Usability of Destination-Sequenced Distance Vector Routing Protocol Routes

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***Abstract*—The success of fundamental network tasks of traffic delivery from a source to a destination node is mainly dependent on the efficiency of the routing protocol. In mobile ad hoc networks, the effectiveness of routing protocols is additionally demanding due to the dynamic nature of network nodes. In this paper, we dealt with the exploitation of the routes generated using DSDV bellman-ford routing protocol. Through a total of 3960 network simulations with different topologies, network loads and mobility nodes, various parameters of the DSDV were considered. Our results show that there are a large number of unused routes, and techniques for improving the efficiency of routing and reducing routing overhead can be implemented.**

***Index Terms*—routing protocols, networking, network performances, simulations**

I. Introduction

The task of routing protocol is to analyze the state of the network and based on the information exchanged between neighbouring nodes, construct a view of network topology and find the optimal path[1] between remote nodes (if such a path exists). The network topology reflects available destination nodes, and in general, depending on the search path timing, routing protocols can be divided into proactive, reactive, and hybrid. In the former, routes are searched only when needed, usually using flooding techniques [1], [2]. On the other hand, protocols that continuously exchange information about all possible paths are designated as proactive protocols. Such protocols, keep up-to-date information about the state of the network through exchanges of information on network topology or exchanges of routing tables even no data traffic exists [3], [4]. Aiming to simplify the problem by introducing a hierarchical network organization, hybrid protocols are based on the combination of proactive and reactive routing.

Unlike approaches dealing with the efficiency of routing protocols [5]–[7], defining optimal routing metrics [8]–[10] and analyzes of information propagation techniques [11], [12], in this paper, we deal with the practical utilization of routes defined by the proactive routing protocol. That is, we address the following questions: In a network where a proactive protocol is used, how many routes are actually used? More precisely, how much exchange of information on all the routes practically contributes to the utilization of the network? Our results show that a large number of routes in the network are not practically used, and techniques that optimize routing protocols (caching of routing entries, predictive routing, feedback routing and other) can be based on the obtained results to achieve higher routing optimization.

The rest of the paper is organized as follows: Section II provides the basis of proactive routing. The simulation setup is presented in section III while we provide an evaluation of the obtained result and discuss the broader aspects of our approach in section IV. Section V concludes this study and outlines future work.

II. Proactive Routing Protocols

This section provides basic information on the basics of proactive routing through the example of DSDV routing protocol. In the proactive routing approach, nodes are actively involved in route discovery and maintenance even when no data traffic exists. Therefore, routes are built, maintained and prepared for eventual data traffic, which generates more control/routing traffic in low-loaded networks. However, such an approach allows the delay to be reduced as the information on the established paths is ready and known in advance.

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

In this paper, DSDV is used to illustrate the proactive routing approach. We discuss DSDV, according to the definition of Perkins and Bhagwat (1994) [3]. DSDV is based on the distributed Bellman-Ford algorithm where each node maintains two tables of information. For each destination, x, each node i keeps an address of node k that can be used to reach destination x as the next hop. DSDV requires each node to exchange and advertise its routing tables periodically. The traditional DSDV protocol settings are that periodic exchange of routing tables occurs every 15 seconds. Additionally, when receiving a DSDV packet, each node is required to analyze the values and further propagate them over the network to distribute the information to all nodes. There are different approaches to realize a consistent view of the network, and one of them is introducing a deliberate delay of smaller values that are added to 15 seconds to allow nodes to unite changes they receive from other nodes and then propagate merged values further into the network. The process is repeated on all nodes until all nodes receive propagated information. However,

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[1]In this paper, the paths and routes are used as synonyms, which denote the sequential series of nodes for connecting two distant nodes of the network.

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due to its distributed fashion, it is known that such kind of information exchange can lead to short-lived loops. Nodes due to the lack of a consistent view of the state of the network can route traffic using obsolete routing information, which can lead to traffic circulation. The simplest way to avoid the formation of routing loops is to mark routing entries with sequential numbers where a larger sequential number indicates fresher information. Next, each node uses triggered packets for fast propagation of values that can not wait for 15 seconds. However, if possible, the node will strive to merge triggered and periodic changes into one packet to minimize the information being sent. The period in which such an approach is considered is 5 seconds before sending a periodic report [4], [13]. It is important to note that DSDV uses the same message format for both periodicals and triggered reporting.

III. Simulation Setup

This section provides details about the setup of simulations that were used in our experiment.

To measure the amount, frequency and usability of defined routes, we simulated networks with random topologies consisting of 10, 20, 30, 40 and 50 nodes. We considered the impact of node mobility and the number of traffic-generating applications. The simulations were performed using the NS-3 Simulator of version 3.28 [14]. For the same parameters of the number of nodes, the speed of movement, and the number of traffic-generating applications, 10 different scenarios were generated, which resulted in total 3960 simulations. The BRITE topology generator to generate random topologies since it is supported under NS-3 and the source code is freely available [15]. Table I lists the simulation parameters including parameters of WiFi NetDevices which were set to provide a maximal coverage area of 150 m^2 and enable multi-hop communication. Parameters not given here are default parameters of the NS-3 v3.28 simulator.

TABLE I: Parameter values of the simulation

Parameter	Value
Simulation area	1000x1000 m^2
Number of Nodes	10, 20, 30, 40, 50
Number of NetDevices per node	1
Wifi Phy mode	DsssRate11Mbps
Wifi Propagation Delay	Constant Speed Propagation Model
Data Traffic Type	UDP Constant Bit Rate
Data Traffic Rate	512 kbps
Data Traffic Application	OnOffApplication
Mobility Model	Random WayPoint
Mobility Model Pause Interval	Constant (1 second)
Node speed in mobility model	0,1,5,10,15,20,25,30,35,40,45,50 m/s
Total Simulation time	250 seconds

The number of traffic-generated applications is defined depending on the total number of nodes n in the following way:

- Simulations with a total of 1, $n/6$, $n/5$, $n/4$, $n/3$, $n/2$ and $n-1$ traffic applications are performed.
- For each of the applications, a node is randomly selected from the $(0,(n/2)-1)$ range of nodes and the source traffic application is installed on the selected node.
- For each of the applications, a node is randomly selected from the $(n/2,n-1)$ range of nodes and the destination traffic application is installed on the selected node.

Therefore, the network was loaded with traffic of constant intensity generated from randomly selected sources towards randomly selected destination nodes. In all simulations, UDP constant bit rate (CBR) OnOff applications with rate of 512 kbps were used.

To analyze the influence of mobility, we simulated networks using random waypoint mobility model with constant pause interval of 1 second and speeds of 0, 1, 5, 10, 15, 20 25, 30, 35, 40, 45 and 50 m/s. Further, the DSDV routing tables are extended to keep information about the usage of routing entries. That is, each time the new entry to the routing table is added, the column ”entriesUsed” is set to 0. The DSDV routing protocol is extended to increase the value of the field ”entriesUsed” each time the routing entry is used. It is important to note, that local lookup actions[2] are excluded from modifying the field since no routing actions are taken in such queries. Table II shows the example of extended DSDV routing table with ”EntriesUsed” column included. No other changes to the simulator source code have been made in either the DSDV module or other modules. Thus, all simulations performed used the unchanged original source-code of the NS-3 simulator with the modification described above that allowed the monitoring of the DSDV route usage.

IV. Simulation Results and Discussion

This section provides basic results of the simulations conducted in our experiment.

A. Paceket Delivery Ratio and Delay

Fig. 1 shows the packet delivery ratio (the ratio of received and sent application packets) for different values of mobility. It shows that for the static network (mobility is 0 m/s) the PDR and the average delay (show in Fig. 2) values are maximal. However, with the increase of mobility, the values are reduced. For mobility values of 50 m/s, the PDR is slightly increased since the faster movement of nodes allows the faster and better utilization of network resources but with increased delay as it can be concluded from Fig. 2.

B. Forwarding Actions

When the mobility of network nodes is increased, the routes are less stable, and multiple forwarding actions are needed to reach a final destination. Fig. 3 shows the impact of mobility on forwarding actions depicting that for values of 10 and 15 m/s the maximal number of forwarding actions are recorded. When the network nodes move too fast, it is challenging to find suitable routes (as evident from PDR values) and forwarding actions are reduced as well.

[2]Local lookup actions include lookups whether a packet with DSDV entries carries new routing information or the information already exists in the local routing table.

TABLE II: The example of DSDV routing table with the "EntriesUsed" column

Destination	Gateway	Interface	Hops	SeqNum	Lifetime	SettTime	EntriesUsed
10.1.1.1	10.1.1.1	10.1.1.3	1	4	0.018s	5.000s	6
10.1.1.4	10.1.1.4	10.1.1.3	1	6	0.006s	5.000s	3
10.1.1.255	10.1.1.255	10.1.1.3	0	6	0s	0s	61

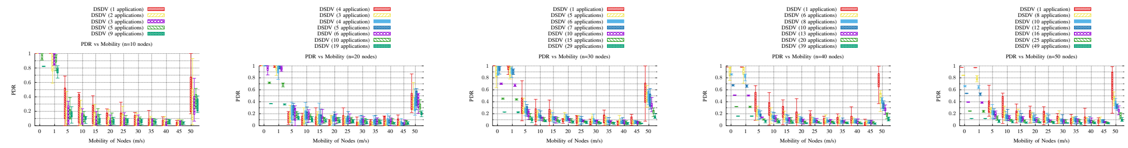

Fig. 1: Packet Delivery Ratio (the ratio of received and sent application packets) vs Mobility.

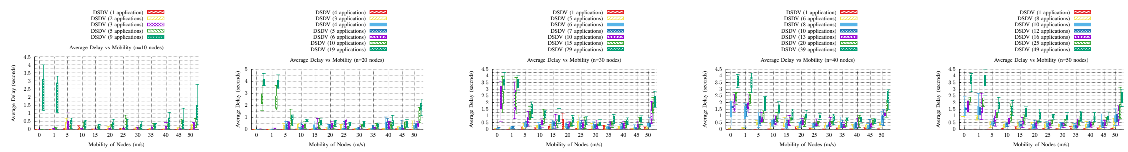

Fig. 2: Average delay of application packets vs Mobility.

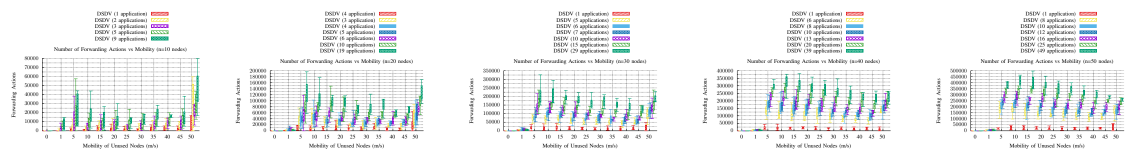

Fig. 3: Number of forwarding actions vs Mobility.

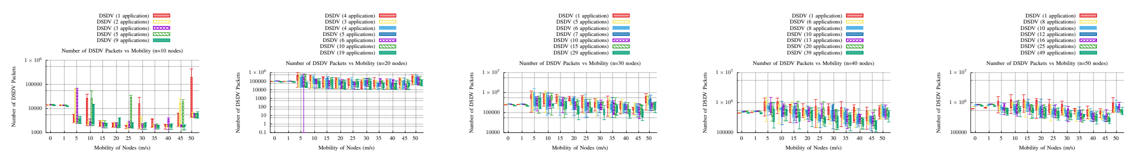

Fig. 4: Total number of exchanged DSDV routing packets vs Mobility.

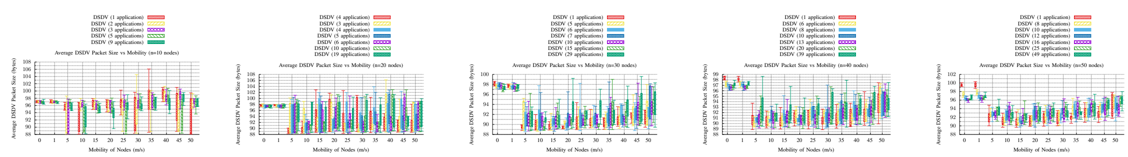

Fig. 5: Average size of DSDV routing packet vs Mobility.

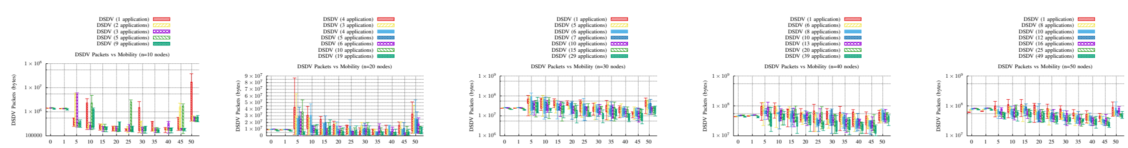

Fig. 6: Overall size of DSDV routing packet vs Mobility.

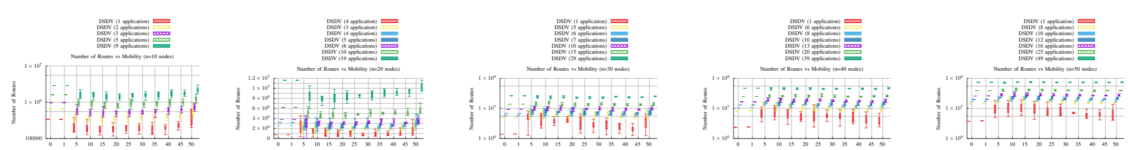

Fig. 7: Total number of DSDV routes vs Mobility.

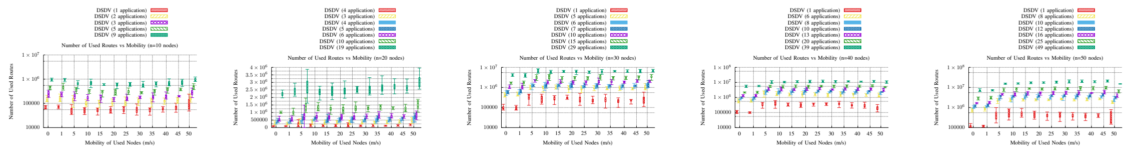

Fig. 8: Total number of used DSDV routes vs Mobility.

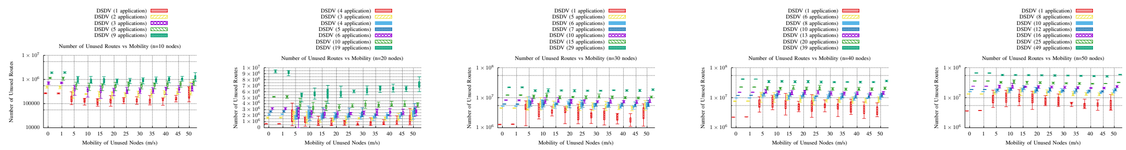

Fig. 9: Total number of unused DSDV routes vs Mobility.

C. Routing Data

As expected, for a network with more nodes, there are more routing packets to exchange, as shown in Fig. 4. However, the number of routing packets decreases when mobility increases. For static networks (mobility 0 m/s) the number of exchanged routing packets is fixed regardless of traffic load. However, the number of triggered DSDV packets (packets not waiting for 15 seconds of periodic route update interval) is increasing when mobility increases. As shown in Fig. 5 and Fig. 6, the size of routing packets varies for different mobility but in general the advertise packets are decreasing for increased mobility (Fig. 6).

D. Route usage

Our results show that in average 19.428% of generated and exchanged routing tables are used[3]. In networks with 10 nodes the average usage of routing entries is 32.788%, in networks with 20 nodes the average usage is 20.505%, in networks with 30 nodes the average usage is 16.847%, in networks with 40 nodes the average usage is 15.897% while in networks with 50 nodes the average usage is 14.942%. Fig. 7 shows the overall number of established routes, Fig. 8 shows the number of used routes while Fig. 9 shows the overall number of unused routes.

It is worth considering the impact of network load. When the network is loaded with only one application generating the traffic, the average route usage was 26.52% for n=10 nodes; 13.62% for n=20 nodes; 8.01% for n=30 nodes; 5.842% for n=40 nodes and 4.806% for n=50 nodes. When the network is loaded with additinal traffic in the way that each node is either source or destination of application traffic, the average route usage was 38.4% for n=10 nodes; 28.163% for n=20 nodes; 24.595% for n=30 nodes; 22.692% for n=40 nodes and 22.137% for n=50 nodes.

TABLE III: Minimum, maximum, and average route usage statistics for different network loads and networks of 10, 20, 30, 40, and 50 nodes.

		Route Usage (%)		
Nodes	Applications	Min	Max	Average
10	1	0.119	0.468	0.265
10	2	0.179	0.516	0.298
10	3	0.181	0.572	0.328
10	5	0.219	0.530	0.353
10	9	0.271	0.556	0.394
20	1	0.064	0.341	0.136
20	3	0.09	0.303	0.181
20	4	0.09	0.288	0.183
20	5	0.09	0.321	0.196
20	6	0.11	0.349	0.214
20	10	0.123	0.343	0.243
20	19	0.170	0.416	0.281
30	1	0.039	0.161	0.08
30	5	0.067	0.219	0.141
30	6	0.067	0.259	0.154
30	7	0.07	0.239	0.158
30	10	0.089	0.304	0.189
30	15	0.090	0.316	0.209
30	29	0.121	0.327	0.245
40	1	0.033	0.106	0.058
40	6	0.053	0.291	0.140
40	8	0.054	0.258	0.151
40	10	0.054	0.247	0.163
40	13	0.067	0.275	0.177
40	20	0.067	0.285	0.194
40	39	0.097	0.338	0.226
50	1	0.025	0.094	0.048
50	8	0.041	0.205	0.127
50	10	0.052	0.229	0.142
50	12	0.051	0.243	0.152
50	16	0.053	0.259	0.164
50	25	0.060	0.289	0.190
50	49	0.084	0.327	0.221

V. Conclusion

This paper addressed the question of the usability of destination-sequenced distance vector routing protocol routes. The work summarized the measurements that were performed using NS-3 v3.28 [4] simulator with BRITE random topology generation. Our measurements of 3960 simulations, showed that, in general, 19.32% routes were used. In the best case,

[3]Here, we explicitly refer to the records that exist in routing tables and were used for routing.

[4]The latest version of the simulator that was available at the time of experimenting. However, no significant changes to the modules: DSDV, mobility were not made in version 3.29 and 3.30 (https://www.nsnam.org/news/2019/08/21/ns-3-30-released.html), and we are convinced that identical results can be achieved using the versions mentioned above of the NS-3 simulator.

the usage of DSDV routes with the value of 43.07% was recorded in the network with ten nodes where each node was used as either a source or destination of application data. That is, the rest of the exchanged routes were not used. The obtained results show there is an open space for improving the efficiency of routing and reducing routing overhead data which is important from various aspects (such as energy consumption in sensor and wireless networks and other).

The main contribution of this paper is the analysis of the performance of DSDV routing protocol for different settings mobile ad-hoc networks considering mobility, a number of nodes and network load. Our future work will focus on techniques and approaches for improving the reduction of routing overhead and increasing the practical usability of routing entries. Also, we plan to gain knowledge and comparable results when investigating different routing protocols.

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