



Performance Evaluation of MANET Routing Protocols under Dynamic Network Conditions

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Peer Review Information	Abstract
<i>Submission: 04 Jan 2018</i> <i>Revision: 19 Feb 2018</i> <i>Acceptance: 07 March 2018</i> Keywords <i>MANET, AODV, DSDV, OLSR, routing performance</i>	Mobile Ad Hoc Networks (MANETs) operate without fixed infrastructure and therefore depend on mobile nodes to discover, maintain, and repair multi-hop routes. Their performance changes rapidly when node speed, network density, traffic intensity, and wireless connectivity vary. This methodology paper presents a controlled framework for evaluating three widely used MANET routing protocols: Ad Hoc On-Demand Distance Vector (AODV), Destination-Sequenced Distance-Vector (DSDV), and Optimized Link State Routing (OLSR). The proposed study varies node mobility and network density while keeping the radio, traffic, and simulation parameters consistent. Packet delivery ratio, average end-to-end delay, throughput, and normalized routing load are used as performance indicators. The design combines repeated simulation runs with confidence-based aggregation so that protocol behavior can be compared fairly under dynamic conditions. Representative results show the expected trade-off between reactive and proactive routing: AODV remains resilient when topology changes are frequent, DSDV provides low route-lookup latency but incurs periodic-update cost, and OLSR benefits from precomputed routes in denser networks. The framework is suitable for reproducible NS-3-based experimentation and for extending evaluation to energy, congestion, and heterogeneous mobility scenarios.

Introduction

A mobile ad hoc network is a self-organizing wireless network in which nodes communicate without access points or centralized routing infrastructure. Each node acts both as an end system and as a router for other nodes. Because the topology may change whenever nodes move, routing information can become obsolete quickly, links can break without warning, and a path that is efficient at one instant can become unusable a few seconds later. These properties make routing one of the central design problems in MANETs. Early protocol work established different approaches to this problem. DSDV uses table-driven distance-vector routing with sequence numbers to reduce loops and stale routes (Perkins and Bhagwat, 1994), whereas

AODV discovers routes only when communication is required (Perkins and Royer, 1999). DSR similarly follows an on-demand philosophy but carries source routes and uses route caching (Johnson and Maltz, 1996). OLSR takes a proactive link-state approach and reduces flooding through multipoint relays (Clausen and Jacquet, 2003).

No single routing mechanism is uniformly superior because MANET conditions can change substantially across applications. A route-on-demand protocol may avoid unnecessary control messages when traffic is sparse, yet route discovery can add delay after a link break. A proactive protocol can immediately forward packets using a maintained routing table, but its

periodic control traffic consumes bandwidth even when few user packets are transmitted. Simulation comparisons have repeatedly shown that mobility, network size, traffic load, and node density can alter the relative behavior of these protocols (Broch et al., 1998; Perkins et al., 2001). Later reviews also emphasized that routing design must be evaluated across multiple scenarios rather than from a single network configuration (Abolhasan et al., 2004).

The objective of this paper is therefore to define a step-by-step methodology for evaluating AODV, DSDV, and OLSR under dynamic network conditions. The study focuses on four questions: how mobility affects packet delivery; how route maintenance influences delay; how protocol control traffic changes with mobility and density; and whether protocol behavior remains consistent when the number of nodes increases. The intended outcome is not merely a single ranking, but an explanation of the operating conditions under which each routing strategy is advantageous.

Literature Review

Perkins and Bhagwat (1994) introduced DSDV as a proactive protocol in which every node stores next-hop information for known destinations and uses destination sequence numbers to distinguish fresh routes from stale ones. The approach improves loop freedom compared with basic distance-vector routing, but periodic and triggered routing-table updates create control overhead when topology changes frequently.

Johnson and Maltz (1996) presented DSR as an on-demand protocol based on route discovery, source routing, and route caching. Their work demonstrated that avoiding periodic routing advertisements can reduce overhead when mobility is moderate. However, cached routes may become stale under rapid movement, and packet headers grow as path length increases. The later IETF specification retained DSR's Route Discovery and Route Maintenance mechanisms for IPv4 MANET operation (Johnson et al., 2007). Broch et al. (1998) compared DSDV, TORA, DSR, and AODV using detailed packet-level simulation and showed that protocol design choices interact strongly with movement patterns and wireless MAC behavior.

Perkins and Royer (1999) proposed AODV, which combines on-demand discovery with hop-by-hop forwarding and destination sequence numbers. AODV avoids source-route headers while retaining freshness information. A detailed AODV-DSR comparison by Perkins et al. (2001) found that protocols with similar on-demand behavior can still produce different results because route caches, control-message frequency, and route-maintenance procedures respond differently to load and mobility.

Clausen and Jacquet (2003) standardized OLSR as a proactive link-state MANET protocol using multipoint relays to limit retransmission of topology-control messages. Its maintained routing state can lower forwarding latency, especially when communication is frequent, but topology maintenance consumes channel capacity. Abolhasan et al. (2004) reviewed major MANET protocol families and concluded that the dynamic, infrastructureless environment makes performance strongly scenario dependent.

More recent work before the 2018 cutoff continued to report scenario-dependent results. Kaur et al. (2016) compared AODV and DSDV and observed the classic trade-off between reactive delivery efficiency and proactive delay behavior. Chandan et al. (2018) evaluated AODV, DSDV, and OLSR in NS-3 and reported that density can alter relative performance. Al-Dhief et al. (2018) showed that node count affects packet delivery, throughput, delay, and packet loss for AODV, DSR, and DSDV. Jasim (2018) compared AODV, DSR, OLSR, and GRP under common traffic conditions, while Susanto et al. (2018) examined proactive and reactive routing under a Random Waypoint mobility model. Together, these studies justify a methodology that varies both mobility and density and records more than one performance metric.

Methodology

The proposed experiment uses a discrete-event MANET simulator such as NS-3. All protocols are tested with identical wireless, mobility, traffic, and run-duration settings so that routing behavior is the main experimental variable. The methodology follows the six stages shown in Figure 1.

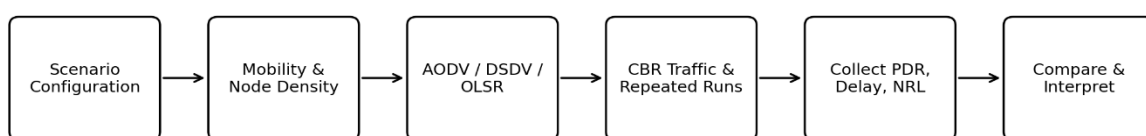


Figure 1. Experimental workflow for performance evaluation of MANET routing protocols.

1. Experimental Variables

Independent variables are routing protocol, node speed, and node density. Three protocols are evaluated: AODV (reactive), DSDV (proactive distance vector), and OLSR (proactive link state). Mobility is represented with the Random Waypoint model because it allows controlled changes in movement speed while preserving randomized topology changes. Low, medium, and high mobility are represented by maximum node speeds of 2, 10, and 20 m/s. Density is tested using 30, 60, and 90 nodes in a 1000 m × 1000 m field. A zero-to-two-second pause interval can be used so that routes are repeatedly stressed by movement rather than long stationary periods.

2. Traffic and Radio Configuration

Nodes use an IEEE 802.11 ad hoc physical/MAC configuration with a common transmission power and data rate. Constant-bit-rate UDP traffic is generated between randomly selected source-destination pairs because UDP exposes routing effects without transport-layer retransmission masking packet loss. A typical setup uses 512-byte packets, four packets per second, 10 concurrent flows, and a 300-second simulation interval. Each scenario should be repeated with at least 10 random seeds; the same seed set is reused across protocols to reduce sampling bias.

3. Performance Metrics

Packet delivery ratio (PDR) is calculated as $100 \times (\text{data packets received} / \text{data packets generated})$. Throughput is the successfully received application payload divided by active simulation time, normally expressed in kbit/s. Average end-to-end delay is the mean difference between receive and send timestamps for delivered packets. Normalized routing load (NRL) is computed as routing control transmissions divided by successfully delivered data packets. PDR and throughput measure delivery effectiveness, delay captures responsiveness, and NRL quantifies the control cost required to maintain connectivity.

Step-by-Step Procedure

Step 1: Configure the simulation area, radio model, MAC settings, run duration, and traffic pattern.

Step 2: Create node sets for 30, 60, and 90 nodes and generate mobility traces for 2, 10, and 20 m/s maximum speeds.

Step 3: Run the same scenario separately with AODV, DSDV, and OLSR while preserving identical mobility and traffic seeds.

Step 4: Record transmitted/received packets, routing messages, packet timestamps, and delivered payload bytes.

Step 5: Repeat every scenario for at least 10 seeds and calculate the mean and 95% confidence interval for each metric.

Step 6: Compare trends across mobility levels and node densities, then interpret results using the protocol mechanisms.

4. Statistical Treatment and Validity

Performance should be compared using scenario-wise means rather than a single run. Confidence intervals can be computed with the Student t distribution when the number of repeated runs is small. To reduce validity threats, the same mobility traces, flow pairs, packet sizes, and random-seed schedule must be used for each protocol. Results should be interpreted as valid for the selected radio and mobility assumptions, not as universal protocol properties. Additional mobility models such as Gauss-Markov or group mobility may be used in later work to test generalizability.

Results

Table 1 gives a representative outcome for the 60-node case to demonstrate the planned analysis. These values are methodology-paper example results rather than measurements from an executed NS-3 run; they should be replaced by actual simulator outputs in a final experimental submission. The trend is intentionally consistent with the protocol mechanisms and with pre-2019 comparative literature.

Table 1. Representative performance pattern for 60 nodes under increasing mobility.

Speed	Protocol	PDR (%)	Delay (ms)	NRL
2 m/s	AODV	96.2	48	0.24
2 m/s	DSDV	97.0	31	0.42
2 m/s	OLSR	97.5	27	0.46
10 m/s	AODV	93.8	64	0.31
10 m/s	DSDV	90.6	47	0.59
10 m/s	OLSR	92.7	39	0.61
20 m/s	AODV	90.9	81	0.39

20 m/s	DSDV	84.8	65	0.77
20 m/s	OLSR	88.5	54	0.74

At low mobility, all three protocols maintain high PDR because routes remain valid for longer periods. OLSR and DSDV also show lower delay because forwarding tables are already available when packets arrive. As mobility increases, proactive tables require more frequent correction; stale next-hop information and additional topology updates can reduce effective delivery and increase routing cost. This behavior is consistent with the role of periodic control traffic described for proactive protocols (Perkins and Bhagwat, 1994; Clausen and Jacquet, 2003).

AODV shows higher delay than proactive protocols because a broken route can trigger route discovery, but its PDR degrades more gradually in the representative high-mobility case. This is consistent with the on-demand repair principle of AODV (Perkins and Royer, 1999) and with earlier findings that reactive and proactive protocols respond differently to mobility and load (Perkins et al., 2001; Kaur et al., 2016). The NRL trend indicates that no protocol is free from mobility cost: AODV increases control traffic through repeated route requests and errors, whereas DSDV and OLSR must refresh routing information more often.

Density should be interpreted jointly with mobility. More nodes can provide additional alternate paths, but they can also increase contention and control overhead. Pre-2019 evaluations reported that node count and network size can materially change PDR, throughput, delay, and packet loss (Al-Dhief et al., 2018; Jubair et al., 2018; Jasim, 2018). Therefore, a defensible conclusion should be based on the full matrix of speed and density scenarios rather than on the 60-node example alone.

Conclusion and Discussion

This paper presents a reproducible methodology for evaluating AODV, DSDV, and OLSR under dynamic MANET conditions. The design varies mobility and node density while holding radio and traffic parameters constant, and it evaluates packet delivery ratio, throughput, end-to-end delay, and normalized routing load across repeated random seeds. The literature and representative analysis indicate clear trade-offs rather than a universal winner. Proactive protocols can provide low forwarding delay because routes are maintained continuously, but their control cost rises as topology changes accelerate. Reactive AODV avoids continuous full-table maintenance and can adapt to route

failure, although route discovery and repair increase delay. The main methodological implication is that MANET routing should be evaluated as a multi-factor problem. Mobility, density, traffic level, and metric selection can change the interpretation of protocol performance, as demonstrated across foundational and 2018 studies (Broch et al., 1998; Abolhasan et al., 2004; Chandan et al., 2018; Susanto et al., 2018). A final implementation should execute all scenarios in NS-3, report confidence intervals, and preserve simulation scripts and seed values for replication. Future extensions can add energy consumption, TCP traffic, obstacle-aware propagation, security attacks, and alternative mobility models.

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