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A Throughput Based Fuzzy System In MANET

Pushpender Sarao

***Abstract-** In mobile ad-hoc network, throughput is very important performance parameter. It depends upon different other network parameters like speed of nodes, pause time, density of nodes. To obtain a desired throughput in mobile ad-hoc network, a fuzzy based throughput calculation work has been performed in this paper. In this work, DSDV routing protocol is implemented in two steps: one is fuzzy based system and another is network simulation based scenarios. Designing the rule based fuzzy system and evaluating the DSDV routing protocol in network simulator work is carried out in this research work. Throughput is considered as main performance parameter for evaluating the table driven protocol. Fuzzy system is designed using one input parameter throughput and four output parameters like pause time, maximum speed, node density, and maximum number of connections. An input will be given by the user and based on that input value; other output parameter values will be calculated by the fuzzy system. In network simulator based scenario, varying the maximum number of connections, maximum speed, pause times, number of nodes, different scenarios were generated and routing protocol's performance is evaluated.*

***Index Terms-** throughput, route, node density, fuzzy rules, pause time, membership function.*

I. INTRODUCTION

Mobile ad-hoc network is very useful ad-hoc network. Due it its low installation cost and low space requirement, it is very popular. At any location within few minutes, mobile ad-hoc network can be installed. For military operations, it is mostly used in certain circumstances. But there are so many challenges to optimize the route in this ad-hoc network. To achieve the desired performance parameter in a limited period of time, it is a tedious task. Also high speed of nodes will create a problem to establish the network connections. If frequency of connection breakage is more, then number of dropping packets will be increased. As a result overall performance as well as throughput of the network will be decreased. sIn his work, to achieve a desired throughput in a wireless ad-hoc network, a fuzzy system is designed. Also to analysis the performance, network simulator based throughput calculation for DSDV routing protocol is carried out. Paper is organized as follow: Literature work about this proposed work is discussed in section II. In section III, based on one input parameter and four output parameter, fuzzy system have be designed. Here, based on fuzzy rules, desired throughput is identified. Section IV elaborates the DSDV route inspection using the network simulator NS-2.35. The simulation work was carried out for 50s. XGraph and NSG2 were used as the graph designing tools. Varying the nodes, pause times, connections, speed, and route was inspected. Experimental setup for simulation work is explained in section IV. Section V concludes this research work.

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II. RELATED WORK

Samiksha Nikam and B.T. Jadhav proposed a fuzzy and simulator based model to maintain the desired throughput in mobile ad-hoc network. Based on network parameters like mobility of nodes, density of nodes, connection rate, number of connections, throughput was calculated. In this proposed system [1], throughput will be given by the user and using fuzzy system, other output parameters (nodes, speed, connections, and pause time) will be calculated. These output values will be given as input to the network simulator and then based on this input, throughput will be calculated. Pushpender Sarao proposed a route analysis work for a table driven routing protocol in MANETs. This evaluation work was carried out using the fuzzy expert system and network simulation (NS 2.35). Delay was considered as input parameter for generating the output parameters (pause time, speed, connections, node density, and pause time). It was concluded that end-to-end delay will be more at low connections and higher rate of node density [2].

In [3], R. Logesh Babu, P. Balasubramanie discussed the opportunistic routing (OR) in mobile ad-hoc network. For security purposes, OR routing protocol works well. Also OR routing protocol was evaluated with certain performance metrics. Performance metrics like number of hops, end-t-end delay, PDR(packet delivery ratio) with respect of 50-250 node density were used to analysis the performance of OR routing protocol. It was concluded that using the trust values of the nodes, security in OR is possible. Reza Mohammadi et al. suggested the fuzzy system based routing protocol in wireless sensor networks. it was discussed that maintaining the energy of the nodes under the water for wireless sensor network is tedious task[4]. Also the depth based routing (DBR) routing protocol and its features were described in detail. After that enhancement suggestions (to improve the performance of DBR protocol) were given with proper evidences. The proposed enhanced fuzzy based DBR protocol was evaluated with performance metrics like end to end delay, packet delivery ratio, and hop count, number of nodes, energy, depth, delay, and speed. End of this work, it was claimed that fuzzy based DBR routing protocol works well as compare to existing DBR routing protocol.

Mala Chelliah et al. proposed a multiple parameter based AODV routing protocol using Fuzzy Logic in wireless mesh networks. The main objective behind this proposed work [5] is to reduce the network congestion. It was declared that multiple parameters based AODV performs better than AODV having multiple parameters. The proposed AODV having the parameters:

hop count, buffer occupancy, and node energy. Simulation work was carried out using network simulator 2. Also performance evaluation for proposed protocol was implemented using NS-2 network simulator based on several performance parameters. The performance parameters were used as: average throughput, average round trip time, speed, routing overhead. It is declared that multi-parameters based AODV outperforms as compare to existing routing algorithms.

Sai Krishna Mothku et al. [6] proposed an energy efficient fuzzy based routing protocol in heterogeneous network. The proposed protocol is delay aware routing protocol. Fuzzy system was composed of four input parameters (energy, available buffer, distance, link quality) and one output parameter (next hop selection chance). Triangular membership functions were designed with 3-5 linguistic variables. A comparison work was carried out using performance parameters (nodes end to delay. It was concluded that proposed protocol have a capability to reduce the packet dropping rat and it is also a delay aware and energy saving protocol.

Nihad et al. proposed an approach to enhance the route stability of AODV using fuzzy system in MANET [7]. In the fuzzy proposed system, input parameters (residual energy, node movement, hop count) are fed into the fuzzy system and an output parameter (trust value) is calculated for each node in the network. Based on this trust value, next route is decided. Also a comparison work for AODV, fuzzy AODV, and MBCR (Minimum battery cost routing) protocols with respect to some performance parameters (average throughput, pause time, packet delivery ratio, average end-to-end delay, average routing load). It was concluded that proposed fuzzy based AODV outperforms as compare to traditional AODV and MBCR routing protocols (in respect of node mobility, end-to-end delay, control overhead).

Subhrananda Goswami et al. presented a performance prospective comparison work of routing protocols [8]. With respect of node density, performance of AODV, DSDV, and DSR routing protocols have been evaluated on fuzzy based system as well as on network simulator. The performance metrics are considered as: control overhead, packet delivery ratio. It was declared that fuzzy based system is best suitable system to choose an appropriate routing protocol out of AODV, DSDV, and DSR. Based on different network conditions and different applications, we can select a suitable protocol. AODV was declared as better routing protocol as compare to DSDV and DSR protocol in terms of fast data transmission.

III. THROUGHPUT USING FUZZY SYSTEM

Fuzzy system has been designed to calculate throughput in the DSDV routing protocol [9]. In fuzzy system, the flowing steps are integral part as given below:

- Fuzzifier←(taking input as membership function, routing parameters)
- Inference Engine←(fuzzy Rule Base)
- (Get Outputs)←Defuzzifier

There is one input 'throughput' and four output variables 'pause time', 'number of nodes', number of connections' , 'maximum speed'(as shown in figure 1). For input variable 'throughput', nine linguistic variables were used. Also for output variables 'pause time', 'maximum number of connections', 'nodes', 'speed' nine linguistic variables were applied. Linguistic variables for output variable 'throughput' were: L3, L2, L1, M, H, JH, MH, VH, and SH. While linguistic variables for output variables 'speed' and 'pause time' were: L4, L3, L2, L1, M, D, H, JH, and MH.
Triangular type membership functions [10][11][12] were applied for all the input and output variables. Due to higher computational efficiency, triangular membership functions are used for real time operations. Mamdani type fuzzy system was designed based on one input and four output variables. Here, when input variable will be assigned some value, user will get the corresponding output values for output variables (pause time, speed, nodes, and connections). Range for throughput variable was decided as 35kbps to 148 kbps. Maximum and minimum range for nodes was taken as 10 to 118 nodes. Maximum speed for all nodes was decided from 6ms to 86ms. For all parameters, 7 to 68 connections were considered.

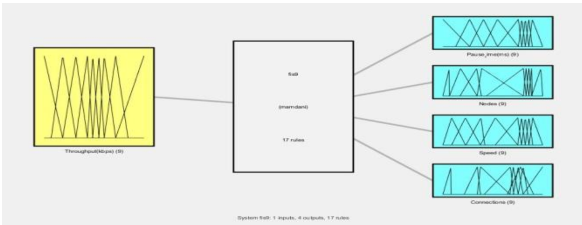

Figure 1: Fuzzy system with 1 input, 4 outputs, 17 rules

Input and output membership functions with nine linguistic variables are depicted in figure.

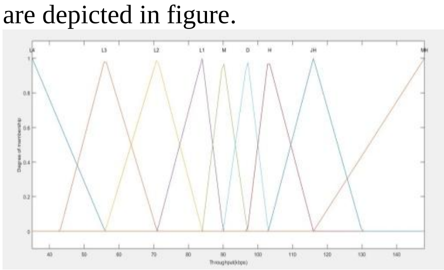

Figure 2: Input membership function 'Throughput'

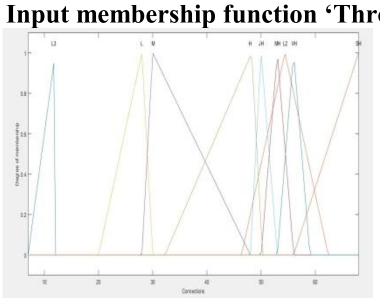

Figure 3: Output membership function 'Connection'

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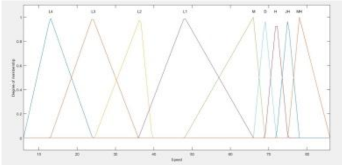

Figure 4: Output membership function 'Speed'

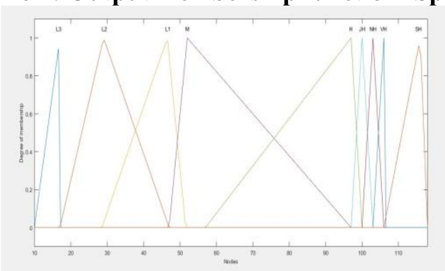

Figure 5: Output membership function 'Nodes'

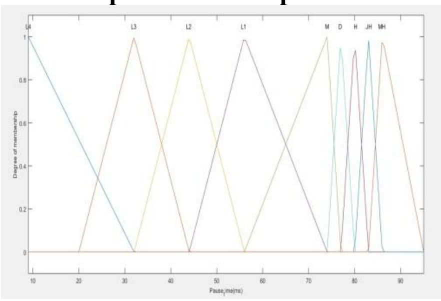

Figure 6: Output membership function 'Pause time'

Total seventeen fuzzy rules were designed for mamdani type fuzzy system. These designed fuzzy rules are explained in detail as below:

```
>> plotmf(fis,'input',1)
>> plotmf(fis,'output',1)
>> plotmf(fis,'output',2)
>> plotmf(fis,'output',3)
>> plotmf(fis,'output',4)
>> plotfis(fis)
>> showrule(fis)

ans =

1. If (Throughput(kbps) is L4) then (Pause_time(ms) is L3)(Nodes is L3)(Speed is L4)(Connections is L3) (1)
2. If (Throughput(kbps) is L4) then (Pause_time(ms) is L1)(Nodes is L2)(Speed is L3)(Connections is L2) (1)
3. If (Throughput(kbps) is L3) then (Pause_time(ms) is L2)(Nodes is L2)(Speed is L3)(Connections is L2) (1)
4. If (Throughput(kbps) is L2) then (Pause_time(ms) is L2)(Nodes is L1)(Speed is L2)(Connections is L) (1)
5. If (Throughput(kbps) is L1) then (Pause_time(ms) is L2)(Nodes is L1)(Speed is L2)(Connections is M) (1)
6. If (Throughput(kbps) is M) then (Pause_time(ms) is M)(Nodes is JH)(Speed is L1)(Connections is M) (1)
7. If (Throughput(kbps) is M) then (Pause_time(ms) is M)(Nodes is M)(Speed is L1)(Connections is M) (1)
8. If (Throughput(kbps) is M) then (Pause_time(ms) is D)(Nodes is JH)(Speed is L1)(Connections is H) (1)
9. If (Throughput(kbps) is M) then (Pause_time(ms) is D)(Nodes is JH)(Speed is M)(Connections is H) (1)
10. If (Throughput(kbps) is M) then (Pause_time(ms) is D)(Nodes is JH)(Speed is D)(Connections is H) (1)
11. If (Throughput(kbps) is D) then (Pause_time(ms) is D)(Nodes is JH)(Speed is H)(Connections is H) (1)
12. If (Throughput(kbps) is D) then (Pause_time(ms) is H)(Nodes is NH)(Speed is H)(Connections is MH) (1)
13. If (Throughput(kbps) is MH) then (Pause_time(ms) is D)(Nodes is M)(Speed is D)(Connections is SH) (1)
14. If (Throughput(kbps) is JH) then (Pause_time(ms) is MH)(Nodes is SH)(Speed is MH)(Connections is SH) (1)
15. If (Throughput(kbps) is D) then (Pause_time(ms) is D)(Nodes is M)(Speed is D)(Connections is VH) (1)
16. If (Throughput(kbps) is H) then (Pause_time(ms) is L1)(Nodes is M)(Speed is D)(Connections is MH) (1)
17. If (Throughput(kbps) is L2) then (Pause_time(ms) is M)(Nodes is M)(Speed is MH)(Connections is H) (1)

>>
```

```
>> fis

fis =

          name: 'fis9'
          type: 'mamdani'
     andMethod: 'min'
      orMethod: 'max'
   defuzzMethod: 'centroid'
     impMethod: 'min'
     aggMethod: 'max'
         input: [1x1 struct]
        output: [1x4 struct]
          rule: [1x17 struct]
```

Based on input values given to the' throughput' variable, we got output values for the output variables (pause time, nodes, speed, connections). Input given to the fuzzy system and corresponding output result is depicted in table 1.

Table 1: Output variable values w.r.t. Input variable values

Sr. No.	Throughput	Pause time	Nodes	Speed	Connections
1	37.47	46.5	27.9	27.2	43.4
2	41	46.5	28	20.3	43.5
3	45.24	46.6	28.1	20.4	43.5
4	51.89	45.9	28.4	22.2	48.1
5	57.95	48	42.7	30.5	48.8
6	68.55	55.6	56.6	48.6	38.5
7	75.6	55.4	58.1	52.9	36.4
8	82.67	47.3	50.8	38.4	34.9
9	93.97	71.6	72.9	57.2	43.9
10	105.3	61.6	69	73.3	56.9
11	110.9	68.9	78.2	76.7	60.9
12	117.3	87.6	108	78.3	64.2
13	25	85.1	78.9	76.8	63.1
14	128.6	81.4	71.2	73.1	63.2
15	133.5	77	67.2	69	63.6
16	138.5	77	66.3	69	63.9

As shown in table 1, when numbers of connections are increasing, throughput is also increasing.
This is due to the chances for dropping the packets will be less due to alternative route paths for data transmission.

When throughput value is increased, pause time value will vary with different values. When numbers of nodes are varying, throughput (in most of the cases) is increased. In initial stage, at constant pause time, constant connections, constant nodes and reducing the speed, throughput is increased.

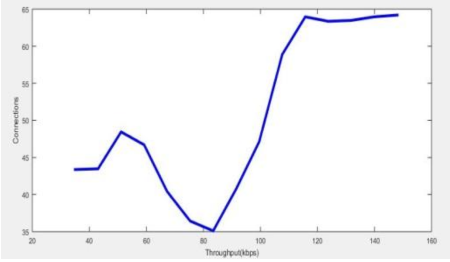

Figure 7: Throughput W.R.T. Connections

Figure 7 represents the graph for throughput with respect to connections. When we desire the higher throughput, we need more connections to reduce the dropping packets. From throughput 80kbps-160 kbps, we need 40-65 connections approximately. When we need only small, throughput, fewer connections are sufficient.

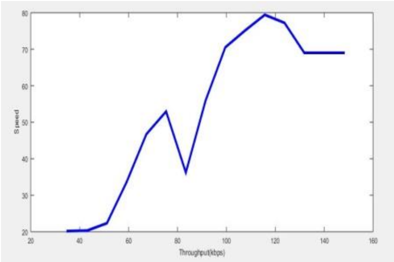

Figure 8: Throughput W.R.T. Speed

Figure 8 represents the graph for throughput with respect to speed. Throughput from 40-70kbps, speed is required more (approximately 20-50 m/s). When we desire throughput 85kbps, 30-40m/s speed is required. Again throughput from 85-120kbps, more speed is required. For throughput 140kbps, we need 70 m/s speed.

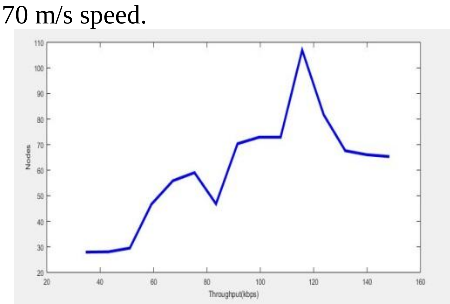

Figure 9: Throughput W.R.T. Nodes

Figure 9 illustrates the graph for throughput with respect to nodes. Here, throughput 40-160kbps, numbers of nodes are also varying. Varying the throughput values, node value is also varying.

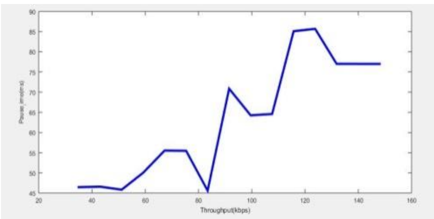

Figure 10: Throughput w.r.t. Pause time

Figure 10 illustrates the graph for throughput with respect to pause time. For throughput 40-160kbps, pause times are varying with varying the throughput values.

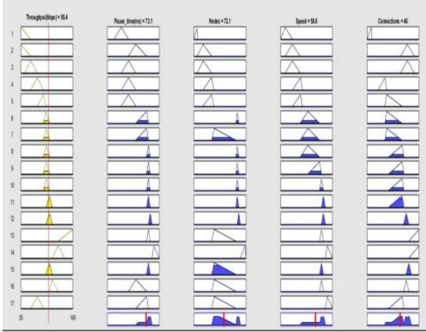

Figure 11: Fuzzy Rule Bar For Throughput 95.4 Pause Time 73.1 Nodes 72.1 Speed 59.8 Connection 46

Figure 11 depicts the fuzzy rule bar for throughput 95.4 pause time 73.1 nodes 72.1 speed 59.8 connection 46. It means when we desire the throughput value just above the medium, we require just higher the values for pause time, nodes, speed and number of connections.

IV. THROUGHPUT USING NETWORK SIMULATOR-2

Experimental setup:

For simulation work, we have used network simulator NS-2.35[13]. Network simulator is most likely used simulator by researchers to simulate the wireless network. Using network simulator, we can analysis the several performance metrics for a specific network protocol. For using simulator NS-2.35, we have to write tcl scripts. For getting the performance parameters, we have to write awk/perl [14] scripts. When we will execute tcl script, we will get trace file and nam files. Using trace files and awk/perl scripts, we will execute a command in LINUX terminal for calculating the throughput with respect to other parameters.

In this experimental work, we created a wireless scenario with 16 wireless nodes for simulation time 50s. The tcl scripts are written for DSDV routing protocol in wireless ad-hoc network. Throughput is considered a very important performance metrics for evaluating the overall performance of the wireless network. A number of trace and nam files are generated by executing the tcl scripts. For graphical representation work, we have used the xgraph, excel, and TraceGraph[15] tools. Varying the values of the pause times, maximum number of connections, maximum number of nodes, and speed, we evaluated the network performance. For pause times, we have taken a range from 0-100s, while range for nodes was taken as 20-120 nodes. Speed range and connection range was decided 10-80m/s and 4-14 respectively.

Using cbrgen tcl file, we created 5 files for maximum number of connections (4, 7, 10, 13, and 15). In terminal, we typed a sample command (for generating 4 connections) as below:

```
ns cbrgen.tcl –type cbr –nn 16 –seed 1.0 –mc 4 –rate 6.0
>16-dsdv-connection-4
```

Also we have created 8 speed files by using setdest tool. For implementing this, we typed a command in the terminal. The sample command is given as below:

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```
setdest –v 1 –n 16 –p 0 –M 10 –t 50 –x 848 –y 100>16-dsdv-speed-10
```

This command will generate the traffic for 16 nodes with pause time 0 and maximum speed 10 m/s.

We simulated the DSDV routing protocol in different network scenarios. In some cases, we executed tcl files varying the maximum number connections, pause times, maximum speed, and node density.

We simulated all tcl scripts for only DSDV routing protocol [16]. Some common simulation parameters(as shown in table 2) for all scenarios were as: simulation time(50s), network topology(848×100), packet size(512 bytes), radio propagation model(Two Ray Ground), mac protocol(802.11), link layer type (LL), interface queue type(PriQueue), antenna model (Omni antenna), connection type (UDP), traffic type(CBR), routing protocol(DSDV), channel type(wireless channel).

In scenario-I (speed), we consider the speed as 10, 20, 30, 40, 50, 60, 70, and 80 m/s with maximum number of connections as 7. Pause time was taken as 0. Other parameters like simulation time, network topology, node density, packet size etc. were kept same as in other scenarios.

Table 2: Simulation Parameters

Simulation Parameter	Value
Speed	10,20,30.40.50.60.70.80
Network topology	848 ×100, 1200×520
No. of nodes	16, 20,40,60,80,100,120
Simulation time	50s
Pause time(s)	0,10,20,40,60,80,100
Max. Speed(m/s)	80,
Max. Connection	4,7,10,13,14
Seed	1.0
Send rate	0.1666
Packet size	512
Radio-Propagation Model	TwoRayGround
Mac Protocol	802.11
Interface queue type	PriQueue
Antenna model	Omni Antenna

In scenario-II (connections), we consider number of maximum number of connections as 4, 7, 10, 13, and 14. Pause time was taken as 10s. Maximum speed was decided as 20 m/s. while other parameters like network topology, number of nodes, send rate (0.1666), seed (1.0), packet size etc. were kept same as in all other scenarios.

In scenario-II-I, simulation work was carried out for maximum 7 connections, maximum speed 10m/s, and pause time 0s. But other simulation parameters like simulation time, number of nodes, network topology and packet size etc. were kept same.

In scenario-III, maximum numbers of nodes were taken as 20, 40, 60, 80, 100, and 120 at network topology (1200×520), packet size (575 bytes);While other parameters like radio propagation model, channel type, simulation time, antenna model, and traffic type etc. were taken as same as in other scenarios.

In scenario IV, pause time was taken as 0,10,20,40,60,80, and 100s at 6 maximum number of connections, maximum speed as 20 m/s and packet size 575 bytes. Other simulation parameters like node density (16), network topology (848×100) were decided as same as in previous scenarios.

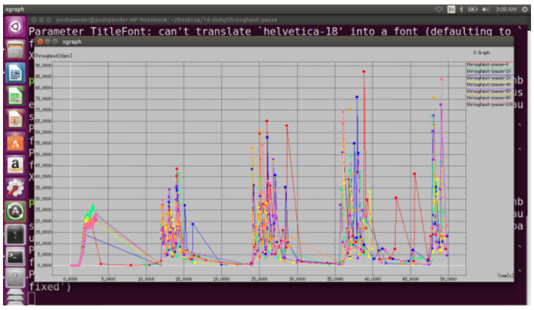

Figure 12: Throughput w.r.t. Pause time

Figure 12 shows the throughput with respect to pause times 10 and 100. As simulation time is increasing, automatically throughput improvement is also there both for pause times 10 and 100. Throughput fluctuates from low simulation times to high throughput times. Throughput is higher for pause time 100 as compare to throughput at pause time 10. At initial stages of simulation time (0-12s), throughput for pause time 10 is higher than throughput at pause time 100.

Figure 12 shows the throughput with respect to pause time 60. Throughput is fluctuating rapidly as simulation time is updated. For pause time 60, throughput is highest at simulation time 50s.

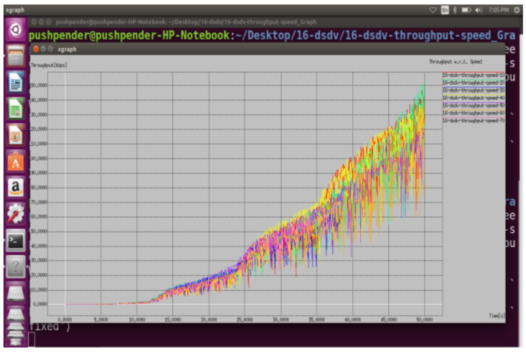

Figure 13: Throughput Vs Speed

Table 3: Speed Vs Throughput

Speed(ms)	Throughput(kbps)
10	103.66
20	106.93
30	83.14
40	90.85
50	80.92
60	81.97
70	78.73
80	105.12

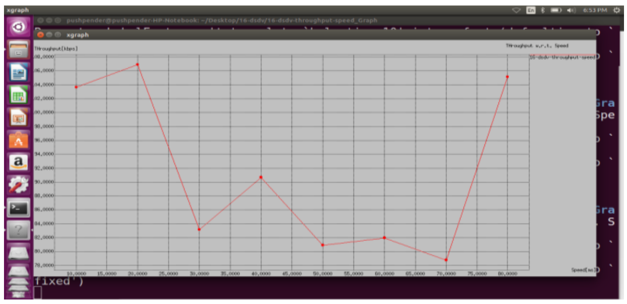

Figure 14: Throughput W.R.T. Speed

Figure 14 depicted graph for throughput with respect to speed. If we desire higher throughput, speed have to maintain. If speed goes down, throughput automatically will be increased (As shown in table 3).

With increasing the speed, throughput is not smoothly (i.e. at same rate) increased. We can see in graph presentation, at lower rate of speed, throughput is increased when speed is increased from 20 m/s to 30 m/s. throughput is suddenly decreased, but again when speed is increased, throughput is also increased. Throughput at 50 m/s and 60 m/s is approximately same (i.e. little bit change).

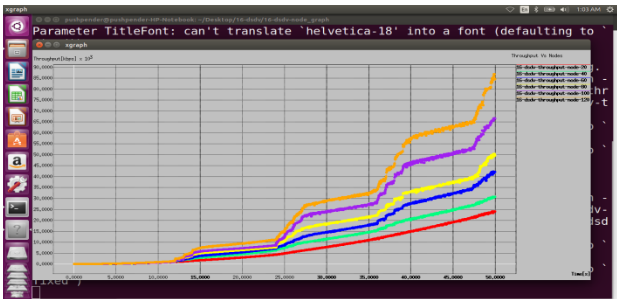

Figure 15: Throughput w.r.t. Nodes

Figure 15 illustrates the throughput with respect to various node density 20,40,60,80,100 and 120. At node density 20, throughput is very low while it is very hih at node density 120. From node density 20 to 120, throughput is increasing rapidly. Fluctuations of throughput (with respect to time) at node density 20 and 40 is less while fluctuations of throughput at node density 60,80,100 and 120 is higher. As simulation time is increased, throughput fluctuations are come out rapidly. Throughput from simulation time 0 to 12s is approximatly same (i.e. very low) for node density 20,40, 60,80,100 and 120.

Figure 15 depicts the throughput at node density 60. As simulation time is increasing, throughput is also increasing. From simulation time 0-5s, throughput is lowest while it is highest at simulation time 50s. From simulation time 0-50s, throughput is rapidly fluctuated.

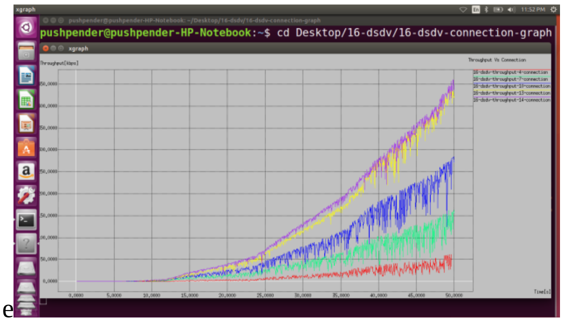

Figure 16: Throughput w.r.t. connections

Figure 16 shows the graph for throughput with respect to 13 connections. Throughput is increasing from lowest simulation time to highest simulation time. Fluctuations are very less for simulation times 0-12s. But it is slightly(little bit) increasing for simulation timings 12-35s. fluctuations from 40-45s simulation time, it is increasing rapidly. It goes down at highest simulation time(i.e. 50s).

Figure 16 illustrates the throughput with respect to 7 connections. Throughput is increasing as the simulation time is increased. It is lowest upto 12s simulation time while at simulation time 50s, it is average. Also throughput is rapidly fluctuated from 0-50s simulation time.throughput fluctuations are increasing more rapidly from low simulation time to highest simulation time. Fluctuations of throughput for simulation time 40-50s is decreasing.

Figure 16 illustrates the throughput with respect to 4 connections. Throughput is increasing as the simulation time is increased. It is lowest upto 12s simulation time while at simulation time 50s, it is highest. Also throughput is rapidly fluctuated from 0-50s simulation time.throughput fluctuations are increasing more rapidly from low simulation time to highest simulation time.

Table 4: Throughput Vs Pause time

Pause_time(s)	Throughput(kbps)
0	38.60
10	848.35
20	3.80
40	15.67
60	703.58
80	150.96
100	695.85

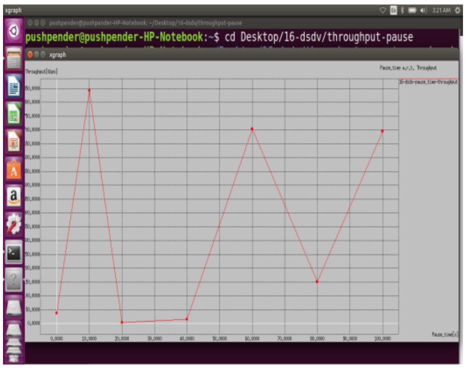

Figure 17: Pause time w.r.t. Throughput

Figure 17 illustrates graph for pause time with respect to throughput. When pause time is increased, throughput is varying with different values. It is highest at lower values of pause time. At pause time 20, 30 throughput values are approximately same(as shown in table 4). Also for pause time 60 and 100, throughput is same. At pause time 10, throughput is highest; while throughput is high at pause time 20.

Table 5: Throughput Vs Node density

Nodes	Throughpu t
20	170.04
40	498.14
60	232.34
80	119.40
100	143.01
120	523.94

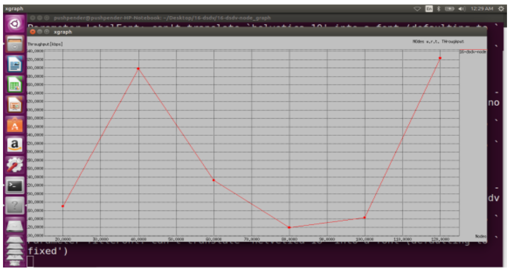

Figure 18: Nodes w.r.t. Throughput

Figure 18 shows the graph for nodes with respect to throughput. When density of nodes is increased, throughput is varying with different values. In initial stage, node density is little bit increasing,

throughput is also increased. But after that if node density is increased, throughput is suddenly decreased. Throughput is highest when node density (i.e. number of nodes) is 120(as shown in table 5), while at node density 80, throughput is lowest. Throughput is varying with node density 20 t0 120.

Table 6: Throughput Vs Connections

connections	Throughput
4	50.41
7	123.09
10	152.93
13	168.16
14	168.82

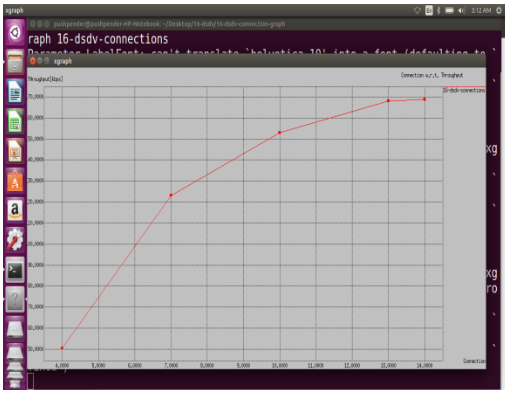

Figure 19: Throughput w.r.t. Connections

Figure 19 and table 6 represent the throughput with respect to connections. As numbers of connections are increased, throughput is also increased. When number of connections will be more, automatically rate of dropping packets will be reduced. Overall performance of network will be enhanced. When there are 4 connections in the network scenario, throughput is lowest. But throughput is highest at 14 connections (as shown in figure 19).

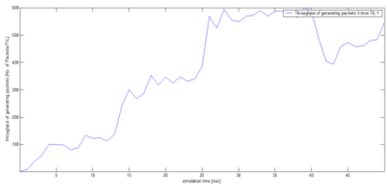

Figure 20: Throughput For Generating Packets At 14 Connections

Figure 20 illustrates the throughput for generated packets when number of connections are 14. Form simulation time 0-42 s, throughput is increasing at a specific rate. But after that it is suddenly decreasing up to simulation time 50s. Throughput is increasing at low rate form simulation time 0-12s. After that is suddenly increased. At simulation time 40s, throughput is highest. Overall for all simulation times, throughput is fluctuating with different rates.

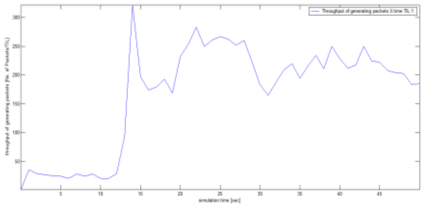

Figure 21: Throughput of generated packets at speed 80 m/s

Figure 21 depicts the graph for throughput of generated packets at speed 80 m/s. throughput is approximately same for simulation time 0-12s. It is highest at simulation time 15s. For simulation time 30s to 42s, throughput is continuously fluctuating at the same intervals. At simulation time 20s, throughput is approximately average. Overall throughput is fluctuating with respect to simulation time.

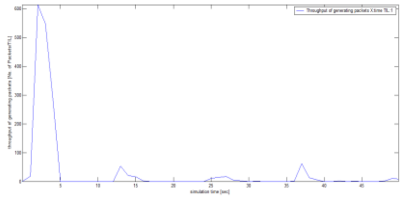

Figure 22: Throughput Of Generated Packets At Pause Time 100

As depicted in figure 22, throughput of generated packets (at pause time 100) is highest at simulation time 0-5s. But it is very low for simulation times 5-50s. During these timings, throughput is fluctuated with some time intervals. Overall throughput of generated packets is same for simulation times 5-50s.at pause time 100, average throughput is very poor.

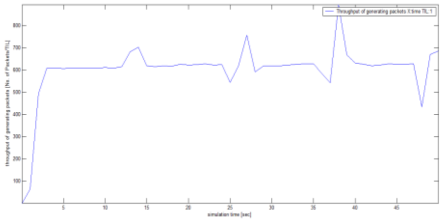

Figure 23: Throughput Of Generated Packets At Node Density 120

As depicted in figure 23, throughput of generated packets is approximately same for all simulation times. But it is fluctuating only at some specific time intervals. At simulation time 40, it is highest while it is lowest at simulation time 48. There is small fluctuation in throughput of generated packets with node density 120.

V. CONCLUSION

A throughput based fuzzy system has been implemented for DSDV routing protocol using fuzzy rules and network simulator NS-2.35. Considering throughput as a very important performance matric in route analysis, simulation work for DSDV routing protocol is carried out. As number of connections will be more in a network scenario, throughput will also be improved. In initial stages, at low pause times, throughput will be more, but as pause time will be increased, throughput performance will be going down. Speed parameter value will be increased; number of dropping packets and breaking of connections will be more.

But throughput with respect to speed will vary at different simulation times. It totally depends on other network parameters like number of connections. If there are sufficient numbers of connections, then increasing the speed, throughput will be improved. Overall designed fuzzy system works well that is designed based on experimental work on network simulator NS-2.35.

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