Performance Analysis of MANET Routing Protocols in NS-3

1. Introduction

This report presents a performance analysis of different routing protocols for ad hoc mobile networks (MANETs) using the NS-3 simulator. The main goal is to compare the performance of various protocols as the number of nodes in the network changes, while keeping mobility and traffic patterns constant. This analysis is critical to understanding how these protocols behave under different network loads and to selecting the most appropriate protocol for a given application.

The project evaluates routing protocols by defining a simulation scenario and analyzing the output to understand their performance. This involves a standard design flow: defining the problem, setting the parameters, designing the architecture, and statistically analyzing the results to ensure logical consistency. The basic idea is to compare some performance and energy parameters of the **AODV** and **DSDV protocols**. The comparison is also contextualized with theoretical expectations to validate the output graphs.

2. MANET Routing Protocols

MANET routing protocols are mainly divided into reactive and proactive; Their key differences lie in how they discover and maintain routes.

- **Reactive** Protocols: These protocols, such as AODV, only discover paths when it is actually necessary to send data. When a node needs to send a packet, it initiates a route discovery process to establish a path to the destination. The network remains silent until a connection is requested, at which point a request is forwarded to intermediate nodes to create a path.
- **Proactive** Protocols: In contrast, proactive protocols such as DSDV consistently maintain routes to all possible destinations in the network. This is done through a combination of periodic updates, ensuring that a route is always available when needed.

These different approaches have advantages and disadvantages that simulations can help quantify.

2.1. AODV (Ad hoc On-Demand Distance Vector)

AODV is a reactive protocol that initiates on-demand path discovery. When a node needs a route to a destination, it transmits a route request (RREQ). Each node has a sequence number that grows monotonically to keep the routes up to date. AODV uses three main types of messages: **RREQ**, **RREP** (Route Reply), and **RERR** (Route Error). RREQ packets are sent in broadcast, and upon receiving a request, a node can send an RREP to the sender through a temporary path.

2.2. DSDV (Destination-Sequenced Distance-Vector Routing)

DSDV is a proactive routing protocol based on the Bellman-Ford algorithm, where nodes periodically transmit routing updates. Each node maintains a route table that lists the next hop for each reachable destination. These tables are periodically transmitted to the neighbors. Each entry in the routing table contains a sequence number generated by the destination, which helps to update routes according to their "freshness".

3. Simulation setup

The performance of the AODV and DSDV protocols was evaluated in a simulated ad hoc network, varying the number of nodes and maintaining fixed mobility.

3.1. Performance metrics

The following metrics were used to evaluate the protocols:

- **Packet Delivery Ratio (PDR):** The ratio of the total number of packets delivered to the total number of packets sent by the source node.
- **Dropped Packets**: Total number of packets that failed to reach their destination.
- **Average End-to-End Delay**: The average time it takes for a packet to travel from source to destination.

3.2. Simulation parameters

The simulations were conducted using the following parameters, extracted from the provided C++ files:

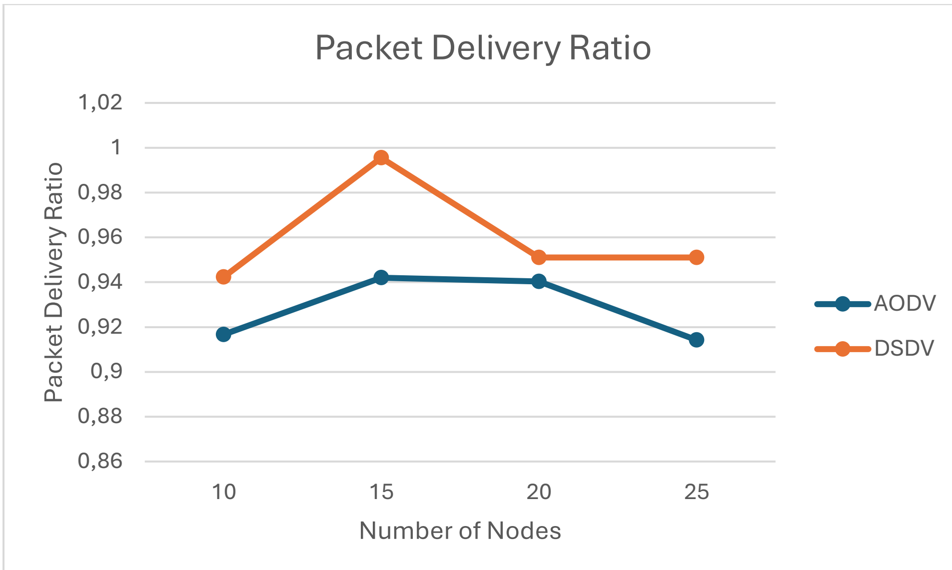
- **Number of nodes**: 10, 15, 20 and 25.
- Simulation area: 500m x 500m.
- Simulation time: 300 seconds.
- **Traffic type**: CBR (Constant Bit Rate) over UDP.
- Package size: 512 bytes.
- **Data rate**: 2048 bps.
- **Mobility model**: Random Waypoint Model with a speed of 2.0 m/s and a pause time of 5.0 s.
- Transmission power: 30 dBm.
- Wi-Fi standard: 802.11b.
- **Propagation model**: Log Distance Propagation Loss Model.
- Routing protocols: AODV, DSDV.

4. Results and analysis

This section presents the results obtained from the simulations and provides a comparative analysis of the AODV and DSDV protocols.

4.1. Packet Delivery Ratio (PDR)

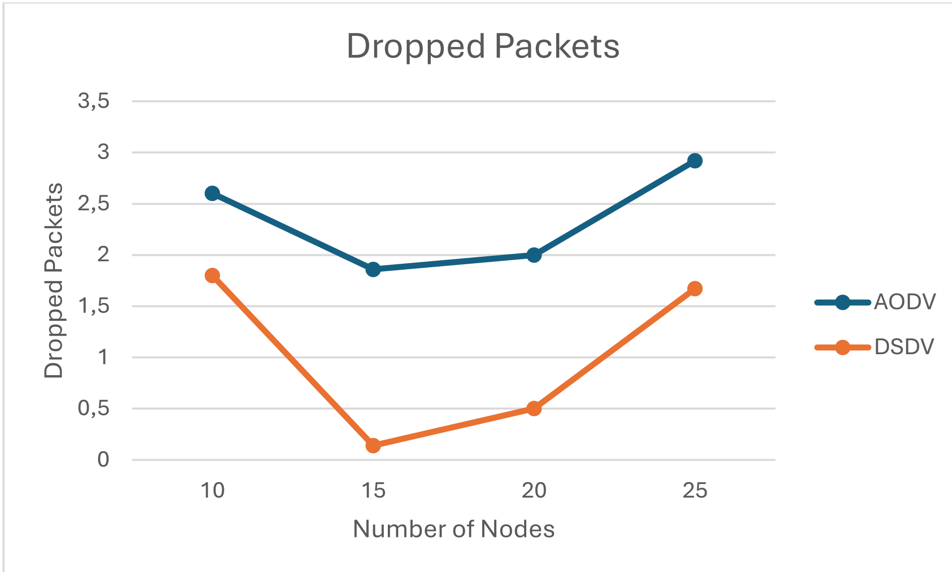
The **Packet Delivery Ratio (PDR)** graph shows how the ratio of successfully delivered packets varies as the number of nodes increases.



- **AODV**: The PDR for AODV initially increases from about 0.915 with 10 nodes to a peak of 0.94 with 15 nodes. As the size of the network grows to 20 and 25 nodes, the PDR decreases slightly and then stabilizes at around 0.915. This behavior suggests that AODV works well in moderately dense networks, but may struggle in larger networks due to the higher routing overhead and congestion potential.
- **DSDV**: DSDV protocol shows a higher PDR than AODV, especially in small and large networks. It starts at 0.94 with 10 knots, reaches a peak of almost 1.0 (0.995) with 15 knots and stands at 0.95 for both 20 and 25 knots. The proactive nature of DSDV, where routes are always maintained, contributes to its high delivery rate, as routes are readily available when packets need to be sent.

4.2. Dropped packets

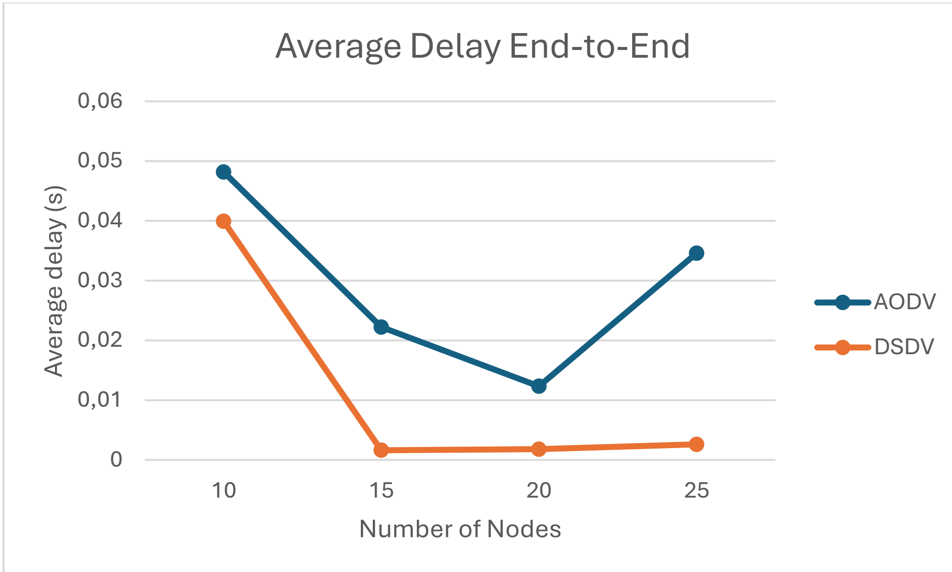
The **Lost Packets** graph illustrates the number of packets lost during transmission as the network size increases. This parameter was calculated as the difference between the packets sent and the packets received.



- **AODV**: AODV shows a higher number of lost packets than DSDV in all scenarios. Packet loss is highest at 10 and 25 nodes, with a noticeable drop at 15 nodes. This trend mirrors the results of the PDR, where network performance peaked with 15 nodes. The higher number of lost packets can be attributed to the reactive nature of AODV, where the latency of route discovery can lead to packet loss if a path is not found in time.
- **DSDV**: DSDV consistently demonstrates fewer lost packets. The trend shows a significant drop from 10 to 15 nodes, followed by a gradual increase as the network expands to 20 and 25 nodes. This indicates that proactively maintaining DSDV routes is effective in minimizing packet loss, although the overhead of maintaining these routes may lead to a slight increase in losses in larger networks.

4.3. Average End-to-End Delay

The **Average End-to-End Delay** graph highlights the time it takes for packets to travel from source to destination.



- **AODV**: AODV has a significantly higher end-to-end delay than DSDV. The delay is maximum at 10 knots (about 0.048s), drops sharply to 15 and 20 knots, and then rises again with 25 knots. The high initial delay is due to the route discovery process that reactive protocols must perform. As the network becomes denser, route discovery may become more efficient, but increased traffic and interference in larger networks may again increase delay.
- **DSDV**: DSDV maintains a very low and stable end-to-end delay for all node densities. The lag remains consistently below 0.005s for 15, 20 and 25 knots, with a slightly higher value for 10 knots. This is a direct benefit of its proactive approach; Since the routes are already established, packets can be forwarded immediately without experiencing the latency of the route discovery phase.

5. Conclusion

The simulation results provide a clear comparison between AODV and DSDV routing protocols as network density changes.

- **DSDV** consistently outperforms AODV in terms of **Packet Delivery Ratio** and **Average End-to-End Delay**, and also shows a lower number of **Lost Packets**. This is mainly due to its proactive nature, where routes are maintained at all times, ensuring that data can be transmitted with minimal delay and a higher likelihood of success.
- **AODV**, being a reactive protocol, experiences higher delays and higher packet losses due to the latency associated with on-demand route discovery. However, it's worth noting that AODV is generally expected to have lower routing overhead in networks with sporadic traffic, a metric not explicitly measured in these new charts but discussed in the original project document.

In summary, for applications where high reliability (high PDR, low packet loss) and low latency are critical, **DSDV** appears to be the superior choice in simulated scenarios. However, the trade-off is the constant routing overhead associated with proactive protocols, which could impact scalability and power consumption in very large or highly dynamic networks. The choice between these protocols would ultimately depend on the specific requirements and constraints of the MANET application.