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PERFORMANCE COMPARISON OF ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORKS

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ABSTRACT

A mobile ad hoc network (MANET) conflates independent nodes which converse with the aid of wireless channels without established network rudiments and any centralized administration. Routing protocols help in supporting communication by unveiling routes between nodes, consequently playing a significant role in the entire performance of MANETs. Many routing protocols

INTRODUCTION

Mobile Ad-hoc Networks, (MANETs) as argued by Sarmah (2014) has been a popular research topic since mid-1990. Studies in the area have recorded a sporadic increase and there is no master-slave relationship between the base station and the mobile users, unlike in conventional cellular networks. MANET is made up of a set of mobile nodes that are connected using wireless links; the nodes communicate and share information without a central lining infrastructure. The nodes are locomotive; therefore, the objective connectivity of communication in a network (the network topology) keeps changing, Nagendra & Rajat, (2015). In this type of network, nodes can autonomously move in any direction, necessitating the nodes to change their links consistently.

To maintain communication between the nodes, a routing protocol is necessary to create paths that will facilitate

for MANETs were explored by research enthusiasts to understand how they could effectively and efficiently transmit data. Good understanding of these routing protocols is important in understanding how the MANETs work. This paper extrapolated some commonly used MANET routing protocols viz: Optimized Link State Routing protocol (OLSR), Ad-hoc on-demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Destination Sequenced Distance Vector (DSDV. Network Simulator (NS-3) was used in simulating and evaluating the performance of the protocols under varying scenarios, where, scalability, mobility and speed of nodes experience changes dynamically. The outcome justifies that DSR has the most favourable performance in terms of mobility and speed of the nodes, while OLSR works better than the other protocols in terms of scalability.

Keywords: *MANET, Throughput, Packet Delivery Ratio, Network Simulator, Dynamic Source Routing*

sending of data packets from a source to destination nodes. A routing protocol is the major mainstay that coordinates how nodes comply in the way to route packets between one another in MANETs.

The performance of MANETs is anchored on strong communications and agreement among the nodes in a routing protocol. But deficiencies in the performance of routing protocols in some situations is anticipated, therefore, factors that mostly affect routing protocols like network size, mobility, speed of the nodes, power consumption, and so on need thorough investigation as espoused by Royer & Toh, (1999). Researchers posit that the investigation will strengthen robustness, flexibility, and rapid deployment, of MANETs Narendra, & Yadav, (2002).

This paper analysed and compared four commonly used routing protocols; AODV, DSR, DSDV and OLSR based on the mobility, scalability and speed of the nodes using Network Simulator (NS-3). Packets delivery ratio, throughput and packets dropped were selected as performance parameters in justifying the findings.

Other sections of the paper are juxtaposed as follows: section two presents some related work while section three present the methodology describing the simulation environment and the performance metrics. Results of the findings are presented in the fourth section and the last section hosts the concluding aspect of the research.

Related work

Several literatures have been advanced to compare and analyse different routing protocols in Mobile Ad hoc Networks. For example, Roy et al. (2018) have conducted a comparative study of AODV, DSDV, and DSR protocols to trace performance metrics include end-to-end delay, packet delivery ratio, and throughput under different data rates. The network scenario was established within terrain of 500m*500m for 50 nodes. The simulation findings show that AODV can be used in low-delay networks, whereas DSR may be employed in restricted networks where higher throughput and PDR are critical requirements. As future work, the authors have suggested demonstrating the advantages and disadvantages of other accessible routing protocols and suggested a new routing protocol for MANET's that will solve the problems of existing routing protocols.

Hashim et al. (2019) have evaluated OLSR and AODV routing protocols in a wide variety of scenarios via NS2 simulator, that is under different numbers of nodes, different node speed, and different data rates. After analyzing the simulation data, it was discovered that OLSR performs better in terms of average end-to-end delay, making it ideal for delay-sensitive applications. whereas the AODV outperforms in terms of throughput and packet delivery ratio, making it ideal for applications that rely on throughput.

Another study by Jair et al. (2017) have studied three routing protocols that were evaluated for behavioural and performance analysis in the urban environment. The NS2 simulator was used to test proactive, reactive, and hybrid protocols. The proactive OLSR protocol achieved the highest reduction in overhead, whereas the AODV reactive approach performed better in terms of transfer rate at the TCP level. In addition, the hybrid protocol ZRP yielded the best results in terms of latency reduction and delivery rate increase.

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Mohammed et al. (2015) have evaluated and compared the performance of two routing protocols, AODV and OLSR in the MANET network. Authors have developed network scenario to run seven times by using different network densities with number of nodes: 10, 20, 30, 40, 50, 60, 70 and the terrain area of the suggested scenario was equal to 500 m*500 m. Authors have examined the impact of changing the number of nodes on protocol performance by tracking evaluation parameters, such as throughput, packet delivery ratio, and average end-to-end delay. Simulation results indicate that the number of nodes or network size have a significant impact on routing protocol performance, they indicated the AODV outperforms the OLSR in several aspects, especially in regard to overhead and throughput.

In a study, Singh & Hans (2015) carried out a performance analysis in reactive routing protocols and proactive routing protocols with different packet size using NS2 simulator under different traffic conditions. The delay, throughput and packet delivery ratio as argued by the duo are common measures parameters used for the comparison of performance of reactive protocols and proactive protocols. The performance of AODV, DSR and DSDV routing protocol in the study varies under different traffic conditions. Size of data packet also affects the performance of routing protocols. The protocols perform differently under FTP and CBR traffic conditions. The performance of DSR routing protocol is better in different traffic condition i.e., with TCP and CBR, TCP and FTP, UDP and CBR. The study concludes that DSR routing protocol is better option to apply in real applications.

Methodology

Performance Parameters

Three main performance parameters were used in this research: Throughput, packet delivery ratio and number of packets dropped. Throughput determines the stability of the network in different traffic conditions. Packet delivery ratio accounts to the percentage of packets delivered when the network is subjected to different traffic conditions. Number of packets dropped was considered to observe if the number of packets received is affected more by forwarded packets or dropped packets. These three parameters are evaluated through the three phases of the research so as to make the performance analysis of the protocols.

Throughput

It gives the ratio of the channel capacity used for useful transmission (Data packets correctly delivered to the destination) and is defined as the total number of packets received by the destination. It is in fact a measure of the effectiveness of a routing protocol measured in bits/second.

Throughput = (Number of packets sent) / (Simulation Time)

Packet Delivery Ratio

It is the ratio of data packets received to packets sent. It defines the fraction of the packets delivered from source to destination when the network is subjected to different traffic conditions. It also gives an idea about the number of packets dropped or forwarded by the routing protocol.

Packet Delivery Ratio = (Number of packets Received) / (Number of packets sent)

Number of Packets Dropped

Packet drop occurs when one or more packets of data travelling across a computer network fail to reach their destination. Packet drop is measured as number of packet loss with respect to packets sent.

Number of Packet dropped = (Number of packets sent by the source node) – (Number of packet received by the destination node)

Simulation Setup

In this research, NS-3 is installed on Linux (Ubuntu) operating system as virtual machine while Windows is used as the host machine. The simulation environment is set up where four major protocols; DSDV, OLSR, AODV and DSR are analysed with the performance parameters: throughput, packet delivery ratio and packets dropped. Simulations were divided into three phases- mobility, speed and network load. The next three sections detailed the description of the simulation setup used in each phase.

Phase1: Performance analysis by varying mobility

In the first phase, mobility was considered by keeping the number of nodes and the sources/sinks as constant variables and the performance parameters were plotted against pause time. Pause time is the main variable for analysis since maximum mobility is one of the most important factors in moving nodes (Ehsan & Uzmi, 2004). Pause time basically determines the mobility rate of the model, as pause time increases the mobility rate decreases. Pause time is the amount of time taken by each of the moving nodes before they start transmitting packets. The pause time is inversely varying with the mobility of the nodes. It means the nodes are constantly sending packets without any wait time at low pause time. Table 1 below shows the summary of the simulations setup to be used in phase 1

Table 1: Simulation Setup for Phase 1

Parameters	Value
Simulation Time	200 seconds
Area	800 × 800 m
Packet Size	521 bytes
DSSS rate	11Mbps
Packet rate	4 packets/second
Mobility model	Random Way-point model
Sources/sink	10
Maximum Speed	20 m/s
Pause Time	0, 50, 100, 200 s
Protocols	AODV, DSR, DSDV, OLSR
Number of nodes	50

Phase2: Performance analysis by varying speed

In the second phase, speed of the nodes is the main variable, and the performance parameters are plotted against maximum speed. Table 2 below shows the summary of the simulations setup to be used in phase 2

Table 2: Simulation Setup for Phase 2

Parameters	Value
Simulation Time	200 seconds
Area	800 × 800 m
Packet Size	521 bytes

DSSS rate	11 Mbps
Packet rate	4 packets/second
Mobility model	Random Way-point model
Sources/sink	10
Maximum Speed	1, 2, 5, 20, 50 m/s
Pause Time	0 s
Protocols	AODV, DSR, DSDV, OLSR
Number of nodes	50

Phase3: Performance analysis by varying network load

The third phase deals with the network scalability to determine how the ad-hoc routing protocols performed against various network loads. Table 3 below shows the summary of the simulations setup to be used in phase 3

Table 3: Simulation Setup for Phase 3

Parameters	Value
Simulation Time	200 seconds
Area	800 × 800 m
Packet Size	521 bytes
DSSS rate	11 Mbps
Packet rate	4 packets/second
Mobility model	Random Way-point model
Sources/sink	One-third of the number of nodes
Maximum Speed	20 m/s
Pause Time	0 s
Protocols	AODV, DSR, DSDV, OLSR
Number of nodes	20, 40, 60, 80, 100

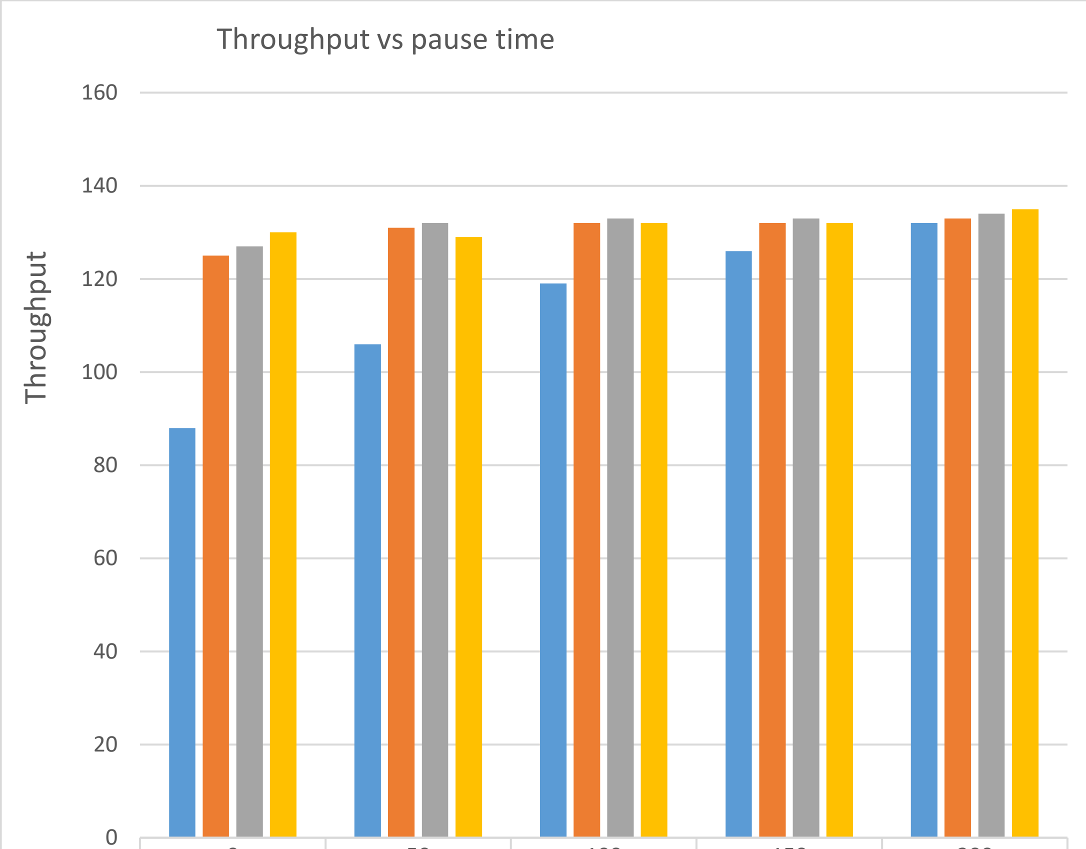
Results and Discussion

Simulation results at varying mobility

Throughput

The first performance metric, throughput is calculated for all four routing protocols for 0, 50, 100, 150 and 200 pause time. The results in figure 1 indicate that

OLSR performs better than DSDV in this case and stands almost as tall as the reactive protocols, AODV and DSR.

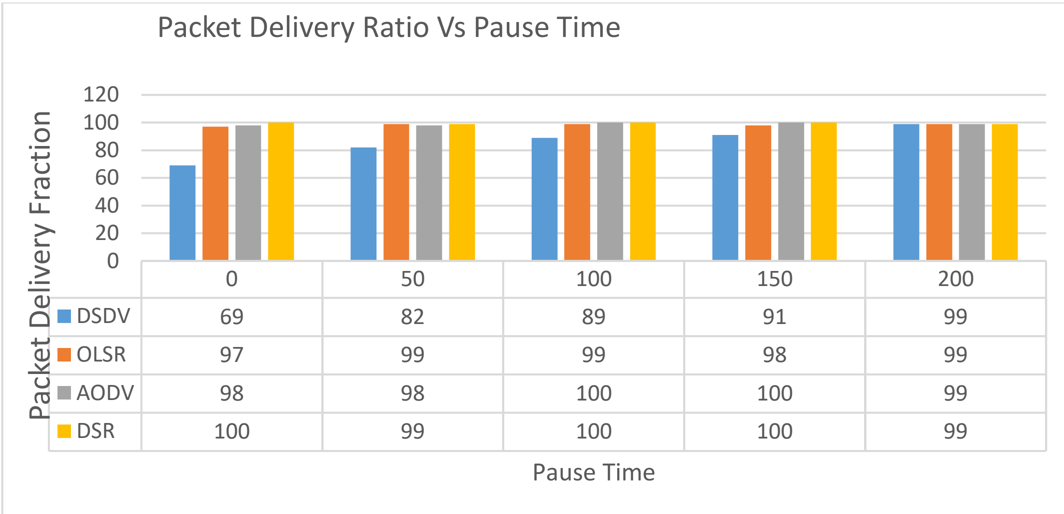


	0	50	100	150	200
DSDV	88	106	119	126	132
OLSR	125	131	132	132	133
AODV	127	132	133	133	134
DSR	130	129	132	132	135

Figure 1: Throughput of the protocols at varying mobility

Packet Delivery Fraction (Ratio)

Next, the packet delivery ratio is analyzed by varying mobility. All the protocols deliver a greater performance of packet delivery ratio except DSDV. From figure 2, it is observed that at higher mobility, performance of DSDV drops down. OLSR proves better performance compared to DSDV as its performance is slightly below AODV and DSR's packet delivery ratio.

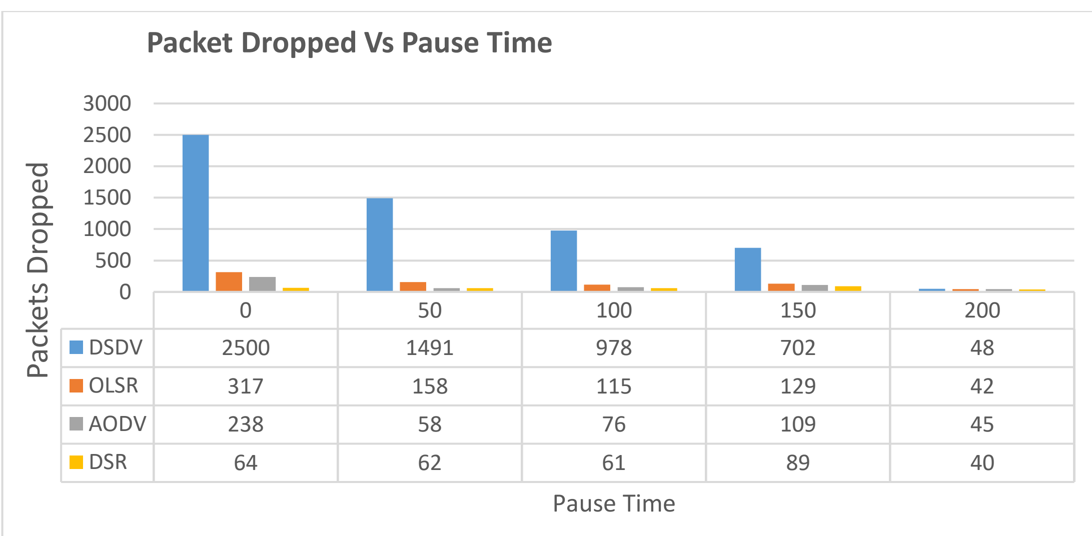


	0	50	100	150	200
DSDV	69	82	89	91	99
OLSR	97	99	99	98	99
AODV	98	98	100	100	99
DSR	100	99	100	100	99

Figure 2: Results of Packets Delivery Ratio at varying mobility

Number of Packets Drop

Figure 3 shows the number of packets dropped when mobility is varied. DSR shows the best performance out of all the four protocols. Performance of AODV and OLSR are comparable. DSDV showed worst performance as the number of dropped packets was high at maximum mobility. As the mobility is decreased or the pause time is increased, DSDV performs well because the nodes get enough time to update the routing tables.



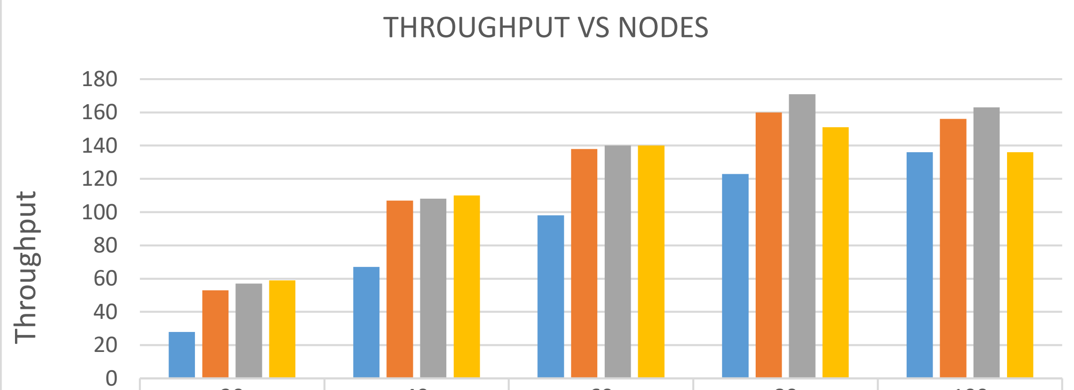
	0	50	100	150	200
DSDV	2500	1491	978	702	48
OLSR	317	158	115	129	42
AODV	238	58	76	109	45
DSR	64	62	61	89	40

Figure 3: Packets Drop Results at varying Pause time

Simulation results at varying scalability

Throughput

Figure 4 shows the average throughput of the ad-hoc routing protocols under varying network load. It is seen that AODV performs the best compared to the other protocols. DSR could not uphold the performance at higher network load. DSDV significantly has inferior performance because of regular link changes and connection failures. OLSR performs better than DSR and DSDV which makes it capable of running in large network but requires extra time to set up routing tables before delivering packets but packets seem to be thoroughly forwarded and received which gives a consistently high average throughput.



	20	40	60	80	100
DSDV	28	67	98	123	136
OLSR	53	107	138	160	156
AODV	57	108	140	171	163
DSR	59	110	140	151	136

Number of Nodes

Figure 4: Results of Throughput at varying number of nodes

Packet Delivery Fraction (Ratio)

Figure 5 gives the packet delivery ratio of all the protocols when the nodes are varied. Looking at the trend, it can examine when the network load is increased, the packet delivery ratio for all the protocols gets condensed. DSR has a peak packet delivery ratio of close to 100% when the number of nodes is 20. But as the load is improved, the performance degrades. For a large network scenario (100 nodes), packet delivery comes down which shows that DSR does not perform well

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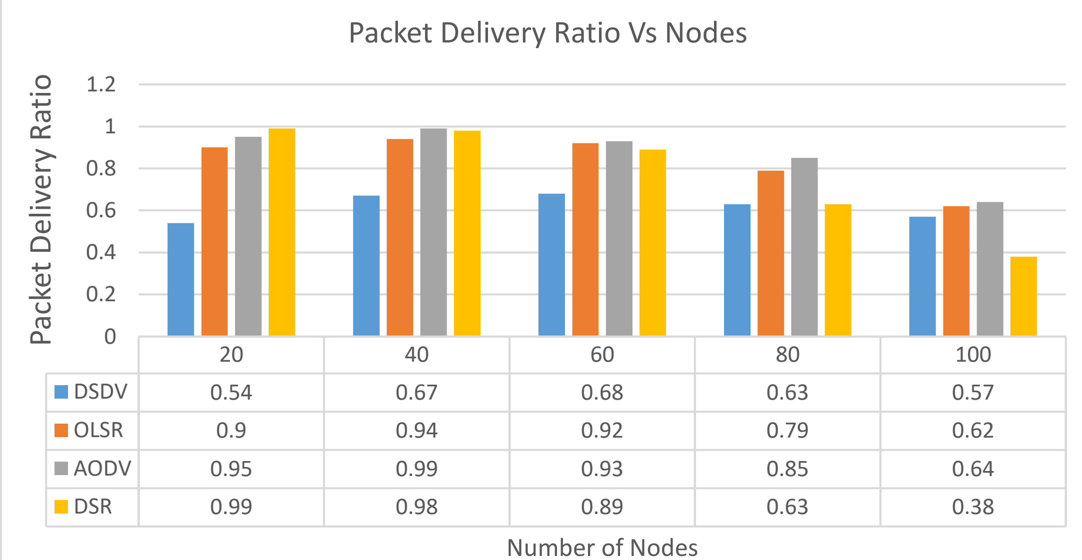
when the network size is complex. AODV and OLSR shows similar trend with AODV slightly showing better performance in small and large networks. DSDV has a low packet delivery ratio throughout the different scale of networks but it has a certain kind of consistency. The packet delivery ratio of DSDV is consistent between throughout the different scale of networks.

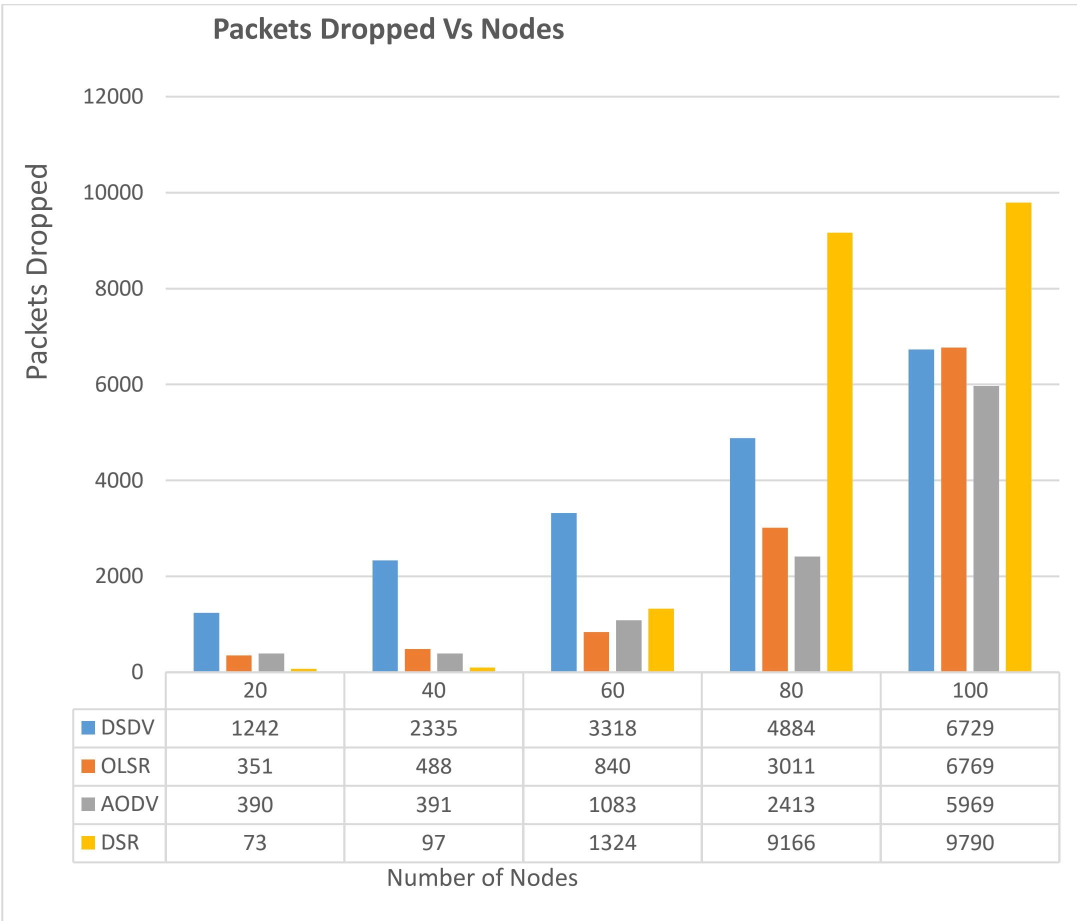


	20	40	60	80	100
DSDV	0.54	0.67	0.68	0.63	0.57
OLSR	0.9	0.94	0.92	0.79	0.62
AODV	0.95	0.99	0.93	0.85	0.64
DSR	0.99	0.98	0.89	0.63	0.38

Figure 5: Results of Packets Delivery Ratio (Fraction) at varying Number of nodes

Number of Packets Drop

In Figure 6, it was observed that all the protocols are exposed to large networks as more number of packets started plummeting after 60 nodes. DSDV started dropping packets even in small scale networks and number increases in large scale networks. This makes DSDV a tougher choice for a well-organized routing protocol for loaded ad-hoc networks. DSR performs better in small network but the performance start degrading when the size of the network is increased. DSR's performance is comparable to its other peer, AODV but it fails to keep up the performance when the load on the network is increased. This is possibly because as the network size increases, DSR becomes more aggressive with caching. In large networks, routes become larger thus increasing the probability of route errors and stale routes which in turn is enough to drop more packets. OLSR's performance is comparable to AODV but it lost more packets than AODV in small as well as large networks.



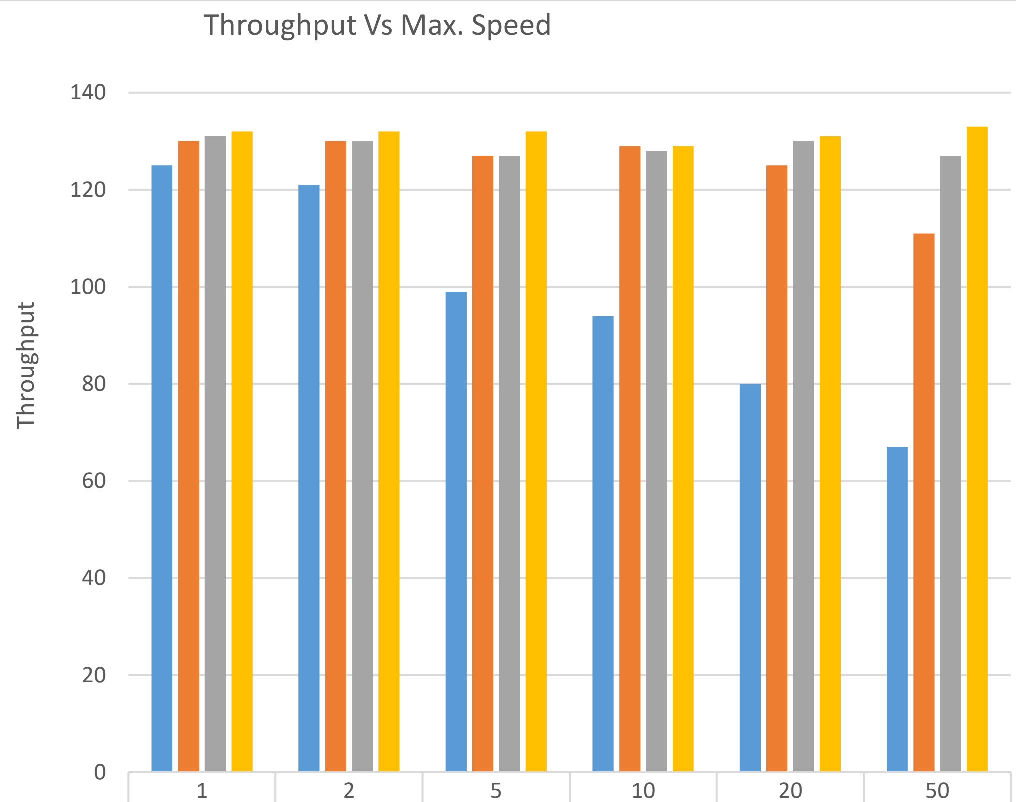
	20	40	60	80	100
DSDV	1242	2335	3318	4884	6729
OLSR	351	488	840	3011	6769
AODV	390	391	1083	2413	5969
DSR	73	97	1324	9166	9790

Figure 6: Results of Packets Drop at varying Number of nodes

Simulation results at varying speed of the nodes

Throughput

The results in Figure 7 observed that OLSR dominates its peer, DSDV throughout the simulation. DSR shows maximum and consistent throughput throughout all speeds. It has an average speed of 131 kbps which is higher than AODV, 129 kbps and OLSR, 125 kbps. DSDV suffers decrease in throughput close to 68 kbps at maximum speed (50 meters/sec). This is because of frequent link changes and connection failures. It can also be observed that throughput for OLSR has started decreasing at high speed because of its proactive nature.

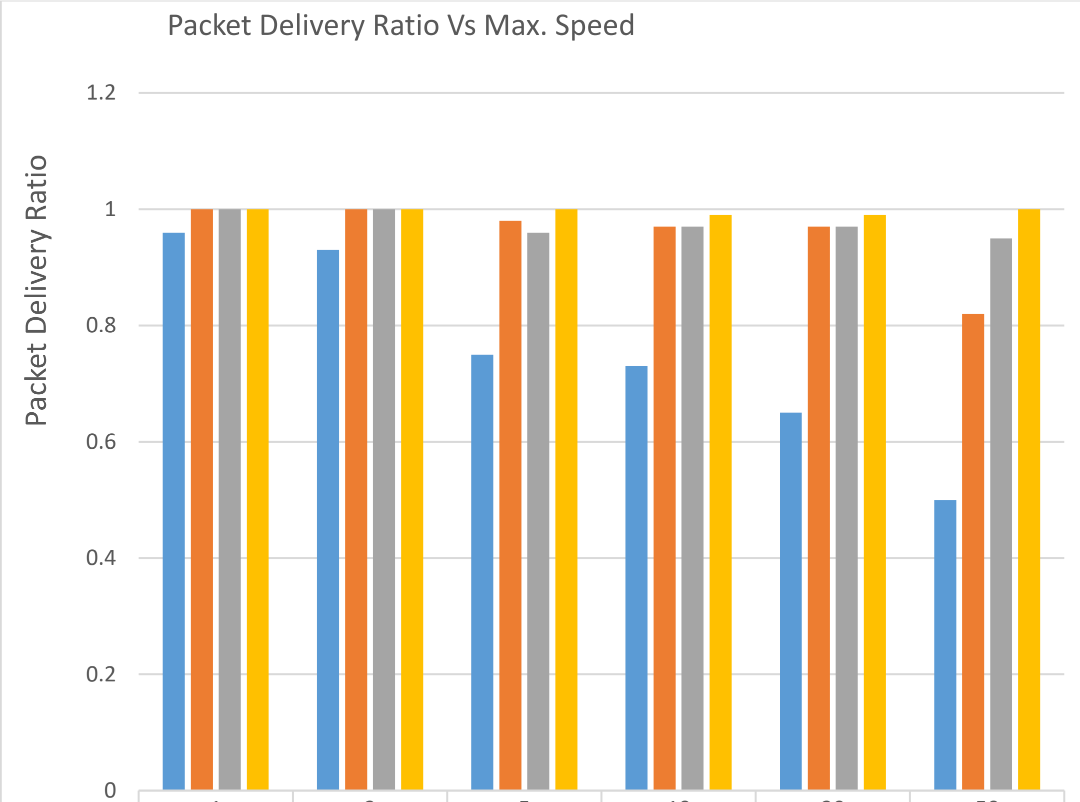


Speed	1	2	5	10	20	50
DSDV	125	121	99	94	80	67
OLSR	130	130	127	129	125	111
AODV	131	130	127	128	130	127
DSR	132	132	132	129	131	133

Figure 7: Result of Throughput at varying Max. Speed of the nodes

Packet Delivery Fraction (Ratio)

When the packet delivery ratio is calculated against varying speed, it is observed from Figure 8 that DSR again outperforms all the protocols at all speeds maintaining a packet delivery ratio close to 100%. AODV's performance is comparable to DSR delivering almost 98% of the packets. DSDV delivers close to 96% of the packets at low speed but could not keep the same rate with the increase in speed because of its frequent link changes and connection failures. Packet delivery in DSDV drops to as low as 51% in high speed. OLSR again performed better than DSDV as its performance closely matched with the reactive protocol delivering close to 98% of the packets.



	1	2	5	10	20	50
DSDV	0.96	0.93	0.75	0.73	0.65	0.5
OLSR	1	1	0.98	0.97	0.97	0.82
AODV	1	1	0.96	0.97	0.97	0.95
DSR	1	1	1	0.99	0.99	1

Speed

Figure 8: Results of Packets Delivery Ratio (Fraction) at varying Max. Speed of the nodes

Number of Packets Drop

In figure 9, the number of packets dropped is plotted by varying speed. DSR once again shows most favourable results with the number of dropped packets being drastically low. Even high speed, DSR is able to maintain a low drop rate because of its efficiency in its dynamic routing algorithm. AODV and OLSR performed well in low speed but as the speed increased, the number of dropped packets also increased. DSDV once again failed to perform well at a maximum speed of 50 meters/second.

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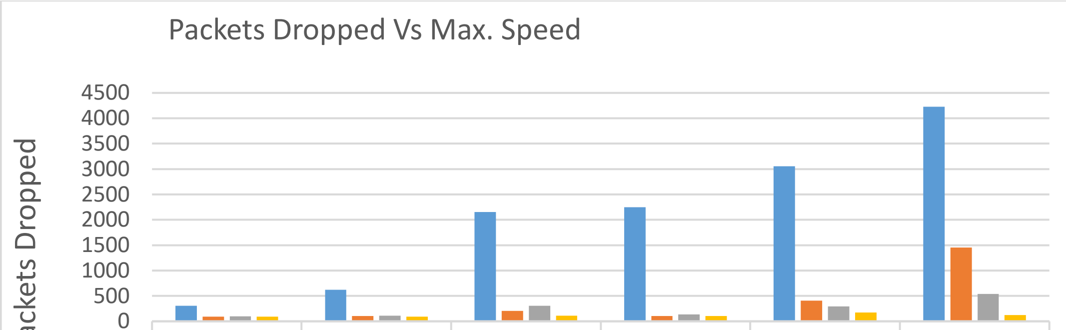

	1	2	5	10	20	50
DSDV	306	620	2151	2249	3056	4227
OLSR	94	106	207	103	407	1455
AODV	96	109	309	137	294	540
DSR	92	93	112	106	175	121

Figure 9: Results of Packets Drop at varying Max. Speed of the nodes

Conclusion

A performance comparison of MANET routing protocols - AODV, DSR, DSDV and OLSR under diverse conditions of mobility, speed and network load is carried out in this research.

The simulation results concluded that, DSR has the most advantageous performance in terms of mobility and speed and small scale networks. DSR loses its charm when the load in the network is increased. AODV has shown consistent results irrespective of the network load, speed and mobility but it fails to break DSR in small scale networks but maintains its superior performance even in large scale networks.

OLSR has an equal performance with AODV and has beaten DSR and DSDV when the network load is high. Even though it fails to cope with the level of AODV, it can be a superior protocol having demonstrated comparable performance to AODV and its proactive nature of routing packets.

All in all, DSR should be the first preference in terms of small scale networks with any mobility or speed. AODV or OLSR should be considered when the load of the network is increased. OLSR's proactive nature and comparable performance to AODV can certainly be an edge over AODV in large scale networks.

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