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Performance Characterization and Comparative Study of DSR and OLSR Routing Protocols in Mobile Ad Hoc Networks

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Abstract

This study investigates and compares the performance of two prominent routing protocols within mobile ad hoc networks under varying network densities and mobility scenarios. The evaluation focuses on key performance indicators such as packet throughput, reliability in packet delivery, and overall network delay. The simulation was carried out using a widely recognized network simulator, and the protocols were assessed under conditions with different numbers of nodes and movement speeds. The results show that one protocol significantly outperforms the other in terms of lower delay, higher packet delivery rate, and superior network organization. These findings indicate the importance of selecting the appropriate routing protocol based on network density, mobility, and performance requirements. Additionally, the study outlines potential areas for future work, including energy optimization and hybrid protocol development, to address the evolving needs of mobile ad hoc networks.

Keywords: Mobile ad hoc networks, routing protocols, packet delivery, network simulation, performance evaluation, network delay, mobility.

1. INTRODUCTION

The Mobile Ad Hoc Network (MANET) is a self-organizing, self-configuring, and self-healing wireless network that has drawn significant attention in recent years [1]. Built through a distributed collection of mobile nodes communicating wirelessly, it requires neither a centralized base station (BS) nor an access point (AP). In scenarios where traditional infrastructure is inadequate, MANETs provide an alternative that can be rapidly deployed, particularly beneficial in disaster zones where communications are disrupted [1]. Historical evidence shows that communication demands spike following catastrophic events, highlighting the importance of adaptable wireless networks [2].

Improvements in mobile devices have greatly advanced wireless communication, playing a vital role in emergency and search-and-rescue (SAR) operations [1]. MANETs can minimize losses in disaster zones by supporting SAR operations efficiently [3,4]. Their ability to self-organize and self-heal enables continuous function despite environmental disruptions, offering rapid deployment and improved responsiveness [5,6].

Devices in a MANET, such as computers, mobile phones, cameras, and sensors, communicate and share data over the wireless network. Each mobile node can independently join or leave the network at will, causing frequent topological changes. Besides transmitting data, every node also acts as a router [7,8]. Such dynamic topologies demand highly efficient routing protocols.

2. LITERATURE SURVEY

In MANETs, the "ad hoc routing protocol" determines optimal paths for packet delivery between source and destination nodes [1]. Routing protocols manage routing tables dynamically amidst limited resources and unpredictable node mobility, complicating routing decisions.

Proactive Routing (Table-driven protocols): These protocols maintain up-to-date routing tables by continually broadcasting topological updates, ensuring every node has fresh routing information. Nodes exchange control messages whenever changes occur [9]. The advantage is

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that routes are immediately available when needed, but at the cost of high control overhead.

Reactive Routing (On-demand protocols): Reactive protocols initiate route discovery processes only when required. This minimizes unnecessary control traffic but introduces route discovery latency. Mechanisms like sequence numbers are used to ensure up-to-date routing information [10-11].

K. Natarajan and G. Mahadevan [12] examined how mobility speeds impact various protocols such as ZRP, LAR, OLSR, FSR, DSDV, DSR, and AODV. Their study demonstrated that LAR and AODV could reliably deliver 50%-60% of packets even under varying mobility conditions. Meanwhile, DSR exhibited longer delays compared to AODV and DSDV.

Similarly, Lakshman Naik L, R. U. Khan, and R. B. Mishra [13] conducted simulations using varying node speeds to evaluate routing protocols. OLSR was found to outperform both AODV and DSDV in throughput and PDR metrics, although performance slightly degraded with higher speeds.

3. ROUTING PROTOCOLS

3.1 OLSR PROTOCOL (OPTIMIZED LINK STATE ROUTING)

OLSR is an optimization over traditional link-state protocols. By employing Multipoint Relays (MPRs), OLSR limits the number of transmissions required to disseminate topology information, significantly reducing overhead in mobile networks [9].

The protocol uses two main mechanisms:

- **Neighborhood Identification:** Detecting one-hop and two-hop neighbors using HELLO messages [2].
- **Topology Control:** Disseminating network topology using TC messages forwarded by MPRs.

Other control messages include:

- **MID Messages:** Managing multiple interfaces on nodes.
- **HNA Messages:** Advertising connectivity to external networks [7].

MPRs are selected to cover the two-hop neighborhood efficiently. They are dynamically updated to adapt to topology changes [18], ensuring optimal network performance despite node mobility.

3.2 DSR PROTOCOL (DYNAMIC SOURCE ROUTING)

DSR is an on-demand protocol that reduces bandwidth consumption by avoiding periodic updates. It relies on source routing and route caches to efficiently manage routing information [5].

4. SIMULATION

In this study, simulations were meticulously designed and executed using Network Simulator 2 (NS-2), a well-known simulation platform renowned for its accuracy in modeling both wired and wireless networks. NS-2 was chosen due to its extensive support for Mobile Ad Hoc Network (MANET) protocols and its ability to provide detailed control over simulation parameters, enabling researchers to recreate realistic mobile networking environments.

4.1 Simulation Setup

The simulation area was configured to a square grid measuring 1000 meters by 1000 meters, providing ample space for node mobility while allowing observations of protocol behavior under varying densities and movements. A Random Waypoint Mobility Model was employed, which is one of the most widely used models to simulate the erratic and dynamic movements typical in MANET environments.

Multiple node densities were considered to evaluate the scalability and robustness of the routing protocols under different network loads. Simulations were conducted with 20, 40, 60, 80, and 100 nodes, respectively. To ensure diverse mobility conditions, node speeds were varied across five different levels: 10 m/s, 15 m/s, 20 m/s, 25 m/s, and 30 m/s.

Each simulation was run for a maximum of 900 seconds. This duration was selected based on established best practices in the literature, ensuring sufficient time for network stabilization and protocol convergence. To maintain consistency and comparability across tests, IEEE 802.11 was selected as the MAC layer protocol, which is standard for wireless LAN environments.

Traffic was generated using Constant Bit Rate (CBR) sources, ensuring a steady stream of data packets to test the routing efficiency. Packet sizes were standardized at 512 bytes to maintain uniformity in evaluating throughput, delivery ratio, and latency.

4.2 Performance Metrics

Three key performance metrics were evaluated to comprehensively compare OLSR and DSR protocols:

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- **Average End-to-End Delay:** Measures the average time taken for data packets to traverse from the source node to the destination node.
- **Packet Delivery Ratio (PDR):** Calculates the ratio of successfully delivered packets to the total number of packets transmitted by the sources.
- **Number of Clusters Formed:** Indicates the network organization efficiency and how well the nodes manage connectivity under different densities.

4.3 Simulation Execution

Each scenario was simulated multiple times to ensure reliability and to account for randomness introduced by the mobility model. Results from multiple simulation runs were averaged to provide statistically significant performance data. NS-2 trace files were parsed and analyzed using AWK scripts and custom Python scripts to extract the required performance metrics.

Additionally, graphs were generated to visualize the relationships between network density, mobility, and protocol performance. These graphical results provide intuitive insights into how each protocol adapts to different operational conditions, highlighting the strengths and limitations of OLSR and DSR protocols.

5. RESULTS & DISCUSSION

The results obtained from the simulation experiments were carefully analyzed to understand the comparative performance of the OLSR and DSR routing protocols under varying network conditions. Three key metrics—Average End-to-End Delay, Packet Delivery Ratio (PDR), and Number of Clusters Formed—were studied in detail.

5.1 Average End-to-End Delay Analysis

The Average End-to-End Delay represents the time taken for a data packet to travel from the source to the destination. It was observed that OLSR consistently exhibited lower latency compared to DSR across all node densities. This outcome can be attributed to the proactive nature of OLSR, where routes are readily available, thus minimizing the time spent in route discovery. On the other hand, DSR, being a reactive protocol, introduces additional latency due to on-demand route establishment.

The trend shows that as the number of nodes increases, the delay also increases for both protocols. However, the increase in OLSR was more gradual compared to DSR, emphasizing its suitability for high-density networks where low-latency communication is critical.

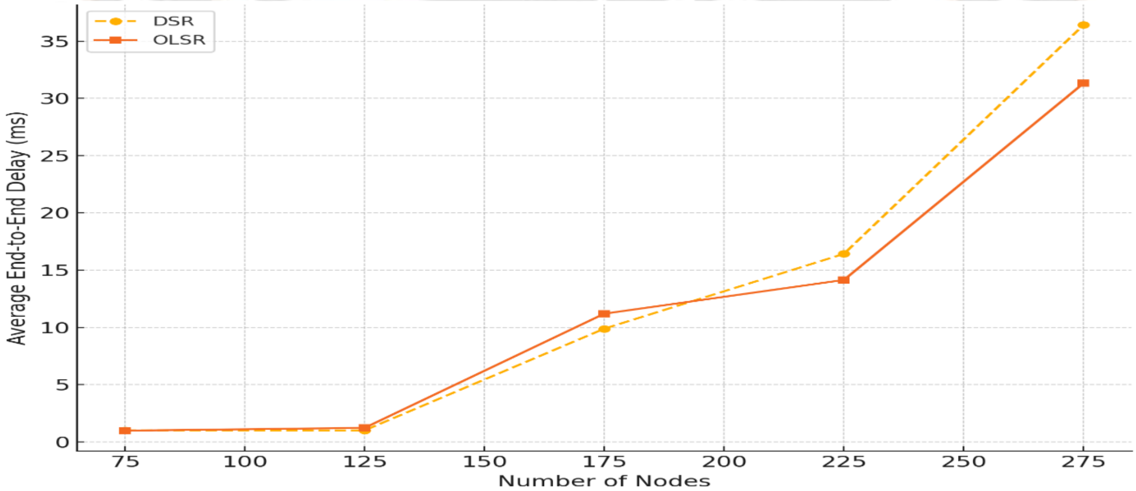

Fig. 5.1: Average End-to-End Delay vs Number of Nodes (OLSR vs DSR)

5.2 Packet Delivery Ratio (PDR) Analysis

PDR is a measure of the network's reliability, calculated as the ratio of the number of packets successfully received by the destination to those sent by the source. Simulation results indicate that OLSR consistently achieved a higher PDR compared to DSR under all network densities.

This superiority is largely due to the maintenance of fresh routing tables in OLSR, ensuring that valid routes are almost always available. Conversely, DSR's route discovery

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mechanisms may occasionally fail, especially in highly dynamic environments, leading to packet drops.

An important observation is that PDR for both protocols decreased slightly as the number of nodes increased. The decrease was sharper for DSR, highlighting its vulnerability to scalability challenges.

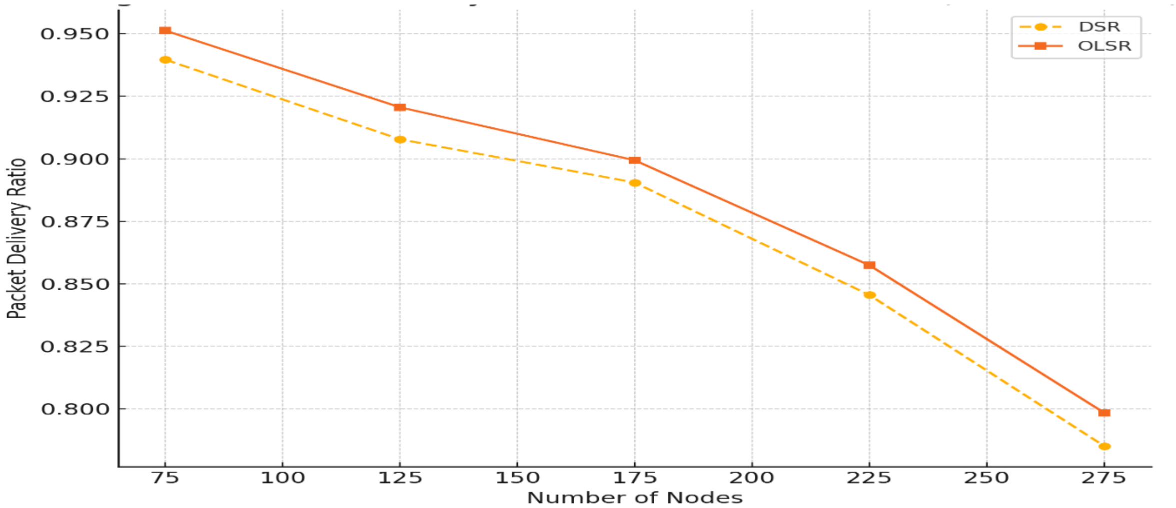

Fig. 5.2: Packet Delivery Ratio vs Number of Nodes (OLSR vs DSR)

5.3 Number of Clusters Formed Analysis

Cluster formation is an important metric indicating the network's ability to organize itself for efficient communication. A higher number of well-formed clusters generally signifies better load distribution and localized management, leading to enhanced network performance.

The results show that OLSR formed a significantly higher number of clusters than DSR at every tested node density.

This advantage stems from OLSR’s use of Multipoint Relays (MPRs) that naturally lead to better connected and structured networks.

The impact of higher cluster formation was visible in OLSR's superior performance in both latency and PDR. More clusters facilitated quicker local route repairs and enhanced data packet forwarding efficiency.

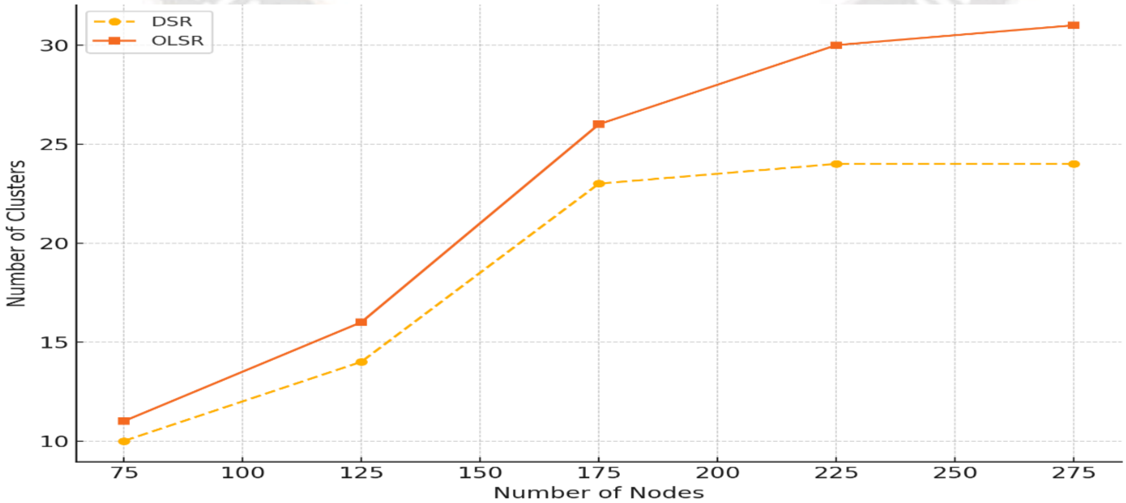

Fig. 5.3: Number of Clusters Formed vs Number of Nodes (OLSR vs DSR)

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5.4 Overall Discussion

From the detailed analysis of simulation results, it is evident that OLSR outperforms DSR across all measured performance metrics. The proactive routing mechanism, enhanced by MPRs, ensures that OLSR delivers lower latency, higher packet delivery ratios, and better cluster formation efficiency.

However, it is also noteworthy that proactive protocols like OLSR may introduce additional control overhead, which, although manageable in these simulations, could impact energy consumption in resource-constrained devices. On the other hand, DSR's reactive nature, while conserving energy during low-traffic scenarios, struggles under dynamic and dense environments due to increased route discovery times.

These insights emphasize that while OLSR is better suited for high-mobility, high-density MANET scenarios requiring robust and reliable communication, DSR may still be preferred in low-density, low-mobility environments where minimizing control overhead is a priority.

6. CONCLUSIONS

This paper presented a detailed comparative analysis of OLSR and DSR protocols under varying node densities and mobility conditions using NS-2 simulations. Results demonstrated that OLSR consistently outperforms DSR in terms of average end-to-end delay, packet delivery ratio, and the number of clusters formed. The proactive nature of OLSR, supported by efficient MPR selection, enables better network stability and reliability, even under dynamic conditions.

Future work may explore additional factors such as varying packet sizes, energy consumption models, and different mobility scenarios like group mobility models, which could further impact protocol performance.

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