# Simulation and Evaluation of MANET Routing Protocols for Educational Purposes

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***Abstract*—**A Mobile Ad-hoc Network (MANET) is a collection of self organized wireless mobile nodes dynamically forming a temporary network without the aid of any fixed infrastructure and centralized administration control stations. In this paper the Network Simulator 2 (ns2) is used in order to compare and evaluate some of the most popular routing protocols for MANETs: namely the DSDV and the DSR. The work can be used as an educational paradigm as the ns2 is a free and widely used simulation environment.

***Keywords;*** *MANET; ns-2; routing protocols; educational scenarios*

## I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a collection of self-organized wireless mobile nodes dynamically forming a temporary network without the aid of any fixed infrastructure and centralized administration control stations. A node can move anytime in an ad hoc scenario and, thus a routing protocol is needed which can adapt to the dynamically changing wireless topology. However, since there is no fixed infrastructure in this network, each mobile node operates not only as a node but also as a router forwarding packets from one node to other mobile nodes in the network that are outside the range of the sender. Routing, as an act of transporting information from a source to a destination through intermediate nodes, is a fundamental issue for networks [1], [2].

MANETs have many applications: they can be used in military communication and operations, in search and rescue operations, in commercial and civilian environments, in home and enterprise networks, in entertainment, in sensor networks, in context aware services and in education. Several protocols have been proposed for MANETs. In this paper we focus on the operation of the two of the most popular routing protocols which are: the Dynamic Source Routing (DSR) and the Destination-Sequenced Distance Vector (DSDV). As a tool in our work we use the Network Simulator 2 (NS-2) which is an open source freeware software which has become a popular tool for modeling networks at many universities and academic communities [3], [4].

This paper attempts to compare the two most popular routing protocols mentioned above by constructing simple simulation scenarios. This can be very useful for educational purposes, in order for students to comprehend the fundamental differences of proactive and reactive routing protocols.

The rest of the paper is organized as follows: in Section II a brief overview of the DSDV and DSR routing protocols is provided. The simulation scenario and the simulation results are described in Section III and Section IV respectively. The paper is concluded in Section V.

## II. MANET ROUTING PROTOCOLS

In this section, a brief description of DSDV and DSR routing protocols is given.

### A. *Destination-Sequenced Distance Vector*

The Destination-Sequenced Distance Vector (DSDV) routing protocol [1], [2] is a proactive routing protocol which is based on the Bellman-Ford algorithm. Each node in the network maintains a routing table which contains all available destinations with associated next hop towards them, metric and destination sequence numbers. Routing tables are updated by exchanging periodic messages (routing information) between mobile nodes. Each node periodically broadcasts its routing table to its neighbors. Broadcasting of the information is done with Network Protocol Data Units (NPDU) in two ways: a full dump and an incremental dump. A full dump requires multiple NPDUs, while the incremental requires only one NPDU to fit in all the information. A receiving node updates its table if it has received a better or a new route. When an information packet is received from another node, the receiver compares the new sequence number with the available sequence number for that entry. If that sequence number is larger, the entry will be updated with the new sequence number. If the information arrives with the same sequence number, the metric entry will be required. If the number of hops is smaller than the previous entry, the table will be updated. Update is performed periodically or when a significant change in the routing table is detected since the last update. If the network topology changes frequently, a full dump will be carried out, since an incremental dump will cause less traffic in a stable network topology. Route selection is performed according to the metric and sequence number criteria. The sequence number represents also the time indication that the destination node sends, allowing routing table update. If two identical routes are possible, the route with the larger sequence number will be saved and used, while the other will be destroyed.

### B. *Dynamic Source Routing*

The Dynamic Source Routing DSR protocol [3], [6] is a reactive protocol. It is an on-demand routing protocol that is based on the concept of source routing. This means that the source determines the complete path from the source node to the destination node, which ensures routing to be trivially loop-free in the network. The protocol is designed for use in multi hop ad hoc networks comprised of mobile nodes. It allows the network to be completely self-organized and self-configured without the need of any network infrastructure or administration. DSR does not use periodic routing messages like DSDV, thus reducing the overhead introduced by the protocol. In this way battery consumption is also reduced and large routing updates are avoided. Moreover, it is supported by the MAC layer to identify link failure. The DSR routing protocol discovers routes and maintains information regarding the routes from one node to other by using two main mechanisms:

- Route discovery – finds the route between a source and destination
- Route maintenance – in case of route failure, it invokes another route to the destination.

As the route is part of the packet itself, routing loops, short lived or long lived, cannot be formed as they can be immediately detected and eliminated. This property of DSR opens up the protocol to a variety of useful optimizations. If the destination alone can respond to route requests and the source node is always the initiator of the route request, the initial route may be the shortest. The DSR packet carries all information pertaining to route in its preamble (header) thus permitting the intermediate nodes to cache the routing information in their route tables for future use. Route maintenance is the mechanism by which the node keeps record of the dynamic changes of the network topology. In other words, the source node checks for any link failure between source and destination. If a link failure is found between source and destination, the source node tries to find another route to the destination or invokes route discovery.

## III. SIMULATION SCENARIOS

In this section the experimental setup used in the simulation scenarios is presented. The main goal is to compare the ability of the DSDV and DSR protocols to adapt to dynamic network topology changes while continuing to successfully deliver data packets from source to their destinations. In order to measure this ability, four different scenarios are generated by varying the number of nodes. The first scenario consists of five mobile nodes, the second consists of fifteen mobile nodes, the third consists of twenty mobile nodes and the fourth consists of thirty mobile nodes.

### A. *Simulation Parameters*

The simulation parameters that were used in our experiments are presented in Table I.

TABLE I. SIMULATION PARAMETERS

| **Parameter** | **Value** |
|---|---|
| Simulator | NS 2.26 |
| Routing Protocols | DSDV, DSR |
| MAC Layer | 802.11 |
| Packet Size | 512 Bytes |
| Simulator Time | 150 sec |
| Simulator Area | 1000 m x 1000 m |
| Traffic Type | TCP (FTP) |
| Number of Mobile nodes | 5, 15, 20, 30 |

Figure 1 depicts the simulation scenario where a MANET is formed with five mobile nodes.

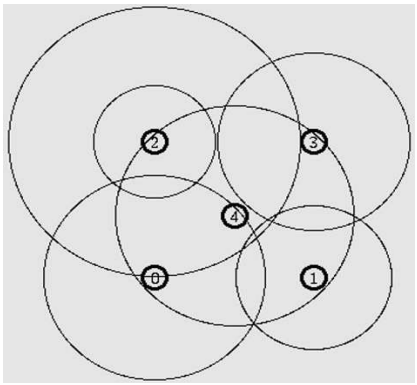


Figure 1. A draw of a five nodes scenario.

### B. *Performance Metrics*

A number of quantitative metrics can be used for evaluating the performance of MANET routing protocols. This metrics are frequently used in the literature [3], [6], [7], [8]. The following metrics were used in the developed simulation scenarios in order to evaluate and compare the performance of the routing protocols:

*a) Packet Delivery Ratio (PDR):* It is the number of data packets delivered to the destination divided by the total number of packets generated by the sources. This metric shows the reliability of the routing protocol. The higher the ratio is, the more complete and reliable is the routing protocol. PDR is given by:

$$PDR = \frac{P_r}{P_s}$$

where $P_r$ is the total number of packets received by a destination and $P_s$ the total number of packets sent by the source node.

*b) Normalized Routing Load (NRL):* It is the number of routing packets transmitted by each node in a network divided by the number of data packets received from the receiver-

nodes. Essentially, it is a metric that indicates the effectiveness of the routing protocol as it pertains to the extra load in the network, the additional packages of information. NRL is given by:

$$NRL = \frac{Routing\_Packets}{Total\_Received\_Packets}$$

*c) End-to-End Delay (E2E):* This metric includes all possible delay that may be caused by: buffering during route discovery, queuing at the interface queue, retransmission delay at the MAC layer, propagation and transfer time. It is defined as the time taken for a data packet to be transmitted across a MANET from source to destination. The E2E metric is given by:

$$E2E = T_r - T_s ,$$

where, $T_r$ is the time that a packet is received and $T_s$ the time that this packet was injected into the network.

## IV. Simulation Results

In this Section the simulation results are presented and analyzed.

Table II summarizes the results for the PDR statistic. It is clear that the DSR protocol exhibits higher PDR values than the DSDV in all four simulation scenarios. This is an expected result since DSR can adapt very rapidly in topology changes that may be caused by node movement, thus allowing for a more effective delivery of data to the destination.

TABLE II. Packet Delivery Ratio

| Scenario | DSDV | DSR |
|---|---|---|
| 5-nodes | 0.9748 | 0.9965 |
| 15-nodes | 0.9806 | 0.9868 |
| 20-nodes | 0.9670 | 0.9938 |
| 30-nodes | 0.9533 | 0.9842 |

DSDV, on the other hand, uses full dump and incremental dump messages in order to find routes in the network. This causes extra overhead on the network and possible queue losses. DSR is obviously a more reliable routing protocol than DSDV.

In Table III the results for the NRL are depicted. Generally speaking, both DSDV and DSR introduce extra load to the network for route discovery. The concept of incremental dumb used by the DSDV reduces its NRL making it a slightly more effective protocol than DSR regarding the routing load.

Last in Figure 2, one may observe the dependence of E2E delay on the routing protocol used and the number of mobile nodes. One can see that the DSR exhibits higher E2E delay figures. This may be attributed to the fact that DSR does not receive frequent routing updates so some of the already known routes may become obsolete while the node topology changes over time.

TABLE III. Normalized Routing Load

| Scenario | DSDV | DSR |
|---|---|---|
| 5-nodes | 0.013 | 0.125 |
| 15-nodes | 0.03 | 0.1 |
| 20-nodes | 0.08 | 0.952 |
| 30-nodes | 0.357 | 1.738 |

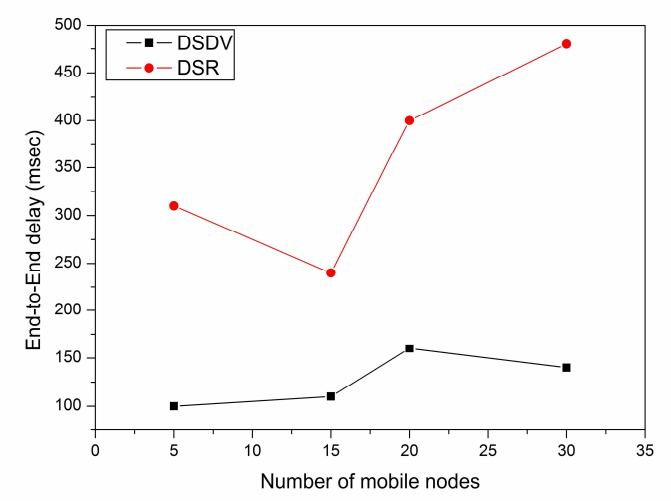


Figure 2. Dependence of the E2E delay on the routing protocol and the number of mobile nodes

## V. Conclusions

In this paper, the Network Simulator 2 was used in order to compare and evaluate some of the most popular routing protocols for MANETs: namely the DSDV and the DSR. This work had an educational purpose as the Network Simulator 2 is a free simulation tool which can be used for modeling networks in many university courses. Furthermore, MANETs have become a part of any advanced networking teaching module in the majority of higher education institutions. It is demonstrated that through simple simulation scenarios a practical view of the functionality of MANET routing protocols can be achieved. This can be an invaluable tool for any university networking course.

## References


[1] Sabina Baraković, Suad Kasapović, and Jasmina Baraković, "Comparison of MANET Routing Protocols in Different Traffic and Mobility Models ", Telfor Journal, Vol. 2, No. 1, 2010.

[2] Azzedine Boukerche, Athanasios Bamis, Ioannis Chatzigiannakis, Sotiris Nikoletseas. "A mobility aware protocol synthesis for efficient routing in ad hoc mobile networks." The International Journal of Computer and Telecommunications Networking, Vol. 52, Issue 1, pp 130-154, Jan, 2008.

[3] Rajeshwar Singh, Dharmendra K Singh, Lalan Kumar, "Performance Evaluation of DSR and DSDV Routing Protocols for Wireless Ad Hoc Networks", Int. J. Advanced Networking and Applications Volume: 02, Issue: 04, Pages: 732-737 (2011).

[4] The Network Simulator – ns-2, available: http://isi.edu/nsnam/ns/.

[5] Azzedine Boukerche, "Algorithms and Protocols for Wireless, Mobile Ad Hoc Networks" , Wy-IEEE Press, 2008.

[6] Bikash Rath and S. Chinara , "Implementing and Comparing DSR and DSDV routing protocols for mobile ad-hoc networking", Department of Computer Science and Engineering National Institute of Technology Rourkela , 2009.

[7] Ajay and Ashwami KumarSingla, "Performance Evaluation of Manet Routing Protocols on the Basic of TCP Traffic Pattern", *International Journal of Information Technology Conference and Services* (IJITCS), Vol.1 No. 5, October 2011.

[8] Harminder S.Bindra, Sunil K. Maaker nad L.Sangal, "Performance Evaluation of Two Reactive Protocols of MANET using Group Mobility Model," *International Journal of Computer Science Issues*, Vol. 7, Issue 3, No. 3, May 2010.