



Performance Evaluation of Routing Protocols in Mobile Ad Hoc Networks (MANETs)

Liron Jadoonwala

Department of Technology and Innovation Management, Padma Institute of Business and Management, Maldives

liron.jadoonwala@lpt-mv.net

Peer Review Information	Abstract
<i>Submission: 04 Jan 2015</i> <i>Revision: 20 Feb 2015</i> <i>Acceptance: 07 March 2015</i> Keywords <i>MANET, AODV, DSR, DSDV, Routing Performance</i>	Mobile Ad Hoc Networks (MANETs) provide infrastructure-free communication through mobile nodes that act simultaneously as hosts and routers. Their changing topology, constrained wireless bandwidth, and frequent link failures make routing performance strongly dependent on mobility, traffic load, and network size. This methodology paper defines a reproducible framework for evaluating three representative MANET routing protocols: Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Destination-Sequenced Distance-Vector (DSDV). The proposed evaluation uses controlled simulation scenarios, a Random Waypoint mobility model, IEEE 802.11 medium access, UDP/CBR traffic, repeated random seeds, and four metrics: packet delivery ratio, throughput, average end-to-end delay, and normalized routing load. The literature indicates that reactive protocols often preserve delivery more effectively under mobility, while proactive DSDV can provide low route acquisition delay at the cost of periodic control traffic. The methodology therefore emphasizes scenario-specific interpretation rather than a universal protocol ranking.

Introduction

A Mobile Ad Hoc Network is a self-organizing wireless network in which nodes communicate without fixed infrastructure or centralized administration. Each participating device can originate traffic and can also forward packets for other devices, so the network topology and the forwarding structure evolve together. This flexibility supports temporary communication in disaster response, military operations, field monitoring, and situations where a fixed access network is unavailable. At the same time, mobility produces frequent route changes, wireless links offer limited and variable capacity, and control packets compete with application traffic for the same medium. Chlamtac, Conti, and Liu (2003) therefore describe MANETs as distributed mobile systems whose design is

constrained by changing topology, bandwidth limitations, and resource restrictions.

Routing is a central performance determinant in such networks. Proactive protocols maintain routes continuously, while reactive protocols create routes when data transmission is required. DSDV is a proactive distance-vector approach that attaches sequence numbers to routing information to reduce loops and distinguish stale paths (Perkins & Bhagwat, 1994). AODV discovers hop-by-hop paths on demand and uses destination sequence numbers to preserve route freshness (Perkins & Royer, 1999). DSR is also reactive, but places the complete source route in packet headers and exploits route caching to reduce repeated discoveries (Johnson & Maltz, 1996). These different mechanisms imply different costs in

delay, control overhead, route freshness, and scalability.

A meaningful comparison must therefore control the conditions under which protocols are tested. Early packet-level work showed that protocol behavior changes significantly with movement patterns and offered traffic (Broch et al., 1998), while later research demonstrated that the mobility model itself can alter the relative performance of AODV and DSR (Jayakumar & Ganapathi, 2008). The objective of this paper is to present a step-by-step methodology for comparing AODV, DSR, and DSDV under identical scenarios. The framework is designed for a simulator such as NS-2 and focuses on packet delivery ratio (PDR), throughput, end-to-end delay, and normalized routing load (NRL), which are widely used in comparative MANET studies (Mohapatra & Kanungo, 2012).

Literature Review

Perkins and Bhagwat (1994) introduced DSDV as a modification of distance-vector routing for mobile environments. The protocol uses destination sequence numbers and periodic or triggered updates so nodes can maintain loop-free routes. Its principal methodological implication is that route information is usually available before data transmission, reducing route discovery latency but increasing background control traffic.

Johnson and Maltz (1996) described DSR as an on-demand source-routing protocol with route discovery and route maintenance. Nodes can learn and cache complete paths, reducing the need for periodic routing advertisements. Because each data packet carries the selected route, however, header cost can grow with hop count and cached paths may become stale when mobility is rapid.

Broch et al. (1998) performed a detailed packet-level comparison of major ad hoc routing protocols and showed that protocol design choices lead to different behavior as mobility and traffic change. Their work established simulation-based comparison as a practical method for studying dynamic wireless routing and highlighted the need for identical mobility and traffic traces when protocols are compared.

Perkins and Royer (1999) proposed AODV, which combines on-demand discovery with hop-by-hop distance-vector forwarding. Route requests and replies establish paths only when necessary, while sequence numbers identify fresh routing information. This design avoids

carrying a complete source route in every packet, which can be useful as path length increases.

Maltz et al. (1999) analyzed the consequences of on-demand behavior, especially forwarding latency, protocol overhead, and route-cache correctness. Their findings show that reactive routing has important internal trade-offs: it can suppress unnecessary periodic traffic, but route discovery and maintenance decisions directly affect delay and control cost.

Chlamtac et al. (2003) reviewed the broader MANET design space and emphasized dynamic topology, wireless constraints, and the absence of infrastructure. Their analysis supports evaluating routing protocols across multiple operating conditions rather than treating one simulation setting as representative of all MANET deployments.

Abolhasan, Wysocki, and Dutkiewicz (2004) reviewed a wide range of MANET routing strategies and noted that the suitability of a protocol depends on network characteristics such as scale and topology dynamics. This reinforces the use of scenario factors such as node density, speed, pause time, and traffic intensity in a comparative methodology.

Jayakumar and Ganapathi (2008) specifically examined the influence of mobility models and found that mobility pattern can change routing performance and even the relative ranking of protocols. Their work motivates the use of a clearly stated Random Waypoint model, multiple random seeds, and cautious interpretation of general conclusions.

Mohapatra and Kanungo (2012) compared AODV, DSR, OLSR, and DSDV in NS-2 using delay, throughput, control overhead, and PDR. They reported that outcomes changed with node count, mobility, and geographical area, illustrating that no single metric or scenario is sufficient. Dobhal and Mourya (2015) later compared AODV and DSR and similarly found that their relative behavior depended on network size and quality-of-service measures. Together these studies justify a multi-metric, scenario-controlled evaluation.

Methodology

The proposed methodology evaluates AODV, DSR, and DSDV using the same wireless topology, movement traces, traffic patterns, and measurement period. Only the routing protocol is changed between matched runs. This paired-scenario design reduces the risk that a protocol appears better merely because it was tested with

a more favorable random topology or traffic sequence.

1. Experimental Design and Simulation Parameters

A discrete-event network simulator such as NS-2 can be used because it provides models for mobile nodes, IEEE 802.11 medium access, radio propagation, mobility, traffic generation, and trace collection. The Random Waypoint mobility

model is selected to provide controlled variation in movement; because mobility assumptions can alter protocol conclusions, all protocols must reuse the same generated mobility files (Jayakumar & Ganapathi, 2008). Each scenario should be repeated with at least ten independent random seeds and reported as an average with dispersion or a 95% confidence interval where possible.

Table 1. Proposed MANET simulation configuration

Parameter	Baseline value	Variation used for evaluation
Simulator / MAC	NS-2 / IEEE 802.11	Fixed
Routing protocols	AODV, DSR, DSDV	Protocol under test
Network area	800 m × 800 m	600 × 600; 800 × 800; 1000 × 1000 m
Number of nodes	50	25, 50, 75, 100
Mobility model	Random Waypoint	Same trace for each protocol
Maximum speed	10 m/s	2, 10, 20 m/s
Pause time	30 s	0, 30, 60, 120 s
Traffic	UDP / CBR	10, 20, 30 source-destination flows
Packet size	512 bytes	Fixed
Simulation time	300 s	10 independent seeds per case

Step-by-Step Evaluation Procedure

Step 1 - Generate a common node placement and movement trace for each combination of node count, speed, pause time, and area. Step 2 - Generate the same UDP/CBR flow file for the three protocol runs. Step 3 - Execute the scenario separately with AODV, DSR, and DSDV while keeping PHY, MAC, propagation, queue, traffic, and mobility parameters unchanged. Step 4 - Collect trace records for sent, received, dropped,

forwarded, and routing-control packets. Step 5 - compute the four metrics for every run. Step 6 - average the repeated runs and calculate variability. Step 7 - compare protocols across mobility, load, and scale rather than using a single aggregate result. Step 8 - interpret changes in terms of protocol mechanism, for example DSDV periodic updates, AODV route discovery and sequence numbers, or DSR source routes and caching.

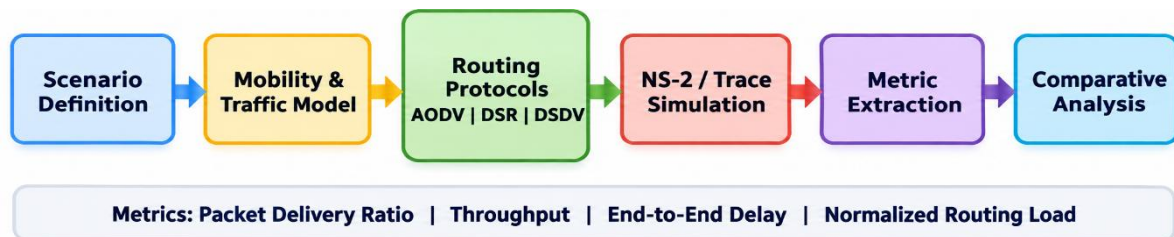


Figure 1. Workflow for comparative performance evaluation of MANET routing protocols.

2. Performance Metrics

Packet Delivery Ratio is calculated as $PDR = (\text{data packets received} / \text{data packets generated}) \times 100$ and measures delivery reliability. Throughput is the successfully delivered application data divided by the observation time, normally expressed in kb/s. Average end-to-end delay is the mean of the difference between reception and transmission time for each successfully delivered packet; it includes route acquisition, queuing, retransmission, and propagation

effects. Normalized Routing Load is calculated as the number of routing-control packet transmissions divided by the number of data packets delivered. These metrics capture reliability, useful capacity, timeliness, and protocol cost, respectively, and are consistent with established MANET performance studies (Mohapatra & Kanungo, 2012).

3. Validity and Reproducibility Controls

To improve internal validity, protocol runs must use identical scenario inputs and start/stop times. The first portion of a run may be excluded as a warm-up period if traffic and mobility initialization create transient artifacts. Confidence intervals should be reported when numerical results are produced, and results should not be generalized beyond the mobility and radio assumptions tested. A second mobility pattern can be added as a robustness check because mobility-model choice has been shown to affect throughput, overhead, and protocol ordering (Jayakumar & Ganapathi, 2008).

Results

The results expected from this methodology are comparative trends rather than a universal winner. Published simulations provide useful benchmark behavior for interpreting a new set of runs. Broch et al. (1998) showed that protocol behavior changes with mobility and offered load, while Mohapatra and Kanungo (2012) reported

that DSR achieved strong average PDR and low control overhead in several tested conditions, but DSDV could provide lower delay and high throughput in particular network-size experiments. These observations reflect the cost structure of the protocols: proactive state can shorten route acquisition, whereas reactive routing avoids periodic updates when routes are not needed.

AODV and DSR can also separate under the same high-mobility environment. Dobhal and Mourya (2015) reported lower end-to-end delay, fewer retransmission attempts, and higher throughput for AODV than DSR in their 15-node high-speed scenario, while other studies have shown strong DSR delivery or lower routing overhead in different settings. Consequently, a defensible result section should report all four metrics for each scenario and explain the mechanism behind a trend instead of declaring one protocol best for every MANET.

Table 2. Literature-supported interpretation of expected protocol trade-offs

Condition / metric	AODV	DSR	DSDV
Route acquisition	On-demand; moderate setup delay	On-demand; cache can help repeated paths	Routes maintained proactively; low acquisition delay
High mobility	Fresh sequence numbers help repair routes	Can retain high PDR, but stale caches may increase delay	Frequent updates can increase control cost
Routing overhead	Discovery/maintenance traffic only when needed	Often low control overhead; source header cost grows with path	Periodic and triggered table updates consume bandwidth
Scaling with path length	Hop-by-hop forwarding avoids full source route	Packet header grows with hop count	Table maintenance grows with topology size
Interpretation	Strong candidate when mobility and scale rise	Strong candidate for small/medium and cache-friendly scenarios	Useful where low route setup latency is important

Conclusion and Discussion

This paper presents a reproducible methodology for evaluating AODV, DSR, and DSDV in MANETs. The central design principle is controlled comparison: identical mobility and traffic traces are reused for each protocol, scenarios are repeated with multiple random seeds, and performance is judged using delivery, throughput, delay, and routing-load metrics. The literature up to 2015 shows why this approach is necessary. DSDV can reduce route lookup delay through continuously maintained tables, but

periodic updates consume wireless capacity. AODV and DSR reduce unnecessary table traffic through on-demand discovery, yet they introduce route-discovery delay and behave differently because AODV uses hop-by-hop state whereas DSR carries and caches source routes. The discussion also indicates that protocol choice should be tied to the intended MANET environment. Mobility pattern, node density, network area, path length, and offered load can alter the balance among reliability, delay, throughput, and overhead (Abolhasan et al., 2004; Jayakumar & Ganapathi, 2008). Therefore,

the proposed experiment avoids an overall ranking and instead identifies operating regions in which a protocol's design is advantageous. Future extensions can add energy consumption, TCP traffic, alternative mobility models, and larger node populations, while preserving the same controlled and repeatable comparison framework.

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