Analyzing the Impact of Scalability on QoS-aware Routing for MANETs

Rajneesh Kumar Gujral[1], Manpreet Singh[2]

[1]Assoc. Professor, Computer Engineering Department, M. M. Engineering College, M. M. University, Ambala, Haryana, India-133207.

[2] Professor, Computer Engineering Department, M. M. Engineering College, M. M. University, Ambala, India - 133207.

Abstract

Mobile Ad hoc networks (MANETs) are self-created and self organized by a collection of mobile nodes, interconnected by multi-hop wireless paths in a strictly peer to peer fashion. Scalability of a routing protocol is its ability to support the continuous increase in the network parameters (such as mobility rate, traffic rate and network size) without degrading network performance. The goal of QoS provisioning is to achieve a more deterministic network behaviors, so that information carried by the network can be better delivered and network resources can be better utilized .In this paper, we are going to analyze the impact of scalability on various QoS Parameters for MANETs routing protocols one proactive protocol (DSDV) and two prominent on-demand source initiated routing protocols. The performance metrics comprises of QoS parameters such as packet delivery ratio, end to end delay, routing overhead, throughput and jitter. The effect of scalability on these QoS parameters is analyzed by varying number of nodes, packet size, time interval between packets and mobility rates.

Keywords: *MANETs, Scalability, QoS, Routing Protocols.*

1. Introduction

Mobile Ad hoc networks (MANETs) are self-created and self organized by a collection of mobile nodes, interconnected by multi-hop wireless paths in a strictly peer to peer fashion [1]. The increase in multimedia, military application traffic has led to extensive research focused on achieving QoS guarantees in current networks. The goal of QoS provisioning is to achieve a more deterministic network behaviors, so that information carried by the network can be better delivered and network resources can be better utilized. The QoS parameters differ from application to application e.g., in case of multimedia application bandwidth, delay jitter and delay are the key QoS parameters [2].After receiving a QoS service request, the main challenges is routing with scalable performance in deploying large scale MANETs .Scalability can refer to the capability of a system to increase total throughput under an increased load [3]. Many protocols have been proposed but a few comparisons have been made with respect to scalability. The routing protocols Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV) and Temporally Ordered Routing Algorithm (TORA) protocol had been analyzed theoretically and through simulation using an Optimized Network Engineering Tools (OPNET) by varying node density and number of nodes [4].

The effect of scalability of a network on Genetic Algorithm based Zone Routing Protocols by varying the number of node is analyzed in [5].In [6], simulation have been conducted to investigate scalability of DSR ,AODV and LAR routing protocols using prediction based link availability model. Simulation results of the modified DSR (MDSR) as proposed in [7] has less overhead and delay as compared to conventional DSR irrespective of network size. In [8] simulation based comparative study of AODV, DSR, TORA and DSDV was reported which highlighting that DSR and AODV achieved good performance at all mobility speed whereas DSDV and TORA perform poorly under high speeds and high load conditions respectively. In [9] showed the proactive protocols have the best end-to-end-delay and packet delivery fraction but at the rate of higher routing load. In [10] three routing protocols were evaluated in a city traffic scenarios and it was shown that AODV outperforms both DSR and the proactive protocol FSR. In [11] simulation study of AODV, DSR and OLSR was done which shown that AODV and DSR outperform OLSR at higher speeds and lower number of traffic streams and OLSR generates the lowest routing load. In[12] more limited study was conducted which favoring DSR in terms of packet delivery fraction and routing overhead whereas OLSR shows the lowest end-to-end delay at lower network loads. In[13] simulation based performance comparison on DSDV, AODV and DSR is done on the basis of Packet delivery ratio, Throughput, End to End delay & routing overhead by varying packet size, time interval between packet sending & mobility of nodes on 25 nodes using NS2.34. In [14] author performed realistic comparison between two MANETs protocols namely AODV (reactive protocol) and DSDV (proactive protocol). It is analyzed that the performance of AODV protocol is better than the DSDV protocol in term of PDF, Average end-to-end delay, packet loss and routing overhead by taking fixed number of nodes and varying number of nodes which helps in improving scalability of MANETs. In [15] author evaluated the scalability of on-demand ad hoc routing protocols by taking of up to 10,000 nodes. To improve the performance of on-demand protocols in large networks, five modification combinations have been separately incorporated into an on-demand protocol, and their respective performance has been studied. It has been shown that the use of local repair is beneficial in increasing the number of data packets that reach their destinations. Expanding ring search and query localization techniques seem to further reduce the amount of control overhead generated by the protocol, by limiting the number of nodes affected by route discoveries. While the performance improvements of the modifications have only been demonstrated with the AODV protocol. In [16] author proposed an effective and scalable AODV (called as AODV-ES) for Wireless Ad hoc Sensor Networks (WASN) by using third party reply model, n-hop local ring and time-to-live based local recovery. The above said work goal is to reduce time delay for delivery of the data packets, routing overhead and improve the data packet delivery ratio. The resulting algorithm "AODV-ES" is then simulated by NS-2 under Linux operating system. The performance of routing protocol is evaluated under various mobility rates and found that the proposed routing protocol is better than AODV. In [17] moreover, most of current routing protocols assume homogeneous networking conditions where all nodes have the same capabilities and resources. Although homogenous networks are easy to model and analysis, they exhibits poor scalability compared with heterogeneous networks that consist of different nodes with different resources. The author studies simulations for DSR, AODV, LAR1, FSR and WRP in homogenous and heterogeneous networks. The results showed that these which all protocols perform reasonably well in homogenous networking conditions, their performance suffer significantly over heterogonous networks

In this paper, the impact of scalability on QoS Parameters such as packet delivery ratio, end to end delay, routing overhead, throughput and jitter has been analyzed by varying number of nodes, packet size, time interval between packets & mobility rates. The rest of paper is organized as follow. In section 2, gives an overview of routing protocols, section 3 describe the performance metrics, Section 4 simulation results and analysis are discussed and section 5 concludes the paper.

2. Overview of Routing Protocols

Routing protocols for MANETs have been classified according to the strategies of discovering and maintaining routes into three classes: proactive, reactive and Hybrid [18]

Destination-Sequenced Distance Vector (DSDV): DSDV is a table-driven routing [9] scheme for MANETs. The Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements. Every mobile station maintains a routing table that lists all available destinations, the number of hops to reach the destination and the sequence number assigned by the destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid the formation of loops.

Dynamic Source Routing (DSR): is an on-demand protocol designed to restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach [19]. The major difference between this and other on-demand routing protocols is that it is beacon-less and hence does not require periodic hello packet (beacon) transmission, which are used by a node to inform its neighbors of its presence. The basic approach of this protocol (and all other on-demand routing protocols) during the route construction phase is to establish a route by flooding Route Request packets in the network. The destination node, on receiving a Route Request packet, responds by sending a Route Reply packet back to the source, which carries the route traversed by the Route Request packet received.

Ad hoc On-demand Distance Vector (AODV): AODV routing protocol is also based upon distance vector, and uses destination numbers to determine the freshness of routes. AODV minimizes the number of broadcasts by creating routes on-demand as opposed to DSDV that maintains the list of the entire routes. To find a path to the destination, the source broadcasts a route request packet. The neighbors in turn broadcast the packet to their neighbors till it reaches an intermediate node that has recent route information about the destination or till it reaches the destination. A node discards a route request packet that it has already seen. The route request packet uses sequence numbers to ensure that the routes are loop free and to make sure that if the intermediate nodes reply to route requests, they reply with the latest information only.

3. QoS Based Performance Metrics

The performance metrics includes the following QoS parameters such as PDR (Packet Delivery Ratio), Throughput, End to End Delay, Routing overhead and Jitter.

Packet Delivery Ratio (PDR): also known as the ratio of the data packets delivered to the destinations to those generated by the CBR sources. This metric characterizes both the completeness and correctness of the routing protocol also reliability of routing protocol.

$$PDR = \frac{\sum_{1}^{n} CBRrece}{\sum_{1}^{n} CBRsent} * 100$$

Average End to End Delay: Average End to End delay is the average time taken by a data packet to reach from source node to destination node. It is ratio of total delay to the number of packets received.

$$Avg\_End\_to\_End\_Delay = \frac{\sum_{1}^{n}(CBRrecetime - CBRsenttime)}{\sum_{1}^{n} CBRrece} * 100$$

Throughput: Throughput is the ratio of total number of delivered or received data packets to the total duration of simulation time.

$$Throughput = \frac{\sum_{1}^{n} CBRrece}{simulation\ time}$$

Normalized Protocol Overhead/ Routing Load: Routing Load is the ratio of total number of the routing packets to the total number of received data packets at destination.

$$Routing\_Load = \frac{\sum RTRPacket}{\sum CBRrece}$$

Jitter: Jitter describes standard deviation of packet delay between all nodes.

4. Simulation Results and Analysis

The performance of QoS parameters on routing protocols AODV, DSR and DSDV is simulated using NS-2.34.The parameters used for simulation and different scenario on which they are analyzed are shown in Table 1 and Table 2 respectively. The positioning and communication among nodes is represented in Figure 1.

Table 1 Simulation Parameters

Parameters	Value
No of Node	25,50,75,100
Simulation Time	10 sec
Environment Size	1200x1200
Traffic Size	CBR (Constant Bit Rate)
Packet Size	500 and 1000 bytes
Queue Length	50
Source Node	Node 0
Destination Node	Node 2
Mobility Model	Random Waypoint
Antenna Type	Omni directional
Simulator	NS-2.34
Mobility speed	1000,2000 m/s
Packet Interval	0.015,0.15 ns

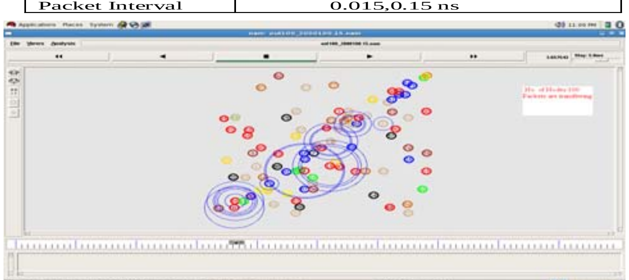


Figure 1. (Simulation Showing Packets transferring)

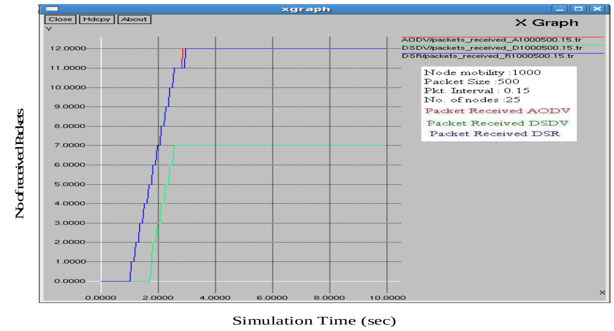


Figure 2(Packets Received when number of nodes=25 packet size=500 bytes, interval=0.15 sec Mobility=1000)

In scenario 01, Figure 2 shows that packet received in AODV and DSR is higher as compared to DSDV. The result in Table 3 shows that PDR, throughput, end to end delay is same in AODV and DSR is better than DSDV. Routing load is minimum in AODV. Jitter is less in DSDV as compared to AODV and DSR but throughput and PDR is also very low.

Table 3 (Performance Matrix number of nodes=25 packet size=500 bytes, interval=0.15 sec Mobility=1000)

Table-3	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter (sec)
AODV	60/12	20.00	1.84	1.33	7.08	140.67
DSDV	60/7	11.66	2.07	0.77	8.57	106.87
DSR	60/12	20.00	1.85	1.33	20.41	147.88

Table -4 (Performance Matrix number of nodes=50 packet size=500 bytes , interval=0.15 sec Mobility=1000)

Table-4	Packets Sent/ Received	PDR	End – End	Throughput	Routing Loa	Jitter (sec)
AODV	60/56	93.33	5.61	6.22	5.08	155.88
DSDV	60/6	10.00	2.13	0.66	10.0	100.02
DSR	60/51	85.00	5.83	5.66	7.60	176.09

Table 2 shows different parameters taken for different simulation scenarios

Scenario no	No of nodes	Packets Size (bytes)	Packets Interval	Mobility(m/sec)
01	25,50,75,100	500	0.15 sec	1000
02	25,50,75,100	500	0.015 sec	1000
03	25,50,75,100	1000	0.15 sec	1000
04	25,50,75,100	1000	0.015 sec	1000
05	25,50,75,100	500	0.15 sec	2000
06	25,50,75,100	500	0.015 sec	2000
07	25,50,75,100	1000	0.15 sec	2000
08	25,50,75,100	1000	0.015 sec	2000

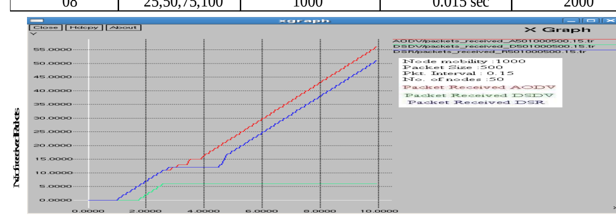


Figure 3 (Packets Received when number of nodes=50 packet size=500 bytes, interval=0.15 sec Mobility=1000)

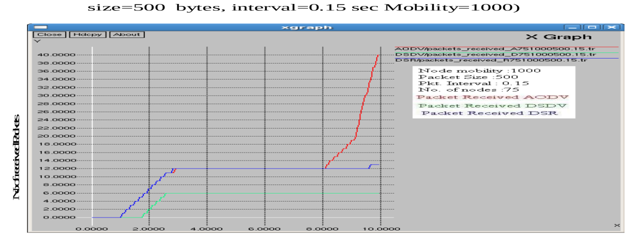


Figure 4 (Packets Received when number of nodes=75 packet size=500 bytes, interval=0.15 sec Mobility=1000)

Table 5(Performance Matrix number of nodes=75 packet size=500 bytes, interval=0.15 sec Mobility=1000)

Table-5	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter (sec)
AODV	60/42	70.00	7.16	4.66	7.80	281.66
DSDV	60/6	10.00	2.13	0.66	10.00	100.00
DSR	60/14	23.33	2.97	1.55	53.50	631.54

Table 6 (Performance Matrix number of nodes=100 packet size=500 bytes, interval=0.15 sec Mobility=1000)

Table-6	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter (sec)
AODV	60/47	78.33	7.36	5.22	6.27	246.87
DSDV	60/7	11.66	2.06	0.77	8.57	107.03
DSR	60/31	51.66	6.10	3.44	18.61	363.61

Figure 3, 4 and 5 shows that number of packets received in AODV is more as compared to DSR and DSDV when numbers of nodes are scalable from 50, 75 and 100. AODV having that highest PDR and throughput with minimum routing load and jitter from DSR. We have also analyzed that in DSDV Jitter, end to end delay is low as compared to AODV and DSR but throughput, number of packets received and PDR is very low. The overall performance of AODV is best as four QoS parameters out of six has favourable results as indicated in Table 4, Table 5 and Table 6.

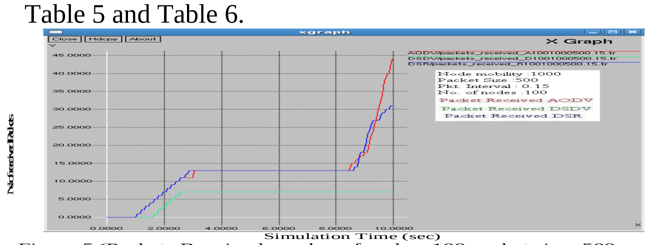


Figure 5 (Packets Received when number of nodes=100 packet size=500 bytes, Interval=0.15 sec Mobility=1000

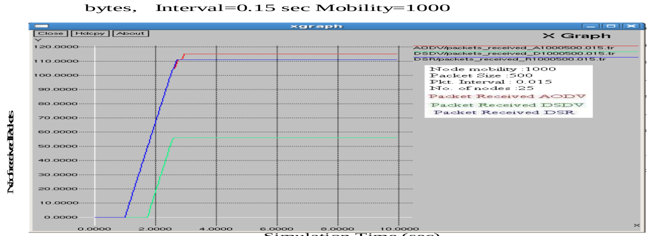


Figure 6 (Packets Received when number of nodes=25 packet size=500 bytes, interval=0.015 sec Mobility=1000)

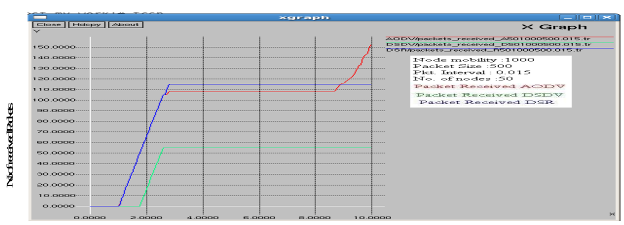


Figure 7 (Packets Received when number of nodes=50 packet size=500 bytes, interval=0.015 sec Mobility=1000)

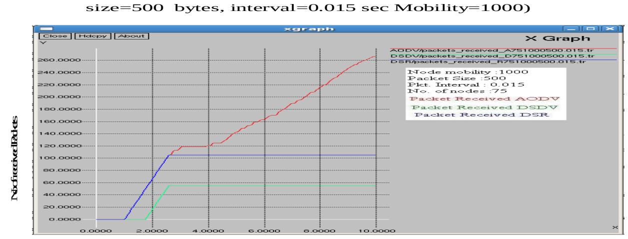


Figure 8 (Packets Received when number of nodes=75 packet size=500 bytes, interval=0.015 sec Mobility=1000)

Table 7 (Performance Matrix number of nodes=25 packet size=500 bytes, interval=0.015 sec Mobility=1000)

Table-7	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/115	19.16	1.87	12.77	8.95	17.17
DSDV	600/56	9.33	2.15	6.22	10.71	14.46
DSR	600/111	18.50	1.83	12.33	15.98	15.57

Table 8 (Performance Matrix number of nodes=50 packet size=500 bytes, interval=0.015 sec Mobility=1000)

Table-8	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	600/154	25.66	4.09	17.	11.16	73.43
DSDV	600/55	9.16	2.16	6.11	10.90	14.24
DSR	600/115	19.16	1.86	12.77	15.08	16.81

Table 9 (Performance Matrix number of nodes=75 packet size=500 bytes, interval=0.015 sec Mobility=1000)

Table-9	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/266	44.33	4.74	29.55	6.12	92.84
DSDV	600/55	9.16	2.16	6.11	10.90	14.27
DSR	600/105	17.50	1.78	11.66	16.39	14.66

Table 10 (Performance Matrix number of nodes=100 packet size=500 bytes, interval=0.015 sec Mobility=1000)

Table-10	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	600/208	34.66	4.64	23.11	8.45	89.00
DSDV	600/64	10.66	2.09	7.11	9.37	14.35
DSR	600/113	18.83	1.97	12.55	14.94	45.8

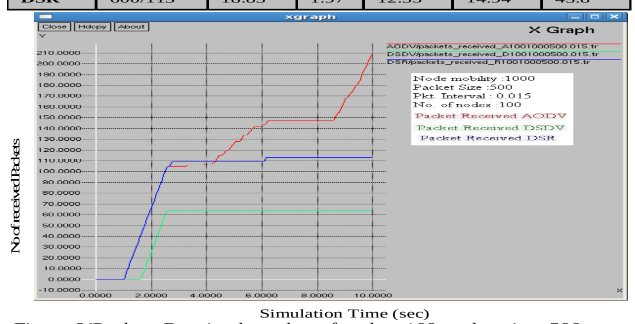


Figure 9(Packets Received number of nodes=100 packet size=500 bytes, interval=0.015 sec Mobility=1000)

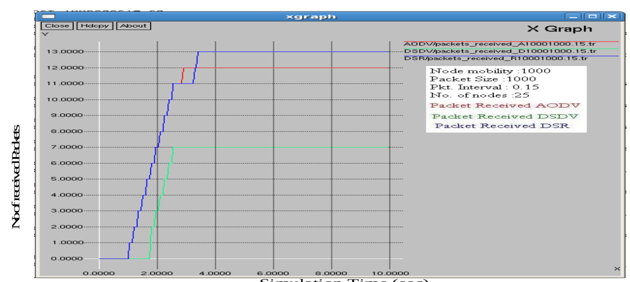


Figure 10(Packets Received number of nodes=25 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

In scenario 02, Figure 6, 7, 8 and 9 shows that number of packets received in AODV is more as compared to DSR and DSDV, when numbers of nodes are scalable from 25, 50, 75 and 100. AODV is also having the highest PDR and throughput with minimum routing load and jitter relative to DSR. We have also analyzed that in DSDV, Jitter, end to end delay is low as compared to AODV and DSR but throughput, number of packets received and PDR is also on lower side. The overall performance of AODV is better, as four QoS parameters out of six has favourable results as indicated in Table 7, Table 8, Table 9 and Table 10.

Table 11(Performance Matrix number of nodes=25 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

Table-11	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/12	20.00	1.85	1.33	7.08	141.34
DSDV	60/7	11.66	2.08	0.77	8.57	106.66
DSR	60/13	21.66	1.99	1.44	23.15	156.70

Table 12(Performance Matrix number of nodes=50 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

Table-12	Packets Sent/ Received	PDR	End - End	Throughput	Routing Loa	Jitter
AODV	60/54	90.00	5.75	6.00	5.20	202.22
DSDV	60/6	10.00	2.13	0.66	10.0	100.02
DSR	60/59	98.33	5.76	6.55	7.61	176.60

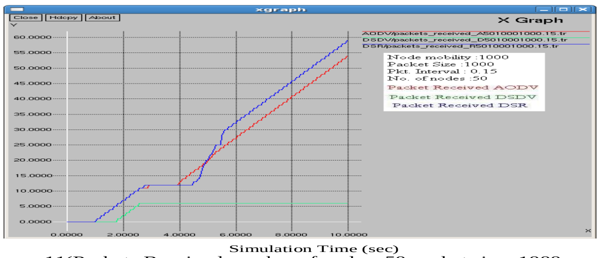


Figure 11(Packets Received number of nodes=50 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

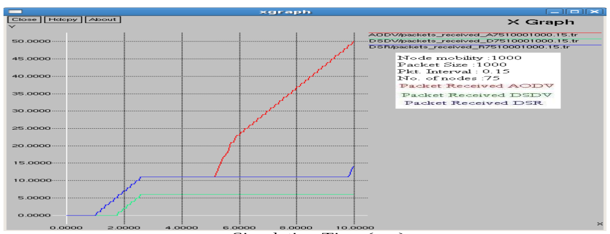


Figure 12(Packets Received number of nodes=75 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

Table 13 (Performance Matrix number of nodes=75 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

Table-13	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/50	83.33	6.01	5.55	6.44	175.20
DSDV	60/6	10.00	2.13	0.66	10.00	100.00
DSR	60/14	23.33	3.50	1.55	39.57	626.18

Table 14(Performance Matrix number of nodes=100 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

Table-14	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/47	78.33	5.91	5.22	5.68	190.106
DSDV	60/7	11.66	2.06	0.77	8.57	107.03
DSR	60/31	51.66	5.74	3.44	15.32	411.98

In scenario 03, Figure 10 and 11 shows number of packets received in DSR are more in comparison with AODV and DSDV, when numbers of nodes are 25 and 50. The performance of DSR is also better for other QoS parameters with these numbers of nodes as depicted in Table 11 and Table 12.Figure 12 and 13 shows the number of received packets and performance of DSR degrades when number of nodes are increased to 75 and 100 as shown in Table 13 and Table 14.

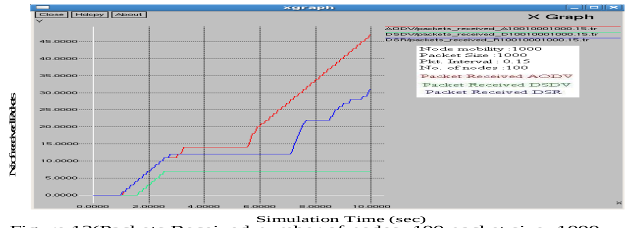


Figure 13(Packets Received number of nodes=100 packet size=1000 bytes, interval=0.15 sec Mobility=1000)

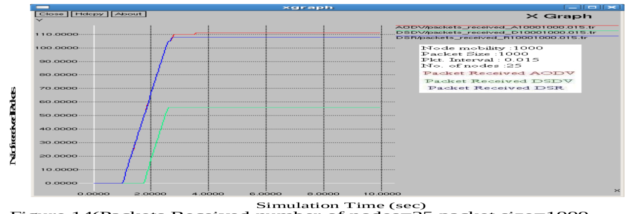


Figure 14(Packets Received number of nodes=25 packet size=1000 bytes, interval=0.015 sec Mobility=1000)

Table 15(Performance Matrix number of nodes=25 packet size=1000) bytes, interval=0.015 sec Mobility=1000)

Table-15	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/111	18.50	1.84	12.33	6.46	22.62
DSDV	600/56	9.33	2.15	6.22	10.71	14.39
DSR	600/108	18.00	1.81	12.00	12.89	14.20

Table 16 (Performance Matrix number of nodes=50 packet size=1000 bytes, interval=0.015 sec Mobility=1000)

Table-16	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	600/142	23.66	3.05	15.77	8.76	89.68
DSDV	600/55	9.16	2.16	6.11	10.90	14.16
DSR	600/105	17.50	1.79	11.66	12.86	14.79

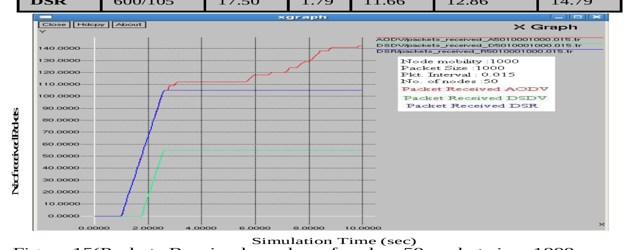


Figure 15(Packets Received number of nodes=50 packet size=1000 bytes, interval=0.015 sec Mobility=1000)

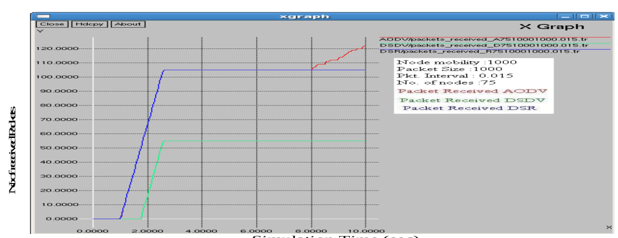


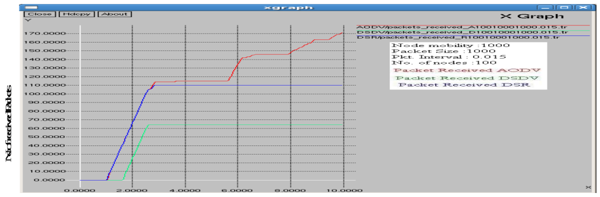
Figure 16(Packets Received number of nodes=75 packet size=1000 bytes, interval=0.015 sec Mobility=1000)

Table 17(Performance Matrix number of nodes=75 packet size=1000 bytes, interval=0.015 sec Mobility=1000)

Table-17	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/123	20.50	2.84	13.66	10.31	83.63
DSDV	600/55	9.16	2.16	6.11	10.90	14.20
DSR	600/105	17.50	1.78	11.66	12.36	14.62

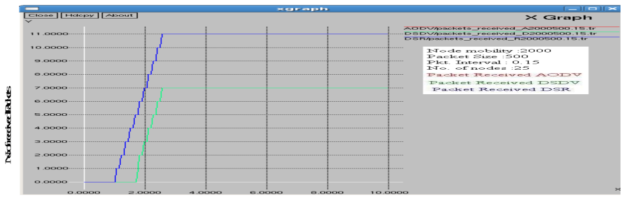
Table 18 (Performance Matrix number of nodes=100 packet size=1000 bytes, interval=0.015 sec Mobility=1000)

Table-18	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/171	28.50	3.63	19.00	6.65	72.67
DSDV	600/64	10.66	2.09	7.11	9.37	14.29
DSR	600/110	18.33	1.83	12.22	11.97	12.19



Simulation Time (sec)

Figure17 (Packets Received number of nodes=100 packet size=1000 bytes, interval=0.015 sec Mobility=1000)



Simulation Time (sec)

Figure 18(Packets Received number of nodes=25 packet size=500 bytes, interval=0.15 sec Mobility=2000)

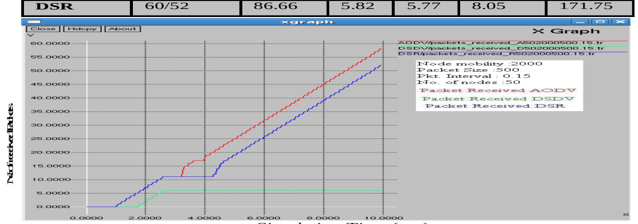
In scenario 04, Figure 14, 15, 16 and 17 shows that number of packets received in AODV is more as compared to DSR and DSDV, when numbers of nodes are scalable from 25, 50, 75 and 100. AODV is also having the highest PDR and throughput with minimum routing load and jitter relative to DSR. We have also analyzed that in DSDV, Jitter, end to end delay is low as compared to AODV and DSR but throughput, number of packets received and PDR is also on lower side. The overall performance of AODV is better, as four QoS parameters out of six has favourable results as indicated in Table 15, Table 16, Table 17 and Table 18.

Table 19 (Performance Matrix number of nodes=25 packet size=500 bytes, interval=0.15 sec Mobility=2000)

Table-19	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/11	18.33	1.75	1.22	20.00	122.72
DSDV	60/7	11.66	2.07	0.77	8.57	106.87
DSR	60/11	18.33	1.75	1.22	8.09	122.72

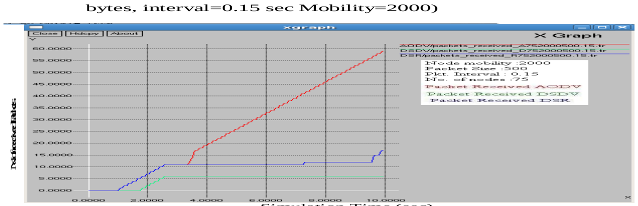
Table 20 (Performance Matrix number of nodes=50 packet size=500 bytes, interval=0.15 sec Mobility=2000)

Table-20	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	60/58	96.66	5.55	6.44	5.81	150.60
DSDV	60/6	10.00	2.13	0.66	10.00	100.02
DSR	60/52	86.66	5.82	5.77	8.05	171.75



Simulation Time (sec)

Figure 19(Packets Received number of nodes=50 packet size=500 bytes, interval=0.15 sec Mobility=2000)



Simulation Time (sec)

Figure 20(Packets Received number of nodes=75 packet size=500 bytes, interval=0.15 sec Mobility=2000)

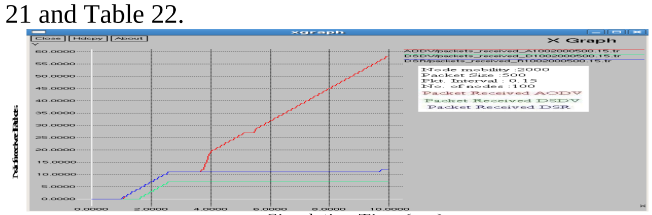
Table 21 (Performance Matrix number of nodes=75 packet size=500 bytes, interval=0.15 sec Mobility=2000)

Table-21	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/59	98.33	5.53	6.55	5.89	148.04
DSDV	60/6	10.00	2.13	0.66	10.00	100.00
DSR	60/17	28.33	4.41	1.88	42.52	513.65

Table 22 (Performance Matrix number of nodes=100 packet size=500 bytes, interval=0.15 sec Mobility=2000)

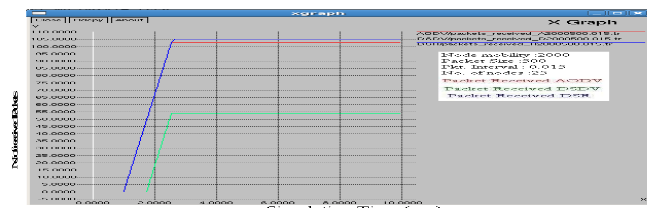
Table-22	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	60/58	96.66	5.57	6.44	5.36	150.50
DSDV	60/7	11.66	2.06	0.77	8.57	107.03
DSR	60/12	20.00	2.41	1.33	60.08	712.08

In scenario 05, Figure 18 shows, when number of nodes 25 the number of packets received in AODV and DSR equal, so its QoS parameters are almost same as depicted in Table 19. Figure 19, 20 and 21 shows when numbers of nodes are scalable from 50, 75 and 100 the number of received packets and performance of DSR degrades. The overall performance of AODV is best as four QoS parameters out of six has favourable results as indicated in Table 20, Table 21 and Table 22.



Simulation Time (sec)

Figure 21(Packets Received number of nodes=100 packet size=500 bytes, interval=0.15 sec Mobility=2000)



Simulation Time (sec)

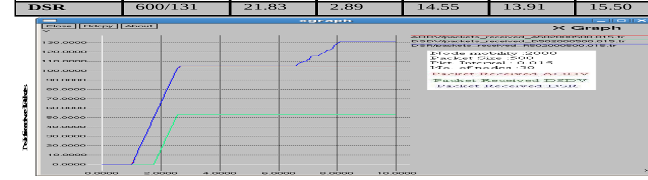
Figure 22(Packets Received number of nodes=25 packet size=500 bytes, interval=0.015 sec Mobility=2000)

Table 23(Performance Matrix number of nodes=25 packet size=500 bytes, interval=0.015 sec Mobility=2000)

Table-23	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/103	17.16	1.77	11.44	12.01	14.69
DSDV	600/54	9.00	2.13	6.00	11.11	14.43
DSR	600/105	17.50	1.78	11.66	11.09	14.69

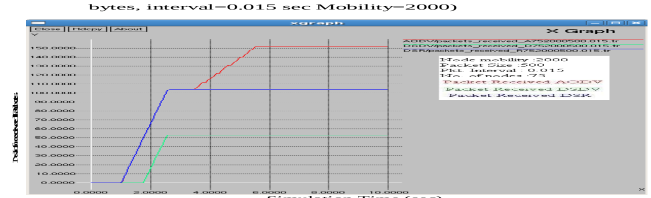
Table 24 (Performance Matrix number of nodes=50 packet size=500 bytes, interval=0.015 sec Mobility=2000)

Table-24	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/104	17.33	1.77	11.55	17.00	15.50
DSDV	600/53	8.83	2.14	5.88	11.32	14.21
DSR	600/131	21.83	2.89	14.55	13.91	15.50



Simulation Time (sec)

Figure 23(Packets Received number of nodes=50 packet size=500 bytes, interval=0.015 sec Mobility=2000)



Simulation Time (sec)

Figure 24(Packets Received number of nodes=75 packet size=500 bytes, interval=0.015 sec Mobility=2000)

Table 25 (Performance Matrix number of nodes=75 packet size=500 bytes, interval=0.015 sec Mobility=2000)

Table-25	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	600/152	25.33	2.64	16.88	11.38	38.67
DSDV	600/53	8.83	2.14	5.88	11.32	14.25
DSR	600/104	17.33	1.77	11.55	16.54	38.67

Table 26(Performance Matrix number of nodes=100 packet size=500 bytes, interval=0.015 sec Mobility=2000)

Table-26	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	600/230	38.33	4.30	25.55	6.23	80.04
DSDV	600/62	10.33	2.07	6.88	9.67	14.33
DSR	600/104	17.33	1.77	11.55	17.09	80.04

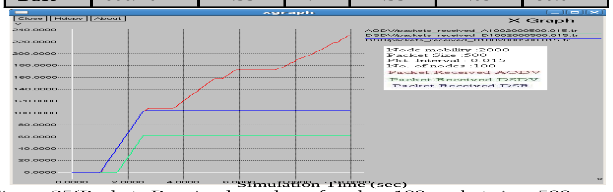


Figure 25(Packets Received number of nodes=100 packet size=500 bytes, interval=0.015 sec Mobility=2000)

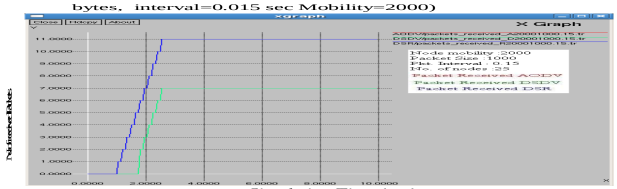


Figure 26(Packets Received number of nodes=25 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

In scenario 06, Figure 22 and 23 shows number of packets received in DSR are more in comparison with AODV and DSDV, when numbers of nodes are 25 and 50. The performance of DSR is also better for other QoS parameters with these numbers of nodes as depicted in Table 23 and Table 24.Figure 24 and 25 shows the number of received packets and performance of DSR degrades when number of nodes are increased to 75 and 100 as shown in Table 25 and Table 26.

Table 27 (Performance Matrix number of nodes=25 packet size=1000 bytes, interval=0.15 sec Mobility=2000)

Table-27	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/11	18.33	1.76	1.22	20.36	122.7
DSDV	60/7	11.66	2.08	0.77	8.57	106.6
DSR	60/11	18.33	1.76	1.22	9.18	122.7

Table 28 (Performance Matrix number of nodes=50 packet size=1000 bytes, interval=0.15 sec Mobility=2000)

Table-28	Packets Sent/ Receiv	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/58	96.66	5.57	6.44	5.81	151.02
DSDV	60/6	10.00	2.13	0.66	10.00	100.02
DSR	60/36	60.00	6.75	4.00	17.75	595.09

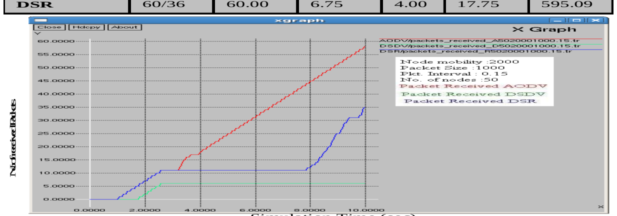


Figure 27(Packets Received number of nodes=50 packet size=1000 bytes, interval=0.15 sec Mobility=2000)

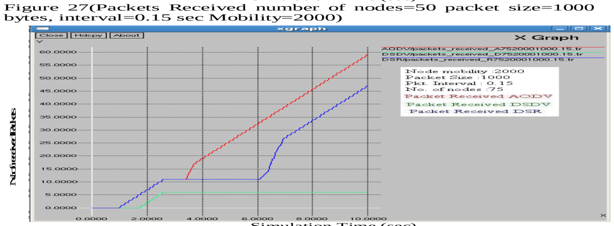


Figure 28(Packets Received number of nodes=75 packet size=1000 bytes, interval=0.15 sec Mobility=2000)

Table 29 (Performance Matrix number of nodes=75 packet size=1000 bytes, interval=0.15 sec Mobility=2000)

Table-29	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	60/59	98.33	5.56	6.55	5.89	148.46
DSDV	60/6	10.00	2.13	0.66	10.00	100.00
DSR	60/47	78.33	6.25	5.22	9.36	212.20

Table 30(Performance Matrix number of nodes=100 packet size=1000 bytes, interval=0.15 sec Mobility=2000)

Table-30	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	60/58	96.66	5.61	6.44	5.36	150.84
DSDV	60/7	11.66	2.06	0.77	8.57	107.03
DSR	60/22	36.66	5.43	2.44	20.90	618.23

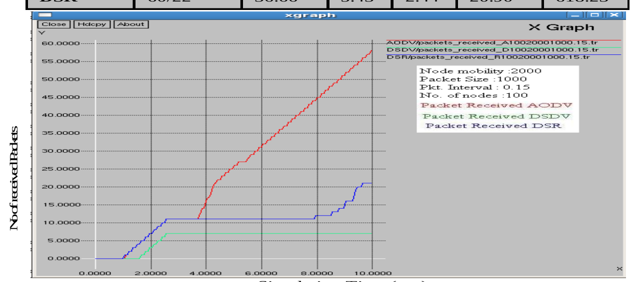


Figure 29(Packets Received number of nodes=100 packet size=1000 bytes, interval=0.15 sec Mobility=2000)

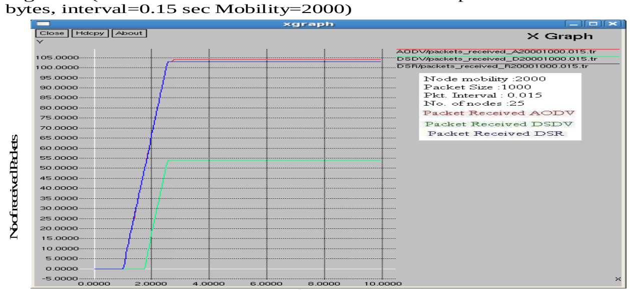


Figure 30(Packets Received number of nodes=25 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

In scenario 07, Figure 26 shows, when number of nodes 25 the number of packets received in AODV and DSR equal, so its QoS parameters are almost same as depicted in Table 27. Figure 27, 28 and 29 shows when numbers of nodes are scalable from 50, 75 and 100 the number of received packets and performance of DSR degrades. The overall performance of AODV is best as four QoS parameters out of six has favourable results as indicated in Table 28, Table 29 and Table 30.

Table 31 (Performance Matrix number of nodes=25 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

Table-31	Packets Sent/ Received	PDR	End-End Delay	Through put	Routing Load	Jitter
AODV	600/104	17.33	1.78	11.55	6.08	16.09
DSDV	600/54	9.00	2.14	6.00	11.11	14.36
DSR	600/103	17.16	1.77	11.44	11.51	14.64

Table 32 (Performance Matrix number of nodes=50 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

Table-32	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/194	32.33	4.07	21.5	6.41	158.26
DSDV	600/53	8.83	2.15	5.88	11.32	14.14
DSR	600/103	17.16	1.77	11.4	12.93	14.78

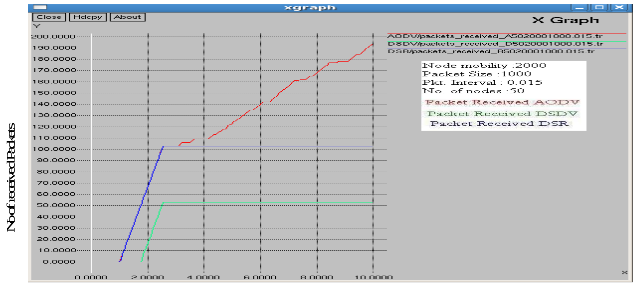


Figure 31(Packets Received number of nodes=50 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

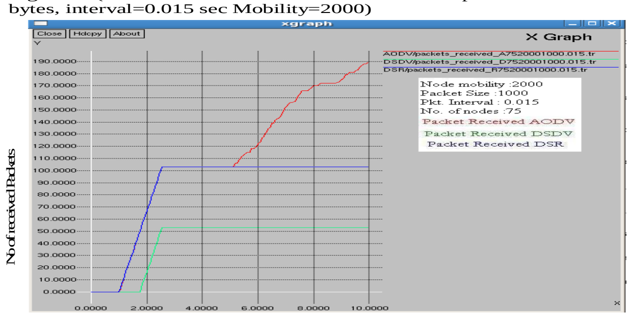


Figure 32(Packets Received number of nodes=75 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

Table 33 (Performance Matrix number of nodes=75 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

Table-33	Packets Sent/ Received	PDR	End-End Delay	Throughput	Routing Load	Jitter
AODV	600/191	31.83	4.25	21.22	6.86	80.96
DSDV	600/53	8.83	2.15	5.88	11.32	14.17
DSR	600/103	17.16	1.77	11.44	13.17	14.61

Table 34(Performance Matrix number of nodes=100 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

Table-34	Packets Sent/ Received	PDR	End - End	Throughput	Routing Load	Jitter
AODV	600/182	30.33	3.83	20.22	7.03	98.19
DSDV	600/62	10.33	2.08	6.88	9.67	14.27
DSR	600/103	17.16	1.77	11.44	12.89	14.79

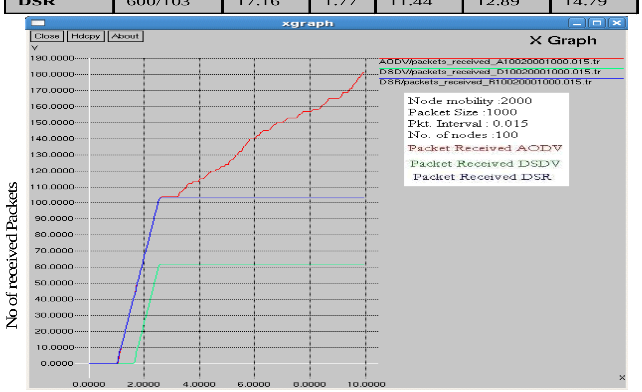


Figure 33(Packets Received number of nodes=100 packet size=1000 bytes, interval=0.015 sec Mobility=2000)

In scenario 08, Figure 30 shows, when number of nodes 25 the number of packets received in AODV and DSR equal, so its QoS parameters are almost same as depicted in Table 31. Figure 31, 32 and 33 shows when numbers of nodes are scalable from 50, 75 and 100 the number of received packets and performance of DSR degrades. The overall performance of AODV is best as four QoS parameters out of six has favourable results as indicated in Table 32, Table 33 and Table 34.

5 Conclusions

As observed by simulation from eight different scenarios, the AODV protocol is QoS-aware routing protocols under the effect of scalability in terms of variation in number of nodes, mobility rate and packet intervals. With the increase in network size, the performance of DSR decreases due to increase in packet-header overhead size as data and control packets in DSR typically carry complete route information. We have also analyzed that the performance of DSDV has not been affected by varying number of nodes, packet size, and mobility rate, its overall performance is less than AODV and DSR Protocol.

References

[1] Nadia Qasim, Fatin Said, Hamid Aghvami , " Mobile Ad Hoc Networks Simulations Using Routing Protocols for Performance Comparisons", Proceedings of the World Congress on Engineering 2008 Vol I WCE 2008, London, U.K, July 2 - 4, 2008.

[2] Mr. Rajneesh Gujral, Dr. Anil Kapil "Secure QoS Enabled On-Demand Link-State Multipath Routing in MANETS" Proceeding of BAIP 2010, pp. 250-257 SPRINGER LNCS-CCIS, Trivandrum, Kerala, India, March 26-27, 2010.

[3] C. Siva Ram Murthy & B.S. Manoj, Ad-hoc Wireless networks, Pearson

[4] N.Adam, M.Y.Ismail, J. Abdullah, "Effect of node density on performances of three Manet routing protocols", in International conference on Electronic devices, Systems and Applications 2010.

[5] P. Sateesh Kumar, S. Ramachandram, "Scalability of Network Size on Genetic Zone Routing Protocol for MANETs,"icacte, International Conference on Advanced Computer Theory and Engineering, pp.763-767, 2008.

[6] Prashant Singh, Daya Krishan Lobiyal, "Scalability of Routing in MANET," iccsn, Second International Conference on Communication Software and Networks, pp.325-328, 2010.

[7] M. Tamilarasi, V.R. Shyam Sunder, Udara Milinda Haputhanthri, Chamath Somathilaka, Nannuri Ravi Babu, S. Chandramathi, T.G. Palanivelu, "Scalability Improved DSR Protocol for MANETs," iccima, vol. 4, pp.283-287, 2007.

[8] J Broch, D. Maltz,D.Johnson, Y.C.Hu,and J.Jetcheva, " A performance comparison of multihop wireless ad hoc network routing protocols," MOBICOM'98,pp.85-97,October 1998.

[9] S.R. Das, R. Castaneda, J. Yan, R. Sengupta, "Comparative Performance Evaluation of Routing Protocols for Mobile Ad hoc Networks," Proceedings of the international Conference On Computer Communications and Networks (ICCCN 1998), pp.153-161, 1998.

[10] S.Jaap,M.Bechler and L. Wolf, "Evaluation of Routing Protocols for Vehicular Ad Hoc network in city traffic scenarios," International Conference on ITS Telecommunications,France,2005.

[11] T. Clausen, P Jacquet,L Viennot, " Comparative study of Routing Protocols for Mobile Ad Hoc Networks," The first

Annual Mediterranean Ad Hoc Networking Workshop, September 2002.
[12] J. Novatnack, L. Greenwald, H. Arora " Evaluating Ad hoc Routing Protocols With Respect to Quality of Service," Wireless and Mobile Computing Networking and Communications WiMob'2005.
[13] Mr. Rajneesh Gujral, Dr. Anil Kapil "Comparative Performance Analysis of QoS-Aware Routing on DSDV, AODV and DSR Protocols in MANETs" Communications in Computer and Information Science,1,volume 101,Information and Communication Technologies,Part 3,pp. 610-615,2010.
[14] Asha Ambhaikar, Debashmita Mitra, Rajesh Deshmukh "Performance of MANET Routing Protocol for Improving Scalability" International Journal of Advanced Engineering & Application, pp. no- 15-18 Jan 2011.
[15] Sung-Ju Lee, Elizabeth M. Belding-Royer, and Charles E.Perkins "Scalability Study of the Ad hoc On Demand Distance Vector Routing Protocol"International Journal of Network Management Vol. 13, pp no.97–114,2003.
[16] Debajyoti Mishra, Ashima Rout and Srinivas Sethi. Article: An Effective and Scalable AODV for Wireless Ad hoc Sensor Networks. International Journal of Computer Applications 5(4):33–38, August 2010.
[17] Huda AlAmri,Mehran Abolhasan, Tadeusz A. Wysocki " Scalability of MANET routing protocols for heterogeneous and homogenous networks" Journal of Computers & Electrical Engineering-CEE, vol. 36, no. 4, pp. 752-765,2010.
[18] Abolhasan, M., T. Wysocki, and E. Dutkiewciz, "A review of routing protocols for mobile ad hoc networks" Elsevier journal of Ad hoc networks,12(1): pp. 1-22,2004.
[19] David .B Johnson, David. A. Maltz, and Josh Broch, " Dynamic Source Routing protocol for Multihop Wireless Ad Hoc Networks," In Ad Hoc Networking, edited by Charles E. Perkins Addison-Wesley,, chapter 5, pp. 139-172.,2001.

First Author Rajneesh Kumar Gujral is working as Assoc. Professor in Department of Computer Science and Engineering, M.M Engineering College, M. M. University Mullana, Ambala. He obtained his BE (Computers) in 1999 from Punjab Technical University (PTU), Jalandhar. He also obtained his MTECH (IT) in 2007 from University School of Information Technology, GGSIP University Delhi. He has about 10 publications in International journals and Conferences. His research areas are Wireless communications which include Mobile Ad hoc and sensor based networks, Network Security and computer communication networks etc.

Second Author Dr. Manpreet Singh is working as Professor and Head of Department of Computer Science and Engineering, M.M engineering college, M. M. University Mullana, Ambala, India. He obtained his Ph.D., M.Tech. and B. Tech. from Kurukshetra University. He has about 25 publications in International journals and Conference. His research areas are Distributed Computing, Grid Computing, Ad hoc and sensor based networks, Distributed Database etc.