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A Table Driven Route Analysis in MANETS

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Abstract- DSDV is inspected based on delay faced during data transmission. Based on other performance parameters, delay is inspected and verified on fuzzy based system as well as on network simulator 2. In simulation work, data rate for transmission is considered as main parameter and other parameter like throughput, normalized routing load, and packet delivery ratio are calculated at different values of pause times. For fuzzy inference system, mamdani inference engine have been used. One input membership function delay has been used. Based on this input function, other four output variable parameters are calculated. This work will be helpful for the researchers to evaluate the delay happened during data transmission in mobile ad-hoc networks.

Index Terms- linguistic variable, fuzzy rules, throughput, normalized routing load, packet delivery fraction;

I. INTRODUCTION

Mobile ad-hoc networks are very popular networks for data communication. Ease of access, network size, and fast data delivery are some best features for mobile ad-hoc networks. Main time is consumed in such type of networks is transmission of data securely and efficiently for source to destination. Routing is one important process for data transmission form one location to another. When network nodes are stable, no much more challenge will be there. But, when network nodes are movable, then so many challenges will be taken place. There is big challenge for time delivery of data when node movement is very high in the mobile ad-hoc networks. it is also difficult to identify the network faults responsible to delay in data delivery without error. To perform the routing process in mobile ad-hoc network, several routing protocols[2] are used for forwarding the data from source to node. Routing protocols may be classified into table driven and on-demand routing. AODV[8] and DSR[9] are on-demand routing protocols[3][4] while DSDV is the table driven routing protocol. In DSDV, table has to be maintained at each node of the mobile ad-hoc network. Network performance can be evaluated based on number of metrics. To identify the network performance and routing protocols, number of connections, pause time, throughput, average delay, end-to-end delay, node density, speed of nodes, normalized routing load, and packet delivery fraction are the main performance metrics. Here, in this work, we analysed the DSDV routing protocol in respect of delay.

This analysis is implemented in two scenarios: first one is network simulator based analysis and second one is fuzzy system based delay analysis. This paper is organized into IV sections. In section II, network simulation based delay based analysis is implemented while fuzzy based delay analysis for DSDV routing protocol is executed in section III. This paper is concluded in section IV.

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II. SIMULATOR BASED ANALYSIS OF DSDV ROUTING PROTOCOL

In this work, simulation work was carried out in network simulator NS-2. NS-2[11[12] is very effective simulator tool which has been used worldwide by the researchers. It has a facility to execute awk and perl scripts for calculating the other network performance parameters. Also there is xgraph[5] and gnuplot tools for graphical representation of the generated data. We analysed the table driven routing protocol DSDV at different pause times with respect to different data rates (0.016, 0.032, 0.064, 0.128, 0.152, 0.750, and 1.00 Mb). We have generated grid topology for 25 movable nodes with UDP connections. Connection was duplex type. The simulation area was taken as x dimension of topology as 1000 and y dimension of topology as 546. Maximum number of mobile nodes for network was taken as 25 with wireless channel and queue size 50. Link layer type was logical link layer. We have used OmniAntenna as an antenna model with mac type Mac/802.11. TwoRayGround model was taken as radio-propagation model. Total simulation was executed for only 90 seconds for DSDV table driven routing protocol. We wrote 21 tcl scripts for ns-2 platform with some specific network parameters. Using the set-dest tool of network simulator, we created traffic and movement data files with maximum speed as 60 m/s and different pause times (10,20, 30, and 40). The packet size was taken as 512. In agent definition part of tcl script, we have taken network parameters values (as shown in table 1).

Table 1: parameters at agent definition

Parameters	Values
Packet size	512
Traffic type	CBR
Connection type	UDP
Number of connections	8
Interval time	0.01

In application definition part of tcl script, the following parameters were decided (as shown in table 2):

Table 2: parameters in application definition

Parameter	value
Data rate	0.016Mb, 0.032 Mb, 0.064Mb, 0.128Mb, 0.512Mb, 0.750Mb, 1Mb
Pause time	10,20,30,40
Packet size	512
Simulation time	90s
Protocol	DSDV

All tcl scripts were executed in ns-2 network environment at Ubuntu 16.04 for only 90 seconds. As we executed tcl files, we got 21 trace files and 21 nam files. The sample command, we typed on Linux terminal was as below:

```
ns   dsdv-pause10.tcl
```

For calculating the performance parameters from trace files, we wrote 5 awk scripts and one perl script. The sample command, we typed in Linux terminal was as below:

```
awk –f   throughput.awk dsdv-pause10.tr
```

For creating the graphs from the results, we have used xgraph tool of network simulator. The sample command for xgraph, we typed in Linux terminal was as below:

```
xgraph    -x   “time[s]”   –y   “Throughput[kbps]”   –t
“Throughput at different pause times”   -P –nb –bb
dsdv-throuput-p10                    dsdv-throughput-p20
dsdv-throughput-p30 dsdv-throughput-p40
```

Performance parameters like throughput, end-to-end delay, average delay, normalized routing load, pause time, data rate were used for evaluating the DSDV routing protocol in different network scenario.

In table 3, data presents the throughput for DSDV at pause times 10,20,30,40 and data rates 0.016,0.032,0.064, 0.128, 0.256, 0.512, 0.750, 1.00 Mb. The visualisation presentation of this data is shown in figure. Evaluation work for DSDV routing protocol in respect of throughput and data rate is depicted in figure. The range for pause time is taken 10-40 while range for data rate is taken as 0.016-1Mb for simulation time 90 seconds.

Table 3: Data rate Vs Throughput at pause time-10, 20, 30, and 40

	# grid-25-dsdv-throughput		
#data rate pause-40	**pause-10**	**pause-20**	**pause-30**
.016 69.52	44.43	42.83	59.41
.032 136.19	88.62	140.76	107.22
.064 420.26	181.89	111.95	196.36
0.128 488.34	338.21	178.34	348.13
0.256 682.43	510.33	260.52	438.11
0.512 765.20	518.39	379.55	443.37
0.750 782.89	605.59	104.03	476.96
1.00 622.59	580.22	388.86	568.18

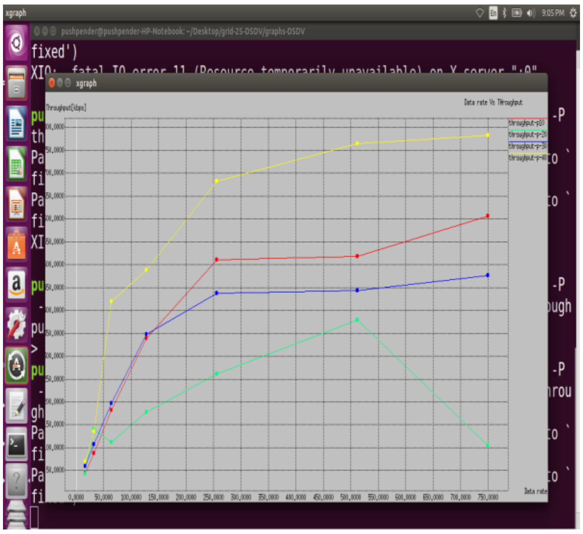

Figure 1: Data rate Vs Throughput at pause time-10, 20, 30, and 40

As illustrated in figure 1, as data rate is gradually increased, throughput at pause times 10, 30, and 40 is also increased. But for pause time 20, it increased from data rates 0.016 Mb to 0.050 Mb and suddenly decreased up to 0.75 Mb data rate. Throughput is highest at pause time 10 from data rate 0.016 Mb to 0.075 Mb as compared to throughput at pause times 20, 30, and 40. Throughput is very poor for pause time 20 at all data transmission rates (i.e. 0.016Mb-0.75Mb) as compared to throughput at pause time 10, 30, and 40. Except throughput at pause time 20, all throughputs regularly improve from data rates 0.016Mb to 0.75 Mb. These results show that data rates directly effects on the throughput. But chances of number of dropped packets will be more.

Table 4: Data rate Vs PDF at pause time-10, 20, 30, and 40

#grid-25-PFD-DSDV
#Data rate pause-10 pause-20 pause-30 pause-40
016 772 1651 1146 604
032 1403 6281 2195 824
064 2380 4762 1700 1173
128 1392 8547 3185 2695
256 3307 8564 3939 2399
512 6602 9349 4757 1654
750 4915 13340 4188 2008
#1 4991 10004 1674 801

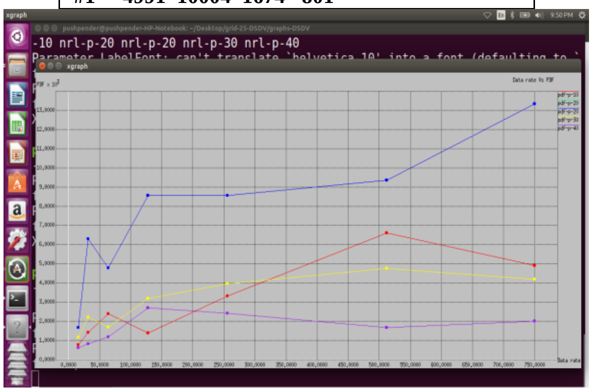

Figure 2: Data rate Vs PDF at pause time-10, 20, 30, and 40

As shown in figure 2 and table 4, packet delivery fraction is evaluated in DSDV with performance parameters pause times and data transmission rate. For pause time 20, packet delivery fraction is gradually increased as the data rate is increased. It highest as compared to other pause times (10, 30, and 40). Except the pause time 40, PDF is increased from 0.016Mb to 0.50Mb.

At pause time 40, packet delivery fraction is increased from data rate 0.016Mb to 0.0128Mb, further it is suddenly decreased up to 0.512Mb and again increased up to 0.75Mb. For pause time 10, packet delivery fraction is frequently changed high to low and low to high. Packet deliver fraction is highest at data rate 0.75Mb for pause time 40 as compared to other packet delivery fractions at pause times 10, 20, and 30. Packet deliver fraction is lowest at pause time 40 for 0.016Mb data rate.

Table 5: Data rate Vs NRL at pause time-10, 20, 30, and 40

#grid-25 -NRL DSDV				
#data rate	**pause-10**	**pause-20**	**pause-30**	**pause-40**
016	0.432	.522	.367	.325
032	0.234	.162	.189	.165
064	0.118	.204	.125	.049
128	0.063	.136	.072	.044
256	0.043	.103	.051	.031
512	0.043	.066	.055	.031
750	0.035	.256	.048	.030
# 1	0.035	.060	.040	.040

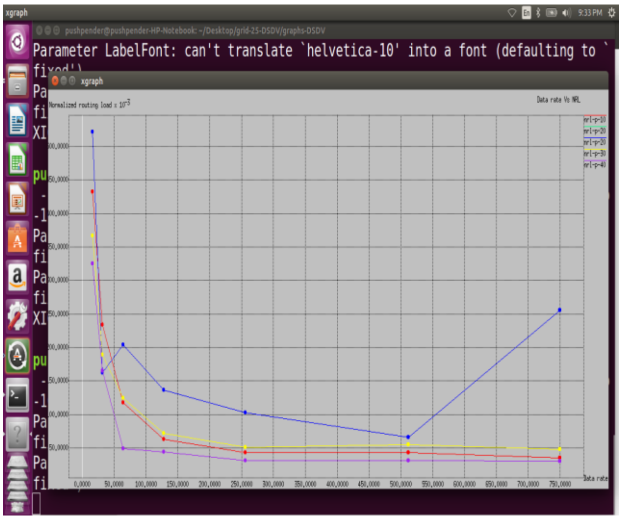

Figure 3: Data rate Vs NRL at pause time-10, 20, 30, and 40

As illustrated in figure 3 and table 5, normalized routing load (NRL) is analysed in respect to data rates. At pause time 20, NRL is highest for all data rates (0.016 Mb-0.75Mb). But, it is lowest for pause time 40. For pause times 10, 30, 40, NRL is decreased as the data transmission rate is increased. But there is different case for pause time 20. In this case, NRL is very high at data transmission rate 0.016 Mb further it is decreased and increased up to 0.064 Mb data rate. It is mostly increases from 0.128Mb data rate to 0.75Mb. Overall, pause 40 is suitable to maintain the NRL for DSDV routing protocol as per our simulation results.

We have evaluated end-to-end delay for DSDV routing protocol at data rates 0.016MB, 0.032Mb, 0.064Mb, 0.128Mb, 0.512Mb, 0.750Mb, 1.00Mb with different pause times (as shown in table 6 and figure 4). End-to-end delay metric is very important during data transmission in a mobile ad-hoc network. It reduces the totally network performance.

Table 6: Data rate Vs E2E delay

E2E Delay				
Data rate	**Pause time 10**	**Pause time 20**	**Pause time 30**	**Pause time 40**
0.016	0.00108	0.00837	0.008021	0.00451
0.032	0.00603	0.13363	0.02894	0.00484
0.064	0.05136	0.08147	0.07224	0.01572s
0.128	0.101199	0.14470	0.32957	0.08347
0.512	0.09691	0.14212	0.11381	0.03668
0.750	0.04511	0.12908	0.07001	0.03177
1.000	0.03924	0.08869	0.04341	0.03148

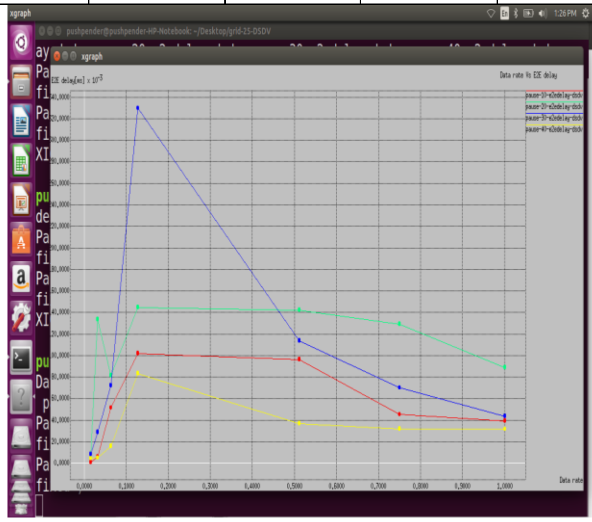

Figure 4: data rate Vs E2E delay

As depicted in figure 4, end-to-end delay is decreased as the data transmission rates are increased at pause time 10, 20, 30, and 40. From data rate 0.016Mb to 1.0Mb, end-to-end delay is fluctuated randomly.it is least at data transmission 0.016Mb. For pause time 40, end-to-end delay is very low as compared to end-to-end delay at pause time 10, 20, and 30. End-to-end delay at pause time 20, it is almost high for all data rates (0.016Mb-1.0Mb), but for pause time 30, it is highest at data rate 0.135 Mb. With respect to pause time 10, 20, and 40 Mb, end-to-end delay is increased for all data rates. In this simulation result, pause time 40 is best for maintaining the end-to-end delay.

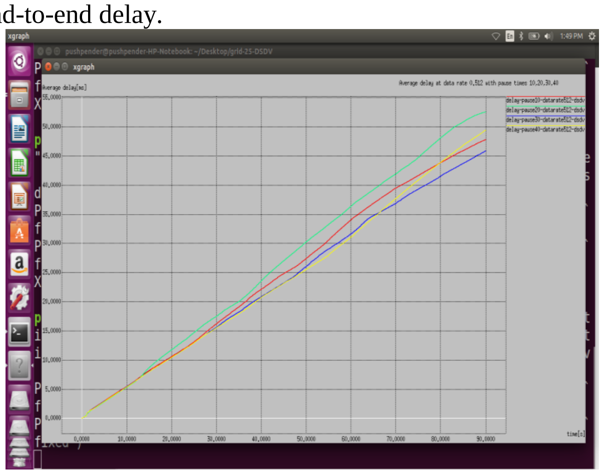

Figure 5: Average delay at data rate 0.512Mb with pause times 10,20,30,40

As illustrated in figure, 5 average delay is visualised with respect to 0.512Mb data rate at pause times 10, 20, 30, and 40. Here, average delay is increased as the simulation time is increased. In this simulated work, the data transmission rate 0.512Mb is average data transmission rate and it is consider to analysis the average delay for all pause times. At pause time 20 with data transmission rate 0.512Mb, the average delay is highest and increased with respect to simulation time.

While, or pause time 30, average delay is minimum as compared to other pause times

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(i.e. 10, 20, and 40). For pause time 10 at data transmission rate 0.512Mb, average delay is average.

III. FUZZY BASED ANALYSIS OF DSDV ROUTING PROTOCOL

We have evaluated network delay using fuzzy inference engine [10]. We have used mamdani system (as shown in figure 18) for getting the output results. Triangular type membership function was used with number of linguistic variables to design the system. We have chosen here one input and four output parameters. The input parameter is delay (as shown in figure 17) while the four output parameters are: node(figure 15), maximum connections (figure 13), maximum speed (figure 14) and pause time (figure 16). For each output membership function[7], we have chosen five linguistic variables as: very low, low, medium, high, and very high. Also for one input membership function 'delay', we have chosen five linguistic variables [6] as: very low, low, medium, high, very high. The range 6-50 was decided for delay membership function while for pause time membership function, it was 0-90. Maximum speed range was chosen from 10 m/s to 50 m/s. maximum connections limit was up to 20 only. We designed total twenty fuzzy rules by considering the one input parameter 'delay' and four output parameters 'pause time' , 'node', maximum speed', and 'maximum connections'. By executing the 22 fuzzy rules in mamdani system, we will get four output values for membership functions by taking only one input membership function. Fuzzy rule viewers are shown in figure 6-8.In Figure 6, Rule viewer shows the delay value 20.71 ms w.r.t. pause time 40, nodes 40, maximum speed 41.2 m/s, maximum connections 13.2. Figure 7 shows the rule viewer for delay 45, pause time 12.8, nodes 49, maximum speed 41.7 m/s, maximum connections 15.8. Figure 8 illustrated the rule viewer for delay 8ms, pause time 28.7, nodes 29.3, maximum speed 29.6, and maximum connection 5.02.

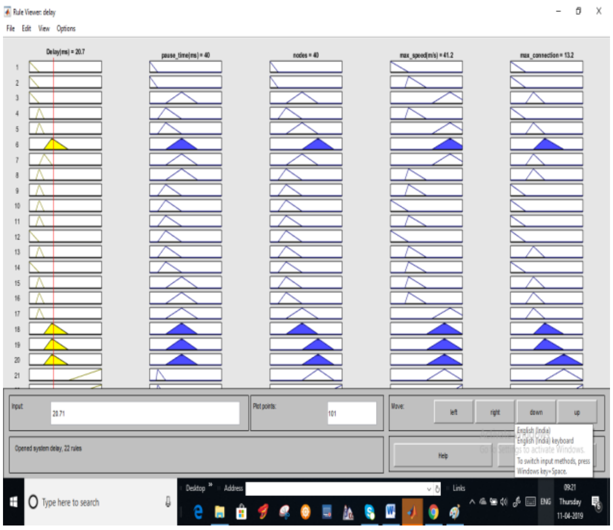

Figure 6: Rule viewer at delay value 20.71 ms w.r.t. pause time 40, nodes 40, max. speed 41.2 m/s, max. connections 13.2

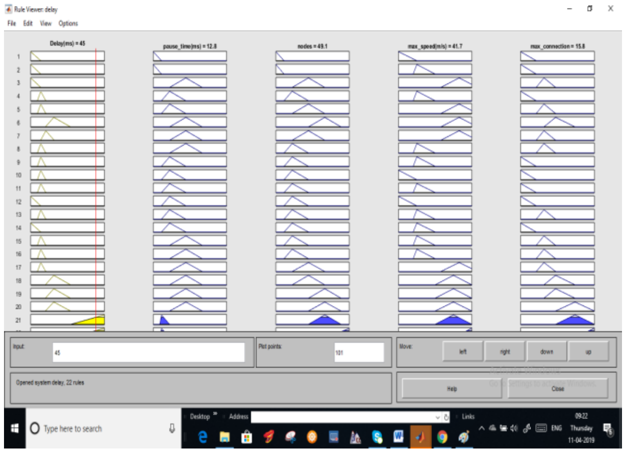

Figure 7: Rule viewer at delay 45, pause time 12.8, nodes 49, max speed 41.7 m/s, max. connections 15.8

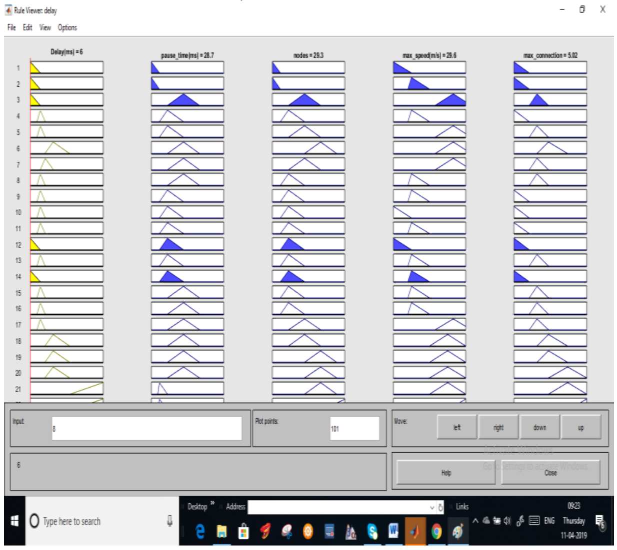

Figure 8: Rule viewer for delay 8ms, pause time 28.7, nodes 29.3, max. speed 29.6, max. connection 5.02

```
>> delay

delay =
Fuzzy system was created with following
specifications as shown as below:

name: 'delay'
 type: 'mamdani'
andMethod: 'min'
orMethod: 'max'
 defuzzMethod: 'centroid'
  impMethod: 'min'
  aggMethod: 'max'
    input: [1x1 struct]
    output: [1x4 struct]
     rule: [1x22 struct]
```

Fuzzy Rules: we designed total twenty two fuzzy rules using one input parameter and four output parameters as described as below:

1. If (Delay(ms) is V_Low) then (pause_time(ms) is V_Low)(nodes is V__Low)(max_speed(m/s) is V__Low)(max_connection is V__Low) (1)
2. If (Delay(ms) is V_Low) then (pause_time(ms) is V_Low)(nodes is V__Low)(max_speed(m/s) is Low)(max_connection is V__Low) (1)
3. If (Delay(ms) is V_Low) then (pause_time(ms) is High)(nodes is Medium)(max_speed(m/s) is High)(max_connection is Low) (1)
4. If (Delay(ms) is Low) then (pause_time(ms) is Medium)(nodes is Low)(max_speed(m/s) is Low)(max_connection is V__Low) (1)
5. If (Delay(ms) is Low) then (pause_time(ms) is Medium)(nodes is Medium)(max_speed(m/s) is High)(max_connection is Low) (1)
6. If (Delay(ms) is Medium) then (pause_time(ms) is High)(nodes is High)(max_speed(m/s) is High)(max_connection is Medium) (1)
7. If (Delay(ms) is Medium) then (pause_time(ms) is High)(nodes is Medium)(max_speed(m/s) is High)(max_connection is Low) (1)
8. If (Delay(ms) is Low) then (pause_time(ms) is High)(nodes is Low)(max_speed(m/s) is Low)(max_connection is Low) (1)
9. If (Delay(ms) is Low) then (pause_time(ms) is Medium)(nodes is Low)(max_speed(m/s) is Low)(max_connection is V__Low) (1)
10. If (Delay(ms) is Low) then (pause_time(ms) is Medium)(nodes is Low)(max_speed(m/s) is V__Low)(max_connection is V__Low) (1)
11. If (Delay(ms) is Low) then (pause_time(ms) is Medium)(nodes is Low)(max_speed(m/s) is Low)(max_connection is V__Low) (1)
12. If (Delay(ms) is V_Low) then (pause_time(ms) is Medium)(nodes is Low)(max_speed(m/s) is V__Low)(max_connection is V__Low) (1)
13. If (Delay(ms) is Low) then (pause_time(ms) is Medium)(nodes is Low)(max_speed(m/s) is Low)(max_connection is Low) (1)
14. If (Delay(ms) is V_Low) then (pause_time(ms) is Medium)(nodes is Low)(max_speed(m/s) is Low)(max_connection is V__Low) (1)
15. If (Delay(ms) is Low) then (pause_time(ms) is High)(nodes is Low)(max_speed(m/s) is Low)(max_connection is Low) (1)
16. If (Delay(ms) is Low) then (pause_time(ms) is High)(nodes is Low)(max_speed(m/s) is Low)(max_connection is Low) (1)
17. If (Delay(ms) is Low) then (pause_time(ms) is High)(nodes is Medium)(max_speed(m/s) is High)(max_connection is Low) (1)
18. If (Delay(ms) is Medium) then (pause_time(ms) is High)(nodes is Medium)(max_speed(m/s) is Medium)(max_connection is Medium) (1)
19. If (Delay(ms) is Medium) then (pause_time(ms) is High)(nodes is High)(max_speed(m/s) is Medium)(max_connection is Medium) (1)
20. If (Delay(ms) is Medium) then (pause_time(ms) is High)(nodes is High)(max_speed(m/s) is Medium)(max_connection is High) (1)
21. If (Delay(ms) is V_High) then (pause_time(ms) is Low)(nodes is High)(max_speed(m/s) is Medium)(max_connection is High) (1)
22. If (Delay(ms) is V_High) then (pause_time(ms) is Low)(nodes is V_High)(max_speed(m/s) is V_High)(max_connection is V_High) (1)

As fuzzy system[1] was implemented, we analysed and got results with respect to delay. As in table 7, at delay 6, pause time 28.7, nodes 28.3, maximum speed 28.6 and maximum connection 5.12. It was observed that as network connections are increasing, the respective delays will also be increased. In last result number 20, at higher delays, pause time, node value, speed, and maximum connections value are also high.

Table 7: Delay Vs Input parameters from Fuzzy System

Sr. No.	Delay	Pause time	Nodes	Max. Speed	Max. Conn.
1.	6	28.7	28.3	28.6	5.02
2.	6.13	28.7	28.3	28.6	5.03
3.	7.48	28.8	28.4	28.7	5.08
4.	8.2	28.9	29.5	29.8	5.12
5.	9.87	29.1	29.6	28.9	5.21
6.	11.8	33	33.5	29.7	5.04
7.	15.3	40	36.4	42.4	9.59
8.	19.9	45	37.5	30	10.5
9.	20.7	40	40	41.2	13.2
10.	25	40	40	41.1	13.3
11.	30	45	37.5	30	10.5
12.	34.2	13.7	48.1	40.6	15.3
13.	38.3	13.3	48.6	41.1	15.5
14.	41.5	13	48.9	41.4	15.7
15.	44.2	18.9	49.1	41.6	15.8
16.	45.5	12.8	48.1	41.7	15.8
17.	47.7	12.7	42.2	41.8	15.9
18.	48.5	12.7	49.2	41.8	15.9
19.	49.1	12.7	49.2	41.8	15.9
20.	50	12.7	49.2	41.8	15.9

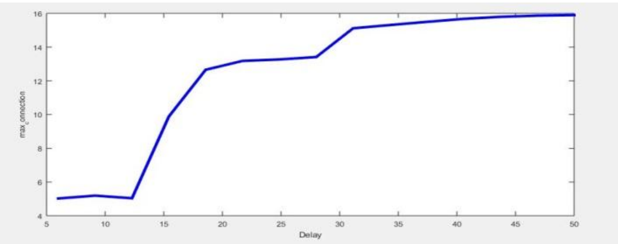

Figure 9: Delay Vs Max. Connection

Figure 9 depicted the delay with respect to maximum connections.

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It is presented that as the connections are increased; the delay value is also high. At higher value of delay, there is higher value of connections.

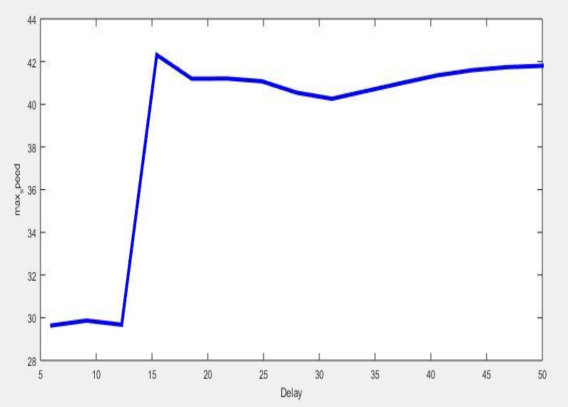

Figure 10: Delay Vs Max. Speed

Figure 10 illustrates the delay with respect to maximum speed. Delay value 5-15, speed value is also increased. But form 15-30 delay, speed is decreased. Again form 30-50 delay value, speed is increased.

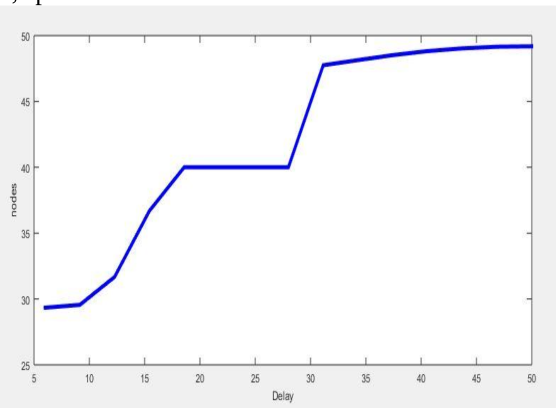

Figure11: Delay Vs Nodes

Figure 11 presented the delay with respect to nodes. From 5-20 delay value, nodes are also increased. Form 5-25 delay, node value is constant. For 30-50 delay value, node value is also increased.

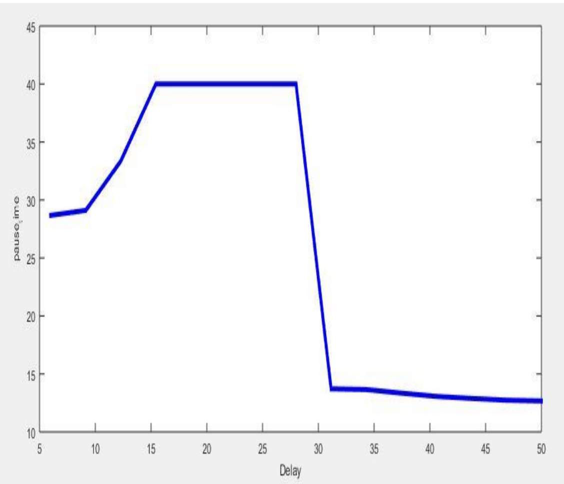

Figure 12: Delay Vs Pause time

Figure 12 illustrates the delay with respect to pause time. As shown in figure, 5-20 delay value, pause time is increased. 15-30 delay value, pause time value is constant. 30-50 delay value, pause time is decreased.

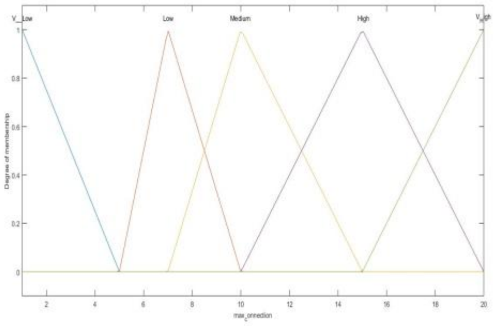

Figure 13: Output Membership function 'max. Connection ' with five linguistic variables

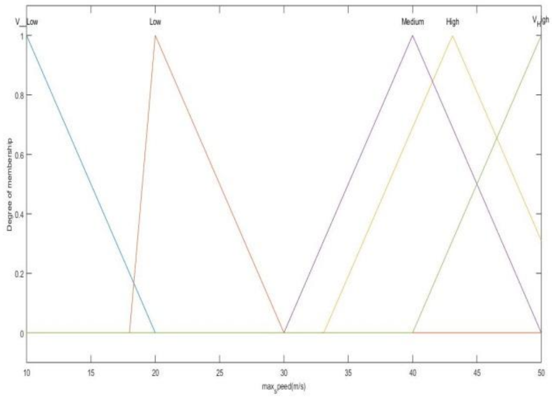

Figure 14: Output Membership function 'max. Speed' with five linguistic variables

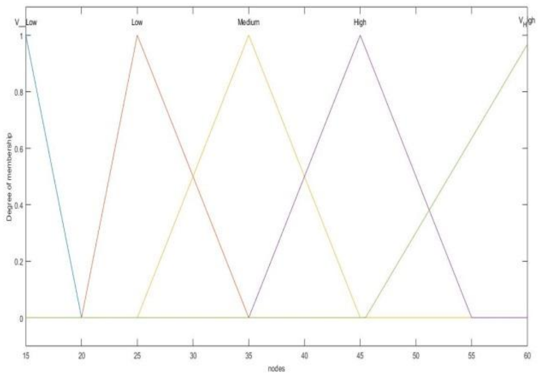

Figure 15: Output Membership function 'Nodes' with five linguistic variables

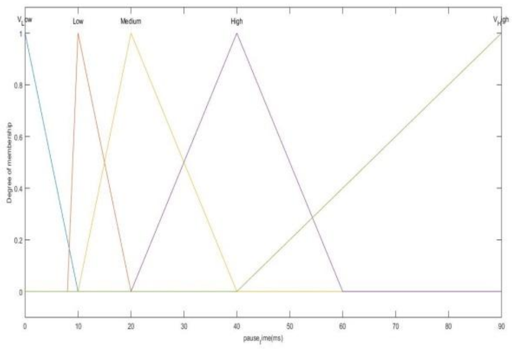

Figure 16: Output Membership function 'Pause time' with five linguistic variables

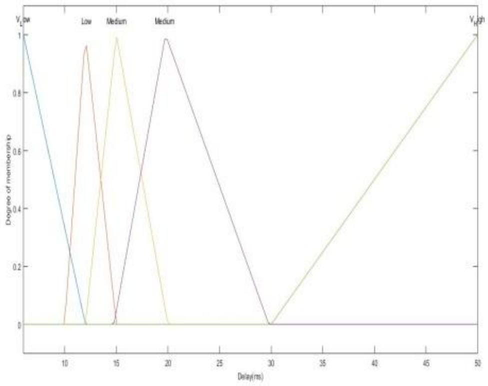

Figure 17: Input Membership function ‘Delay’ with five linguistic variables

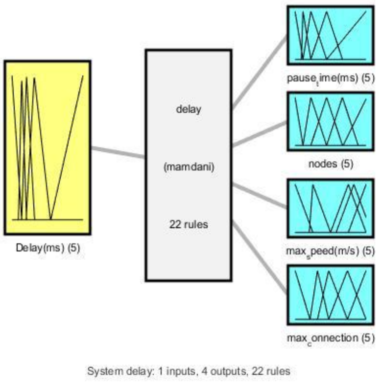

Figure 18: Mamdani fuzzy system: 1 Input, 4 Outputs, and 22 Rules

IV. CONCLUSION

Delay is a performance metric for evaluating the performance of a routing protocol in wireless ad-hoc network. In mobile ad-hoc networks, other performance metrics are also affected like throughput, packet dropped, and number of connections. In this paper, performance of DSDV routing protocol have been analysed on the basis of delay and end-to-end delay. In respect of delay, we analysed other performance parameters in respect of delay for table driven routing protocol (i.e. DSDV). We analysed DSDV at network simulator scenario and fuzzy based mamdani inference system. Normalized routing load is decreased as data rate is increased. As per our results, pause time 40 is suitable to main the delay for DSDV routing protocol at all data transmission rates (i.e. 0.016Mb-0.75Mb). Normalized routing load is decreased as data transmission rate is increased. At pause time 40, NRL is minimum as compared to other pause times (10, 20, and 30). Packet delivery fraction is very low for pause time 40. Also there is highest throughput for pause time 40 while it is very low for pause time 20. As per fuzzy system based delay analysis for DSDV in MANET, pause time 28, speed 28, and number of connections as 5 are suitable performance metrics values for maintaining the network delay. It has been observed from fuzzy based analysis that as the connections are increased, the network delay will also be increased for DSDV routing protocol in mobile ad-hoc networks.

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AUTHOR’S PROFILE

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