Performance Analysis and Comparison of MANET Routing Protocols in Selected Traffic Patterns For Scalable Network

Gouri M. Patil[1]
Department of Computer Science,
Savitribai Phule Pune University
Pune-411 007, India,
email- gourimpatil@gmail.com

Dr. Ajay Kumar[2]
Jayawant Technical Campus,
Jayawant Institute of Business Studies
Pune-411 033, India,
email-ajay19_61@rediffmail.com

Dr. A. D. Shaligram[3]
Department of Electronic Science,
Savitribai Phule University,
Pune-411 007, India,
email-adshaligram@gmail.com

***Abstract*: A MANET is autonomous Network of mobile nodes in which mobile nodes can communicate without any mean of infrastructure. Many routing protocols have been proposed for MANET, but none of them has good performances in all scenarios due to different variance. The variance can be network area size, node scalability, network traffic load, node mobility and node mobility pattern. The traffic model determines the reliability and capability of MANET. In the recent years, MANET has gained the popularity in many diverse applications having different mobility models and traffic patterns. This paper evaluates the performance of Reactive Routing Protocols AODV and DSR in traffic models CBR, Pareto and Exponential using Random Waypoint mobility mode for the scalable network of 10-200 nodes and compared on the basis of three performance metrics: 'Routing Load', 'End-to-End delay' and 'Throughput' using NS-2 simulator. The results story shows that, DSR routing protocol better perform in CBR, PARETO and EXPONENTIAL traffic pattern in terms of routing load and end-to-end delay. If MANET applications requirement is 'throughput' then AODV routing protocol is slightly better in all the three traffic patterns: CBR, PARETO and EXPONENTIAL.**

Keywords- MANET; AODV; CBR; Pareto; Exponentia;, Random Way Point; Routing Load; Throughput; End-to-End Delay.

I. INTRODUCTION

A MANET is wireless network consists of wireless mobile nodes communicating with one another for ad hoc purpose [10]. It is a self creating, self organizing, self configuring and self administrating network of mobile nodes connected by wireless links in which topology changes frequently and it is unpredictable. Each node in the network behaves as router and forward packets for other nodes. When nodes act as routers, they discover and maintain the other nodes in the network. As MANET environment is characterized by frequently changing topology and varying channel conditions, routing is a challenging problem. Many routing protocols have been proposed for MANET, but none of them has good performances in all scenarios due to different variance. The variance can be network area size, node scalability, network traffic load, node mobility and node mobility pattern.

Application layer traffic analysis is important for a particular application on ad hoc network to understand the performance of ad hoc network. The type of resources in communication at application layer depends on type of applications used. For example video streaming over the network requires more resources than sharing a file, sending an email needs accuracy but it does not require bandwidth or delay. For these requirements careful analysis of application traffic in the various conditions is the requirement [7]. Also Traffic estimation reflects the volume of traffic that flows between all possible paths from source and destination in MANET [9]. Efficient routing is the current demand of a Mobile Ad-Hoc Network. In order to communicate well the routing algorithm needed to be the best in all the conditions and traffic environments [5]. Analyzing and understanding the traffic characteristics of the network is an important to understand applications performance.

In the recent years, MANET has gained the popularity in many diverse applications having different mobility models and traffic patterns. A few possible examples are earthquake hit areas, where infrastructure is destroyed; military soldiers in a destructive environment; virtual classrooms, biological detection, tracking of rare animal, space exploration, and undersea operations. Some more examples are as emergency situations like natural disasters, emergency and rescue operations, field applications etc. Each of these applications can potentially involve in different scenarios with different mobility patterns and traffic patterns.

Traffic behavior is one of the key factors for the performance of a network. The traffic patterns play an important role in the performance of routing protocols. In case of Constant Bit Rate (CBR) the traffic pattern generates data packets at a constant rate [1] and is good enough for text transmission. CBR does not accommodate the specific features of multimedia applications and video-conferencing services. Recently, multimedia applications have drawn the attention of researchers a lot in MANET. These multimedia applications have a radically different traffic pattern. The data rate in voice application increases till it reaches a maximum peak. The Exponential Traffic Pattern which is very useful for generating multimedia traffic such as audio, video and text traffic etc. This pattern of traffic can be captured by Exponential distribution

and it is of Variable Bit Rate (VBR) [3]. The third type of traffic pattern is Pareto in which ON-time and OFF-time traffic is considered. The careful analysis of application traffic in the various conditions provides an insight to design routing protocol which can function according to application requirement. So, the relationship between traffic and routing is well worth investigation.

In this paper, two reactive routing protocols AODV and DSR performance are evaluated for scalable MANET network of 10-200 nodes and compared on the basis of three performance metrics such as Routing Load, End-to-End delay and Throughput in three different traffic models as CBR, Pareto and Exponential considering Random Way Point mobility model.

II. LITERATURE REVIEW

From the literature review, it is observed that design and analysis of Mobile ad hoc networks (MANETS) and their performance are studied in the context of realistic traffic models. Most of the research work in MANET is carried out for one or two traffic models.

Ahmed Al-Maashri [1], studies on bursty and self-similar traffic to evaluate the performance of MANET routing protocols DSR, AODV and OLSR. The DSR routing protocol performs well with bursty traffic models than AODV and OLSR routing protocols. The performance of OLSR is very poor for self-similar traffic at high mobility rate and AODV routing protocol has average performance.

Narinder Kaur Panesar [11] compares AOMDV and AODV routing protocol for CBR, Pareto and Exponential traffic models. The AOMDV with CBR traffic perform better than AODV with the increasing number of nodes. With Pareto and Exponential traffic both the routing protocols have constant performance with the increasing number of nodes. In case of throughput, with CBR traffic AOMDV and AODV have same performance. With Pareto traffic both the routing protocols have same performance. With Exponential traffic AODV performs better than AOMDV protocol.

Megha Rastogi [9], analysis for routing protocols AODV and DSR with FTP, CBR, VBR, Pareto and Packmime traffic pattern had obtained over 90% throughput on different pause time under different scenarios. Bindeshwar Singh Kushwah [5], analyzes the behavior of MANET routing protocols using three traffic generators namely Exponential, Pareto and CBR (Constant Bit Rate). DSDV has better performance than AODV and DSR for CBR and Pareto traffic. In case of Exponential traffic, AODV has better performance than DSDV. Arindrajit Pal, Jyoti Prakash Singh[3], presented the behavior of the mobile nodes for different speed for three different traffic patterns such as CBR, Exponential and Pareto. They found through simulations that the AODV routing protocol performs much better than DSR in Exponential and Pareto traffic.

III. OBJECTIVES

- To evaluate and compare the performance of MANET routing protocols on different traffic models for scalable network.

IV. ROUTING PROTOCOLS

Reactive Routing Protocols: It is also refer as an on demand routing protocol due to its nature of route establishment. Data in routing table is maintained only when node wishes to send data to another one. When the node wishes to send a packet to another node, then the protocol detects the path and establishes the connection between the sender node and destination node for subsequent transmission and reception of packets [11]. Ad-Hoc On-Demand Vector Protocol (AODV) reactive routing protocol is primarily developed for MANET. It works with on-demand technology to discover routes between source and destination [7]. It uses various control messages as RREQ, RREP, RERR and HELLO [12]. Dynamic Source Routing (DSR) [10] is reactive protocol operating as on-demand basis and allows mobile nodes to dynamically discover a source route across multiple network nodes to any destination within the ad hoc network. All nodes involved in packet transmission can cache this routing information for later use [8].

V. TRAFFIC MODELS

A Traffic Generator models the traffic which behaves in a predefine structure and schedule manner. It sends the demand to transmit the traffic payload regardless of the state of the agent being attached at a specific time and interval [9]. In simulators, traffic generators use probability distribution functions to generate application traffic which have some patterns, and they have parameters, and value of parameters can be changed to evaluate a protocol.

1. Constant Bit Rate (CBR): CBR traffic Generator creates the payload (emits packets at fixed bit rate [No-193]) which is fixed in size and the generation of packet interval is fixed [9]. It generates traffic at deterministic rate. It is not an on/off traffic [11].

The traffic parameters which are to be configured [5] are,
Packet Size- Size of the generated packet
Data Rate- Rate at which data to be sent
Interval -Time stamp between to packets.

2. PARETO: It is an on/off traffic [11]. Pareto Probability Distribution Traffic is described follow.
A random variable X is said to follow Pareto distribution, when it follows the following probability distribution function.

$$F(x) = P(X > x) = \begin{cases} 1 - \frac{x_{(x_m)}{}^{\alpha}}{x} & x \geq x_m, \\ & x < x_m. \end{cases} \quad (1)$$

Where, is a scale parameter and is a shape parameter.

Using and an on-off traffic can be generated by varying them.

The parameters need to be configured to generate Pareto distribution traffic [5] listed below.
Packet Size - Size of the packet to be generated
Burst Time - On time for traffic generator
Idle Time - Off time for traffic generator
Rate - On time data rate
Shape - Shape parameter for distribution

3. EXPONENTIAL(Variable Bit Rate): Exponential Traffic Generator creates the payloads similar to the CBR but it have the interval of ON/OFF states in which, the ON states the traffic being generated and the OFF states the traffic being not generated in the specified time interval. The ON/OFF states of the traffic generator are exponentially distributed [2, 9, 11].
Exponential probability distribution's PDF is defined as.

$$f(x;\lambda) = \begin{cases} \lambda e^{-\lambda x} & x \geq 0, \\ 0 & x < 0. \end{cases} \quad (3)$$

Where, is the average exponential occurrence rate.
An on-off traffic can be generated by varying the parameter- . Packets can be emitted during on periods, and there is no packet emission during off period. In NS-2, burst time and idle time are taken from exponential distribution to generate application traffic.

The following parameters are needed to be configured for traffic generation.
Packet Size - Size of the packet to be generated
Burst Time - On time for traffic generator
Idle Time - Off time for traffic generator
Rate - On time data rate.

VI. SIMULATION SETUP

Network Simulator NS-2 is simply an event driven simulation tool that has proved useful in studying the dynamic nature of communication networks as MANET. The performance of AODV and DSR routing protocol for varying node density is evaluated having the parameters specified for different traffic pattern like CBR, Pareto and Exponential with Random Way Point mobility model. The communication parameters and movement parameters considered for simulation are given below.

a) *Communication Model:* The simulation uses three types of traffic patterns as Constant Bit Rate (CBR), Pareto and Exponential with a transmission rate of 8 packets per second. The number of nodes varies from 10 to 200 in the denomination of 10, 20, 25 and 50.

Table-1: Communication Parameters selected for simulation

Parameter	Value
Traffic	CBR / Pareto / Exponential
No. of nodes	10, 20, 30, 50,75, 100, 150, 200
Transmission Rate	8 packets/sec

b) *Movement parameters for the study:* For the realistic mobility pattern, Random Waypoint mobility Model is selected in which a node is allowed to move in any direction arbitrarily in topography.

The node may move in any random direction of destination in the 500 meters X 500 meters space and speed of node movement can be vary from minimum of 0.5 meter per second 1.5 meters per second. Moreover after reaching at destination, the node pauses for fixed time of 10 seconds, selects another destination. This procedure is repeated during all the simulation period of 600 seconds. This operation is performed for varied number nodes from 10-200 with the denomination of 10, 20, 25 and 50.

Table-2: Movement Parameters considered for simulation

Parameter	Value
Simulator	NS-2
Simulation time	600 seconds
Area of network	500m x 500m
Pause time	10 seconds
Min. speed of nodes	0.5 meters/sec
Max. speed of nodes	1.5 meters/sec
Mobility Model	Random waypoint

c) *Performance metrics for evaluation:* The performance of the simulated results is analyzed using following performance metrics:

1) Throughput: It is rate of successful data transfer in the network and measured as the ratio of total bytes in a packet received at destination and with time taken. Throughput is expressed in terms of bytes per second or bits per second.

$$Throughput = \frac{\sum Received\ packet\ size}{Stop\ Time - Start\ Time} \quad (1)$$

bytes/sec or bits/sec

2) Avg. End-to-End Delay (E2E): Average time taken by a specific packet is the time to travel from source to destination in a network. It is measure as the total number of time taken for each packets divided by total number of packet received at the destination, is expressed in terms of seconds.

$$Avg.End-To-End\ Delay(E2E) = \frac{\sum(Packet\ Sent\ Time - Packet\ Received\ Time)}{\sum(Packet\ Received)} \quad (2)$$

3) Normalized Routing Load (NRL): The ratio of Number of Routing Packets Received to the Number of Data Packets Received is bits per second (bits/sec).

$$Normalized\ Routing\ Load\ (NRL) = \frac{NRpr}{NDpr} \quad (3)$$

Where, NRpr is the Number of Routing Packets Received and NDpr is the Number of Data Packets Received.

VII. SIMULATION RESULTS AND ANALYSIS

The simulation experiments are conducted for 10-200 nodes with the denomination of 10, 20,25 and 50 for the network area size of 500 x 500 square meters to find the performance of AODV and DSR routing protocols in the traffic patterns of CBR, PARETO and EXPONENTIAL. The experiments are run for 5-6 hours on an average for each case. Further, the obtained results are tabulated in tables and presented through figures for the evaluation and comparison. In SCENARIO-1, MANET performance is evaluated for the traffic models CBR, PARETO and EXPONENTIAL for AODV and DSR routing protocols in terms of routing load, end-to-end delay and throughput. In SCENARIO-2, AODV and DSR routing protocols performance are compared through routing load, end-to-end delay and throughput in CBR, PARETO and EXPONENTIAL traffic patterns.

Scenario-1: Performance evaluation of AODV and DSR routing protocols on CBR, PARETO and EXPONENTIAL traffic pattern for the scalable MANET of 10-200 nodes.

The experimental simulation results of routing load, end-to-end delay and throughput for AODV and DSR routing protocols in CBR, PARETO and EXPONENTIAL traffic patterns for scalable networks of 10-200 nodes are presented in tables and graphs for analysis.

a) 'Routing Load' results and analysis: The simulation results of Routing Load for AODV and DSR with various traffic patterns as CBR, PARETO and EXPONENTIAL for scalable networks are tabulated in Table-3 and comparative is represented in Figure-1 and Figure-2.

Table-3: 'Routing Load' of AODV and DSR routing protocols in CBR, Pareto and Exponential traffic models for scalable network of 10-200 nodes.

Sr. No.	Nodes density	*For AODV Routing Load* (kbps) in traffic patterns			*For DSR Routing Load* (kbps) in traffic patterns		
		CBR	PARETO	EXPONENTIAL	CBR	PARETO	EXPONENTIAL
1	10	**0.003**	**0.004**	**0.002**	**0.001**	**0.0004**	**0.0004**
2	20	**0.006**	**0.010**	**0.004**	**0.001**	**0.001**	**0.0008**
3	30	**0.008**	**0.018**	**0.006**	**0.001**	**0.001**	**0.001**
4	50	**0.011**	**0.032**	**0.013**	**0.006**	**0.004**	**0.004**
5	75	**0.026**	**0.029**	**0.019**	**0.002**	**0.004**	**0.002**
6	100	**0.040**	**0.055**	**0.044**	**0.003**	**0.008**	**0.002**
7	150	**0.056**	**0.102**	**0.085**	**0.001**	**0.004**	**0.004**
8	200	**0.138**	**0.217**	**0.061**	**0.01**	**0.003**	**0.014**

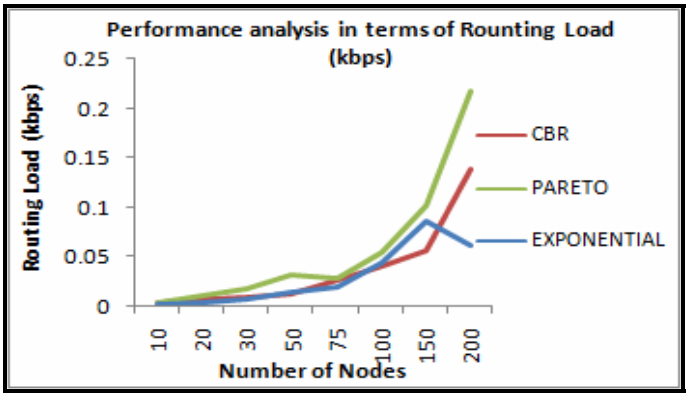

Figure-1: 'Routing Load' in CBR, PARETO and EXPONENTIAL traffic pattern of AODV routing protocol for the scalable network of 10-200 nodes.

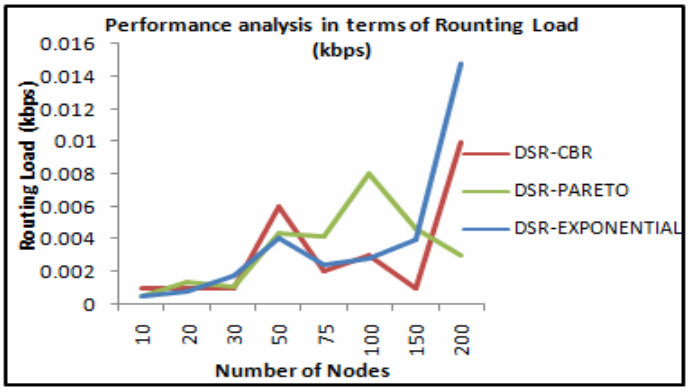

Figure-2: 'Routing load' in CBR, PARETO and EXPONENTIAL traffic pattern of DSR routing protocol for the scalable network of 10-200 nodes.

Observations: From Table-3 and Figure-1 it is observed that 'routing load' of AODV routing protocol in Exponential traffic pattern is better than CBR and Pareto up to 100 nodes MANET network. In case of 150 nodes network CBR is better than Exponential and again Exponential is better for 200 nodes network. Routing load performance in Pareto is high compared to CBR and Exponential traffic pattern.

The routing load for DSR routing protocol in CBR, Pareto and Exponential traffic pattern is very much fluctuating for 10-200 nodes MANET as observed from Table-3 and

Figure-4. For a small MANET up to 30 nodes the routing load performance is similar for all the above three traffic patterns. Further it is observed that for 50 nodes MANET the routing loads are increased compared to 30 nodes MANET and exponential, Pareto traffic pattern gives better performance than CBR. Further, for 75 and 100 nodes MANET CBR and Exponential traffic patterns gives better and same performance compared to Pareto. For 100 nodes MANET CBR traffic pattern is better and for 200 nodes MANET Pareto traffic pattern is better.

b) ***'End-to-End Delay' results and analysis :*** Table-4 shows the simulation results of End-to-End Delay for AODV and DSR routing protocols with various traffic patterns CBR, PARETO, and EXPONENTIAL for scalable networks and comparatively represented in Figure-3 and Figure-4.

Table-4: 'End-to-End Delay' of AODV routing protocol on CBR, PARETO and EXPONENTIAL traffic for scalable network of 10-200 nodes.

Sr. No.	Nodes density	*For AODV End-to-End Delay* (ms) in traffic patterns			*For DSR End-to-End Delay* (ms) in traffic patterns		
		CBR	PARETO	EXPONENTIAL	CBR	PARETO	EXPONENTIAL
1	10	**8.54**	**7.68**	**8.34**	**7.79**	**7.93**	**7.70**
2	20	**8.30**	**7.46**	**7.74**	**7.84**	**7.75**	**7.94**
3	30	**7.90**	**7.76**	**7.81**	**7.82**	**7.87**	**7.87**
4	50	**7.89**	**9.50**	**8.79**	**8.04**	**8.22**	**7.86**
5	75	**8.06**	**7.75**	**7.82**	**7.87**	**7.82**	**7.87**
6	100	**11.82**	**8.97**	**15.65**	**7.89**	**8.31**	**7.94**
7	150	**11.80**	**12.00**	**22.24**	**7.85**	**7.80**	**7.91**
8	200	**18.65**	**20.05**	**12.50**	**8.97**	**7.86**	**8.52**

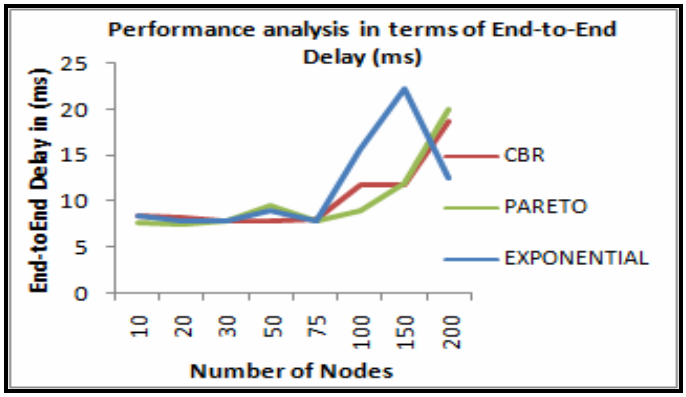

Figure-3: 'End-to-End Delay' in CBR, PARETO and EXPONENTIAL traffic pattern of AODV routing protocol for the scalable network of 10-200 nodes.

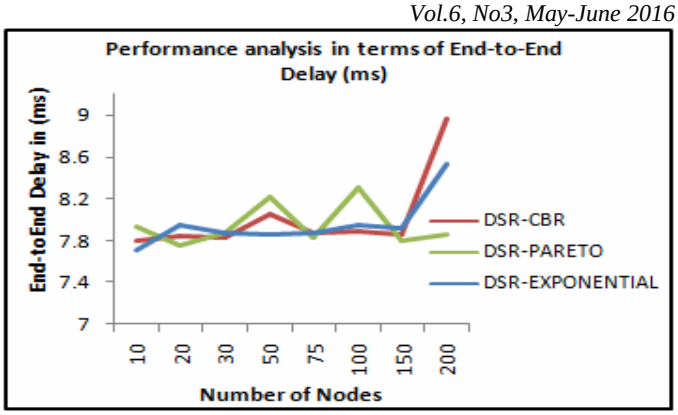

Figure-4: 'End-to-End Delay' in CBR, PARETO and EXPONENTIAL traffic pattern of DSR routing protocol for the scalable network of 10-200 nodes.

Observations: From Table-4 and Figure-3 it is observed that 'End-to-End Delay' is almost same in all three traffic patterns CBR, Pareto and Exponential up to 75 nodes MANET for AODV routing protocol. In case of nodes more than 75 up to 150, the end-to-end delay is drastically increased for exponential traffic pattern and decreased for 200 nodes. The 'End-to-End delay' of AODV with CBR and Pareto traffic pattern started to increased after 75 nodes to 200 nodes.

From Table-4 and Figure-4 it is observed that Exponential traffic pattern gives better end-to-end delay in DSR routing protocol for the MANET up to 150 nodes. In case of 200 nodes MANET end-to-end delay is increased for CBR and Exponential but decrease for Pareto traffic pattern.

c) ***'Throughput' results and analysis:*** Table-5 shows the simulation results of End-to-End Delay for AODV and DSR routing protocols with various traffic patterns CBR, PARETO, and EXPONENTIAL for scalable networks and comparatively represented in Figure-5 and Figure-6.

Table-5: 'Throughput' of AODV and DSR routing protocols on CBR, PARETO and EXPONENTIAL traffic for scalable network of 10-200 nodes.

Sr. No.	Nodes density	*For AODV Throughput* (kbps) in traffic patterns			*For DSR Throughput* (kbps) in traffic patterns		
		CBR	PARETO	EXPONENTIAL	CBR	PARETO	EXPONENTIAL
1	10	**282.80**	**274.66**	**274.68**	**272.9**	**268.06**	**261.20**
2	20	**282.92**	**256.87**	**277.81**	**272.8**	**257.28**	**261.27**
3	30	**283.44**	**268.81**	**276.28**	**271.97**	**258.17**	**265.22**
4	50	**282.89**	**264.42**	**282.14**	**272.56**	**245.35**	**259.96**
5	75	**283.11**	**273.42**	**277.59**	**272.71**	**253.62**	**262.34**
6	100	**283.42**	**284.37**	**272.46**	**272.98**	**260.20**	**261.56**
7	150	**283.73**	**281.47**	**274.40**	**273.07**	**259.48**	**261.86**
8	200	**279.44**	**268.63**	**279.09**	**272.46**	**269.79**	**261.85**

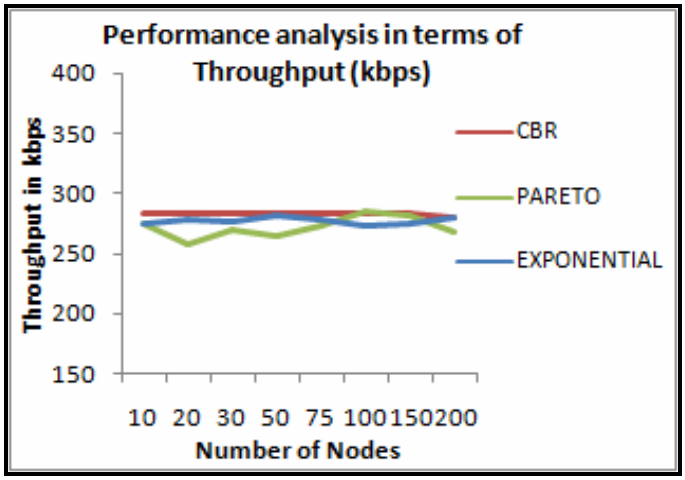

Figure-5: 'Throughput' in CBR, PARETO and EXPONENTIAL traffic pattern of AODV routing protocol for the scalable network of 10-200 nodes.

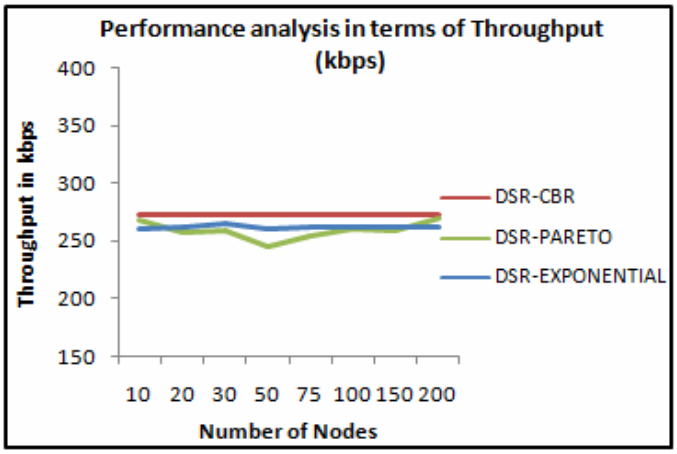

Figure-6: 'Throughput' in CBR, PARETO and EXPONENTIAL traffic pattern of DSR routing protocol for the scalable network of 10-200 nodes.

Observations: Table-5 and Figure-5 shows that AODV routing protocol performance in terms of throughput is better for CBR traffic pattern compared to Pareto and Exponential for 10-200 nodes MANET.

Figure-6 shows that DSR routing protocol performance in terms of 'throughput' is slightly better in CBR traffic pattern compared to Pareto and Exponential for 10-200 nodes MANET.

Scenario-2): Performance comparisons of AODV and DSR routing protocols on CBR, PARETO and EXPONENTIAL traffic pattern for the scalable MANET of 10-200 nodes.

The experimental simulation results of routing load, end-to-end delay and throughput for AODV and DSR routing protocols in CBR, PARETO and EXPONENTIAL traffic patterns for scalable networks of 10-200 nodes are presented in tables and graphs for analysis and comparison.

a) ***'Routing Load' results and analysis:*** The simulation results of Routing Load for CBR traffic of AODV and DSR routing protocols for scalable networks are tabulated in Table-6 and comparative is represented in Figure-7, Figure-8 and Figure-9.

Table-6: 'Routing Load' for CBR traffic of AODV and DSR routing protocols for scalable network of 10-200 nodes.

Sr. No.	Nodes density	*For CBR Routing Load* (kbps) for routing protocols		*For PARETO Routing Load* (kbps) for routing protocols		*For EXPONENTIAL Routing Load* (kbps) for routing protocols	
		AODV	DSR	AODV	DSR	AODV	DSR
1	10	**0.003**	**0.001**	**0.004**	**0.0004**	**0.002**	**0.0004**
2	20	**0.006**	**0.001**	**0.010**	**0.001**	**0.004**	**0.0008**
3	30	**0.008**	**0.001**	**0.018**	**0.001**	**0.006**	**0.001**
4	50	**0.011**	**0.006**	**0.032**	**0.004**	**0.013**	**0.004**
5	75	**0.026**	**0.002**	**0.029**	**0.004**	**0.019**	**0.002**
6	100	**0.040**	**0.003**	**0.055**	**0.008**	**0.044**	**0.002**
7	150	**0.056**	**0.001**	**0.102**	**0.004**	**0.085**	**0.004**
8	200	**0.138**	**0.010**	**0.217**	**0.003**	**0.061**	**0.014**

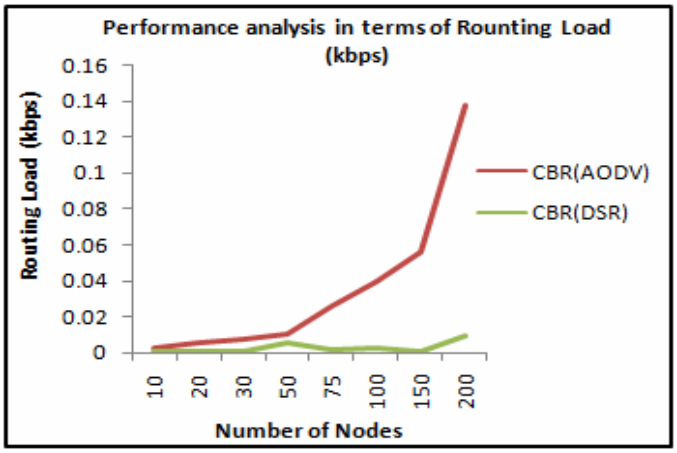

Figure-7: 'routing load' in CBR traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.

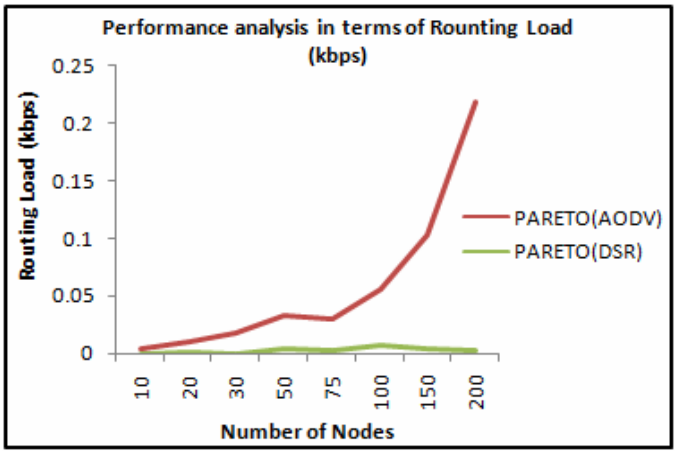

Figure-8: 'Routing load' in PARETO traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.

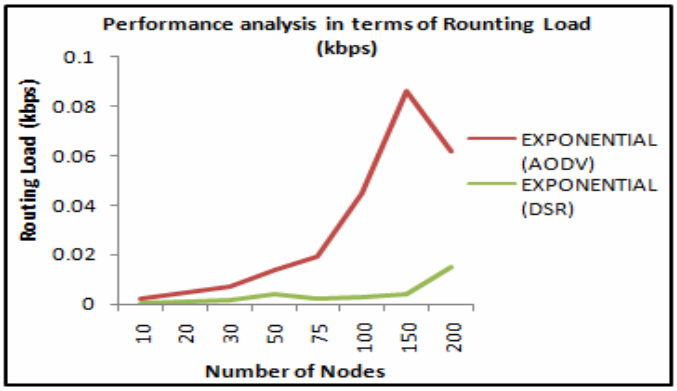

Figure-9: ***'Routing Load'*** *in EXPONENTIAL traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.*

Observations: For CBR traffic pattern, DSR routing protocol is better than AODV for 10-200 nodes MANET in terms of routing load. Till 50 nodes routing load difference for AODV and DSR is of 0.005 kbps but in case of 75-200 nodes MANET the routing load differs by 92+% can be observed form Table-6 and Figure-7.

From Table-6 and Figure-8 it is observed that routing load is far better for DSR routing protocol in Pareto traffic pattern compared to AODV routing protocol for 10-200 nodes MANET.

For 10-200 nodes MANET the routing load is very good for DSR routing protocol in Exponential traffic pattern as per Table-6 and Figure-9.

b) ***'End-to-End Delay' results and analysis:*** Table-7 shows the simulation results of End-to-End Delay for AODV and DSR routing protocol with CBR traffic pattern for scalable networks and comparatively represented in Figure-10, Figure-11 and Figure-12.

Table-7: 'End-to-end delay' for CBR, PARETO and EXPONENTIAL traffic of AODV and DSR routing protocols for scalable network of 10-200 nodes.

Sr. No.	Nodes density	***For CBR End-to-End delay*** (ms) for routing protocols		***For PARETO End-to-End delay*** (ms) for routing protocols		***For EXPONENTIAL End-to-End delay*** (ms) for routing protocols	
		AODV	**DSR**	**AODV**	**DSR**	**AODV**	**DSR**
1	10	**8.54**	**7.79**	**7.68**	**7.93**	**8.34**	**7.70**
2	20	**8.30**	**7.84**	**7.46**	**7.75**	**7.74**	**7.94**
3	30	**7.90**	**7.82**	**7.76**	**7.87**	**7.81**	**7.87**
4	50	**7.89**	**8.04**	**9.50**	**8.22**	**8.79**	**7.86**
5	75	**8.06**	**7.87**	**7.75**	**7.82**	**7.82**	**7.87**
6	100	**11.82**	**7.89**	**8.97**	**8.31**	**15.65**	**7.94**
7	150	**11.80**	**7.85**	**12.00**	**7.80**	**22.24**	**7.91**
8	200	**18.65**	**8.97**	**20.05**	**7.86**	**12.50**	**8.52**

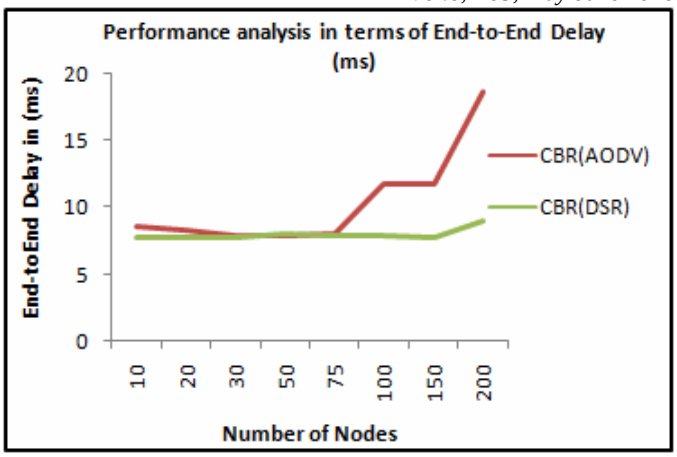

Figure-10: ***'End-to-End delay'*** *in CBR traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes*

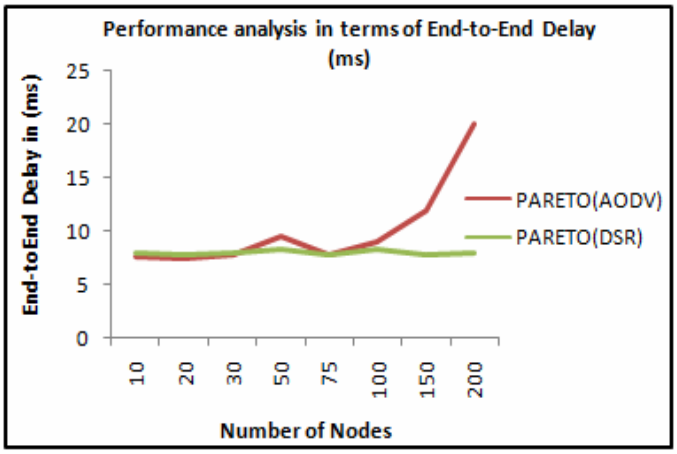

Figure-11: ***'End-to-end delay'*** *in PARETO traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.*

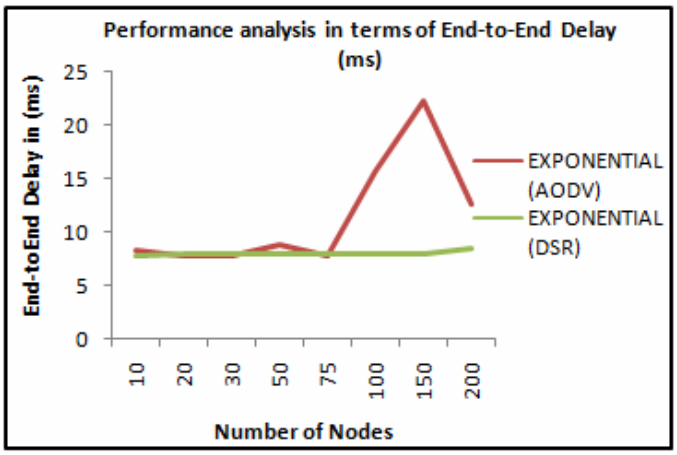

Figure-12: ***'End-to-End delay'*** *in EXPONENTIAL traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.*

Observations: In case of 10-75 nodes MANET AODV and DSR routing protocol gives almost equal performance in terms of end-to-end delay as observed from Table-7 and Figure-10.

Further, if MANET is of 100+ nodes DSR routing protocol is better in CBR traffic pattern.

In case of PARETO traffic pattern 'End-to-End delay' performance metrics is almost same for AODV and DSR routing protocol considering 10-100 nodes MANET as per Figure-11 and Table-7. Beyond 100 nodes MANET DSR is much better than AODV routing protocol.

From Table-7 and Figure-12 observed that performance metrics 'end-to-end delay' is almost same for DSR and AODV routing protocol in Exponential traffic pattern up to MANET of 75 nodes. After that DSR routing protocol performance is better than AODV routing protocol.

c) ***'Throughput' results and analysis:*** The simulation results of Throughput for CBR traffic of AODV and DSR routing protocols for scalable networks are tabulated in Table-8 and comparative is represented in Figure-13, Figure-14 and Figure-15.

Table-8: 'Throughput' for CBR, PARETO and EXPONENTIAL traffic of AODV and DSR routing protocols for scalable network of 10-200 nodes.

Sr. No.	Nodes density	***For CBR Throughput*** (kbps) for routing protocols		***For PARETO Throughput*** (kbps) for routing protocols		***For EXPONENTIAL Throughput*** (kbps) for routing protocols	
		AODV	**DSR**	**AODV**	**DSR**	**AODV**	**DSR**
1	10	**282.80**	**272.90**	**274.66**	**268.06**	**274.68**	**261.20**
2	20	**282.92**	**272.80**	**256.87**	**257.28**	**277.81**	**261.27**
3	30	**283.44**	**271.97**	**268.81**	**258.17**	**276.28**	**265.22**
4	50	**282.89**	**272.56**	**264.42**	**245.35**	**282.14**	**259.96**
5	75	**283.11**	**272.71**	**273.42**	**253.62**	**277.59**	**262.34**
6	100	**283.42**	**272.98**	**284.37**	**260.20**	**272.46**	**261.56**
7	150	**283.73**	**273.07**	**281.47**	**259.48**	**274.40**	**261.86**
8	200	**279.44**	**272.46**	**268.63**	**269.79**	**279.09**	**261.85**

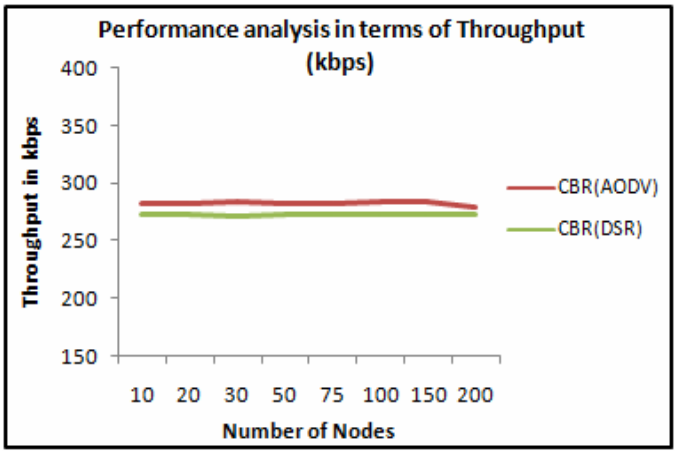

Figure-13: 'Throughput' in CBR traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.

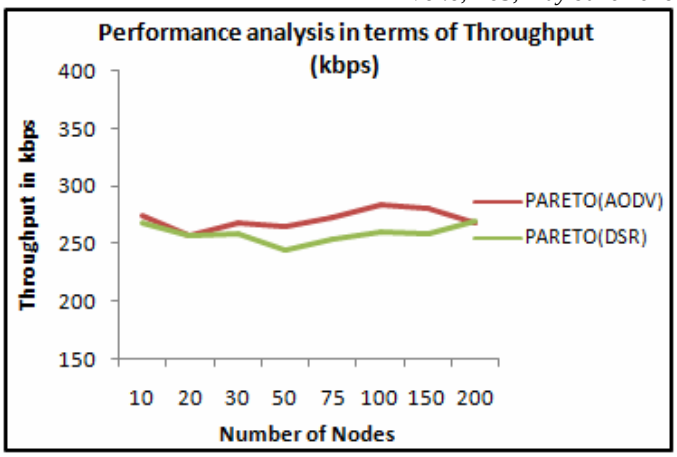

Figure-14: 'Throughput' in PARETO traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.

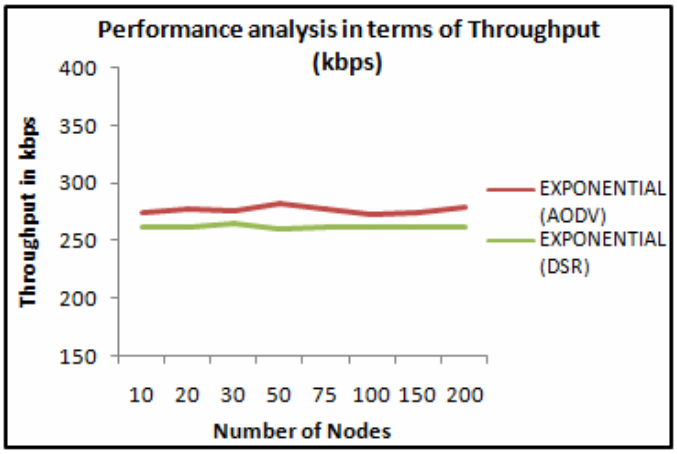

Figure-15: 'Throughput' in EXPONENTIAL traffic pattern of AODV and DSR routing protocol for the scalable network of 10-200 nodes.

Observations: From Table-8 and Figure-13, it is observed that performance metric 'throughput' is almost same for AODV and DSR routing protocol in CBR traffic pattern but AODV is better.

From Table-8 and Figure-14 it is observed that 'throughput' performance metrics for AODV routing protocol is better than the DSR routing protocol in Pareto traffic pattern for 10-200 nodes MANET.

MANET of 10-200 nodes if throughput is performance metrics in Exponential traffic pattern, AODV is better than DSR routing protocol. One can consider DSR also because throughput difference is not very much as per Table-8 and Figure-15.

VIII. CONCLUSION

In the recent years, MANET has gained the popularity in many diverse applications having different mobility models and traffic patterns. Traffic behavior is one of the key factors for the performance of a network. The traffic patterns play an important role in the performance of routing protocols. Constant Bit Rate (CBR) the traffic pattern generates data packets at a constant rate and is good enough for text

transmission but degrade the performance in multimedia applications and video-conferencing services that is of Variable Bit Rate traffic pattern (EXPONENTIAL).

The results story shows that, DSR routing protocol better perform in CBR, PARETO and EXPONENTIAL traffic pattern in terms of routing load and end-to-end delay. If MANET applications requirement is 'throughput' then AODV routing protocol is slightly better in all the three traffic patterns: CBR, PARETO and EXPONENTIAL than DSR.

REFERENCES

1. Ahmed Al-Maashri, Mohamed Ould-Khaoua, " Performance Analysis of MANET Routing Protocols in the Presence of Self-Similar Traffic", In, Proceedings of the 31st IEEE Conference on Local Computer Networks, 2006, 14-16 November 2006, pages pp. 801-807, Tampa, Florida, USA.
2. Ali M. Al-Sharafi, Bander A. Alrimi, "Throughput Comparison of AOMDV and OLSR Ad Hoc Routing Protocols Using VBR and CBR Traffic Models", IEEE, CPS- International Conference on Advanced Computer Science Applications and Technologies, 2013, pg. 466-469, 978-1-4799-2758-6/13.
3. Arindrajit Pal, Jyoti Prakash Singh, Paramartha Dutta "The Effect of speed variation on different Traffic Patterns in Mobile Ad Hoc Network." Published by ELSEVIER Ltd. Selection and/or peer-review under responsibility of C3IT. Procedia Technology 4 2012 pp 743 – 748 doi:10.1016/jprotcy.2012.05.121.
4. Balakrishnan Chandrasekaran, "Survey of Network Traffic Models", /cse567-06/ftp/traffic_models3, pg.1-8, http://www.cse.wustl.edu /~jain/cse567-06/ ftp/traffic_models3/ index.html
5. Bindeshwar Singh Kushwaha, Pramod Kumar Mishra, "Different Traffic Patterns Over Ad Hoc Network RoutingProtocols", International Journal of Computer Applications Volume 138 - No.11, pg. 1-5, March 2016, ISSN 0975 – 8887.
6. B.Malarkodi, P.Rakesh and B.Venkataramani, "Performance Evaluation Of On-Demand Mutipath Distance Vector Routing Protocol Under Different Traffic Models", 978-0-7695-3845-7/09, 2009 International Conference on Advances in Recent Technologies in Communication and Computing, November 18, 2009 at 02:43 from IEEE Xplore.
7. Chetan Kumar Kalaskar,Sujatha P.Terdal, "Traffic Estimation in Mobile Ad Hoc Network Using Probe Packets", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 1, Issue 7, September 2012, pg. 89-92, ISSN 2278 -1323.
8. Ejiro .E. Igbesoko, Thaddeus Onyinye Eze, Mona Ghassemian , "Performance Analysis of MANET Routing Protocols over Different Mobility Models", pg. 1-4.
9. Megha Rastogi, Kamal Kant, "Traffic Generator Based Performance Evaluation of Proactive and Reactive Protocols of Mobile Ad-Hoc Networks", International Journal of Scientific and Research Publications, Volume 2, Issue 5, May 2012, pg. 1-4, ISSN 2250-3153.
10. Mona N., Haifaa A., Soha S., "A Comparative Study of MANET Routing Protocols", IEEE-2014, pg. 178-182, ISBN: 978-1-4799-3166-8
11. Narinder Kaur Panesar, Darshan Singh Sidhu, "Performance Comparison of MANET Routing Protocols using Traffic Models", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 12, December 2014, pg. 717-723, ISSN: 2277-128X.
12. Ritika Sharma, Kamlesh Gupta, "Comparison based Performance Analysis of UDP/CBR and TCP/FTP Traffic under AODV Routing Protocol in MANET", International Journal of Computer Applications, Volume 56– No.15, October 2012, pg. 28-35, ISSN 0975 – 8887.
13. Suresh Kurumbanshi, Dr.Shubhangi Rathkanthiwar, "Designing a Protocol for Residual Energy of a Node after Active Communication in Wireless Adhoc Network", International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) – 2016, 978-1-4673-9939-IEEE-2016.