IOSR Journal of Mobile Computing & Application (IOSR-JMCA)
e-ISSN: 2394-0050, P-ISSN: 2394-0042.Volume 3, Issue 4 (Jul. - Aug. 2016), PP 23-39
www.iosrjournals.org

Simulation Based Performance Evaluation of Various Routing Protocols in MANETs

K. Gangadhara Rao[1], Ch. Suresh Babu[2], B. Basaveswara Rao[3], D. Venkatesulu[4].
[1,2]Department of Computer Science and Engineering, [3]Computer Centre, Acharya Nagarjuna University, Guntur 522501, Andhra Pradesh, INDIA.
[4]Department of Computer Science, Vignan University, Guntur 522213, Andhra Pradesh, INDIA.

Abstract: *Routing protocols are the basic process mechanisms needed to route the packets from one node to another node in Mobile Ad Hoc Networks when nodes are not within the transmission range. The performance of these routing protocols is affected by various factors in particular node density, mobility model, transmission range, etc.. In this paper, simulation studies are conducted to analyse the performance of two proactive (DSDV and OLSR) and two reactive (DSR and AODV) routing protocols using different traffic classes. The performance of these routing protocols are analysed by using QoS performance metrics like packet delivery ratio, throughput, end-to-end delay, normalized routing overhead and jitter. The afore mentioned metrics are evaluated by varying node density, transmission rate and transmission range. Affect of node density, transmission rate and transmission range on various metrics is demonstrated through well defined graphs. Experimental results illustrates that AODV is the best on majority set of performance metrics especially in the context of multimedia jitter.*

Keyword: *AODV, DSR, DSDV, OLSR, MANETs, QoS, Multimedia.*

I. Introduction

Mobile Ad hoc Networks (MANETs) are comprised of mobile nodes which are associated with each other on ad hoc basis. MANETs are both self-forming and self-healing. Mobile nodes in the MANETs communicate through wireless links without any infrastructure. Mobile nodes that are in transmission range of each other, they can communicate directly, otherwise communicate through multi hop routing. Mobile nodes can randomly join or leave to/from the topology that may increase/decrease the node density and frequent link failures in the topology. The nodes generate different types of traffic based on the applications (FTP, CBR, VBR) used in application layer. The nodes in the MANETs are power constrained. As a result node density, traffic and transmission range effects the performance of the network. The overall performance depends upon the routing mechanism used in routing protocols [11]. Hence selection of an efficient and an effective routing protocol is a major issue in MANETs.

MANETs provide various types routing protocols based on different criteria. Most researches interested in multimedia applications. Some of multimedia applications e.g. voice and video generate CBR (Constant Bit Rate) traffic and other applications e.g. VoIP, video-conferencing generate VBR (Variable Bit Rate) traffic [16]. D.Kumar and S.C.Gupta [1] discussed routing protocols using CBR traffic from each group namely proactive, reactive and hybrid. H.K.Prabhakaran et al. [4] considered only transmission range to evaluate the performance of routing protocols using RPGM mobility model. In [12] only CBR and TCP traffic models were discussed. The simulation studies were done in [11],[13],[14] for evaluating the performance of routing protocols under MPEG4 traffic. In order to evaluate the performance of routing protocols on multimedia applications one must consider CBR and/or VBR traffic and QoS metrics.

In the above mentioned literature VBR traffic and one of the important metrics jitter for multimedia applications are not considered. In this paper the performance of the routing protocols namely DSDV, OLSR, DSR and AODV are evaluated by applying different types of traffic such as CBR and VBR for different scenarios with Quality of Service (QoS) metrics [8] like packet delivery ratio, normalized routing overhead, end-to-end delay, throughput and also jitter. The scenarios are Node Density Scenario (NDS), Packet Transmission Rate Scenario (PTRS), and Transmission Range Scenario (TRS), in each of these the respective parameters are varied and the performance of the routing protocols is analysed. The transmission range of the node in mobile ad hoc networks will have more influence on the network connectivity [6] and network throughput [2]. Due to higher mobility of a node, link failures will occur often. When the transmission range of the node is high, it will maintain connectivity between nodes in the network even though mobility is high. Qos is an important parameter and is a challenging task in mobile ad hoc networks because of dynamic topology, resource constraints, and link characteristics [7].

The rest of the paper is organised as follows. Section II narrates a review of related work. Section III describes the metrics used for performance evaluation. The detailed consideration of different scenarios is done in Section IV. Simulation results are discussed in Section V and Section VI discusses conclusions and future scope of the work.

II. Related Work

Several of the researchers in past have focused on parameters like node density, pause time, transmission range and speed in their simulation studies. Suresh Kumar et al. [15] analyzed the performance of DSR and AODV protocols by varying load, traffic(CBR, TCP) and pause time. This paper deals with only reactive protocols and confined to CBR traffic without any consideration for jitter. Ronald.B and Badji.M [14] proposed a formulation of the routing problem in multi-service MANETs and that was implemented in DSR routing protocol. These authors considered only one reactive protocol and the issue of jitter in a multi service MANET is suggested for future work. K.Kunavut and Teerapat.S [13] analyzed the performance of OLSR, DSR and AODV routing protocols using multimedia traffic by varying the parameters load and speed of the node. Authors considered throughput, PDR, end-to-end delay and routing overhead as performance metrics to analyze the performance of these routing protocols and also concluded AODV performs well in case of high mobility and OLSR performs well in case of heavy load. M.Amnai et al. [11] evaluated the performance of AODV routing protocol using VBR traffic and different mobility models. Their effort confines to the analysis of performance of AODV with different mobility models. George Adam et al. [9] evaluated the performance of AODV, DSR and OLSR protocols for MANETs and VANETs. Though they have given due importance to jitter they have not considered transmission range which has a direct bearing on throughput. H.K.Prabhakaran et al. [4] analysed the performance of AODV, DSR, LAR and OLSR protocols using RPGM mobility model by changing transmission range. Evaluation of the four prominent protocols is done under RPGM (Reference point group mobility).Their study is not applicable to the rest of the prominent mobility models in MANETs. V.Lalitha and R.S.Rajesh [6] selected DSDV, DSR and AODV protocols to evaluate the performance by varying transmission power of individual nodes. This study was helpful for design a new power aware routing protocol AODV_RR, which was discussed in [3]. The focus of their study is the power of the individual node and to minimize the energy required to transmit a packet to another node in single and multi hop destinations. D.Kumar and S.C.Gupta [1] studied the performance of OLSR, DSR and ZRP routing protocols by varying transmission range, node density and speed using end-to-end delay and packet delivery ratio in terms of CBR traffic. Qualnet was used for simulation purpose and concluded that DSR is the best performance protocol. It can be said that the simulation study conducted by these authors is not complete because of the reason that they have considered one protocol from each category.

III. Performance Metrics

The performance of the routing protocols should be evaluated on two types of metrics. These are qualitative and quantitative metrics [9]. Qualitative metrics are loop free, security, sleep mode etc. and Quantitative metrics are packet delivery ratio, average end-to-end delay, packet delay variation, routing overhead, etc.. In this paper quantitative metrics like packet delivery ratio, normalized routing overhead, end-to-end delay, throughput [1][5][10] and jitter [18][19][20] are considered to analyze the performance of DSDV, OLSR, DSR and AODV routing protocols.

3.1. Packet Delivery Ratio

The ratio of the data packets successfully received at destinations to the data packets sent by the sources. The performance is better when PDR is high.

$$PDR = \frac{\text{sum of data packets received by the destination}}{\text{sum of data packets sent by the source}} \times 100$$

3.2. Normalized Routing Overhead

The ratio of total number of control packets transmitted to the total number of data packets successfully received at destinations. The performance is better when NRO is low.

$$NRO = \frac{\text{sum of routing control packets}}{\text{sum of data packets delivered}}$$

Here routing control packets are Route Request (RREQ), Route Reply (RREP) and Route Error (RERR) and data packets are CBR/VBR data packets.

3.3. End-to-End Delay

The average amount of time that is taken by a packet to reach the destination. It includes processing delay, queuing delay, transmission delay and propagation delay. The performance is better when the packet end-to-end delay is low. Processing delay is the time from the arrival of packet until it is assigned to an output link for transmission. Queuing delay is the sum of waiting time at a source and intermediate nodes due to the route establishment and congestion. Transmission delay is the sum of time required to push all of the packet's bits into the link from a source to a destination. Propagation delay is the sum of time required to propagate a packet on each link from a source to a destination.

$$E2ED = \frac{\sum_{n=1}^{N}(RT_n - ST_n)}{N}$$

where N is Total number of packets received, RT_n is Time at which Packet n was received, ST_n is Time at which packet n was sent.

3.4. Throughput

The number packets successfully received by the destination per unit time.

$$throughput = \frac{\text{sum of successfully received packets}}{\text{unit time}}$$

3.5. Jitter

Jitter is the delay variation between each received data packets. The variation in the packet arrival time should be minimum to have better performance. This is an important metric in multimedia applications.

$$jitter = (R_{i+1} - S_{i+1}) - (R_i - S_i)$$

Where R_i is receiving time of packet i and S_i is sending time of packet i.

IV. Description Of The Model (Simulation)

The creation of NDS, PTRS and TRS scenarios, different important simulation parameters used in three scenarios and simulation set up discussed below in this section. In NDS, node density is increased and study the behaviour of various routing protocols. In PTRS, transmission rate of the packets is varied and study the behaviour of various routing protocols. The creation of TRS scenario is discussed in the following subsection.

4.1. Transmission Range

In this work one of the important parameters transmission range is considered to evaluate the performance of routing protocols. The transmission range is affected by various factors (transmission power, antenna gain, antenna height, data rate, frequency, receiving threshold, etc.) but mainly two of them are very important namely transmission power and receiving threshold. The transmission power Pt_ of the node is measured in dBm and 0.007214 is the value at distance 100m. The receiving threshold RXThresh_ is measured in dBm and the value of RXThresh_ is 1.4268e-8. The data rate is defined as the number of bits processed per unit time. The frequency is typically measured in MHz or GHz [6]. The transmission power and receiving threshold are calculated with respect to distance. If the distance is smaller than the cross over distance then use free space propagation model otherwise use two-ray ground propagation model. The equation of two-ray ground propagation model [6] is given by

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L}$$

Here distance is greater than cross over distance, two-ray ground propagation model is considered to calculate Pt_ and RXThresh_ values. These are presented in table I.

TABLE I. The Values Of Transmission Power And Receiving Threshold

Distance in meters	Pt_ Values	RXThresh_ values
100	0.007213827	1.4268e-8
200	0.115421235	8.9175e-10

300	0.58432	1.7615e-10
400	1.846739	5.5735e-11
500	4.508642	2.2829e-11
600	9.34912	1.1009e-11

4.2. Simulation Parameters

The topology is built upon 1000mX1000m area and the simulation time is 300sec to run the simulation. The size of the data packets is 1024 bytes. In MANETs each node has the ability to move from one place to another place. Random Way Point mobility model considered to represent mobility of the node in this topology. In this model node mobility is basically depends on node speed and pause time. In this topology each node moves with 10 meter per second constant speed and waits for a pause time 10 seconds then moves towards randomly chosen destination. Some of the important parameters used in various scenarios like NDS, PTRS and TRS presented in Table II.

TABLE II. Simulation Parameters Used In Different Scenarios

Parameters	NDS	PTRS	TRS
Simulation Area (m^2)	1000m X 1000m	1000m X 1000m	1000m X 1000m
Simulation Time (sec)	300	300	300
Number of Nodes	20, 40, 60, 80, 100	100	50
Maximum Connections	5	15	10
Traffic Type	CBR, VBR	CBR, VBR	CBR, VBR
Seed	1	1	1
Packet Size (bytes)	1024	1024	1024
Node Speed (m/sec)	10	10	10
Pause Time (sec)	10	10	10
Transmission Rate (packet/sec)	5	10, 20, 30, 40, 50	5
Transmission Range (m)	250	250	100, 200, 300, 400, 500, 600

4.3. Simulation Setup

Several open source tools like NS2, NS3, OPNET and GloMoSim and also proprietary tools like QualNet are available for wired and wireless network simulation. The simulation environment has been created with NS2.35 version on Ubuntu 14.04 platform to study the performance analysis of routing protocols in MANETs. By default NS2.35 provides support for several of the protocols of MANETs, they are DSDV, DSR and AODV. However, by installing OLSR patch in NS2.35 the support of the simulator can be extended to OLSR also. The performance study focuses on simulation of the four protocols vis-a-vis DSDV, OLSR, DSR and AODV under both the VBR and CBR traffic. The simulation study is divided into following steps. These are

Step 1: Create a Tcl file for each protocol.
Step 2: Generate a Scenario file.
Step 3: Generate a Network Traffic file.
Step 4: Integrate the Scenario file and Network Traffic file with the Tcl file.
Step 5: Execute the Tcl file for the generation of trace file.
Step 6: Use the AWK script to execute the trace file to get the performance metrics of each routing protocol.

The TCL file is created with .tcl extension which describes the characteristics of each node, number of nodes used in topology, number of sources and destinations, traffic application and mobility model. Scenario file that describes the exact motion of each node with random way point mobility model. The network traffic file that describes the type of traffic uses in the application, maximum number of connections to be setup between nodes and the rate at which the packets are transmitted.

The simulation process is presented in the figure 1.

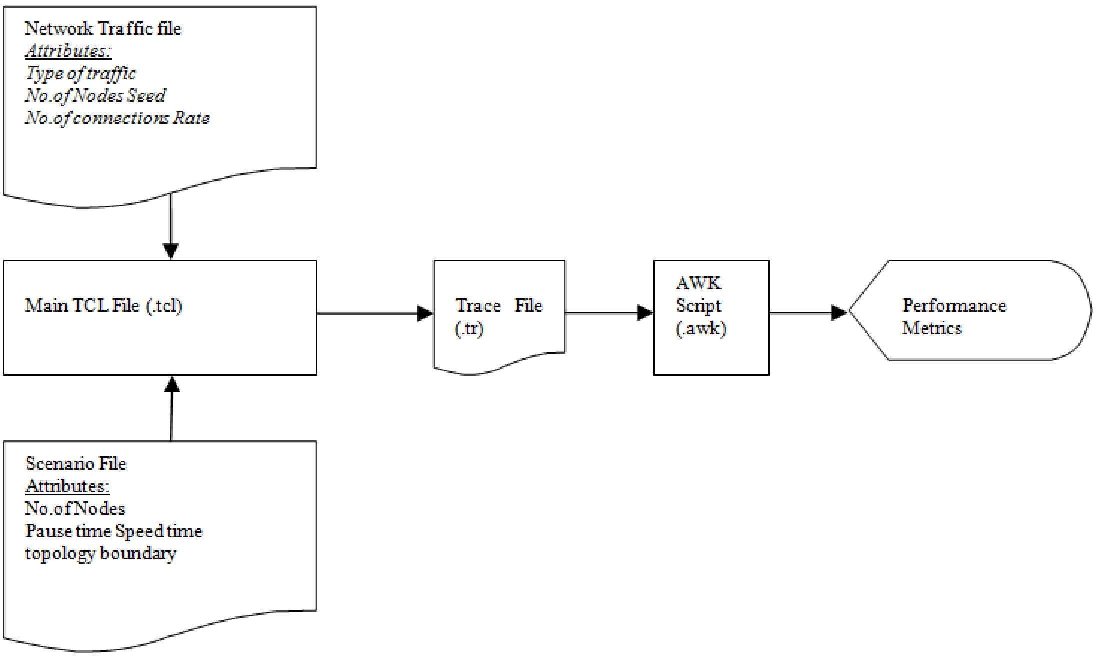

Fig.1 Simulation process

The following command is used to generate this file at terminal [17]. The command is
./setdest [-n no_of_nodes] [-p pausetime] [-M maxspeed] [-t simtime] [-x maxx] [-y maxy] > [filename]
Here "-n" describes number of nodes in the topology, "-p" describes the pause time between movements of the node, "-M" describes the maximum moving speed of the node, "-t" describes the simulation time and "-x, -y" describes coordinates of the boundary for the simulation area. In the NDS, the scenario was created by 20 nodes with random way point mobility model. The maximum moving speed of the nodes' is 10 m/s and the pause time is 10s. This was created using the following command.

./setdest [-n 20 -p 10 -M 10 -t 300 -x 1000 -y 1000 > scen_1-20n-10p-10s.

This scenario file runs 10 times to generate 10 different scenario patterns. The part of the scenario file is shown in figure 2.

```
#
# nodes: 20, pause: 10.00, max speed: 10.00, max x: 1000.00, max y: 1000.00
#
$node_(0) set X_ 202.041125396396
$node_(0) set Y_ 871.530059091340
$node_(0) set Z_ 0.000000000000
$node_(1) set X_ 348.099213653392
$node_(1) set Y_ 171.479420426236
$node_(1) set Z_ 0.000000000000
$node_(2) set X_ 900.566621059053
$node_(2) set Y_ 900.864545344334
$node_(2) set Z_ 0.000000000000
$node_(3) set X_ 324.233165579033
$node_(3) set Y_ 287.634927040912
$node_(3) set Z_ 0.000000000000
$node_(4) set X_ 47.912663306537
$node_(4) set Y_ 627.271807164079
$node_(4) set Z_ 0.000000000000
$node_(5) set X_ 448.412235889059
$node_(5) set Y_ 364.345972143105
$node_(5) set Z_ 0.000000000000
$node_(6) set X_ 198.695736780929
$node_(6) set Y_ 678.805952005004
$node_(6) set Z_ 0.000000000000
$node_(7) set X_ 409.915291299666
$node_(7) set Y_ 996.362763048023
$node_(7) set Z_ 0.000000000000
$node_(8) set X_ 895.946550731753
$node_(8) set Y_ 696.945773662236
$node_(8) set Z_ 0.000000000000
$node_(9) set X_ 714.331755084220
```

Fig.2. Snapshot of Scenario File

The network traffic file that describes the type of traffic uses in the application, maximum number of connections to be setup between nodes and the rate at which the packets are transmitted. This file is created by executing the cbrgen.tcl file. The command line looks like the following [17]
ns cbrgen.tcl [-type cbr|tcp] [-nn nodes] [-seed seed] [-mc maxconnections] [-rate rate] > [filename]

Here the network traffic file was generated with total number of sources 4, number of connections 5, packet transmission rate is 5 packets per second with CBR application. The following command used to create the file and the part of the file is shown in figure 3.

ns cbrgen.tcl -type cbr -nn 20 -seed 1.0 -mc 5 -rate 5.0 > cbr-20-5

```
#
# nodes: 20, max conn: 5, send rate: 0.20000000000000001, seed: 1.0
#
#
# 1 connecting to 2 at time 2.5568388786897245
#
set udp_(0) [new Agent/UDP]
$ns_ attach-agent $node_(1) $udp_(0)
set null_(0) [new Agent/Null]
$ns_ attach-agent $node_(2) $null_(0)
set cbr_(0) [new Application/Traffic/CBR]
$cbr_(0) set packetSize_ 1024
$cbr_(0) set interval_ 0.20000000000000001
$cbr_(0) set random_ 1
$cbr_(0) set maxpkts_ 10000
$cbr_(0) attach-agent $udp_(0)
$ns_ connect $udp_(0) $null_(0)
$ns_ at 2.5568388786897245 "$cbr_(0) start"
#
# 4 connecting to 5 at time 56.333118917575632
#
set udp_(1) [new Agent/UDP]
$ns_ attach-agent $node_(4) $udp_(1)
set null_(1) [new Agent/Null]
$ns_ attach-agent $node_(5) $null_(1)
set cbr_(1) [new Application/Traffic/CBR]
$cbr_(1) set packetSize_ 1024
$cbr_(1) set interval_ 0.20000000000000001
$cbr_(1) set random_ 1
$cbr_(1) set maxpkts_ 10000
$cbr_(1) attach-agent $udp_(1)
$ns_ connect $udp_(1) $null_(1)
$ns_ at 56.333118917575632 "$cbr_(1) start"
#
```

Fig.3. Snapshot of Network Traffic File

To place the scenario file and the network traffic file in the main TCL file, add two variables in parameter options of the node in the main tcl file [2], for example
set val(sc) "/home/suresh/ns2/scen_1-20n-10p-10s"
set val(cp) "/home/suresh/ns2/cbr-20-5"
and add two statements after creation of a node statement in the same file. The two statements are as follows.
source $val(sc)
source $val(cp)
Then execute the main tcl file with the following command
ns myaodv20.tcl
When TCL file is executed, it generates NAM file and Trace file. NAM is an animation tool for visualizing network simulation traces and real world packet traces. Trace file is an important file which records movements of every trace for every second. The snapshot is shown in figure 4.

```
s -t 2.556838879 -Hs 1 -Hd -2 -Ni 1 -Nx 348.10 -Ny 171.48 -Nz 0.00 -Ne -1.000000 -Nl AGT -Nw
--- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 1.0 -Id 2.0 -It cbr -Il 1000 -If 0 -Ii 0 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 6
r -t 2.556838879 -Hs 1 -Hd -2 -Ni 1 -Nx 348.10 -Ny 171.48 -Nz 0.00 -Ne -1.000000 -Nl RTR -Nw
--- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 1.0 -Id 2.0 -It cbr -Il 1000 -If 0 -Ii 0 -Iv 32 -Pn cbr -Pi 0 -Pf 0 -Po 6
s -t 2.556838879 -Hs 1 -Hd -2 -Ni 1 -Nx 348.10 -Ny 171.48 -Nz 0.00 -Ne -1.000000 -Nl AGT -Nw
--- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 1.0 -Id 2.0 -It cbr -Il 24 -If 0 -Ii 1 -Iv 32 -Pn cbr -Pi 1 -Pf 0 -Po 6
r -t 2.556838879 -Hs 1 -Hd -2 -Ni 1 -Nx 348.10 -Ny 171.48 -Nz 0.00 -Ne -1.000000 -Nl RTR -Nw
--- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 1.0 -Id 2.0 -It cbr -Il 24 -If 0 -Ii 1 -Iv 32 -Pn cbr -Pi 1 -Pf 0 -Po 6
s -t 2.556838879 -Hs 1 -Hd -2 -Ni 1 -Nx 348.10 -Ny 171.48 -Nz 0.00 -Ne -1.000000 -Nl RTR -Nw
--- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 1.255 -Id -1.255 -It AODV -Il 48 -If 0 -Ii 0 -Iv 30 -P aodv -Pt 0x2 -
Ph 1 -Pb 1 -Pd 2 -Pds 0 -Ps 1 -Pss 4 -Pc REQUEST
r -t 2.557827274 -Hs 3 -Hd -2 -Ni 3 -Nx 324.23 -Ny 287.63 -Nz 0.00 -Ne -1.000000 -Nl RTR -Nw
--- -Ma 0 -Md ffffffff -Ms 1 -Mt 800 -Is 1.255 -Id -1.255 -It AODV -Il 48 -If 0 -Ii 0 -Iv 30 -P aodv -
Pt 0x2 -Ph 1 -Pb 1 -Pd 2 -Pds 0 -Ps 1 -Pss 4 -Pc REQUEST
```

Fig.4. Snapshot of Trace File

The AWK Script file can be further processed to analyze and extract required information. Here the trace file is parsed with AWK script to study the information about number of packets sent, number of packets received, packet loss, packet delivery ratio, normalized routing overhead, end-to-end delay, throughput and jitter. The snapshot is shown in figure 5.

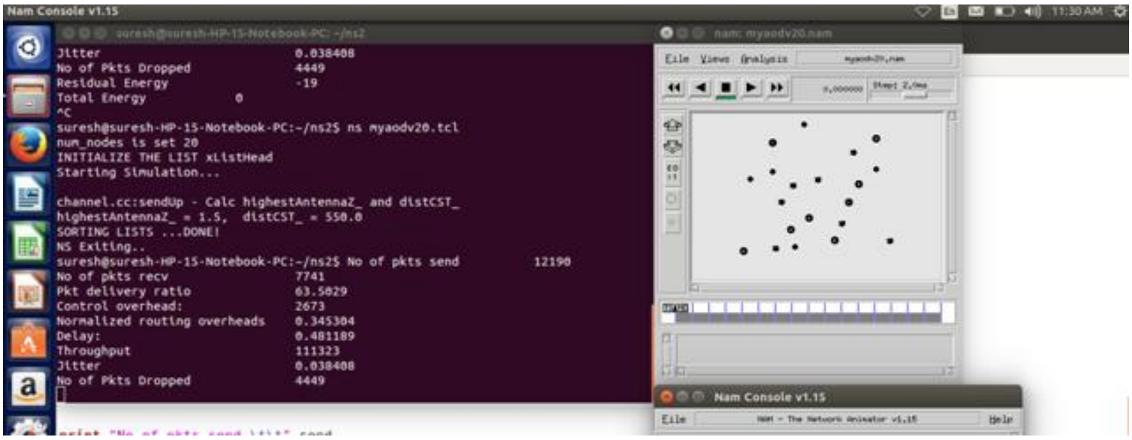

Fig.5. Snapshot of Result and NAM File

This topology runs 10 times with 10 different scenario patterns and the average of these 10 outputs is considered as a value for the performance metric to analyze the performance of routing protocol by varying node density. This process is repeated for four routing protocols namely DSDV, OLSR, DSR and AODV. Therefore 400 simulation runs were conducted to evaluate the performance of each routing protocol under CBR and VBR traffic applications. Also 400 simulation runs were conducted in each of the second and the third scenario by varying transmission rate and transmission range respectively.

V. Results

Looking at only one class of traffic to study various algorithms would not give a total picture for the comparative study of the protocol performance. To accomplish this, CBR and VBR traffic classes are considered to evaluate the performance and the results so obtained are plotted in graphs.

5.1. Node Density Scenario (NDS)

In this scenario of simulation study, number of nodes are varied in the network topology and then observed the performance of each routing protocol. The main aim of this is how does node density effect the performance of network. At beginning Number of nodes in this scenario is 20 and thereafter it goes up to 100 with an interval of 20 nodes. Number of connections are 5, which is maximum connections between source and destination pairs. The packet size is 1024 bytes for all nodes. In this, the simulation results are obtained based on both CBR and VBR traffic classes for DSDV, OLSR, DSR and AODV routing protocols. Here the results are plotted based on CBR and VBR traffic. These are shown in the figures Fig.6 to Fig.15.

Packet Delivery Ratio

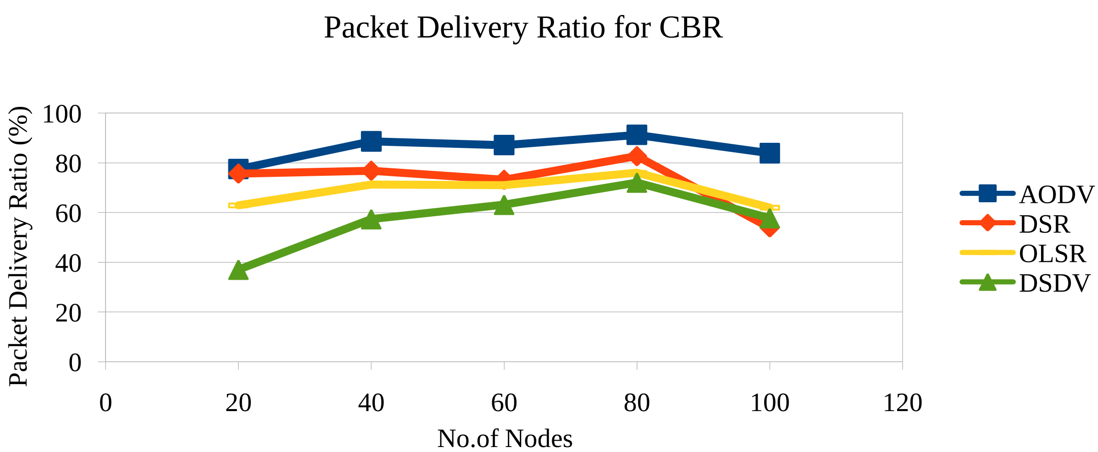

Fig.6. Packet Delivery Ratio Vs Number of Nodes

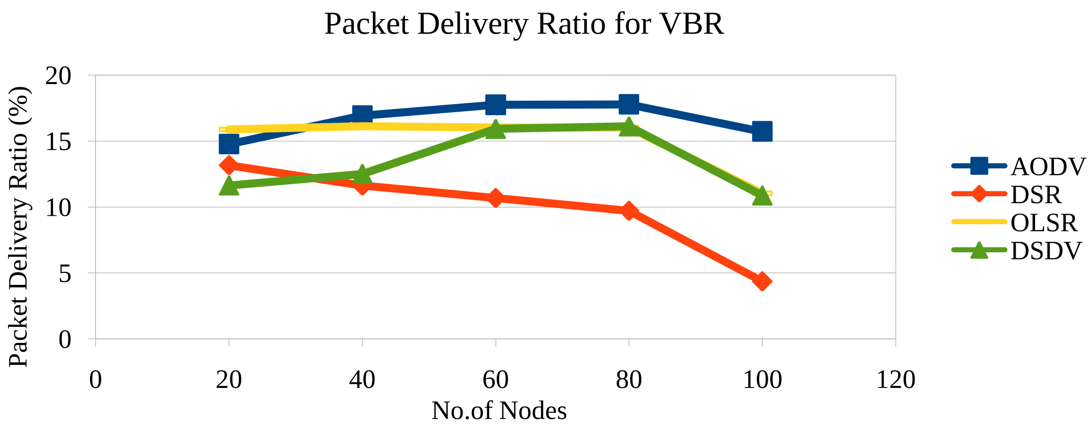

Fig.7. Packet Delivery Ratio Vs Number of Nodes

Fig.6 and Fig.7 depicts packet delivery ratio for CBR and VBR traffic classes respectively. It is being observed that with constant bit rate, AODV and DSR have more or less same packet delivery ratio at lower node density. When the node density is increased delivery ratio also increases to 91.24% up to 80nodes and there is a mild reduction at 100 nodes. In OLSR and DSDV, when node density is increased the size of the routing table also increases this would obviously increase the processing over head at each node for this reason performance of these protocols is very low. DSR performance is also low while node density is increased the same reason could be attributed for this poor performance. In VBR too AODV provides best performance compared to other protocols as shown in fig.7.

Normalized Routing Overhead

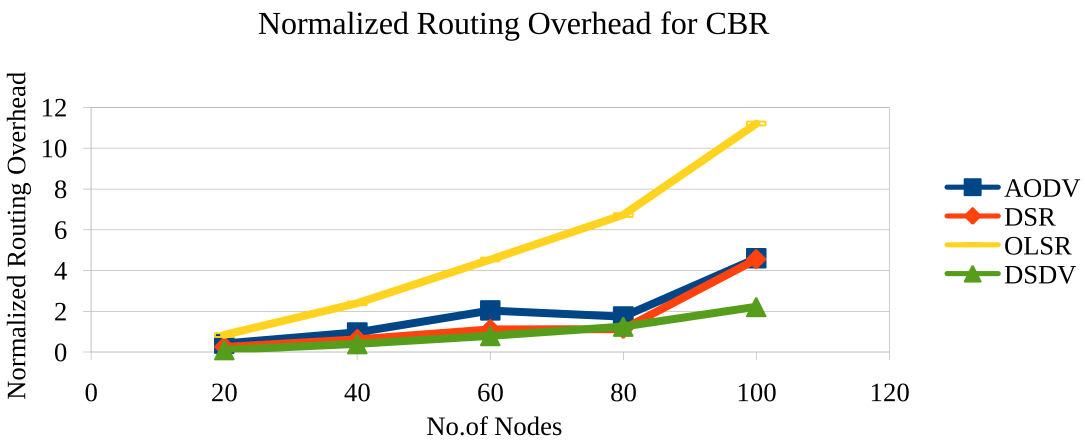

Fig.8. Normalized Routing Overhead Vs Number of Nodes

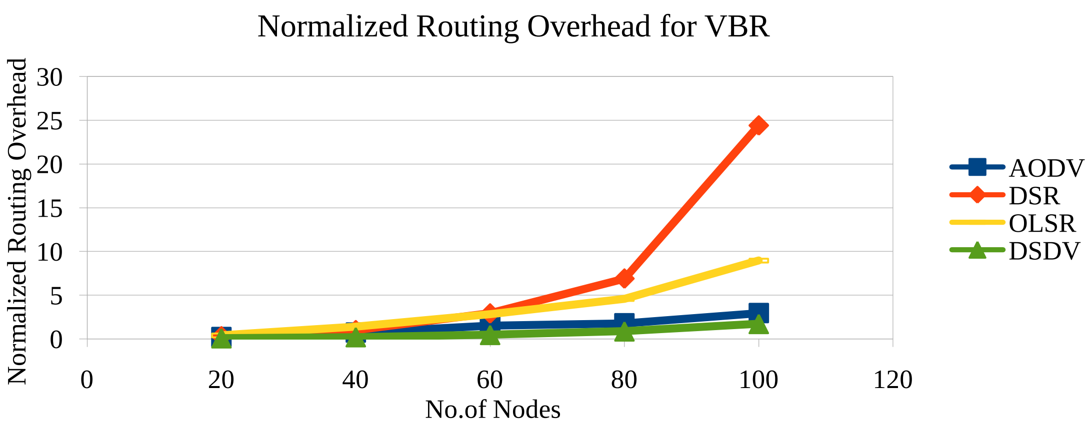

Fig.9. Normalized Routing Overhead Vs Number of Nodes

In both the traffic classes DSDV has lowest normalized routing overhead. OLSR has worst performance in the context of routing overhead. While node density is increased, AODV and DSDV performance is more or less equal in VBR traffic. At high node density DSR has highest normalized routing overhead. In CBR, DSDV and DSR have similar performance up to 80 nodes and OLSR has worst performance. The main reason for the reactive protocols poor performance in the context of routing overhead is because of their dynamic nature while finding the route and configuring it, where as in the case of proactive protocols the route management is table driven. The same can be observed from Fig.8 and Fig.9.

End-to-End Delay

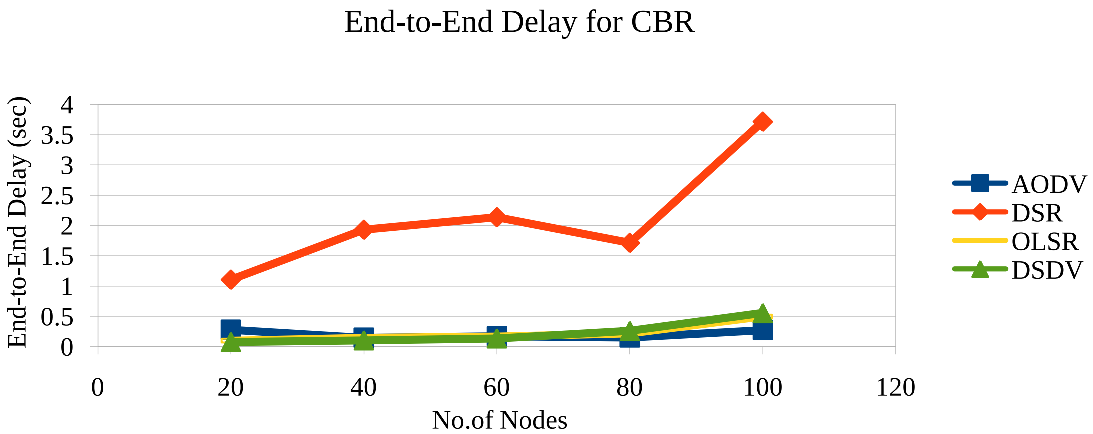

Fig.10. End-to-End Delay Vs Number of Nodes

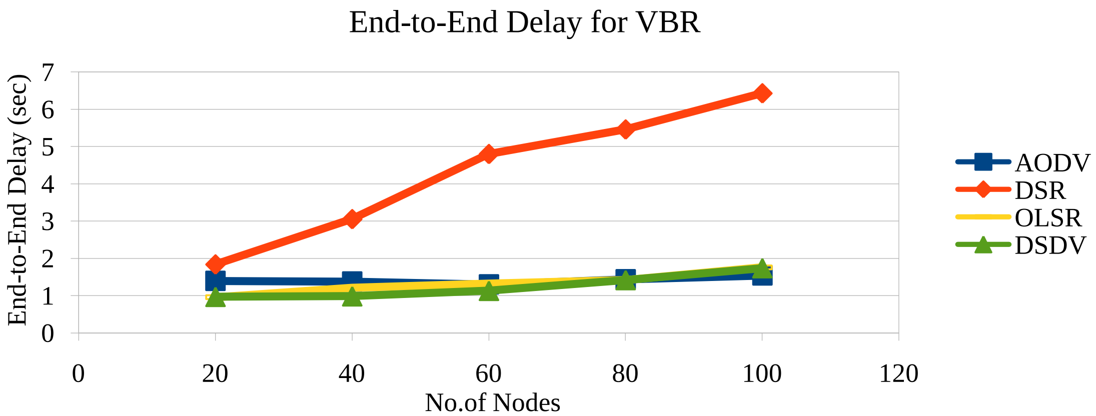

Fig.11. End-to-End Delay Vs Number of Nodes

It is being observed that DSDV and OLSR have low end-to-end delay at lower node density and for AODV it is slightly on the higher side. While node density is increased end-to-end delay is slightly increases in the case of DSDV and OLSR at the same time AODV has the lowest value. DSR has very high end-to-end delay because of the reason that the route establishment is temporal as well as dynamic in nature as one can see from Fig.10 and Fig.11.

Throughput

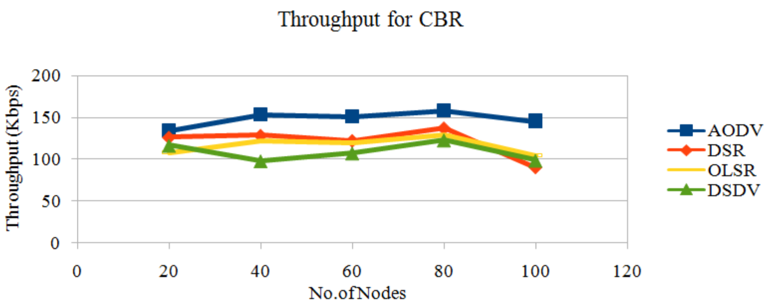

Fig.12. Throughput Vs Number of Nodes

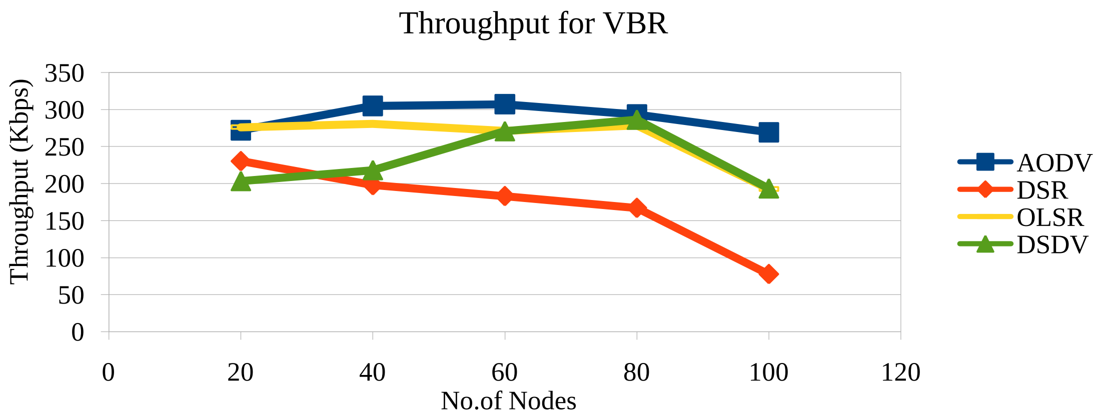

Fig.13. Throughput Vs Number of Nodes

In CBR, AODV has best throughput compared to other protocols since throughput is directly connected to packet delivery ratio. DSDV has the lowest performance, OLSR and DSR are with moderate levels of throughput which is illustrated through Fig.12. In VBR, throughput of AODV is best and it is double the CBR traffic. DSR has very low throughput compared through other protocols and drastically decreases as the node density is increased as shown in Fig.13.

Jitter

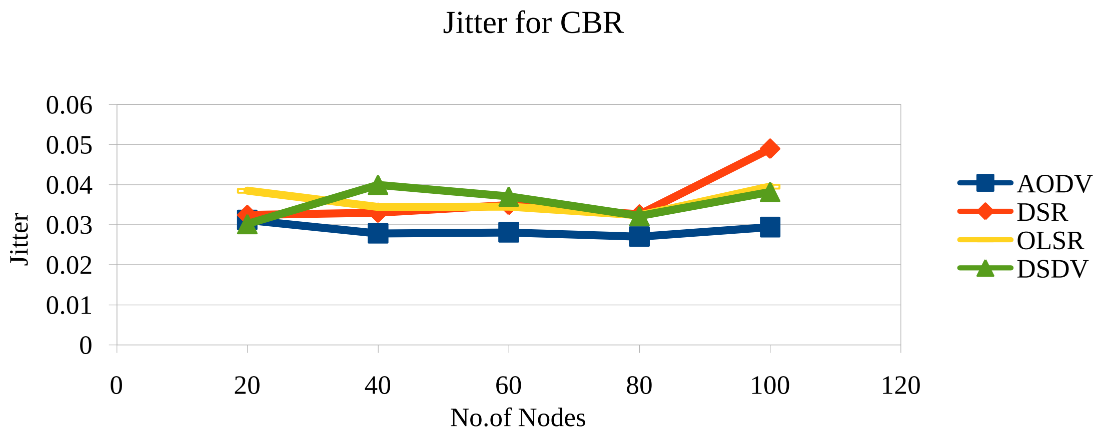

Fig.14. Jitter Vs Number of Nodes

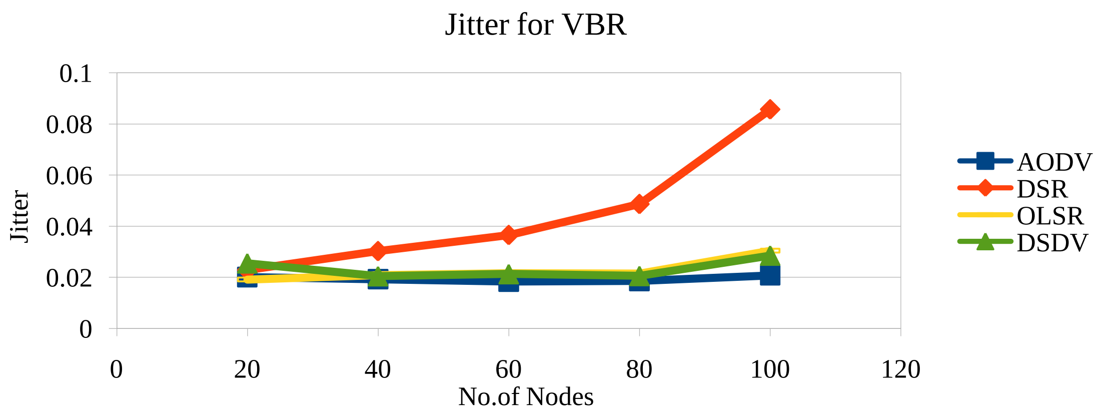

Fig.15. Jitter Vs Number of Nodes

Jitter is otherwise also known as variance in delay especially when MANETs are used for transmitting multimedia traffic where timing and synchronization of audio and video. It is being observed that while node density is increased jitter decreases and then constant up to 80 nodes, then a moderate increase in AODV. AODV has lowest delay variation compared to other protocols in both the traffic classes. DSDV, OLSR, and

DSR have highest delay variations in CBR traffic and DSDV, OLSR have more or less same in VBR traffic. The same is shown in Fig.14 and Fig.15.

5.2. Packet Transmission Rate Scenario (PTRS)

In this scenario it is assumed that all parameters are kept constant except transmission rate mentioned in table II. Number of nodes in this scenario is 100 and number of connections are 15, which is maximum connections between source and destination pairs. The packet size is 1024 bytes for all nodes. Transmission rate at beginning is10 packets/sec and then it is increased up to 50 packets/sec with an increment of 10 packets. In this, the simulation results are obtained based on both CBR and VBR traffic classes for DSDV, OLSR, DSR and AODV routing protocols. Here the results are plotted for CBR traffic only, because of the reason that when the transmission rate is increased for VBR traffic (from 10 to 50 with an increment of 10) the performance of all the protocols is constant. These are shown the figures from Fig.16 to Fig.20.

Packet Delivery Ratio

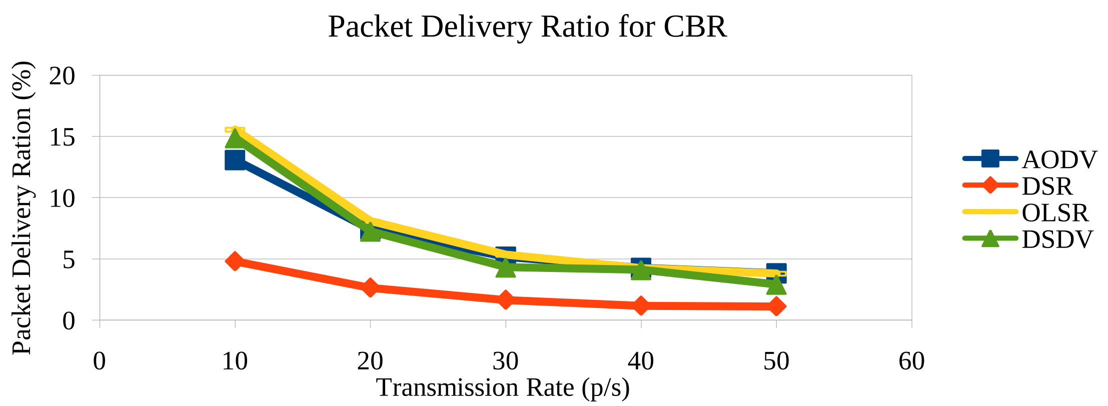

Fig.16. Packet Delivery Ratio Vs Transmission rate

It is being observed that the transmission rate at 10 packets/sec, packet delivery ratio is high in DSDV, OLSR and AODV. While the transmission rate is increased, packet delivery ratio decreases exponentially . The dismal performance of DSR in the context of packet delivery ratio is because of the requirement that each node has to maintain the route in the cache, if the route is not available in the cache the node has to initiate route discovery process. The performance is almost same for DSDV, OLSR and AODV from the transmission rate 20 packets/sec. At high transmission rate AODV performance is slightly on the higher side. In all the cases DSR offers lowest PDR when compared to others as can be observed from Fig.16.

Normalized Routing Overhead

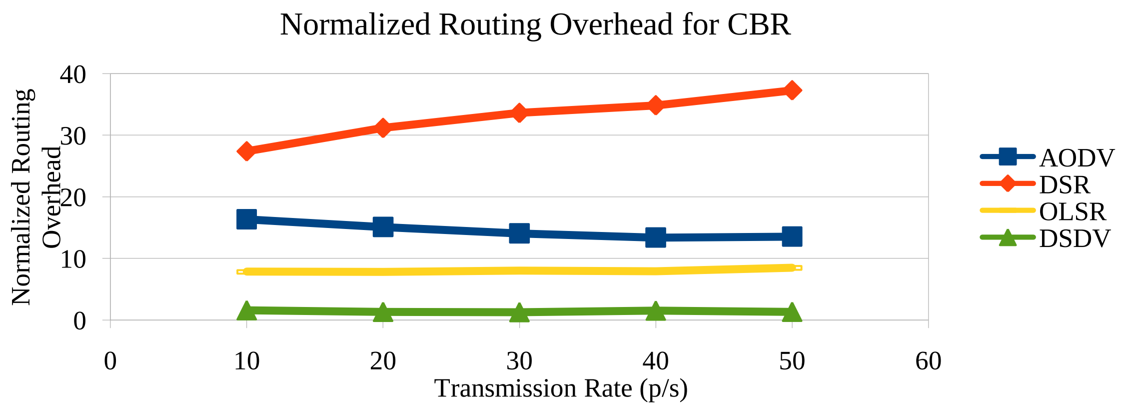

Fig.17. Normalized Routing Overhead Vs Transmission rate

It is being observed DSR is the worst algorithm as far as normalized routing overhead is concerned because of its dynamic nature in terms of sending RREQ control information frequently. In AODV protocol NRO decreases where as it increases in the case of DSR protocol while the transmission rate increased. OLSR also suffers its inherent drawback of transmitting advertisement packets. The performance of DSDV is the best compared to the rest of algorithms, OLSR and AODV are in consecutive positions. The best performance of

DSDV is because of the frequent refreshing/updation of the routing table without any control data overhead. The same is shown in Fig.17.

End-to-End Delay

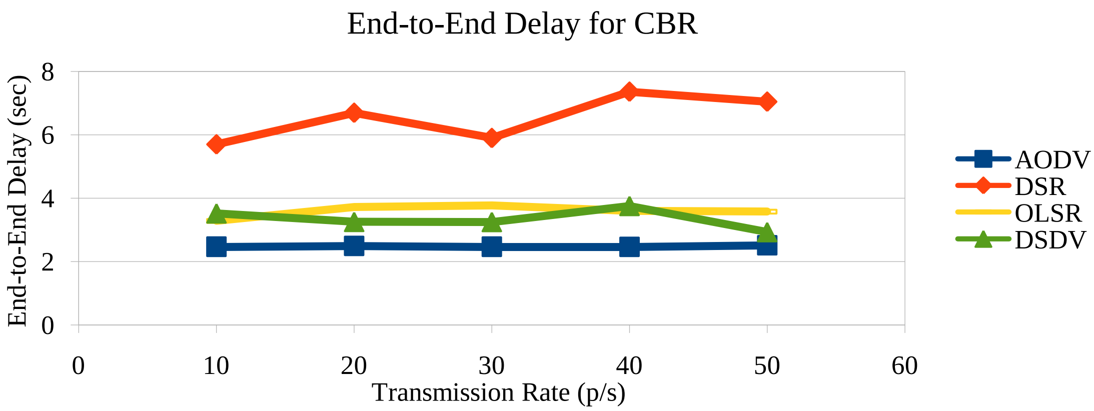

Fig.18. End-to-End Delay Vs Transmission rate

AODV has lowest end-to-end delay and is constant while the transmission rate is increased. DSR has highest end-to-end delay because of the reason, every packet that is sent contains control information and the same has to be looked at and used for routing by all the intermediate nodes including source node. Since AODV uses the routing table and also dynamically looks for route it has the lowest end-to-end delay. Both DSDV and OLSR hangs in between AODV and DSR as far as end-to-end delay is concern, which is clearly visible in Fig.18.

Throughput

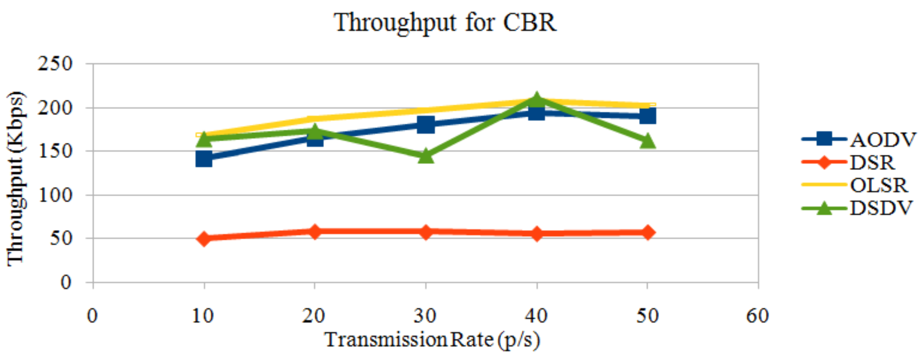

Fig.19. Throughput Vs Transmission rate

Throughput is bound to increase because of increase in transmission rate but each algorithm behaves differently because of their inherent issues. It is being observed that while transmission rate is increased throughput increases in AODV and OLSR protocols, however OLSR happens to be the best as far as throughput is concerned because of the reason that it uses fresh routing information whereas DSR and AODV uses stale route entries. Throughput increases and decreases at respective rates in DSDV because of issues like congestion. The same shown in Fig.19.

Jitter

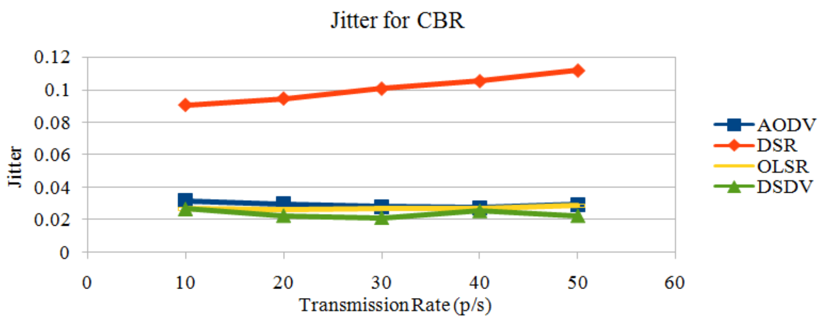

Fig.20. Jitter Vs Transmission rate

It is being observed that the transmission rate at 10 packets/sec, jitter is high in DSR. While the transmission rate is increased, jitter increases linearly. DSDV and OLSR have low jitter at lower transmission rate and for AODV it is slightly on the higher side. While the transmission rate is increased, jitter is more or less same in DSDV, OLSR and AODV, which is clearly visible in fig.20.

5.3. Transmission Range Scenario (TRS)

In this scenario the transmission range of a node is varied in the network topology and then observed the performance of each routing protocol. Transmission range at beginning is 100m and then it is increased up to 600m with an increment of 100m. Number of nodes in this scenario is 50. Number of connections are 10, which is maximum connections between source and destination pairs. The packet size is 1024 bytes for all nodes. In this, the simulation results are obtained based on both CBR and VBR traffic classes for DSDV, OLSR, DSR and AODV routing protocols. Here the results are plotted for both CBR and VBR traffic, which are shown in the figures 21 to 30.

Packet Delivery Ratio

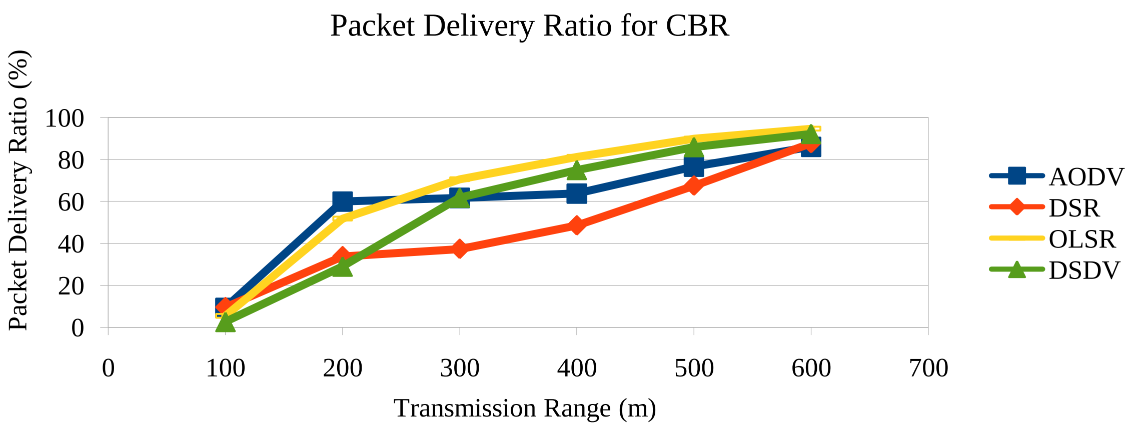

Fig.21. Packet Delivery Ratio Vs Transmission range

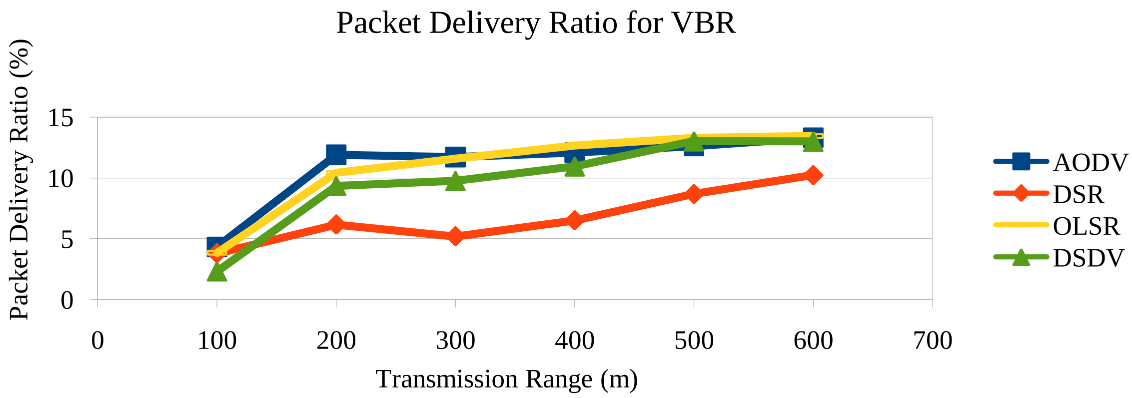

Fig.22. Packet Delivery Ratio Vs Transmission range

Fig.21 and Fig.22 depicts packet delivery ratio for CBR and VBR traffic classes respectively. It is being observed that when the transmission range is low that causes frequent link failures between source and destination. This may result large number of packet loss. Hence the PDR is low at lower transmission range. When transmission range is high the connectivity between source and destination remains constant because of this reason the PDR gets increased. In CBR, PDR increases exponentially in case of DSDV and OLSR, but in case of AODV and DSR it increases linearly and then remains constant for some ranges and then increases. Interestingly the same phenomenon gets repeated in the case of VBR also.

Normalized Routing Overhead

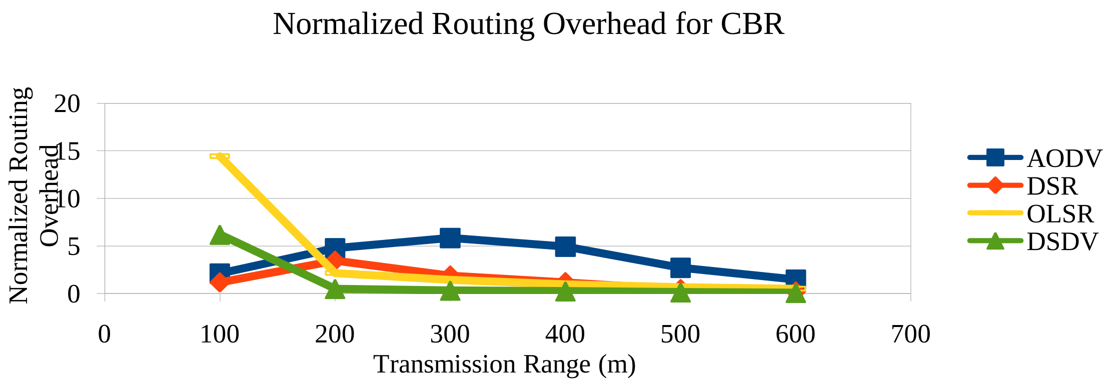

Fig.23. Normalized Routing Overhead Vs Transmission range

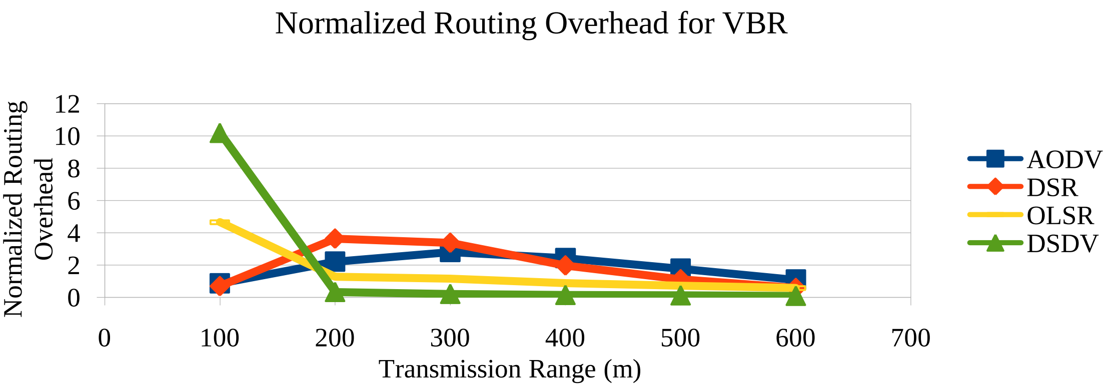

Fig.24. Normalized Routing Overhead Vs Transmission range

A higher transmission range increases the connectivity of the network, which would reduce the generation of control packets during the route discovery process. Due to this the routing overhead will get decreased. In both the traffic classes DSDV has lowest normalized routing overhead. It is being observed that while the transmission range is increased NRO decreases and then constant in case of DSDV and OLSR, but in case of AODV and DSR NRO increases and then decreases in both the traffic classes. The same is shown in Fig.23 and Fig.24.

End-to-End Delay

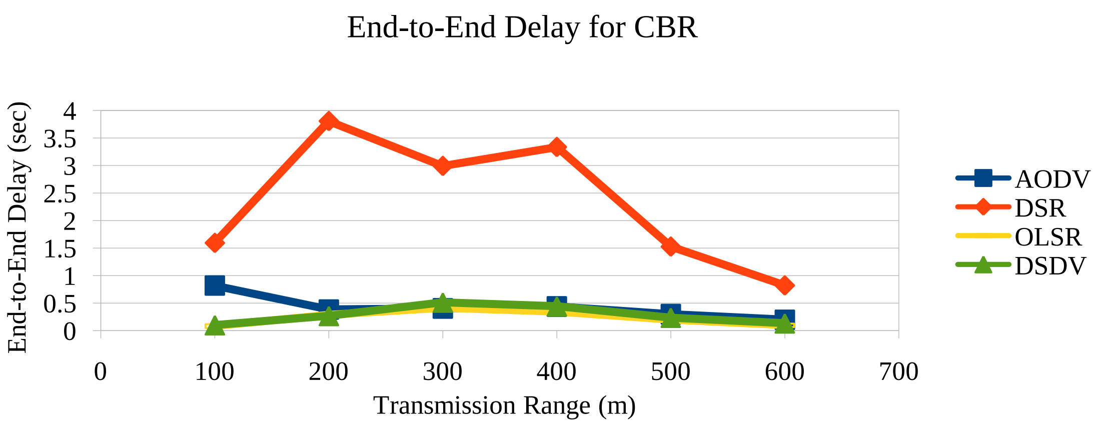

Fig.25. End-to-End Delay Vs Transmission range

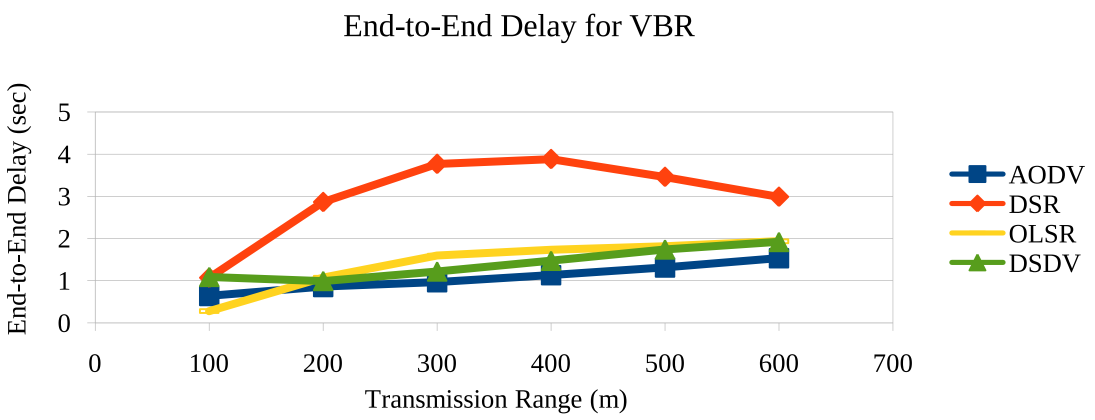

Fig.26. End-to-End Delay Vs Transmission range

It is being observed that in CBR, DSDV and OLSR have similar performance in the context of end-to-end delay. In AODV end-to-end delay decreases while transmission range increased. DSR has a very high end-to-end delay because of the reason that in case of DSR the route lookup depends upon the cache information, further to this each packet that is held by the node contains the information about the entire path and routing requires examination of this information which would definitely increase the end-to-end delay. In VBR, end-to-end delay increases linearly in AODV. In DSR it increases exponentially while transmission range increased and then decreases after 400m. End-to-end delay also increases in DSDV and OLSR routing protocols . Finally AODV has lowest end-to-end delay in both the cases. The same is shown in Fig.25 and Fig.26.

Throughput

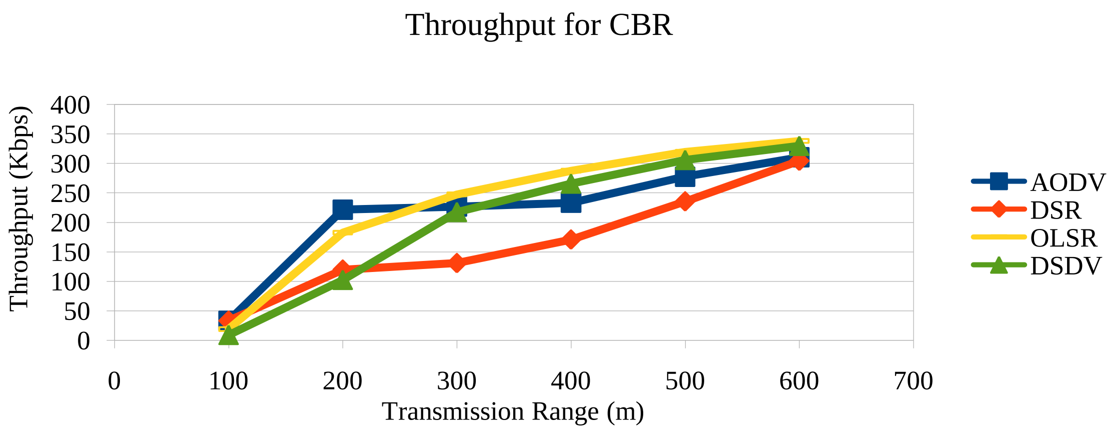

Fig.27. Throughput Vs Transmission range

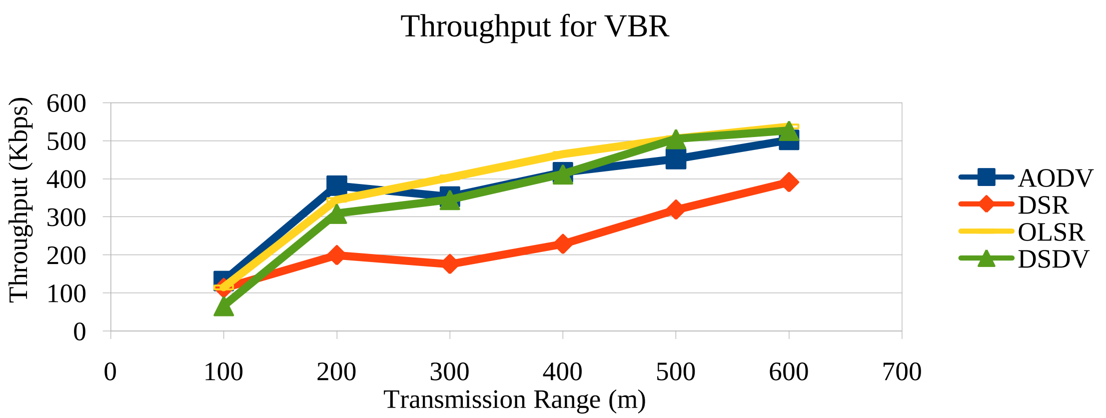

Fig.28. Throughput Vs Transmission range

It is being observed that while the transmission range is increased throughput also increases. In CBR, throughput increases exponentially in case of DSDV and OLSR, but in case of AODV and DSR it increases and then remains constant for some ranges and then increases. Interestingly the same phenomenon gets repeated in the case of VBR also. This is shown in Fig.27 and Fig.28.

Jitter

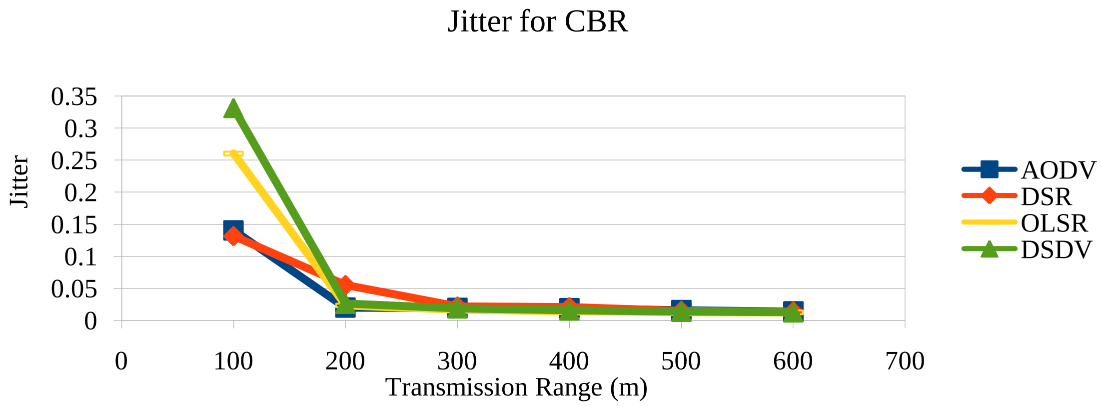

Fig.29. Jitter Vs Transmission range

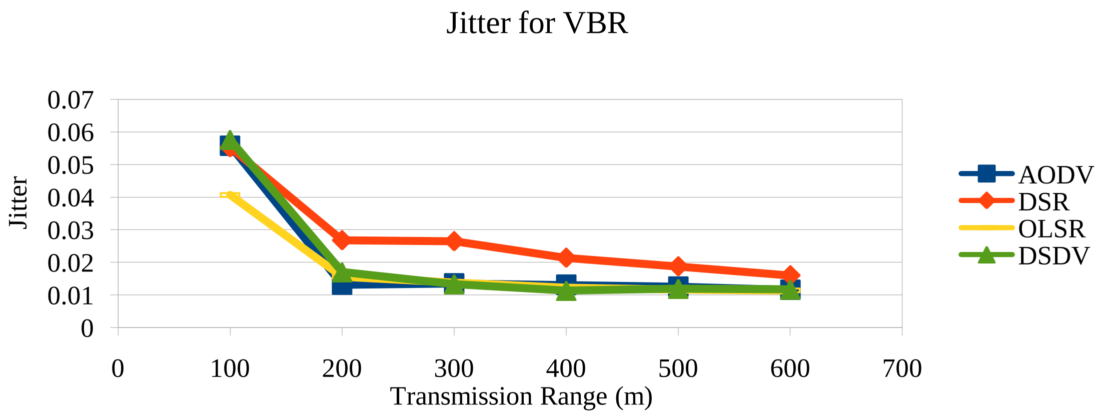

Fig.30. Jitter Vs Transmission range

It is important to have very high quality video and audio streaming in MANETs which would have reduced jitter in the traffic. It is being observed that the jitter has a negative bearing with a steep fall when the transmission range is increased. This interesting phenomenon is observed at around 200m range which also happens to be the default node power in NS2. After 200m range the value of jitter stabilizes between 0.01dB and 0.02dB. One can conclude that there will be a possibility of high jitter when the transmission range is less than 200m and jitter is very low above 200m transmission range. The same is observed both in CBR and VBR traffic across all the protocols. The same is shown in Fig.29 and Fig.30.

Finally, the performance of various routing protocols summarized in table III.

TABLE III. Summary Of Performance Results For Cbr.

Metric	NDS				PTRS				TRS			
	DSDV	OLSR	DSR	AODV	DSDV	OLSR	DSR	AODV	DSDV	OLSR	DSR	AODV
PDR	L	M	M	H	M	H	L	H	M	H	L	M
NRO	H	L	M	M	H	M	L	M	H	M	M	L
E2ED	M	M	L	H	M	M	L	H	M	H	L	M
Throughput	L	M	M	H	M	H	L	M	M	H	L	M
Jitter	L	M	M	H	H	M	L	M	H	H	M	H

H- High, M- Medium and L-Low performance respectively.

VI. Conclusion

This study presents simulation based analysis for evaluating the performance of DSDV, OLSR, DSR and AODV routing protocols under both the CBR and VBR traffic classes by varying node density, transmission rate and transmission range. The simulation results show that AODV is the better one which provides QoS guarantee than the other protocols. AODV is the best routing protocol when packet delivery ratio, end-to-end delay, throughput and jitter metrics are considered, where as DSDV is the best when normalized routing overhead metric is considered .

DSR exhibits lowest performance in all the scenarios and OLSR is moderate. As a result, node density, transmission rate and transmission range affect the performance of the routing protocols in the MANETs. Considering all the facts identified during this analysis, the QoS metrics (throughput and end-to-end delay) do play a vital role in improving the performance. In the future work Queuing model is applied to AODV to enhance the performance with respect to the QoS metrics through simulation studies.

References

[1]. D.Kumar and S.C.Gupta, Transmission range, Density and Speed based performance analysis of Ad hoc networks, *African Journal of Computing & ICT, Vol 8, No 1, march, 2015, pp 173-178.*

[2]. G.Jose Moses, D.Sunil Kumar, P.Suresh varma, N.Supriya, A Simulation based study of AODV, DSR, DSDV routing protocols in MANET using NS-2, *International journal of advanced research in computer science and software engineering, vol 2, no 3, march 2012, pp 43-51.*

[3]. V.Lalitha and R.S.Rajesh, AODV_RR: A Maximum transmission range based Ad hoc on demand distance vector routing in MANET, *Wireless pres communications, Springer, April, 2014*.

[4]. H.K.Prabhakaran, B.Kumar, Dr.Prabhakar Gupta, Performance evaluation of MANET routing protocols under RPGM model by varying transmission range, *IEEE, 2013, pp 823-826*.

[5]. Q.Razouqi, A.Boushehri, M.Gaballah, L.Alsalch, Extensive simulation performance analysis for DSDV, DSR and AODV MANET routing protocols, *27 th International conference on advanced information networking and applications workshops, IEEE, 2013, pp 335-342*.

[6]. V.Lalitha , R.S.Rajesh, The impact of transmission power on the performance of MANET routing protocols, *IOSR Journal of Engineering, vol 3, no 2, Feb. 2013, pp 34-41.*

[7]. A.Kumari, Neha G.,S.C.Gupta, Shrikant U., Performance evaluation and analysis of Qos routing using OLSR and DSDV protocols in Manets under different scenario using NS-2, *Journal of international academy of physical sciences", vol 17, no 4, 2013, pp 419-432.*

[8]. Nurul I Sarkar, Impact of traffic arrival distributions on an 802.11 ad hoc networks: Modelling and performance study, Journal of selected areas in telecommunications, may 2012, pp9-16.

[9]. G.Adam, Ch.Bouras, A. Gkamas, V. Kapoulas, Georgios K, Nikos T., Performance evaluation of routing protocols for multimedia transmission over mobile Ad hoc networks, *IFIP WMNC, IEEE 2011*.

[10]. A.A.A.Radwan , T.M.Mahmoud, E.H.Houssein, Evaluation comparison of some ad hoc networks routing protocols, *Egyptian informatics journal, july, 2011, pp 95-106.*

[11]. M.Amnai, Y.Fakhri, J.Abouchabaka, Evaluation of impact of traffic VBR and mobility on the performance of AODV routing protocols in mobile ad hoc networks, *IEEE, 2010*.

[12]. Dr.P.Bakalis, B.Lawal, Performance evaluation of CBR and TCP traffic models on MANET using DSR routing protocol, *International conference on communications and mobile computing, IEEE, 2010, pp 318-322.*

[13]. K.Kunavut, Teerapat S., Performance evaluation of ad hoc routing protocols to deliver MPEG-4 traffic, *IEEE, 2010, pp 207-210*.

[14]. Ronald B., Badji Molo, Using DSR for routing multimedia traffic in MANETs, *International journal of computer networks & communications, vol 2, no 1 jan 2010, pp 120-138.*

[15]. Suresh Kumar, R.K.Rathy, Diwakar P., Traffic pattern based performance comparison of two reactive routing protocols for ad hoc networks using NS2, *IEEE, 2009, pp 369-373*.

[16]. M.U.Chowdhury, D.Perera, Thao Pham, A performance comparison of three wireless multi hop ad hoc network routing protocols when streaming MPEG-4 traffic, *Deakin university library, IEEE, 2004, pp 516-521.*

[17]. The Network simulator- ns2. http://www.isi.edu/nsnam/ns/.

[18]. Swati Bhasin, Puneet Mehta, Ankur Gupta, Jitter based Comparison of Proactive, Reactive and Hybrid Routing Protocols in Mobile Ad-hoc Network, *International Journal of Computational Engineering & Management, Vol. 15, Issue 5, 2012, pp 69-73*.

[19]. S.Hakak, S.A.Latif, F.Anwar, Md K.Alam, Impact of Key Factors on Average Jitter in MANET, *International Conference on Systems Informatics, Modelling and Simulation, IEEE Computer Society, 2014, pp 179-183.*

[20]. H.B.Said, H.K.Abdulabbas, M. Ismail, Performance Evaluation of MANET Routing Protocols Based on Internet Protocols, *International journal of Engineering Research, Vol.4, Issue 11, 2015, pp 599-603.*