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PERFORMANCE OF ROUTING PROTOCOLS WITH VARYING NODE DENSITY AND GROUP MOBILITY MODEL IN MOBILE AD-HOC NETWORK

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Abstract:
Mobility model and node density have significant role in term of performance of routing protocols in a mobile ad-hoc Network. The performance of MANET routing protocols have been evaluated in terms of performance metrics namely Average Throughput (bits/s), Average End to End Delay (s) and Average Jitter (s). To evaluate the performance of AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols, the researchers have conducted simulation based study using QualNet simulator. Group mobility model has been selected to show the realistic environment of the movement of mobile nodes under the varying node density and CBR traffic pattern. The results of the study have shown that variations in performance of the routing protocols have seen with varying node densityof mobile nodes in MANET.
Keywords: MANET, QualNet, Throughput, End to End Delay, Jitter and Routing Protocols

1. Introduction

A mobile Ad-hoc network (MANET) is a self-configuring network of mobile nodes that forms an unpredictable network. In a Mobile Ad hoc Network (MANET), all nodes have the ability to move and establish connections with other nodes as required for data exchange(Kumar and Kumar, 2015). This decentralized network does not rely on any centralized control. (Upadhyay, Kumar, and Rana, 2019). In a Mobile Ad-hoc network, the routes are dynamic and change as the nodes move.(Larsson and Hedman, 1998, Sethi, Juneja and Chauhan, 2011). In this paper, researchers have presented the analysis of the performance three reactive routing protocols (AODV, DSR and DYMO), two proactive routing protocols (OLSR and Bellman Ford) and one hybrid routing protocol (ZRP) in terms of namely Average Throughput (bits/s), Average End to End Delay (s) and Average Jitter (s) under the varying node density of mobile nodes using group mobility model to demonstrate the realistic network using simulation method (Kumar, Agrawal and Sharma, 2017).

2. Performance Metrics

The following performance metrics have been used to evaluate the performance of MANETs routing protocols in presented study (*Varshney, Agrawal and Sharma, 2016,* Kanimozhi, Ganesh, Karthikeyan, 2023*)*.

1) **Average Jitter(s)**
The time variation between arrival of data packets due to change in route and congestion etc. is known as average jitter. The average jitter is normally used as an indicator to evaluate the stability and consistency of a network. The average jitter should be small for a routing protocol to perform better.
2) **Average Throughput (bit/s)**
The average rate of data packet received by the node per unit time successfully is known as throughput. High average throughput is always desirable in a communication system.
3) **Average End-to-End Delay(s)**
The average time consumed by the network when packets are sent from any source node to destination node is called average end to end delay. The average end-to-end delay should be small for a routing protocol to perform better.

3. Simulation Scenario and Related

The performance of three reactive routing protocols (AODV, DSR and DYMO), two proactive routing protocols (OLSR and Bellman Ford) and one hybrid routing protocol (ZRP) with varying node density has been evaluated under the Group mobility model in this section. The numerous network scenarios have been designed to assess the performance of routing protocols using varying node density as 30, 50, 70, 90 and 110 nodes in MANET with the mobility speed of 20-30 m/s and CBR traffic pattern in the terrain size of 500x500 m^2. The simulation setup is executed for 120 seconds.

4. Results and Discussion

Three performance metrics namely Average Throughput (bits/s), Average End to End Delay (s) and Average Jitter (s) have been used to analyze the performance of routing protocols. Interpretation of results has been described as follows (Upadhyay, Kumar, Wasim, 2021):

1) Average Throughput

The performance comparison of Average Throughput (bits/s) for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols under the Group mobility model with varying node density has been conducted. The resultant Average Throughput of routing protocols has been shown in scientific value format for the ease of analysis. The results of Average Throughput are shown in Table 1 and graphical representation shown in Figure 1.

It is clear from the graph that performance of Bellman Ford protocol in term of Average Throughput (bits/s) is best among all the routing protocols under study in network scenarios of varying node density from 30 to 110 nodes. DSR, AODV and DYMO routing protocols have also performed good in same line. But OLSR protocols has not performed good for 30 and 90 nodes network scenarios, however, it has performed good for other network scenarios. On the other hand, ZRP has performed well at low and high dense network scenarios except 50 and 70 nodes network scenarios where it has shown variation in Average Throughput toward lower side.

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Vol. 5 No. 2 (2023)

Table 1 Average Throughput for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols with varying node density under group mobility model

Average Throughput (bits/s)					
Routing Protocols	**Number of Nodes**				
	30	**50**	**70**	**90**	**110**
AODV	4.21E+03	4.24E+03	4.28E+03	4.27E+03	4.27E+03
DSR	4.29E+03	4.30E+03	4.30E+03	4.30E+03	4.26E+03
DYMO	4.28E+03	4.28E+03	4.28E+03	4.28E+03	4.28E+03
OLSR	4.01E+03	4.29E+03	4.29E+03	3.46E+03	4.29E+03
Bellman Ford	4.33E+03	4.30E+03	4.30E+03	4.32E+03	4.30E+03
ZRP	4.27E+03	3.95E+03	3.99E+03	4.27E+03	4.27E+03

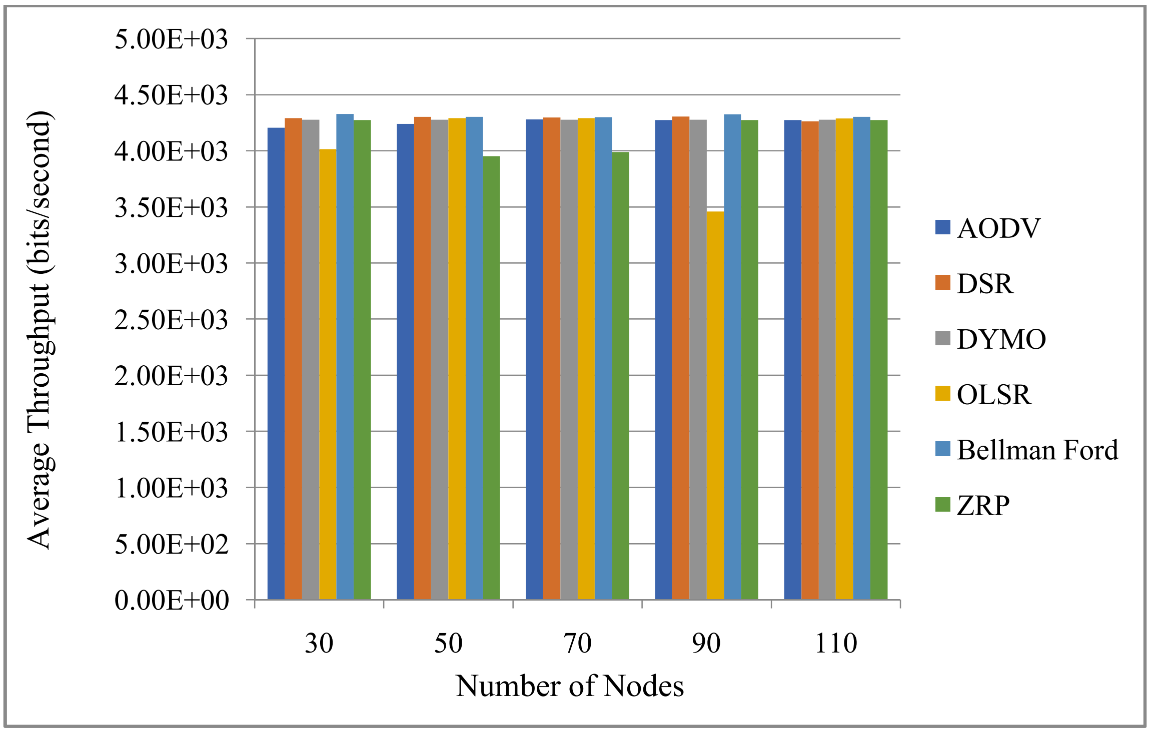

Figure 1 Average Throughput for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing

2) Average End to End Delay

The comparative study of Average End to End Delay (s) for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols under the Group mobility model with varying node density has been conducted. The resultant Average End to End Delay of routing protocols has been shown in scientific value format for easy understanding. The results of Average End to End Delay are shown in Table 2 and graphical representation shown in Figure 2.

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Vol. 5 No. 2 (2023)

Table 2 Average End to End Delay for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols with varying node density under group mobility model

Average End to End Delay (s)					
Routing Protocols	Number of Nodes				
	30	50	70	90	110
AODV	1.28E-02	1.26E-02	1.11E-02	1.05E-02	1.06E-02
DSR	1.38E-02	1.85E-02	1.52E-02	1.71E-02	1.69E-02
DYMO	1.07E-02	1.06E-02	1.06E-02	1.05E-02	1.06E-02
OLSR	1.09E-02	1.05E-02	1.03E-02	1.21E-02	1.10E-02
Bellman Ford	9.22E-03	1.13E-02	1.19E-02	1.37E-02	1.18E-02
ZRP	1.07E-02	1.23E-02	1.54E-02	1.26E-02	1.84E-02

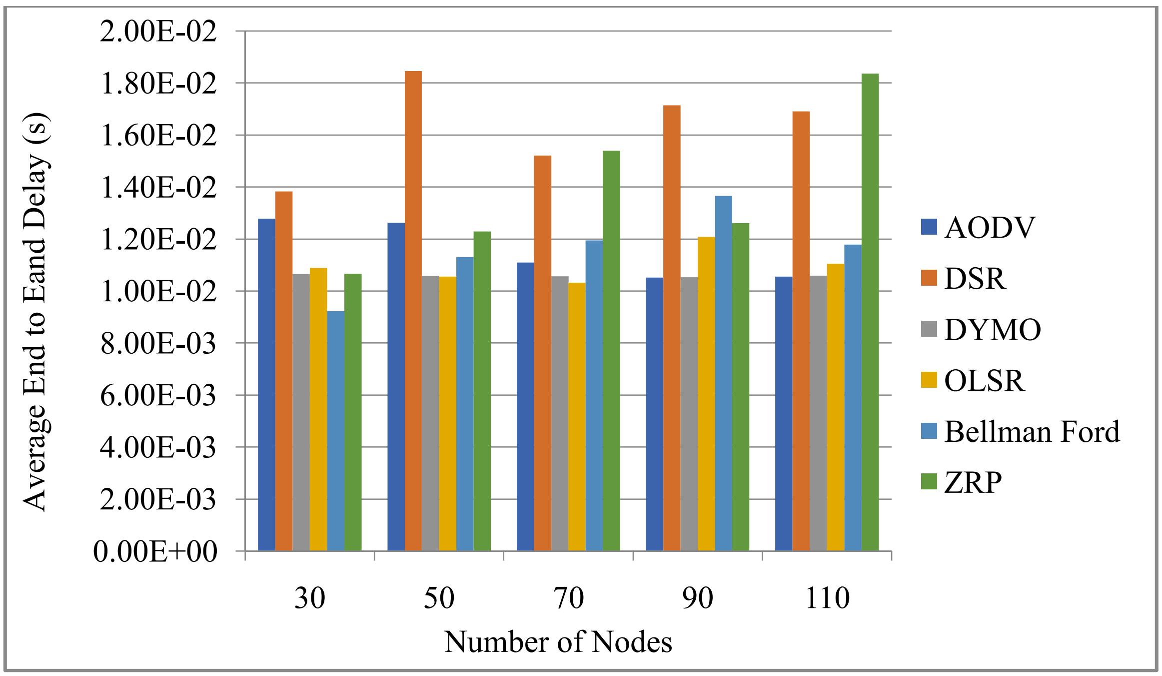

Figure 2 Average End to End Delay for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols with varying node density under group mobility model

DYMO routing protocols has shown outstanding performance with almost constant Average End to End (s) for various network scenarios of 30, 50, 70 90 and 110 nodes in comparison to DSR, ZRP, Bellman Ford, AODV and OLSR routing protocols. Performance of AODV routing protocol has been shown improvement when number of nodes increased. ZRP protocols has also shown increasing pattern of Average End to End Delay for the conducted simulations of varying node density from low to high except decrement in End to End Delay for 90 node scenario. It is also supported by previous study (Kumar, Agrawal and Sharma, 2017). Bellman Ford has shown

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Vol. 5 No. 2 (2023)

poor performance with increment in number of nodes but it has shown improved performance for 110 node scenario. OLSR routing protocol has shown better performance for 30, 70 and 110 nodes scenarios as compared to 50 and 90 nodes scenarios. On the other hand, DSR routing protocols has shown worst performance as compared to other routing protocols.

3) Average Jitter (s)

The performance comparison of Average Jitter (s) for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols under the Group mobility model with varying node density has been discussed here. The resultant Average Jitter of routing protocols has shown in scientific value format for easy understanding. The results of Average Jitter are shown in Table 3 and graphical representation shown in Figure 3.

Table 3 Average Jitter for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols with varying node density under group mobility model

Average Jitter (s)					
Routing Protocols	**Number of Nodes**				
	30	**50**	**70**	**90**	**110**
AODV	4.20E-03	3.70E-03	3.59E-03	3.08E-03	2.62E-03
DSR	5.41E-03	7.60E-03	7.05E-03	8.16E-03	7.26E-03
DYMO	2.75E-03	2.70E-03	2.81E-03	2.82E-03	2.92E-03
OLSR	2.57E-03	2.82E-03	2.47E-03	2.78E-03	2.53E-03
Bellman Ford	1.84E-03	2.63E-03	2.34E-03	3.26E-03	2.24E-03
ZRP	2.91E-03	4.07E-03	5.22E-03	5.77E-03	8.41E-03

The DSR routing protocols has shown worst Average Jitter (s) as compared to other routing protocols. ZRP has also shown poor and increasing Average Jitter with increasing node density in various simulated network scenarios. It is also supported by the previous study (Kumar, Agrawal and Sharma, 2017). On the other side, overall performance of Bellman Ford is best as compared to others. DYMO routing protocols has also shown constant value of Average Jitter irrespective to node density. Performance of AODV routing protocol has increased with increment of nodes in network scenarios. OLSR routing protocol has also performed well with varying node density scenarios under study.

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Vol. 5 No. 2 (2023)

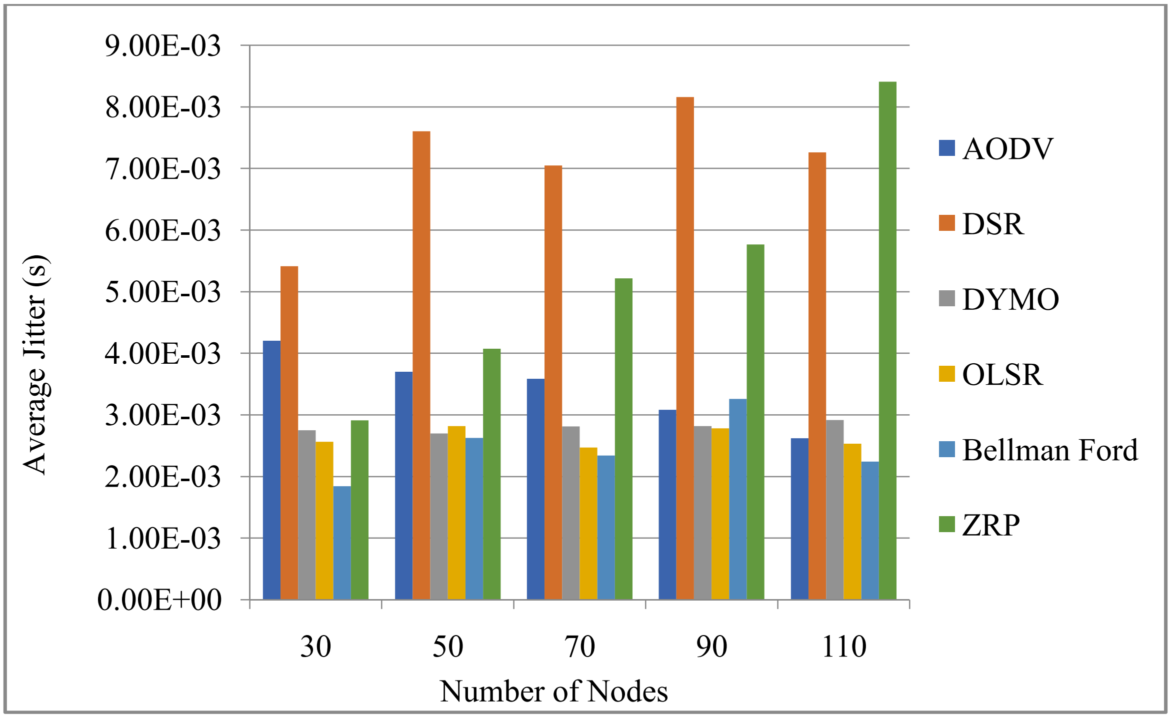

Figure 3 Average Jitter for AODV, DSR, DYMO, OLSR, Bellman Ford and ZRP routing protocols with varying node density under group mobility model

5. CONCLUSION:

Performance analysis of the used routing protocols has been carried out by the researchers under the varying node density of mobile nodesand group mobility model. It is concluded from the results that variation in node density has affected the performance of routing protocols.It is clear from the graph that performance of Bellman Ford protocol in term of Average Throughput (bits/s) is best among all the routing protocols under study. DYMO routing protocols has shown outstanding performance with almost constant Average End to End (s) for various network scenarios. Overall performance of Bellman Ford is also best in comparison of others routing protocols in term of Average Jitter.

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Vol. 5 No. 2 (2023)