditions in MANETs. This article compares the performance of three MANET routing protocols—DSR, AODV, and MP-OLSR—across several factors to see how well they work and suit the network environment.

4.5 DSR Protocol

The Dynamic Source Routing (DSR) protocol operates by accumulating device addresses along the route a data packet takes from the source to its destination. This accumulation may lead to an excessive throughput of IPv6 address types. To address this, DSR was developed, eliminating the reliance on central routing tables. Instead, it defines a flow-id option that allows packet transmission hop-by-hop, preventing overloading by control packets like periodic beacon messages (Hello messages). However, DSR lacks a mechanism to restore damaged links, and its connection setup duration is longer than table-driven protocols. Additionally, its performance declines as the number of nodes in the network increases.

4.6 AODV Protocol

Ad hoc On-Demand Distance Vector (AODV) is an on-demand routing protocol in MANETs that dynamically establishes routes based on immediate needs rather than pre-maintained routes. It aims to overcome issues in the DSR protocol, especially when dealing with numerous nodes between the source and destination. AODV avoids the need for multiple routing tables between source and destination by storing two additional counters in its route tables, aiding in determining updated routes.

4.7 MP-OLSR Protocol

The Multipath Optimized Link State Routing Protocol (MP-OLSR) for MANETs utilizes the Dijkstra algorithm to establish multiple paths for data transmission. As its name suggests, this protocol diversifies data transmission across various available paths. It dynamically creates route tables to accommodate data transfer through multiple feasible routes. However, it faces challenges with route restoration mechanisms and loop prevention strategies. Its algorithmic selection (Round Robin) sometimes requires a better estimation of information loading. Furthermore, it provides pre-determined weights for cost calculation when network conditions don't meet expectations.

5. Study Matrices

Various crucial performance metrics can be examined, with a focus on the following:

5.1 Protocol Evaluation through Packet Delivery Ratio (PDR)

The PDR serves as a metric to evaluate a protocol's effectiveness in transmitting all the data sent within a network. The calculation involves dividing the number of packets sent by the source node (SNp) by the total number of packets received by the destination node (DNp), as defined in equation (1). A higher PDR indicates superior performance. For instance, a PDR of 100% indicates excellent network availability and reliability, denoting that all sent packets reached their intended destination. PDR measurements are typically generated by constant bit rate (CBR) sources, providing statistical data on the average number of successfully delivered packets to their destinations.

$$\mathrm{PDR} = \frac{\mathrm{DNp\_received}}{\mathrm{SNp\_transmitted}} \times 100 \qquad (1)$$

5.2 Throughput in Network Evaluation

Throughput represents the volume of packets or bytes the source node receives within a given time frame. It's a crucial parameter for assessing the performance of network protocols. It quantifies the successful data transmission rate from one location to another, typically measured in bits per second (bps).

The formula to evaluate throughput, as described in Equation (2), is as follows:

$$\mathrm{Throughput} = \frac{(L-C)}{L} \times R \times F(\gamma) \qquad (2)$$

Where the parameters are defined as:
L: Packet length
C: Cyclic Redundancy Check (CRC)
R (b/s): Binary transmission rate
F(γ): Packet success rate

Throughput calculation involves considering factors like packet length, CRC, transmission rate, and packet success rate to determine the effective data transmission capacity of the network.

5.3 End-to-End Delay in Packet Transmission

End-to-End (E2E) Delay denotes the duration taken by a packet to travel from its source to its destination. This metric is crucial as it ensures the timely delivery of packet data, preventing applications from experiencing inefficiencies or becoming unusable due to delays.
The formula to calculate End-to-End Delay, as described in Equation (3), is:

$$\text{End-2-End Delay} = \frac{(N*L)}{R} \qquad (3)$$

Where the parameters are defined as:
N: Number of links in series, incorporating store-and-forward mechanisms between these links
L: Packet length
R: Transmission rate

End-to-End Delay evaluation considers the number of links,packet length, and transmission rate to determine the time a packet takes to traverse the entire path from its origin to its intended destination.

5.4 Performance Analysis of Multicast Protocols

Table 2. Simulation parameters.

Parameters	Simulation Matrix	Values
Configuration	Network Size	2000×2000 Meters
	Number of Nodes	10, 30, 50, 100 and 150
Run	Simulation time	20 sec
Mobility	Model	Random Way Point
	Maximum Speed	5 to 10 m/s
	Pause Time	10 sec
PHY	Propagation Model	Two-ray ground
	Transmission range	300 meters
Traffic	Traffic Types	CBR (Constant Bit Rate)
	Packet Size	1200 Byte
	Packet Rate	10 packets/s
Platform	Simulator	NS-2.29

5.5 Simulation Setup using NS-2

In this simulation, the duration is set to 20 seconds, and the network's scale varies with the number of nodes, ranging from 10, 30, 60, 90, 120, and 150 nodes. The simulated network area is defined as a 2000 x 2000 rectangular-meter grid. NS-2, depicted in Figure 4, refers to Network Simulator Version 2, a freely available, open-source, event-driven simulator specifically designed for research in computer communication networks. It provides a platform to emulate and study network behaviors, protocol functionalities, and performance under various conditions and configurations.

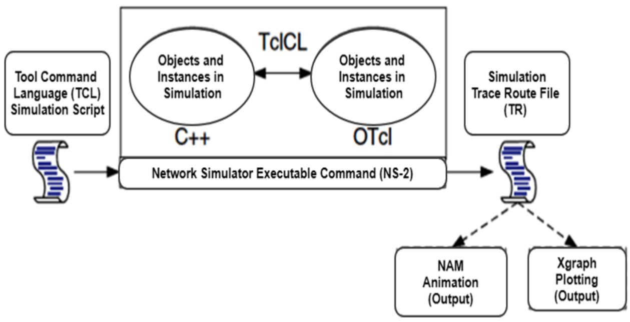

Fig. 4 Architecture of Network Simulator -2

6. Results and Discussions

Three critical overall performance metrics have been identified for assessing these route processes. The simulation results with parameters are listed in Table 3:

Table 3. Summary of simulation results.

Parameters/ Protocols	AODV	DSR	MP-OLSR
Throughput	Low	High	Average
End-2-End Delay	High	Average	Low
Packet Delivery Ratio	Average	Low	High
Network Load	Average	High	Low

6.1 Throughput Comparison

A higher volume of transmitted packets yields network advantages, as illustrated in Figure 5, showcasing the comparison of throughput among the three protocols. The chart demonstrates that the AODV protocol exhibits slightly lower throughput compared to MP-OLSR protocols. Conversely, the DSR protocol showcases higher throughput when compared to both the AODV and MP-OLSR protocols. As the network encounters additional traffic sources, congestion, obscured terminals, and disruptions become more prevalent. Different protocols respond distinctively to these challenges, where latency becomes a pivotal factor influencing network speed. Notably, the throughput of AODV and MP-OLSR protocols appears less concerning than that of DSR. Throughput diminishes with a smaller node count but improves as the network's nodes expand, indicating a dependency on network scale for enhanced throughput.

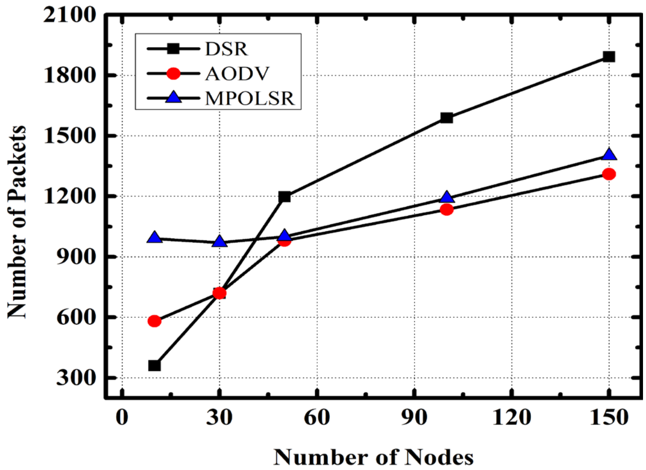

Fig. 5 Throughput

6.2 End-to-End Delay Comparison

Figure 6 illustrates the end-to-end delay characteristics across the three methods, showcasing the average extension rate for each source and destination pair. DSR displays more consistent and notably significant end-to-end delay responses in smaller networks compared to AODV and MP-OLSR. DSR, reliant on cached routes, sometimes directs traffic through outdated paths, resulting in retransmissions and prolonged delays. The increased number of cached routes notably impacts latency in networks with substantial traffic. DSR attempts to mitigate the impact of stale routes by employing multiple pathways. Notably, as the network size increases, AODV shows improved end-to-end latency. Conversely, DSR exhibits decreased end-to-end delay, experiencing relatively less delay as the network expands, particularly under higher loads due to increased route discovery requests. In contrast, MP-OLSR consistently maintains considerably shorter delay times than DSR and AODV, which exhibit longer delays.

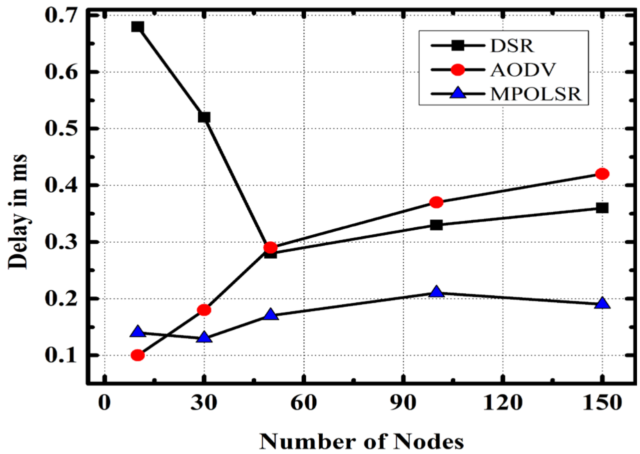

Fig. 6 End-2-End Delay

6.3 Packet Delivery Ratio (PDR) Comparison

The relationship between throughput and packet delivery ratio (PDR) is interconnected. PDR is determined by the destination, which monitors the number of data packets received, influencing the network's overall delivery ratio. Figure 7 shows that MP-OLSR protocols exhibit a higher packet delivery ratio compared to AODV and DSR protocols. DSR displays a lower packet delivery ratio when contrasted with AODV and MP-OLSR regarding the proportion of received data packets at their sources. With increasing node density, Reactive protocols showcased gradual increments in their packet delivery ratios, rising from 0.8 for 10 nodes to unity for higher node densities. As the number of nodes expands, MP-OLSR and AODV protocols demonstrate escalated PDR values. Additionally, MP-OLSR and AODV protocols marginally outperform the DSR protocol regarding packet delivery ratio.

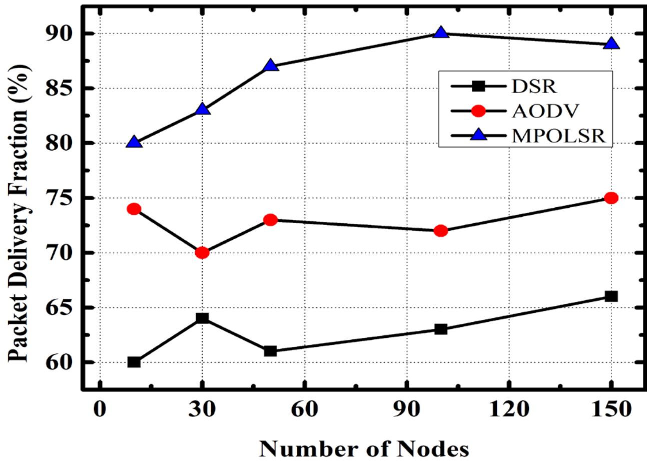

Fig. 7 Packet Delivery Ratio

6.4 Network Load

All upper levels in all wireless local area network (WLAN) nodes have represented the network load in bits/sec, delivered to the WLAN layers. The average load for varying numbers of nodes—10, 30, 60, 90, 120, and 150—is shown in the accompanying graph. When DSR contrasts with other routing protocols, its average load is higher. When comparing the three routing protocols, MP-OLSR works well in more extensive networks since it requires fewer loads as the number of nodes increases. In contrast to DSR and AODV, MP-OLSR performs well in more extensive networks.

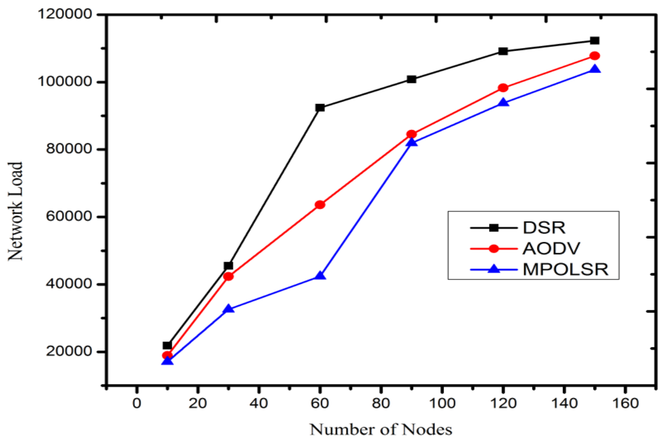

Fig. 8 Average Network Load

7. Conclusion

The DSR routing protocol demonstrates superior performance based on the specified parameters, albeit at the cost of increased latency in larger network areas compared to other routing protocols. In contrast, MP-OLSR performs better overall, particularly in reducing community delays and network load and offering standard network solutions, outperforming DSR and AODV. The simulation and subsequent analysis underscore the significance of routing protocols in determining network performance, considering network resolution and optimal routes. The investigation examined packet delivery rates across DSR, AODV, and MP-OLSR scales. Notably, MP-OLSR constantly sends and receives messages to keep track of the network's topology using a link-state algorithm. This gives it unique routing options compared to the other protocols. MP-OLSR packet traverses various paths selected at the source, dynamically altering the routing table through an on-demand mechanism. In the event of link failure, the protocol swiftly recovers the route. The NS2 simulations indicate that MP-OLSR significantly enhances network performance.

Choosing the appropriate network protocol significantly impacts overall efficiency. Future work aims to expand experiments by considering additional simulation parameters. Future simulations will delve into NS-3 to further explore and elaborate on these findings.

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