Research paper

# PERFORMANCE MEASUREMENT OF ROUTING ALGORITHMS IN AD-HOC NETWORKS

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## Article Info

## Abstract

The main aim of this article is to show the differences performance between ad-hoc routing algorithms. Here we consider the Bellman-Ford (BF), Ad hoc On Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) algorithms facing different node mobility speed. The study covers the following topics: the algorithms, simulation environment and the comparison of measured values. We can state that the modularity speed of the nodes in ad-hoc networks plays a significant role in the overall performance. We can see that different algorithms have different throughput parameters. For example the DSR is very strong at low speed but at higher speeds it is worse than the AODVR. It is seen that the AODVR and DSR are better at high speed than the BF.

## Introduction

With the enormous growth of importance of portable devices and the development of wireless networks, host mobility is becoming an important issue. The performance of these systems is mainly determined by the chosen routing algorithm.

The routing protocols used in wireless networks may be characterized by several parameters such as end to end delay, packet loss or throughput. Nodes in an ad-hoc network can move freely, and this movement causes the topology change of the network. The broken routes need time to reestablish themselves, and during this time packets sent can't find their destination address. If the nodes move faster the end to end delay and the packet loss increase. I performed several simulations to examine the relation between the mobility speed and performance [1-10].

The goal is to make a simulation which can demonstrate various routing algorithms and to show the relation between node speed and performance. The experiments have to be repeatable. The reason for repeating the simulation several times is to obtain enough data for a more accurate result.

## ALGORITHMS

The Bellman-Ford algorithm [1] solves the single-source shortest-path problem. It allows negative edge weights, but does not allow a directed cycle of negative weight. The Bellman-Ford returns 0, indicating that no solution exists (if it encounters a cycle of negative weight). Otherwise, the algorithm returns 1, indicating that it has found all shortest paths from the source.

The Ad hoc On Demand Distance Vector (AODV) [1] is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It

maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. When a source node desires a route to a destination, it broadcasts a route request packet across the network. Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables.

The Dynamic Source Routing protocol [1] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. All aspects of the protocol operate entirely on-demand, allowing the routing packet overhead of DSR to scale automatically to only that needed to react to changes in the routes currently in use. The protocol allows multiple routes to any destination and allows each sender to select and control the routes used in routing its packets, for example for use in load balancing or for increased robustness. Other advantages of the DSR protocol include easily guaranteed loop-free routing, support for use in networks containing unidirectional links, use of only "soft state" in routing, and very rapid recovery when routes in the network change. The DSR protocol is designed mainly for mobile ad hoc networks of up to about two hundred nodes, and is designed to work well with even very high rates of mobility.

## SIMULATION

The simulation contained 50 nodes placed uniformly on a 1 million square meter terrain. Each node has a random-waypoint (random destinations for every node) mobility model, selected randomly at the start of the simulation. The speed of the nodes changes between 2 and 50 m/s. The radio model is a standard radio model with noise, 2.4e9 frequency and 2Mbit/s bandwidth. The antenna TX-power is set to 10 dBm, the RX-sensitivity and

the RX-threshold is -70 dBm, while the MAC protocol is set to 802.11. With these parameters the radio has a 99.5 m range. To run the simulation I used the very powerful, open source GlomoSim simulator, especially designed for ad-hoc network modeling. Among the nodes there are two special nodes, "Node 0" can generate a constant-bit-rate traffic, while the destination of this traffic is denoted as "Node 49". The dataflow starts at the beginning of the simulation and "Node 0" continuously sends 512kbyte items with 500 millisecond delay between two packet. During the experiment we examined the following node mobility speeds: 2, 5, 7, 10, 30 and 50 meter/second.

## RESULTS

While calculating the results we made an effort to consider only reliable values. Each simulation was performed twice with the same setup we considered more than ten different configurations in every test-case. After the experiment ended, we dropped the highest and the lowest values in every test case (in order to decrease dispersion of the data). Before presenting the results, let us specify some definitions.

*Throughput*: is the speed at which a computer or network processes data end to end. It is a good measure of absolute performance, and shows how many bits per second (bit/s) pass a node.

*End to end delay*: is the time taken for a packet to be transmitted across a network from source to destination.

*Random waypoint model and mobility speed:* Each node randomly selects a destination and moves in that direction with the given speed. After it reaches the destination it stays there for some time (in this case 1ms)

The first experiment was about the relation between node-speed and throughput. The goal was to prove that the speed is inversely proportional to the throughput (if the speed increases than the throughput decreases).
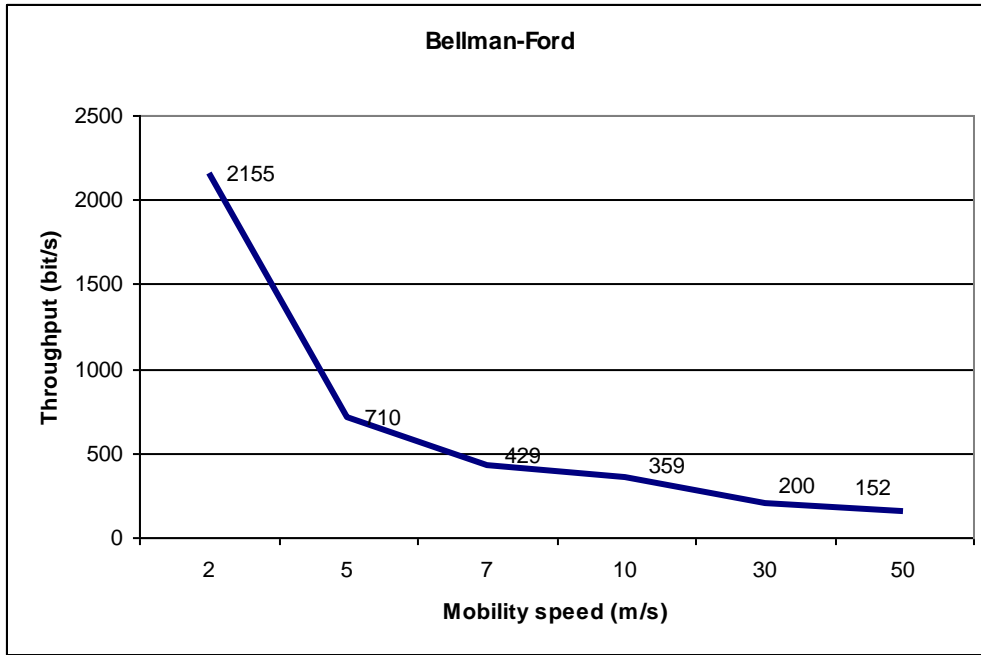
**Bellman-Ford**

Figure 1: Bellman-Ford throughput bitrate

The figure confirms our conjecture to large extent, however, the inverse relation is not accurate (2*2155=4310!=3550=5*710), indicating that there are more parameters in connection this problem. The end to end delay shows the same tendency (slightly deviating from the inverse proportionality):
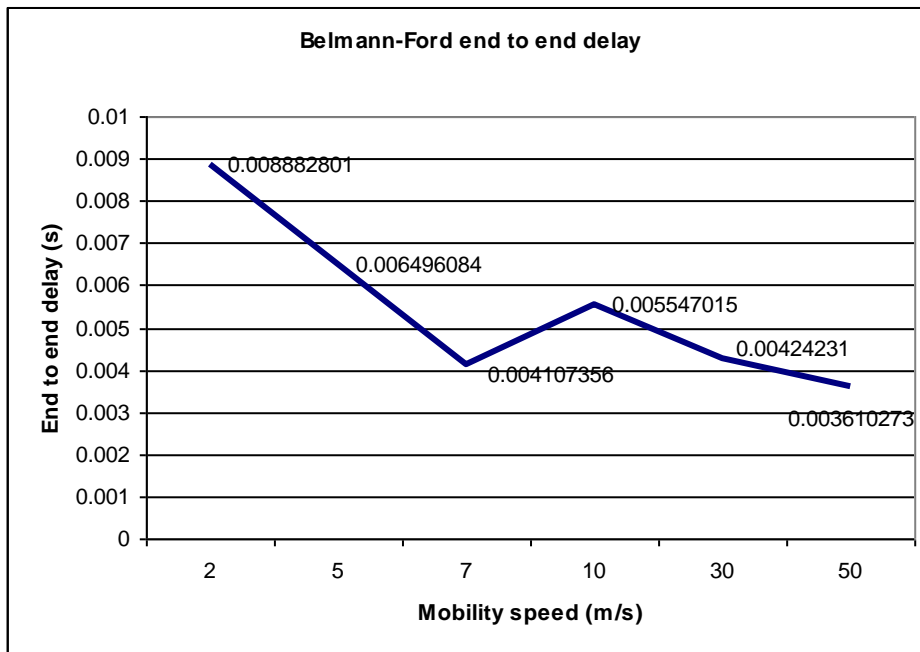
**Belmann-Ford end to end delay**

Fig. 2: Belmann-Ford end to end delay

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There is a strange deviation at 10m/s with a value larger, 7m/s. This little difference is negligible, and probably vanishes for a larger sample, being only a measuring error.

In the second experiment two other routing algorithms were examined. The question was whether every routing protocol responds similarly to the increase of the speed? On figure 3 we can see three different algorithms reacting similarly to the speed. We examined other algorithms too and found the results to be very similar.
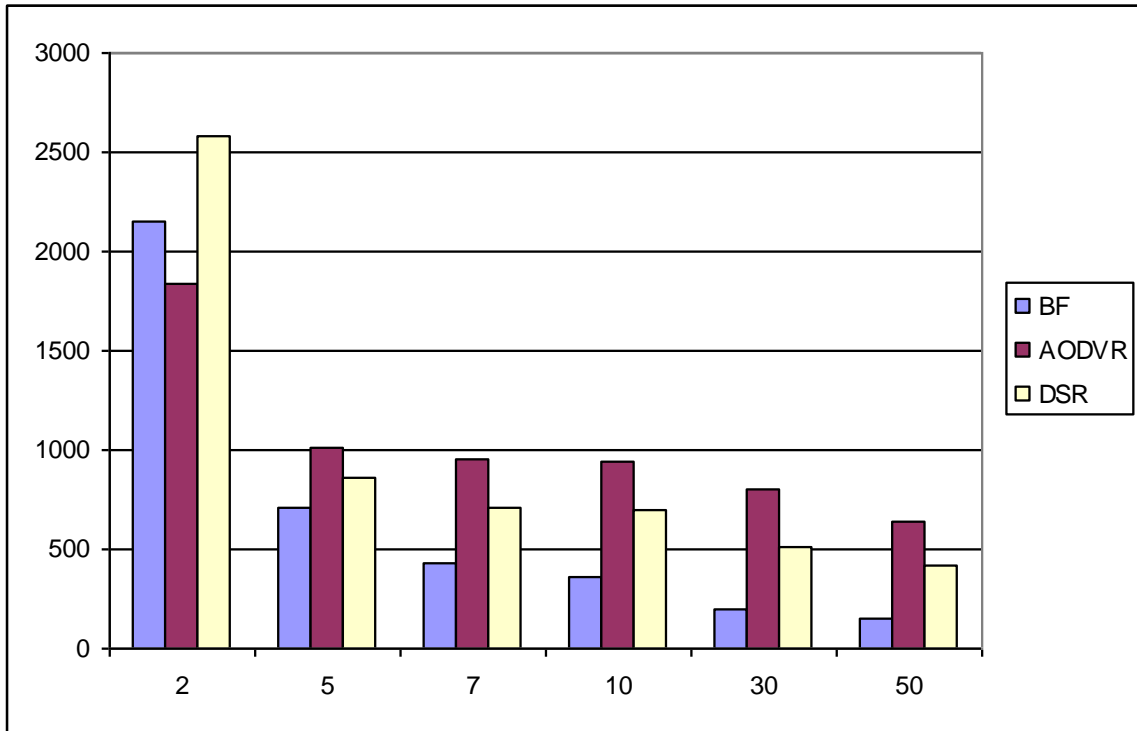


Fig. 3: BF, AODV, DSR troughput bitrate

So, we can state that the modularity speed of the nodes in ad-hoc networks plays a significant role in the overall performance. On the figure we can see that different algorithms have different throughput parameters. For example the DSR is very strong at low speed but at higher speeds it is worse than the AODVR. It is seen from figure 3, that the AODVR and DSR are better at high speed than the BF. However, if we want to find the appropriate algorithm for our ad-hoc network we have to examine the end to end delay as well.
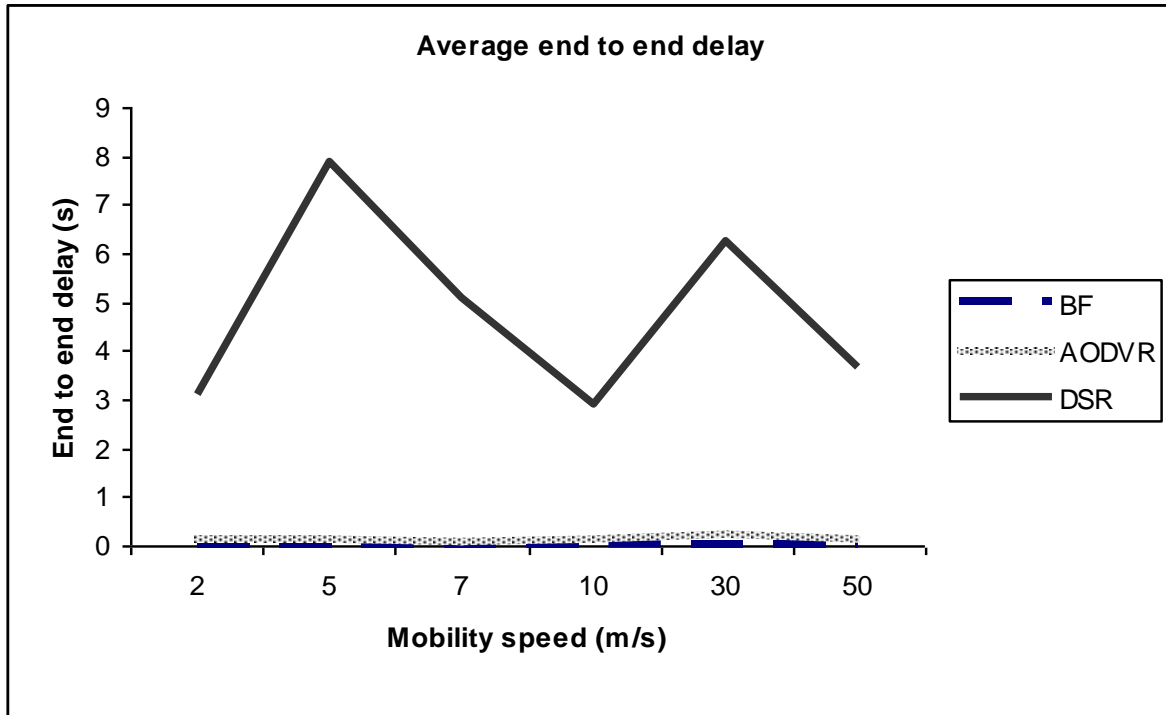
Fig. 4: Average end to end delay

Watching this figure the DSR does not any longer perform so well than before. It acquires large delays at all speeds. Summarizing, if in our network there are lot of mobile nodes, it is preferable to choose the AODVR, otherwise the BF is the better choice. But if the latency is not a big problem for example in streaming video broadcast, we can choose the DSR as well. Considering these values we can make the following table:

Table 1.: Comparison

|       | Latency | Bitrate   | Speed          | Application                  |
|-------|---------|-----------|----------------|------------------------------|
| BF    | Low     | Low       | Very sensitive |                              |
| AODVR | Normal  | Very High | Sensitive      | Real time mobil communication |
| DSR   | High    | High      | Sensitive      | Streaming video (mobil)      |

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