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Fuzzy Approach to Maintain Delay in Ad Hoc Network for DSDV Protocol

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Abstract: Ad-hoc network is very popular due to its flexibility and self-configure nature. Routing protocol plays key role in case of data transmission. The major function of routing protocol is to discover the route and transmit the data with minimum delay. Delay is important performance parameter of ad hoc network and it get affected by network parameters such as node density, mobility , speed of nodes and number of connected nodes. This research paper focuses on delay performance parameter. Due to mobility of nodes it is challenging to maintain low delay in ad hoc network. In this research paper researcher proposed to use fuzzy inference system to maintain delay in the ad hoc network.

1.0 Introduction:

Dynamic nature of ad hoc network raises various performance issues for routing protocols. Performance of network depends the efficiency of protocol used during data transmission. Efficient protocol plays vital role to improve networkperformance. Performance of network protocol is measured by considering various parameters such as throughput, delay, routing load, and packet delivery fraction [2][10]. In this paper researcher focus on only delay performance parameter and DSDV protocol for study.The primary objective of this study is to use fuzzy inference system to maintain delay in ad hoc network. Desired delay is inputted to fuzzy inference system. The outcome of fuzzy system defines values for pause time, number of nodes, maximum speed and maximum connections. Output values specified by fuzzy inference system is used to set an ad hoc network scenario. Simulations perform using network simulator NS2.34 to verify whether delay is maintaining at lower level or not. Fuzzy inference system is implemented in Matlab. The research paper is organized as follows.

Second section describes delay analysis of DSDV protocol.A discussion on work flow of fuzzy inference system is mentioned in section 3. Section4 describes simulation environment and methodology. Section 5 describes fuzzy inference system, followed by result comparison and analysis in section 6.

2.0Delay Analysis of Ad Hoc Network for DSDV Protocol:

DSDV is the first table driven ad hoc network protocol. In this protocol each node maintain routing table that contains all possible destinations within network and number of routing hops to each destination. The information in routing table is updated by increasing sequence number which avoid count to infinity problem. The sequence number shows freshness of route and route with higher sequence number are favorable. Each mobile node of ad hoc network maintain a routing table which stores information about all available destinations, number of hop and a sequence number. Using this routing table packets are transmitted between the nodes. [3] [5].

Delay is important performance parameter of mobile ad hoc network. Due to unstable nature of ad hoc network it is challenging to maintain the low delay during data packet transmission. Delay in ad hoc network get affected bynetwork parameters like (1) pause time, (2) number of nodes, (3) speed of nodes, (4) numer of connected nodes. Simulation study is performed to evaluate and quantify effect of network scenario parameters on delay of ad hoc network. Analysis is performed by varying only one parameter at a time and rest of the parameters are kept constant[7]. Following is the analysis,

1. **Pause Time:**Variation in pause time does not affect delay in ad hoc network significantly . Delay approximately remains constant at specific value.
2. **Number of nodes**: Density of nodes has significant effect on delay. If the number of nodes in the network grows, the size of the routing tables and the bandwidth required to update them also grows which reflect in unstable nature of delay.

3. **Speed of nodes**: When speed of nodes increases nodes enter and exit a network frequently and route changes frequently which reflect in variable delay.
4. **No. of Connections**: As connections between the nodes increases updates packets are broadcasted throughout the network so every node in the network knows how to reach every other node. Thus increasing connections in between the nodes provides alternate route in case of route break. This maintains delay at desired level in the network.

However practically topology of ad hoc network is unstable network parameter can be change any time. If mobility of nodes other network parameters vary in combination then it helps to maintain delay in the ad hoc network . Low mobility scenario helps to maintain moderate delay. In high mobility scenario if number of nodes are kept minimum then delay can be maintain at lower level.In high mobility scenario if number of nodes and speed of nodes are increasing and other parameters are constant delay in ad hoc network become unstable.

It is observed that to maintain delay at desired level is challenging and complex task. In such circumstances fuzzy logic is best suitable to take a decision. In this research paper use of fuzzy logic is proposes to decide pause time, nodes, maximum speed and maximum connections to maintain desired delay.

3.0 Work Flow of Fuzzy System

Fuzzy systems are suitable for ambiguous and approximate reasoning. It help to estimate output values depends upon input variables provided and set of rule extracted considering incomplete or uncertain information. [10]. Fuzzy inference system consists of set of input, output variable and set of rules to control the fuzzy system. Following flow chart depicts work flow of fuzzy system and how it is used to maintain delay in ad hoc network at desired level.

Initially network scenario is created and accordingly parameters pause time (P.T.), nodes (N), maximum speed (M.S.), and maximum connections (M.C.) are set for ad hoc network and run the simulation using network simulator ns2.34. At the end of simulation delay is calculated using trace files. If delay is at desired level then maintain these parameters. Otherwise go to fuzzy inference system and change the parameters to obtain desired delay. Here fuzzy logic is used to decide network scenario parameter values to maintain delay of network at desired level.

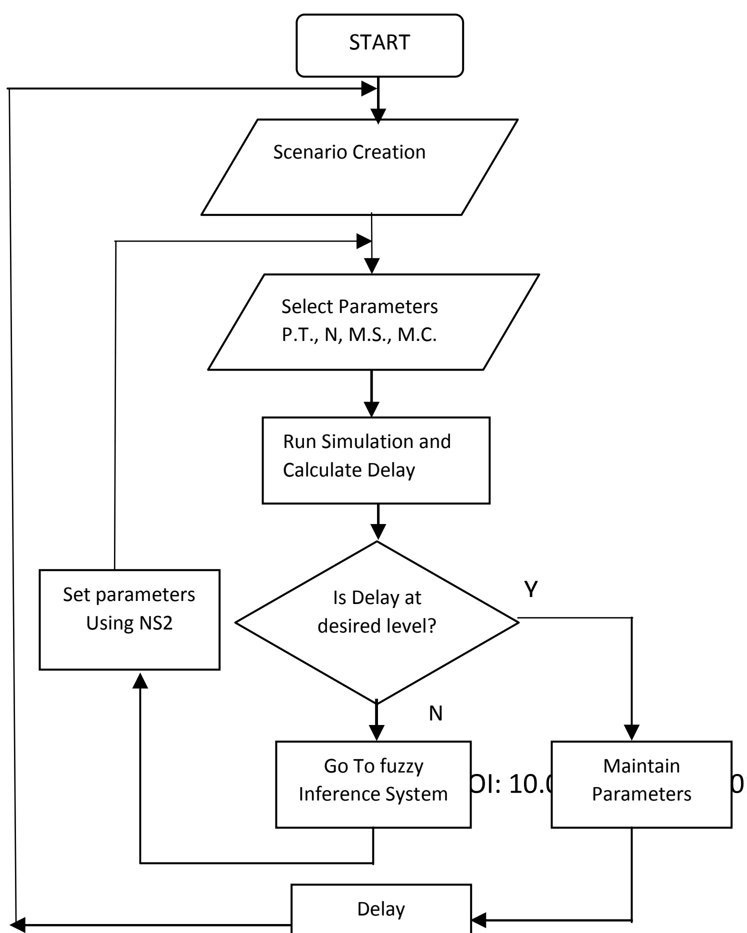

Fig 1.1 Work Flow for Fuzzy System

4.0 Experimental Procedure:

Simulation is carried out with network simulator NS2.34. Ad hoc networks are highly dynamic hence simulation techniques is an option to measure the performance. Network simulators implemented in software are valuable tools for researchers to develop, test, and diagnose network protocols. A delay of ad hoc network is analyzed using network simulator ns2.34 while DSDV protocol is used for routing.

Following steps are performed to run simulation.

1. Select performance parameters. (Delay).
2. Generate scenario and topology files using cbrgen and setdest commands.
3. Write TCL script (.tclExtension file)
4. Execute TCL script (Use ns Command)
5. Generate Trace and NAM file.
6. Execute AWK script to measure performance.

Table 1.1 shows simulation environment designed to evaluate delay. Total 32 Simulations runeach for 100 sec and result is stored in Table 1.2. These results are used to implement fuzzy inference system.

Table 1.1 Simulation Environment for NS2

PARAMETER	**VALUE**
Ad-hoc Routing Protocol	DSDV
Antenna Type	Omni directional
Simulation Time	100 sec
Simulation Area	500 X 500
Traffic Type	CBR
Node Speed	6 - 92 m/s
Data Packets	512bytes
Pause Time	9- 101 ms
Number of Nodes	10 -124
Mobility Model	Random Waypoint
Propagation Model	Two-ray Ground reflection
Interface Queue Type	Drop Tail/ Priority Queue
Interface Queue Length	50 Packets
Max. Number of Connections	7 – 78

Table 1.2 Experimental performance Data Using NS2

	Network Scenario Parameters				Performance Parameter
Sr No.	**Pause Time**	**Nodes**	**Max.Speed**	**Max. Conn.**	**Delay**
1	9	10	6	7	8.51
2	12	13	8	10	9.52
3	15	16	10	10	9.52
4	20	17	12	11	14.81
5	20	17	13	12	14.83
6	23	21	15	14	10.52
7	26	23	18	17	14.91
8	29	26	21	18	21.99
9	32	29	24	20	15.16
10	35	33	27	22	13.07
11	38	37	30	24	10.97
12	41	42	33	26	11.76
13	44	47	36	28	10.82
14	47	52	39	30	11.85
15	50	57	42	32	12.35
16	53	62	45	34	10.29
17	56	67	48	36	13.06
18	59	72	51	38	13.33
19	62	77	54	40	14.32
20	65	82	57	42	15.08
21	68	87	60	44	13.98
22	71	92	63	46	16.2
23	74	97	66	48	15.67
24	77	100	69	50	15.75
25	80	103	72	53	17.97
26	83	106	75	56	19.43
27	86	109	78	59	22.72
28	89	112	81	62	21.95
29	92	115	84	65	28.95
30	95	118	86	68	23.91
31	98	121	89	73	35.93
32	101	124	92	78	51.12

5.0Fuzzy System Construction

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A fuzzy system consist of three steps i.e. fuzzification, inference engine and defuzzification. Fuzzification is the process in which crisp values are transformed into membership values of fuzzy set. Fuzzified data is fed to inference engine. Inference engine calculate fuzzy output using rule base. Defuzzification is a mathematical process used to convert fuzzy output to crisp values. Fuzzy systems are able to make decisions in complex situation. Here fuzzy logic is used to decide parameter values for pause time, nodes, speed and connections in such a way that it help to maintain desired delay. For development of fuzzy based system delay is given as input to fuzzy inference system and output of system gives four parameters i.e. P.T.), nodes maximum speed (M.S.) and maximum connections (M.C.). Following fig1.2 show input and output parameters selected to build fuzzy system. Triangular membership functions are used to design fuzzy sets. Total five fuzzy sets are designed.

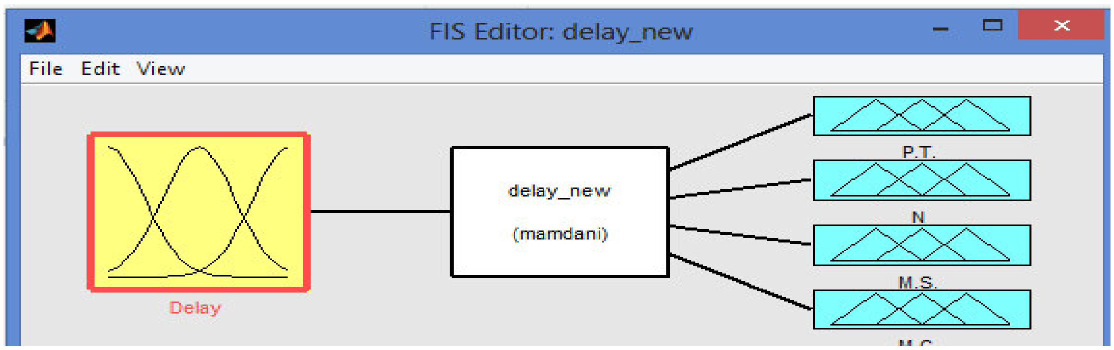

Fig 1.2Input and output parameters

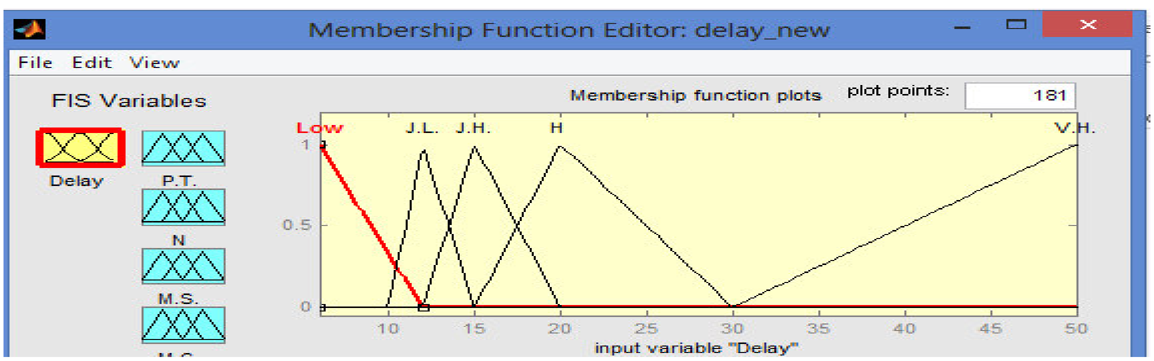

Fig 1.3 Membership Function for Input Variable Delay

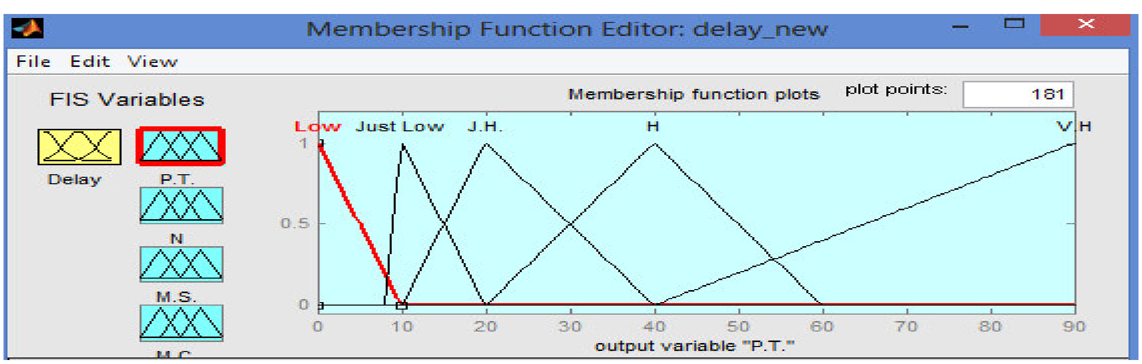

Fig 1.4 Membership Function for Output Variable Pause Time (P.T.)

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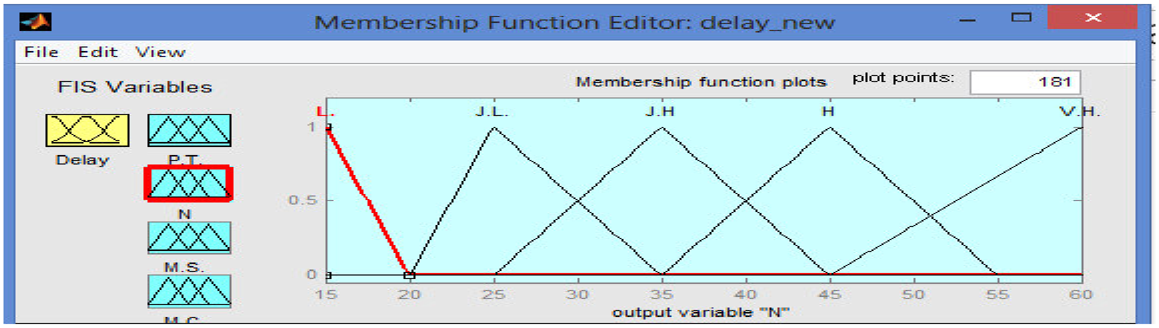

Fig 1.5membership Function for Output Variable Nodes (N)

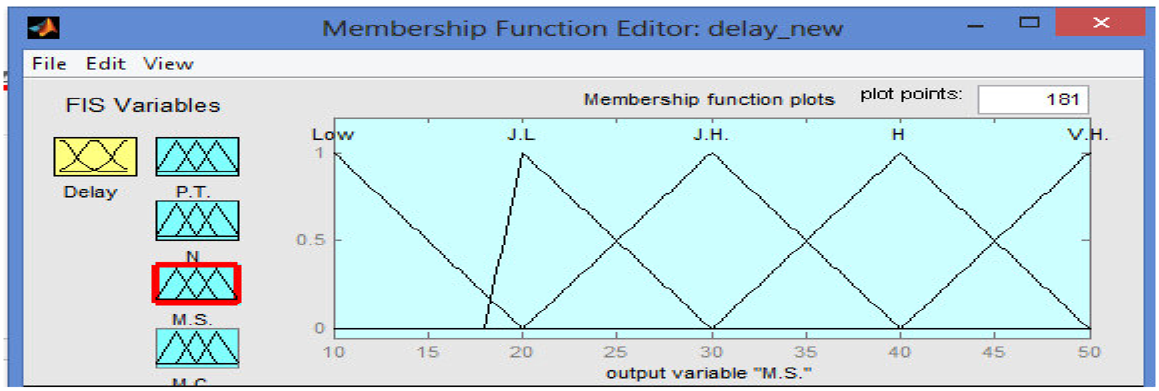

Fig 16 Membership Function for Output Variable Max. Speed (M.S.)

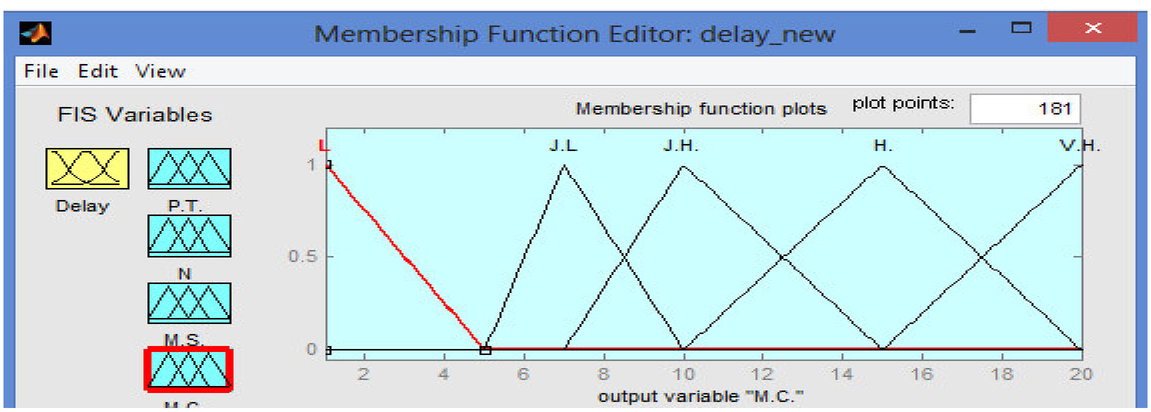

Fig 1.7 Membership Function for Output Variable Max. Connections (M.C.)

Fuzzy Sets: Fuzzy sets are named using linguistic variables such as Low, Just Low, High, Just High and Very High. Table 1.4 shows minimum and maximum ranges to design fuzzy sets. These values are designed by considering performance data of table 1.3.

Table 1.4fuzzy ranges for Input and Output Parameters

Fuzzy parameters	**Min**	**Max**
Delay(ms)	6	50
Pause time(ms)	0	90
Nodes	15	60
Max. speed(m/s)	10	50
Max. Connections	1	20

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Table 1.5 Fuzzy set for Input and Output

Linguistic Variables	**Input parameter**	**Output parameters**			
	Delay	Pause Time	Nodes	Max. Speed	Max.Connections
Low(L)	⌊(6 6 12)	⌊(0 0 10)	⌊(15 15 20)	⌊(10 10 20)	⌊(1 1 5)
Just Low(JL)	^(10 12 15)	^(8 10 20)	^(20 25 35)	^(18 20 30)	^(5 7 10)
Just High(JH)	^(12 15 20)	^(10 20 40)	^(25 35 45)	^(20 30 40)	^(7 10 15)
High(H)	^(15 20 30)	^(20 40 60)	^(35 45 55)	^(30 40 50)	^(10 15 20)
Very High (VH)	⌈(30 50 50)	⌈(40 90 90)	⌈(45 60 60)	⌈(40 50 50)	⌈(15 20 20)

Fuzzy Rule Set suggested by researcher is shown below in table 1.6. Total 33 rules are designed.

Table 1.6 fuzzy rule set

	Delay is		**P.T.**		**N**		**M.S.**		**M.C.**
	L		L		L		L		L
	JL		JL		JL		JL		JL
IF	JH	**THEN**	JH	**AND**	JH	**AND**	JH	**AND**	JH
	H		H		H		H		H
	VH		VH		VH		VH		VH

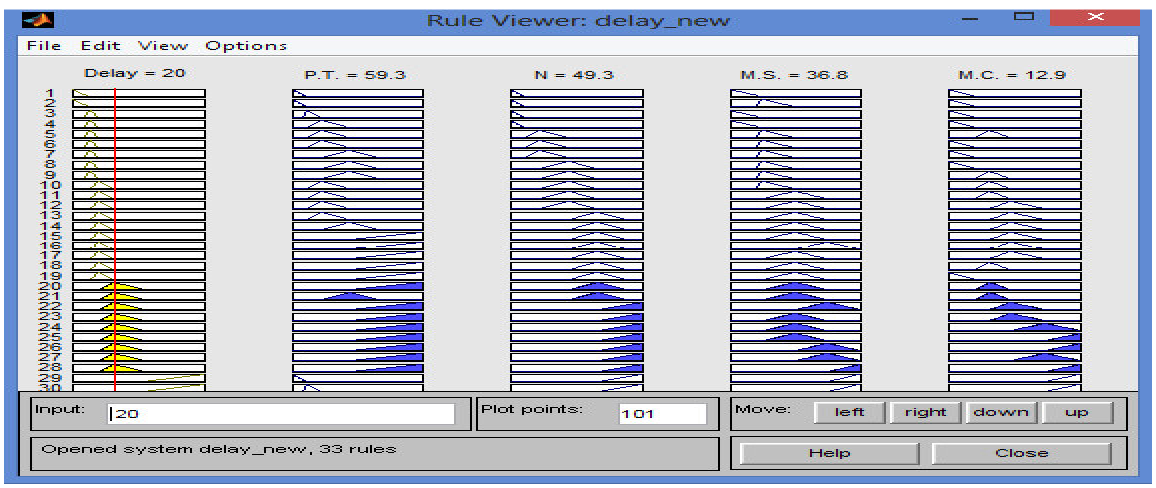


Fig 1.8 Fuzzy rule viewer for Delay =20

6.0Result Comparison:

To check efficiency of Fuzzy Inference system following steps are performed. Fig 1.9 and fig 1.10 shows block diagram of result module. Here two modules are used i.e. Network simulator ns2.34 and fuzzy inference system implemented in Matlab.

1. Random value for delay in the specified range mentioned in table 1.5 is given as input to fuzzy inference system. It is shown in table 1.7 column 2
2. Fuzzy inference system in response to delay offer at the input delivers theoutput valuesas shown in fig 1.9such as Pause Time (P.T.), Nodes (N), and Max. Speed(M.S.), and Max. Connections (M.C.). These values are stored in Table .1.7.

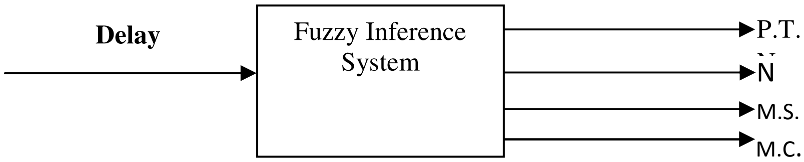
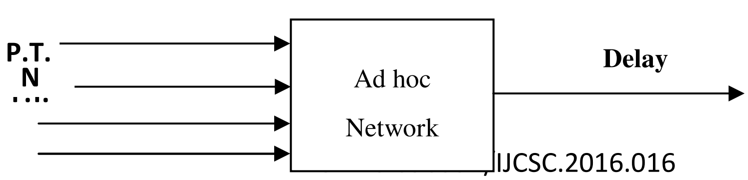


Fig 1.9 block diagram of result module(FIS)

Table1.7 Fuzzy System Output

Sr. No	Delay inputted to FIS	Pause Time	Nodes	Max.Speed	Max. Conn.
1	8.51	3.51	17	18.7	3
2	9.52	3.82	17	19	3
3	14.8	51.7	39	32.2	8
4	10.52	28.8	29.7	19.3	5
5	14.91	51.8	40	32.4	8
6	21.99	59	49	36.7	13
7	15.2	51.8	40	32.7	8
8	13.07	44	33	27	7
9	10.97	30.2	30	18.8	5
10	11.76	30.8	29	18.3	5
11	10.82	29.9	29	19	5
12	11.85	30.8	29	18.3	5
13	12.35	35.4	31	22	6
14	10.29	26	28	19.2	5
15	13.06	43.8	33	26.9	7
16	13.33	47	34	28.3	7
17	14.32	51.1	38	31.1	8
18	15.08	51.8	40	32.7	8
19	16.2	51.6	41	32.9	9
20	15.67	51.7	41	32.8	8
21	15.75	51.7	41	32.8	9
22	17.97	53.3	45	35.1	11
23	19.43	58	48	36.5	13
24	22.72	48.4	39	35	11
25	21.95	48	38	33.5	11
26	28.95	55.8	47.9	35.5	13
27	23.91	58.2	49	36.5	13
28	35.93	9.08	49.3	41.8	15
29	51.12	8.08	49	41.8	16

3. Output from fuzzy inference system is used to set scenario parameters for ad hoc network. Then simulation is run using network simulator NS2.34 as shown in fig 1.10 and at the end of simulation delay is calculated using AWK script. These results are presented in Table 1.7 column 7.
4. These two delay values i.e. delay inputted to fuzzy inference system and delay calculated using fuzzy values are compared. Its graphical representation is shown in Fig. 1.11. It is observed that if network parameters values provides by fuzzy Inference system are used to set scenario for ad hoc network. This helps to maintain delay of network at desired level. This is verified using network simulator ns2.34.



M.S

M.C.

Fig1.10Block diagram of Result Module (NS2.34)

Table 1.8 Experimental Data using fuzzy values

Sr. No	Pause Time	Nodes	Max.Speed	Max. Conn.	Delay calculated (using fuzzy data)
1	3.51	17	18.7	3	8.76
2	3.82	17	19	3	9.66
3	51.7	39	32.2	8	12.21
4	28.8	29.7	19.3	5	9.27
5	51.8	40	32.4	8	13.52
6	59	49	36.7	13	16.02
7	51.8	40	32.7	8	13.52
8	44	33	27	7	10
9	30.2	30	18.8	5	10.28
10	30.8	29	18.3	5	10.39
11	29.9	29	19	5	10.26
12	30.8	29	18.3	5	10.28
13	35.4	31	22	6	11.51
14	26	28	19.2	5	9.81
15	43.8	33	26.9	7	11.12
16	47	34	28.3	7	11.19
17	51.1	38	31.1	8	13.37
18	51.8	40	32.7	8	18.26
19	51.6	41	32.9	9	11.42
20	51.7	41	32.8	8	14.76
21	51.7	41	32.8	9	14.76
22	53.3	45	35.1	11	11.60
23	58	48	36.5	13	11.93
24	48.4	39	35	11	13.72
25	48	38	33.5	11	13.62
26	55.8	47.9	35.5	13	15.52
27	58.2	49	36.5	13	14.08
28	9.08	49.3	41.8	15	22.00
29	8.08	49	41.8	16	24.92

Table 1.9 Result Comparison table

Sr.no.	Delay calculated using only NS2	Delay calculated using fuzzy Data
1	8.51	8.76
2	9.52	9.66
3	14.8	12.21
4	10.52	9.27
5	14.91	13.52
6	21.99	16.02
7	15.2	13.52
8	13.07	10
9	10.97	10.28
10	11.76	10.39

11	10.82	10.26
12	11.85	10.28
13	12.35	11.51
14	10.29	9.81
15	13.06	11.12
16	13.33	11.19
17	14.32	13.37
18	15.08	18.26
19	16.2	11.42
20	15.67	14.76
21	15.75	14.76
22	17.97	11.60
23	19.43	11.93
24	22.72	13.72
25	21.95	13.62
26	28.95	15.52
27	23.91	14.08
28	35.93	22.00
29	51.12	24.92

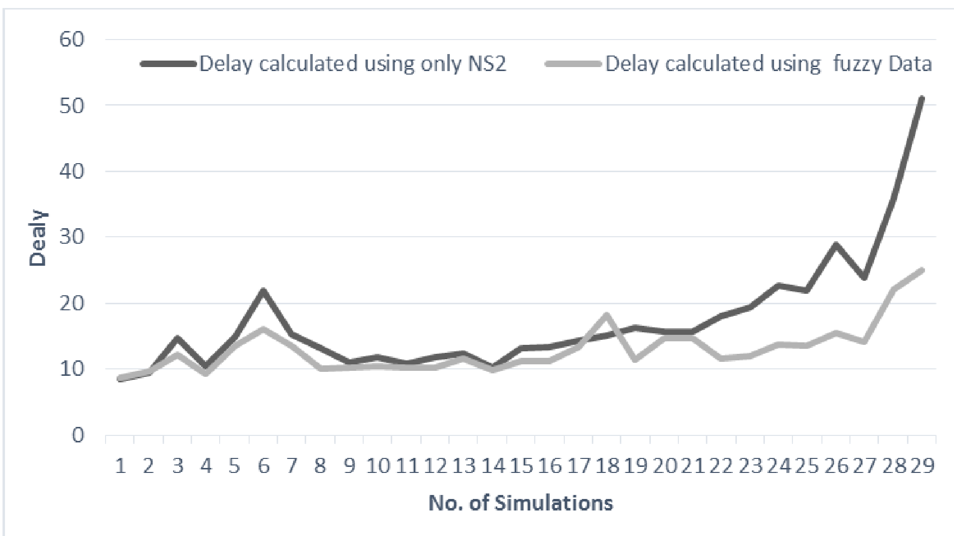


Fig 1.10Graphical Representation of Result Comparison

7.0 Conclusion:

Efficiency of protocol is decided by evaluating protocol performance parameter. Delay is one of the important performance parameter to decide efficiency of protocol. Delay of ad hoc network depends on mobility, density, speed of the node and number of connected node in the network. Due to flexible nature of ad hoc network it is a complex task to maintain delay at lower side. Hence Fuzzy inference system is designed which help to maintain delay of ad hoc network at lower side. The system is implemented in Matlab. It is found that implemented system is helpful to maintain delay in ad hoc network at low level by deciding network parameter values using FIS.

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