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Multi-hop Wireless Network: A Comparative Study for Routing Protocols Using OMNET++ Simulator

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Abstract

The growth of ad hoc networks which occurred in the last few years results in an improvement in routing protocols to handle multi-hop communications. The multi-hop communication is the most suitable solution to overcome the limitation of transmission range of mobile terminals. The selection of routing protocol among the existing ones is a crucial issue, and based on its performance. Thus, in this work the performance of four well-known routing protocols named DSR, AODV, OLSR and DSDV was evaluated based on ad hoc network size (number of nodes). In this work, we have achieved several simulation scenarios to estimate the performance of the mentioned protocols. Results have been achieved by using OMNet++ simulator and we have considered three metrics which are: end-to-end delay, collision and packet delivery ratio for comparison purpose. This metrics are compared based on the number of nodes which have directly affected the number of hops.

Keywords: *MANET, DSR, AODV, OLSR, DSDV, Ad hoc*

1. Introduction

Ad-hoc network is a concept that allows to create a network for temporary purpose or to communicate with decentralized flexible networks. In ad-hoc network there is no central control for network performance and its mechanism. In the ad-hoc networks, every Mobile Terminal (MT) joining in the network has both functionalities which acts as a host when is wants to send its data or to request and other information and it acts as a router by forwarding the packets coming from MTs and intended to other MTs so it is important to take in consideration the routing protocols. Ad-hoc network protocols have their characteristics in which some of them are working only on demand. The topology of ad-hoc network is dynamic which consider most important features because of MTs mobility. MTs positions change very repeatedly, which bring the need to routing protocols that are able to accommodate with topology changes.

MTs in an ad hoc network can comprise of laptops group, personal digital assistants and smart phones which have a very limitation in their resources such as CPU, bandwidth storage capacity, and battery power. This means that the routing protocol should take these limitations in account and try to find the optimal solution that reduce the traffic, increase the capacity and minimizing the energy consumption [1][19][20][22].

Routing protocols should try to enhance the performance in order to maximize the network lifetime as long as possible especially in case of multi-hop route from source to destination [18][21].

Ad hoc network is infrastructure-less type their topology changes dynamically and the communication links are wireless. Nodes work as routers and the formed routes changes dynamically and they are temporary. Several routing protocols have been suggested in the literature handle multi-hop ad hoc networks. Each protocol has its own structure and particular principles. In this paper, four routing protocols in ad hoc network have been analyzed and their performance is compared. The comparative performance of the multi-hop is shown in the simulation of wireless routing protocols: DSR, AODV, OLSR and DSDV [2].

1.1 Dynamic Source Routing (DSR) Protocol

DSR is dynamic source routing is one of common routing algorithm for mobile network. DSR is considered a member of on-demand routing protocol group which reduces the network overhead. It is preferred when the mobility is low. It has two main stages, rout discovery and rout maintenance. The algorithm steps as following. If any node wants to communicate with any other node, first it will check its route cache if the route to the destination node already known to it. If it doesn't know a route to that destination node, then it will initiate a rout discovery method. And that will be done by

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sending a route request message. When the next node to source received that route request packet it will do the same as source node by checking its cache does it have a path to the destination node. If the node doesn't know the path then it attaches its ID to the request packet and transmits the request packet to the next nodes; this mechanism continuous till the request packet either reaches to node that already knew a path to the destination or the needed destination itself receives the request packet. In this case, the node responds with a route reply packet appending with a list of the nodes that forwarded the request packet route until reached the destination. This setup the routing information needed by the source, which then forwards its information packets to the destination using the discovery mechanism route[3][4][5].

1.2 Ad-hoc On-demand Distance Vector (AODV) Protocol

AODV is a reactive protocol promoted in 2003 by two universities which are University of California, and University of Cincinnati. AODV has mixed features of two known protocols one is table-driven protocol DSDV and another is reactive protocol DSR. AODV is designed to work on mobile ad-hoc networks by creating the routes only when it is required to know the destination address. AODV uses a traditional way to keep the destination addresses by assigning one entry in the routing table for everyone. AODV also uses the sequence number to keep its information updated and to try to be loop free. AODV also uses the timers to discard the route that becomes stale and to determine the packet age [6][7].

1.3 Optimal Link State Routing (OLSR) Protocol

It is one of proactive protocols. It works as a table driven. It is obtained from the traditional Link state algorithm. It is optimized for MANET. It minimizes the flooding control messages by sending link state packets to multipoint relays (MPRs). A Node with high connectivity is candidate to be selected as MPR. MPR node might decide to submit just links between its MPR selectors and itself. OLSR grants optimal routes[4], [7].

1.4 Destination-Sequenced Distance Vector (DSDV) protocol

Destination-Sequenced Distance-Vector Routing (DSDV) is table-driven routing protocol in ad hoc mobile networks depending on the Bellman-Ford algorithm. The DSDV protocol assumes that every node in the topology works as a router so that could be utilized in mobile ad hoc networks. In this routing protocol, a table contains the destination ID, the ID of the next node in the short distance route to the destination node, and the shortest distance metric to the destination node. Every node in the topology preserving a table has a list of all reachable destinations in the network and how many hops that nodes are far from it. Each route leads to the destination labeled with a sequence number. The always used route is the route which labeled with the greatest sequence number. The sequence number also helps to distinguish the new from the old routes, thereby preventing the loops. The nodes send their routing tables periodically to the nodes that directly connected with it. A node also sends its routing table if an important modification has happened in its table from the new update transmitted. Thus, the DSDV is not suitable for high dynamic topology. To send the routing table the system has two packet types. The first one is "full dump" and another one is "incremental" updates.[4], [6], [8].

2. Related Work

The literature rich with studies that evaluate ad hoc routing protocols which have been presented by number researchers. There are several metrics have been taken in their consideration to compare these protocol each other. Those works have been experimented using many different simulators.

Comparison between two reactive protocols which are DSR and AODV have been presented by Shamir R. et al. [9]. Three performance parameters have been examined which are routing loads, End-to-End Delay, and the ratio of packet delivery. Different pause times were used and the simulation tool was ns2. The authors have recommended to purpose which of these protocols can be developed.

Broch J. et al [3], in this work the authors present evaluation results for the TORA, DSR ,AODV , and DSDV protocols using ns-2 simulation tool. The simulation has been done with 50 nodes with different pause times. To evaluate the protocols they depended on some parameters such as packet delivery ratio, number of hops required to arrive the destination.

Raju J. et al. have compared the performance of Wireless Routing Protocol (WRP-lite) to Dynamic Source Routing Protocol. The end-to-end delay, hop distribution, packet delivery percentage, and control overhead are chosen as parameters for performance comparison. The Random Waypoint Mobility Model is utilized and the metrics were analyzed for different pause time values. From the results WRP-lite revealed better hop performance and delay, while DSR has less overhead [8].

There is another work has been done by Samir R. Das et al. [10] He has tested three metrics which are the average of packets delivered, the average number of end-to-end delay and the routing loads. He has done the simulation with different number of nodes (30 and 60 nodes) and the simulation tool that has been used is Maryland Routing Simulator. He compared the performance of TORA, DSDV, SPF, DSR, and AODV protocols.

Boukerche A. has presented results of performance comparison for three well-known ad hoc routing protocols which are AODV, DSR and CBRP. He used ns-2 simulator. The metrics utilized to analyze the performance of these routing protocols are end-to-end delay of data packets, throughput and normalized routing overhead for different information sources and using Random Waypoint Mobility model. His results shown that AODV has poor throughput in comparing to CBRP, and DSR, while CBRP has high routing overhead than DSR [11][12].

Yadav M. et al [13], has presented simulation results for the following routing protocols AODV, DSDV, DSR and TORA. The simulation has been done by ns-2 simulator. They used various presented traffic load and different pause time. Routing overheads and packet delivery ratio were the performance metrics in their simulation. The DSR was the best overall routing protocols' performance followed by the AODV, but TORA has the worst performance. The DSDV presented high PDR for long pause time and vice versa.

Al-Ani, R et al [14], this work have been done by OPNET 14.5 simulation tool. The evaluation study has been done for five routing protocols TORA, DSR, OLSR, GRP, and AODV. The protocols were evaluated depends on three QOS parameters.

The results presented that OLSR has the best performance compared to other protocols.

Kumar Sharma et al [15] compared the performance of MANET routing protocols by ns-2 simulation tool. Average delay, throughput, and packet delivery ratio were the simulation parameters. The results, that have been obtained, show that AODV was the best, but DSR was the top in terms of packet delivery ratio.

Usop et al [16] determined to choose the better outperform routing protocol. They evaluate DSDV, AODV, and DSR with ns-2 simulator. DSR gives dramatic poor result when mobility is high. On the other hand AODV and DSDV give good results when the mobility is high.

Maashri et al [17] evaluated three routing protocols performance. These protocols were DSR, OLSR, and AODV. Ns-2 simulator has been used. The simulation metrics are packet delivery ratio, throughput, overhead, and end-to-end delay. The results, that have been obtained, demonstrated that DSR has top performance in terms of the PDR, end-to-end delay, and throughput. In contrast, OLSR has the worst performance in this comparison, followed by AODV.

3. Simulation Environment and Setup

OMNet++ is a discrete simulator and free for academic purposes which supports many components that are used to simulate several types of possible scenarios. Here in our work we have used it to find the simulation results and do some analysis for these results. For our work, we have used the following parameters as represented in table 1.

Table 1: SIMULATION PARAMETERS SETTING

Parameters	Specification
Operating System	Windows 7
Simulation Tool	OMNeT++ V 4.6
Type of mobility model	Random waypoint
The dimension of topology	1600m * 600m
Speed	Uniform(20m/s,50m/s)
Pause time	20s
MAC layer Type	802.11/Mac
Sources (fixed)	2 nodes
Destination (fixed)	2 nodes
Mobile nodes	8, 16, 32, 40 and 80
Packet size	512 bytes
Simulation time	100s

The analyzed performance metrics that we have chosen to do a performance evaluation for the routing protocols that have been included in this study:

- **Packet delivery ratio (PDR)**: the number of packets that have been successfully delivered to destination.
- **Collision**: the network collision is defined as more than one node attempts to transfer the data at the same time.
- **End-To-End delay**: This is defined as the time taken by the packet to be reached to the destination.

3.1. INET Framework for OMNeT++ Simulator

OMNeT++ is a discrete-event and open source simulator which is based on C++. There are many benefits for using this simulator. The main advantage of OMNeT++ is make things easier for learning, creating new modules and updating the implemented ones. INET is the main Framework for this simulator. This framework contains many models for wired such as Ethernet, IP, UDP, SCTP, TCP, IPv6 and wireless networking protocols such as ALOHA,DSDV and many others. INET also has several application models [3][6]. Now there is an extension in INET Framework to support MANET model, which is a new toolbox for the simulation environment for mobile ad hoc networks.

3.2. Simulation Configuration

In this section the results of different simulation scenarios of the four mentioned routing protocols are studied to determine which protocol has better performance and more efficient. We have used five scenarios with different number of mobile nodes 8, 16, 32, 40 and 80, respectively. The performance analysis has been described under the above metrics.

We can notice that from Fig 1 the fixed nodes which are 4 have a fixed location in all scenarios while the other nodes are randomly distributed also in all scenarios.

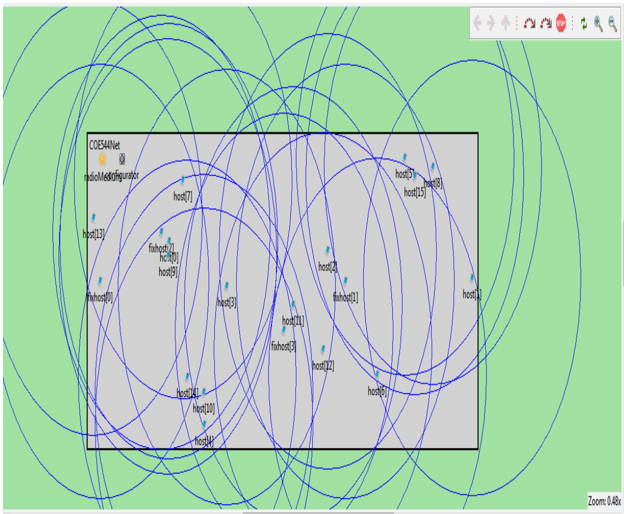

Fig. 1 Execution environment using 16 nodes.

3.3. Simulation Results

As stated in section 3.2, we had run the simulation for our scenarios after that the results have been collected and analyzed.

3.3.1 Packet Delivery Ratio (PDR)

First, we discuss the results as shown in Figure 2 which illustrates the packet delivery ratio versus the number of nodes. We can note that AODV yields the highest PDR and does not affected when the number of nodes is increased, because it has lower routing overhead. In DSDV, the protocol achieves good results at 8 to 40 nodes. However, it fails at 80 nodes due to the significant increase of collisions. For DSR, the PDR increases gradually as well as the number of nodes is increased in case of 8, 16, and 32 due to the availability of alternative routes that are found in sources caches. But we can notice that when the number of nodes be more than 32 the PDR decreases gradually as well as the number of nodes is increased due to increase of collisions. In addition to, OLSR has lower PDR compared with AODV and DSDV, but it seems to be a stable protocol.

3.3.2 Collision

From Figure 3 and 4, it can be observed that in general the collision increases as the number of nodes is increased. In details, we can notice that DSDV achieves unreasonable results when the number of nodes becomes more than 40 nodes due to the protocol weakness when the network is grown. On the other hand, OLSR has the lowest collision as shown in Figure 4 because only the MPR nodes contribute in delivering the data. DSR and AODV fall between these two extremes, but the DSR achieves better results than AODV because this protocol keeps more than one route for same the destination in its cache so the control packets exchanges are smaller than in case of AODV.

3.3.3 End-To-End Delay

Figure 5 illustrates the end-to-end delay. It shows that AODV and OLSR accomplish the same and the best results among the others. DSR has the highest end-to-end delay in case of 8,16,32 and 40 nodes due to the caching strategies used in this protocol, whereas when the number of nodes becomes larger than 40 DSDV produces the highest end-to-end delay because the hop counts is high and the network partitions are more likely to happen.

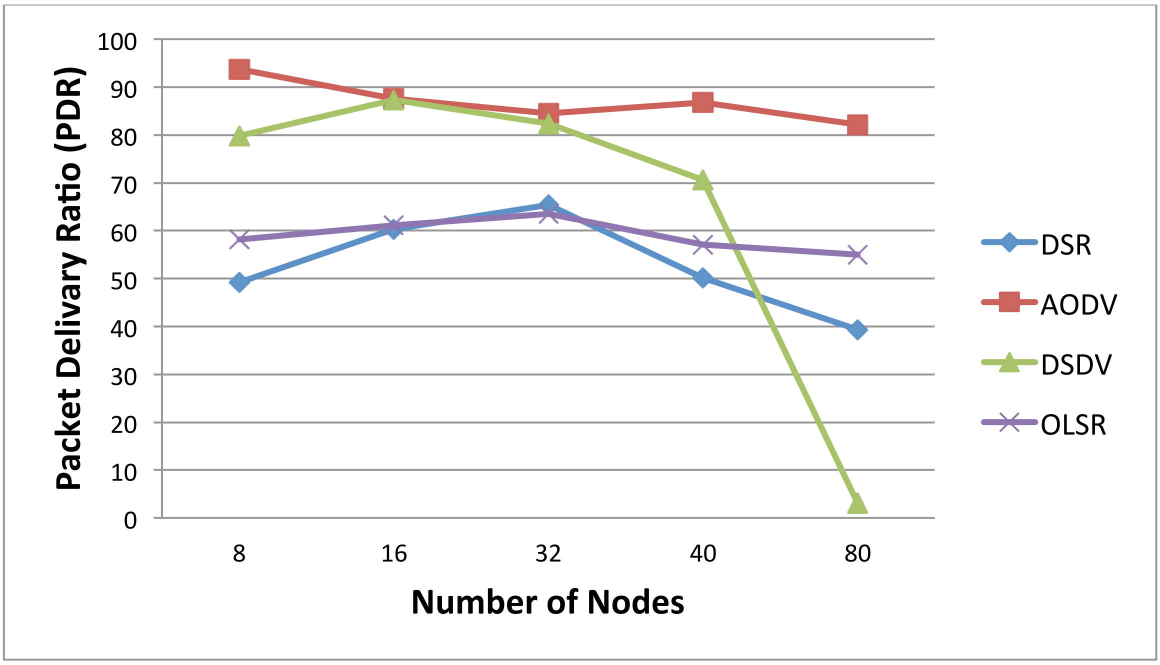

Fig. 2 Packet Delivery Ratio vs. Number of Nodes

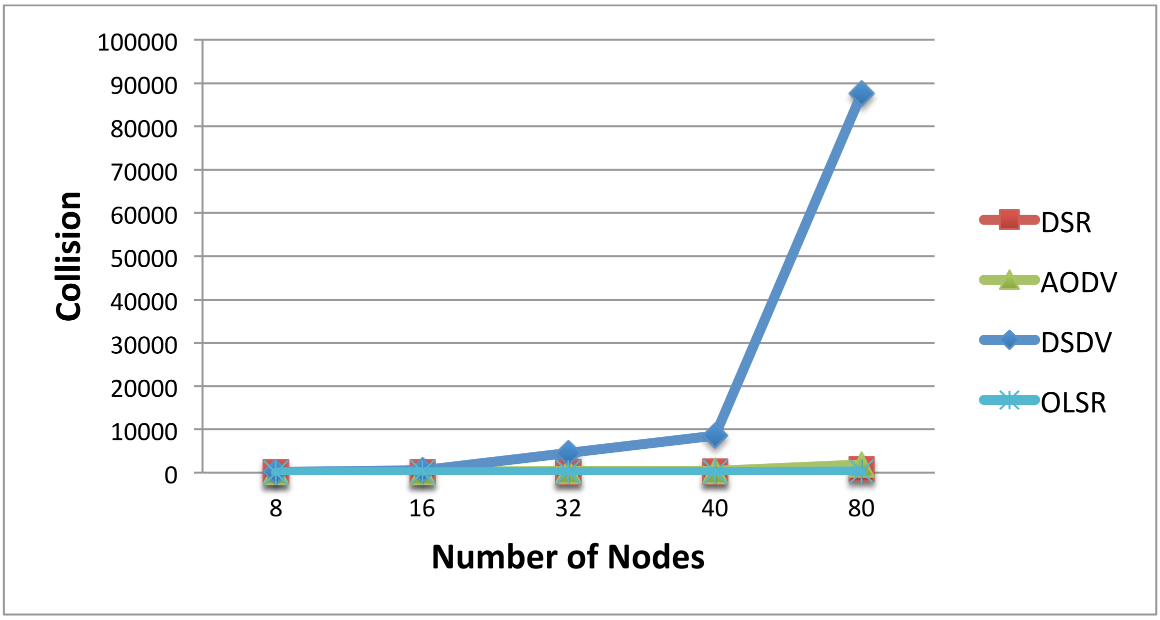

Fig. 3 Collision vs. Number of Nodes

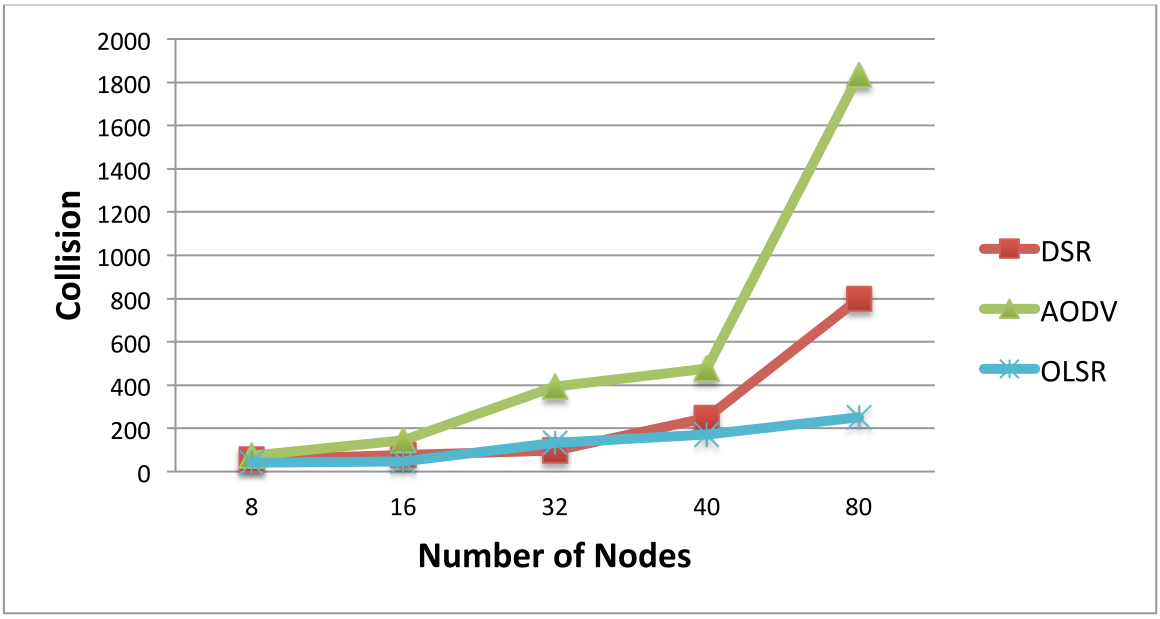

Fig. 4 **Collision without DSDV Collision vs. Number of Nodes**

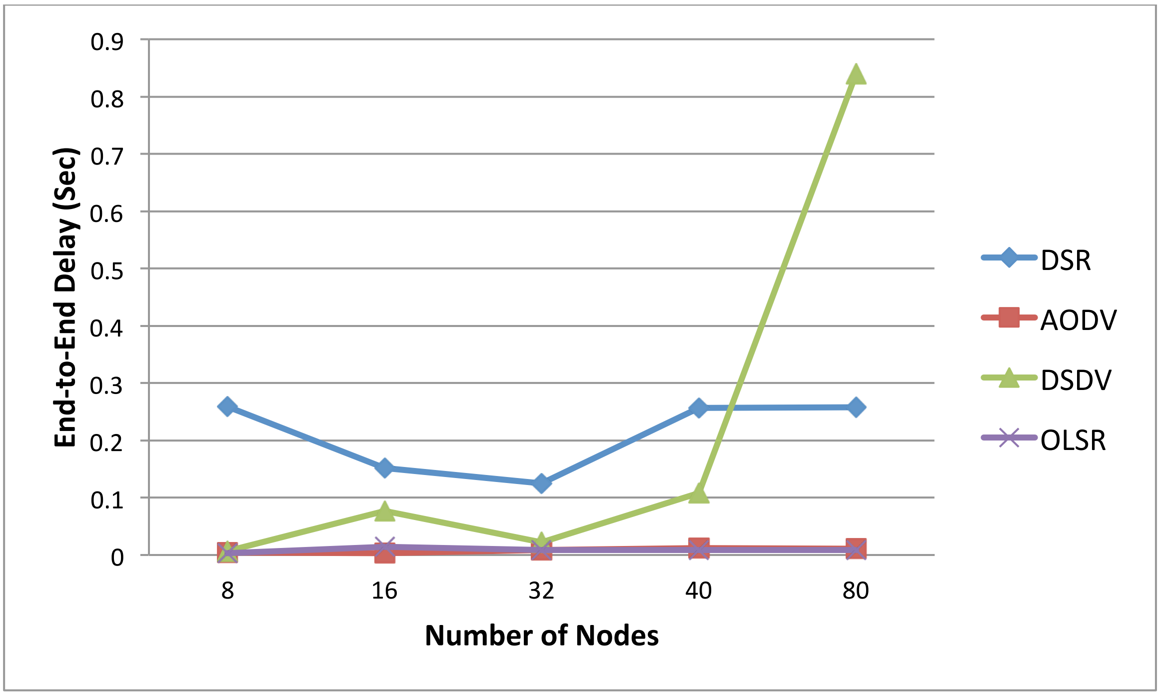

Fig. 5 **End-to-End Delay vs. Number of Nodes**

3. Conclusion

In this current work, we have presented a performance of four routing protocols in case of multi-hop routing. These protocols are two proactive which are OLSR and DSDV and two reactive which are AODV and DSR. We have used three metrics which are the packet delivery ratio (PDR), the collision and end-to-end delay with different scenarios to evaluate the performance of each of them, individually, and then compared the results between each other. In each scenario, different number of nodes has been used. We have used 8, 16, 32, 40 and 80 nodes in this simulation. The four mentioned protocols are configured in each scenario in order to compare each other. The random waypoint mobility model is implemented in all scenarios. After collection and analysis the results we conclude that AODV achieved the best packet delivery ratio, while for the collision, it can be concluded that DSR and OLSR achieved the best results and closed to each other. In the third metric, AODV and OLSR provide the lowest end-to-end delay. From all results, it can be concluded that AODV and OLSR accomplished a good performance compared with DSDV and DSR in all given metrics. We note that DSR is affected by increasing the number of nodes more than the AODV and OLSR. Moreover, DSDV achieved the worst results.

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