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Research Article

Fuzzy Based ICMP-RPL for IOT in enhancing the Performance and Network Life

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Abstract

The advent of Internet of Things in the real world environment paves for heterogeneous connectivity among Things/Objects for real world interaction via internet. Internet a best effort model using IPv4 needs to be replaced with IPv6 a QoS Model for exponential increase in Real world connections for existence of IOT. As IETF has suggested a Routing protocol RPL for IOT in sustaining the needs of constrained devices. In contrast of transforming IPv4 to IPv6 a best effort to QoS, ICMP is identified for achieving reliability in QoS. Here we are implementing Fuzzy Logic based approach for fine tuning of de-facto parameter value of ICMP for enhancement of performance and network life time of RPL. RPL implementation with Fuzzy logic reduces the power consumption by 3.65% and delay by 3.57%.

Keywords: RPL, ICMP, QoS, Fuzzy

1. Introduction

In the current real world there is an exponential increase in devices in various fields like agriculture, medical, educational, and military etc.., needs to be connected through internet for physical interaction with real world environment has coined a term “Internet of Things”. IOT is a connection among the heterogeneous devices which needs to addressed uniquely and there omnipresence makes interaction with real world easier. IOT is embedded with constrained devices for sensing data from real world, transferring the data by communicating among heterogeneous devices and interacting real world environment by actuating devices.

IETF by considering all the constraints proposed RPL protocol for routing for energy lossy networks empowered with limited energy resources. RPL implemented in LLN for enhancement of network life time and performance of QoS metrics. RPL uses OF0 (Zero objective Function) and MRHOF (Minimum Rank Hysteresis Objective Function) for obtaining optimal path using control messages by implementing ICMP Protocol. In Real World, RPL needs to adapt Dynamic condition for Ubiquitous computing in IOT. The de-facto addressed by IETF best suits for Stand-alone environment. A fine tuning of de-facto values by soft computing approach using Fuzzy Logic makes adaptable for Dynamic Enviroment.

2. Literature Review

A.S et al [1] mentioned that PDR, delay, Network Convergence time, Throughput, Etx, latency, Energy Consumption and traffic overhead are the parameter used for measuring the QoS of RPL

M.Qaseen et al [2] analyzed the performance of RPL in regards the power consumption. It is notified with OF0 was 1.20% and 1.23% for Grid and Random topologies, MHROF was 1.15% and 1.16% for Grid and Random topology was decreased.

Wail Mardini et al [3] analyze the power consumption of RPL for varying the network densities, varying the transmission range. In this scenario power ICMP intervals among 2,5,10,15,30,60 Seconds respectively.

S.Pallam et al [4] analyzed the various QoS metrics of RPL by varying ICMP time interval from 40 to 60 to analyze the QoS Metrics.

Raman et al [5] mentioned that Fuzzy-Logic approach applied for TORA to enhance the QoS Metrics in the MANETS.

Rao et al [6] applied the Fuzzy Logic for the STAR Protocol for obtaining dynamic values for Real-World Communication to improve the delay, Jitter and Throughput.

L.Lassouaoui et al [7] indicated that they are attempting to compare the energy required by RPL in two scenarios one with no packet loss and another with 40% Packet loss.

Kangueu et al [8] applied two stage Fuzzification process to enhance the quality of RPL. In first stage delay and Etx is applied FIS and output first stage along with energy is given to second stage FIS to enhance the Quality.

Kangueu et al [9] formulated MCOP with NP-Complete for optimization of QoS Metrics. A Fuzzy approach was implemented on MCOP to enhance QoS Performance for Dynamic Environment.

Olfa et al [10] specifies objective function is highly reliable for an optimal Path. Here the proposed an OF-FL a fuzzy based approach used to combine the metrics for optimal path formation.

3. RPL Protocol

RPL a reactive protocol for dynamic network topology using asymmetric approach. RPL using DAG (Direct Acyclic Graph) a spanning tree based approach in routing the data form the source to destination without forming cycles in graph. Data routing from source to root (for destination) leads in the formation of DODAG (Destination Oriented DAG). Rank Specifying the distance from Root node to the Leaf-node plays a key role in objective function. Objective Function used for determining the optimal Path.

OF0 uses the minimum Hop-Count and MHROF uses the ETX in determining an optimal path between the source and destination (root node). ICMP control messages plays a vital role in DODAG Formation

3.1 DO-DAG Information Object is broadcasted down the network by a root node specifying its ID, Version, type (Storing or Non-Storing), Floating/Grounded, Objective Function in estimating the optimal path. The data is broadcasted for expanding its spanning tree in connection with leaf nodes.

3.2 DO-DAG Information Solicitation data is broadcasted up from source node in search for an existing DO-DAG near it for supporting its expansion

3.3 DO-DAG Advertisement Object is a request from existing sub-DODAG for changing the parent node in regarding the optimal path to root node.

3.4 DO-DAG ACK acknowledgement from root/Parent node to its child/leaf node.

4. Fuzzy Based RPL

RPL uses the de-facto parameter values [11] for calculating the dynamic ICMP values. Fuzzy Based RPL using the no of nodes and Tx Ratio for calculating the dynamic ICMP values. As per IETF draft ICMP de-facto ICMP time value is 60 used for calculating the dynamic ICMP values using the Fuzzy Rules. The implementation of fuzzy is shown in the Fig 1

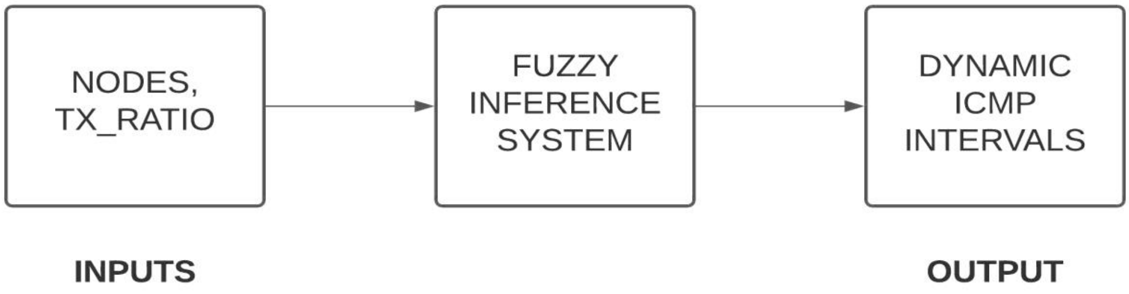

Fig 1 FIS for calculating Dynamic ICMP Interval

4.1 Algorithm for Calculating Dynamic ICMP values using RPL

// input 1: NODES
// input 2: TX_RATIO
// output : ICMP_INTERVAL

1. *Start*
2. *Choose FIS← Sugeno*
3. *Choose input1 ← NODES*
4. *Varying the Range of nodes ← [10 40]*
5. *Choose the number of membership function for nodes← 3*
6. *Choose the membership function nodes← Triangular*
7. *Choose the input2← TX_RATIO*
8. *Vary the Range of TX_RATIO ← [30 70]*
9. *Choose the number of membership function for TX_RATIO← 3*
10. *Choose the membership function TX_RATIO← Triangular*
11. *Choose the output← ICMP_INTERVAL*
12. *Choose number of membership function for ICMP_INTERVAL← 3*
13. *Choose the Output type← Constant*
14. *Specify the If-then rules*
15. *Choose the method for Defuzzification← wtever*
16. *Select Rule Viewer for assessment*
17. *Note ICMP_INTERVAL value for given inputs.*
18. *Select 3D-Surface Viewer*
19. *Stop*

The architectural model of Sugeno Consist of two inputs Nodes and Tx_ratio for calculating the Dynamic ICMP time interval is shown in the Fig 2

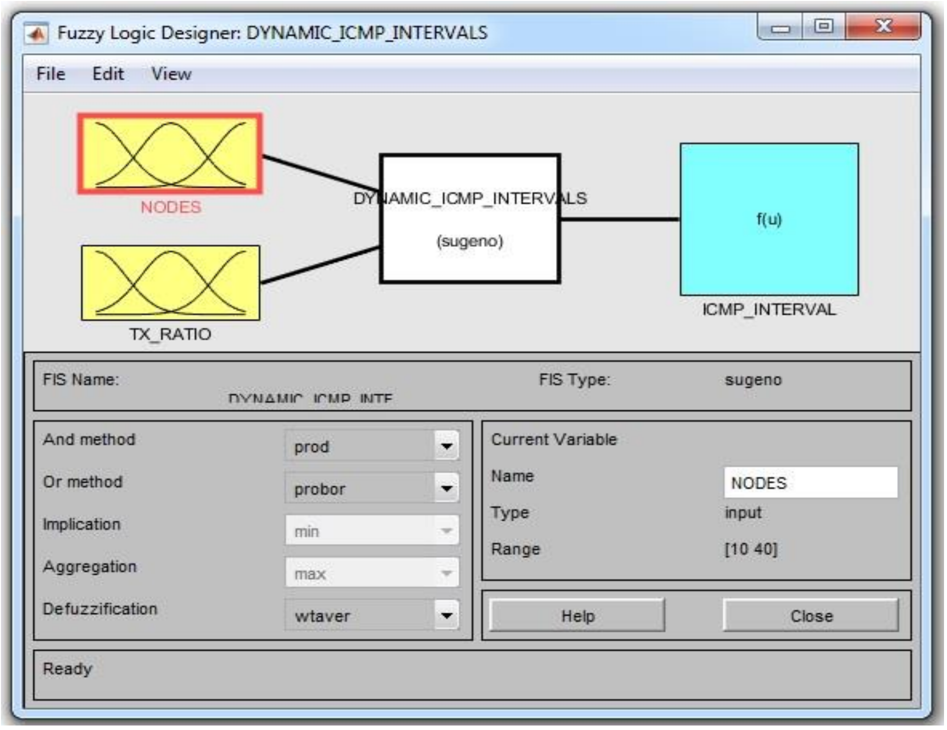

Fig 2 Sugeno Architecture for calculating Dynamic ICMP Interval

The input variable Nodes with range 10 to 40 consists of three membership functions, Low from 10 to 23, Mid from 17 to 32 and High from 27 to 40 is shown in Fig 3

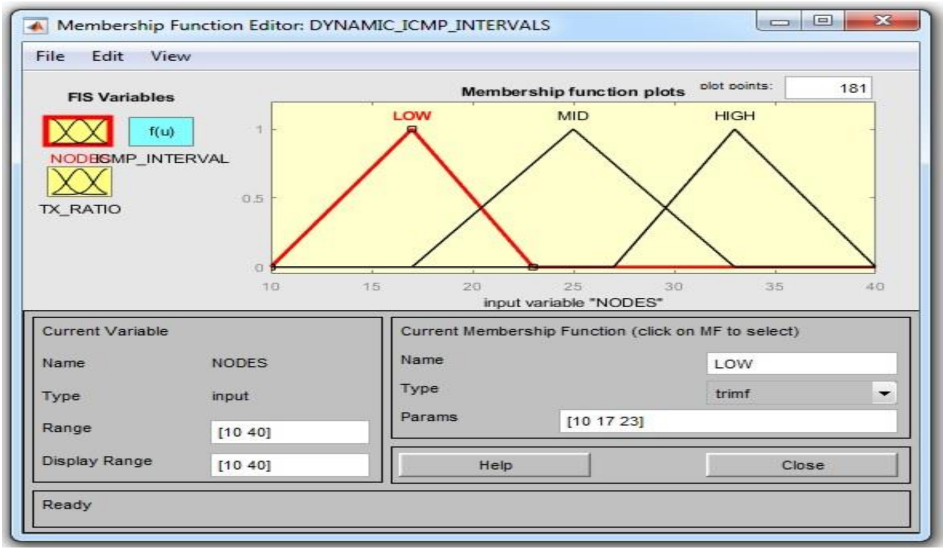

Fig 3 Membership Function for NODES

The input variable Tx_Ratio with range from 30 to 70 consists of Low from 30 to 50, Mid from 45 to 60 and High from 55 to 70 is shown in the Fig 4

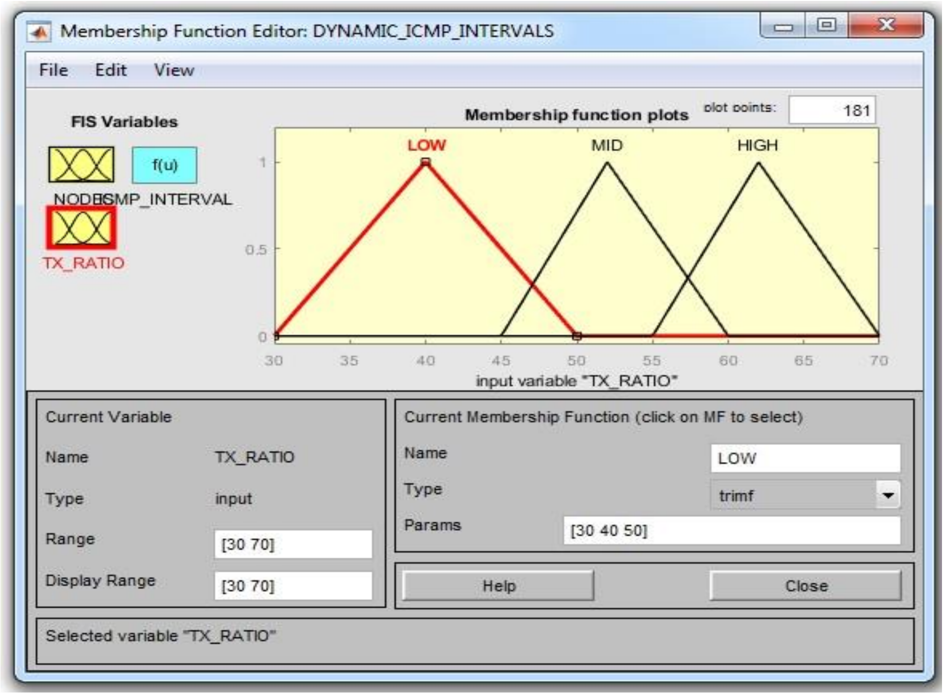

Fig 4 Membership Function for TX_RATIO

The Fuzzy rules for generating the Dynamic ICMP time intervals is shown in Fig 5. Fuzzy rules for two variables with three membership function each for generating the total nine fuzzy rules.

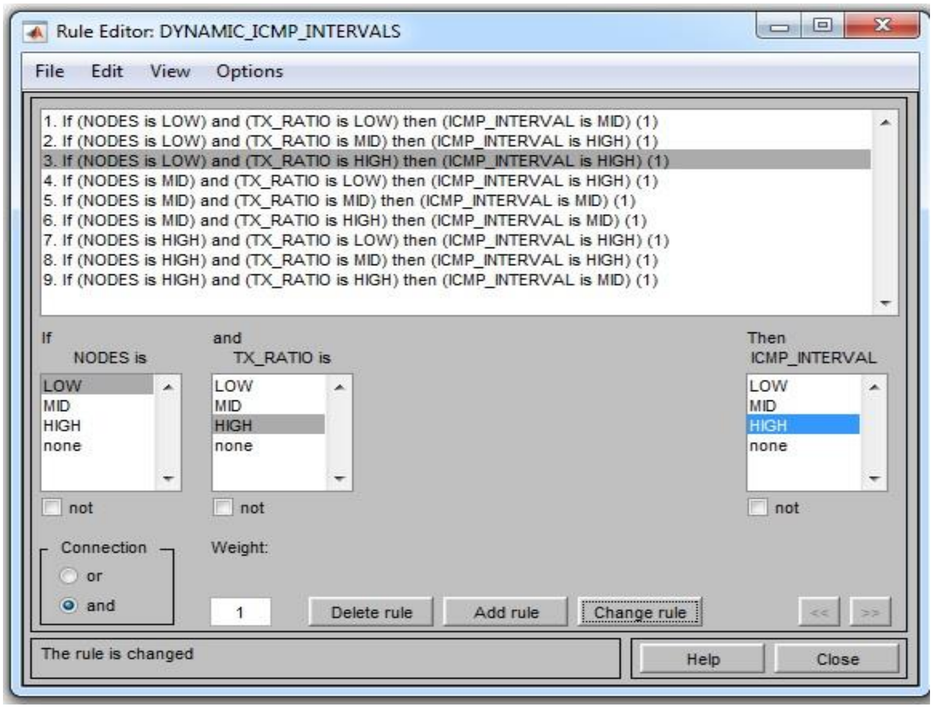

Fig 5 Fuzzy Rules for Dynamic ICMP Intervals

The rule viewer for generating the Dynamic ICMP intervals by varying the both the inputs number of nodes and Transmission Ratio is shown in the Fig 6

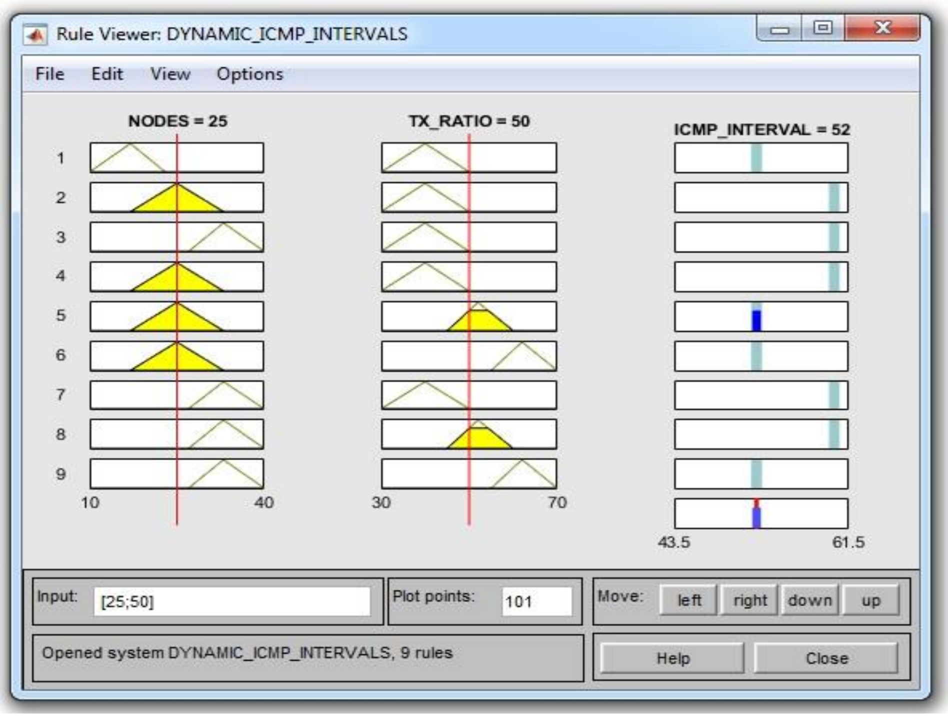

Fig 6 Rule Viewer for Dynamic ICMP Intervals

The Surface Viewer for the Dynamic ICMP intervals is shown in Fig 7. The surface provides an 3D view among the Nodes, Tx_Ratio and Dynamic ICMP intervals

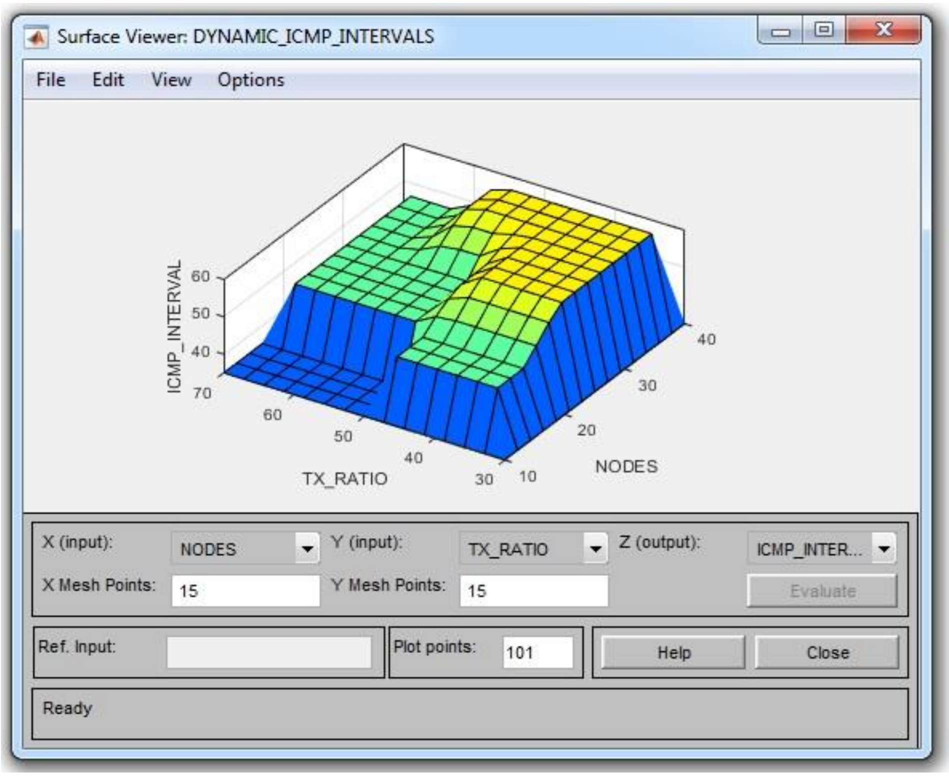

Fig 7 Surface Viewer for Dynamic ICMP Interval

5. Experimental Setup

Cooja a java based graphical simulator using the contiki Operating System suits aptly for IOT environment. Cooja compiled using JNI and using native C-Programming code for implementation of protocol at various levels of IOT stack. Cooja supports various motes for real word like SkyMote, TMote and Zoletria. The simulation parameters are shown in Table 1

Specifications	Value
Model of Propagation	UGDM
Mote Type	Sky Mote
Tx Ratio	30% to 70%
Number of Nodes	10 to 40
Simulation Area	100X100
Time of Simulation	300 Sec
Objective Function	OF0
Topologies	Random, Linear
ICMP time interval	40 to 60 Sec
Speed	Limitless
Seed	Random

Table 1 Simulation Parameters

6. Analysis of Results

6.1 Power: The power consumed by the sink (root) node over all the nodes in a network by implementing Random and Linear Topology. The power consumed in shown in Fig 8

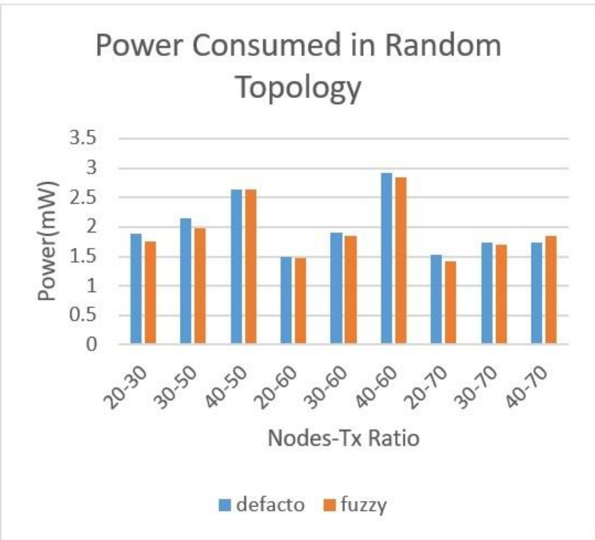

Fig 8(a) Power consumed in Random

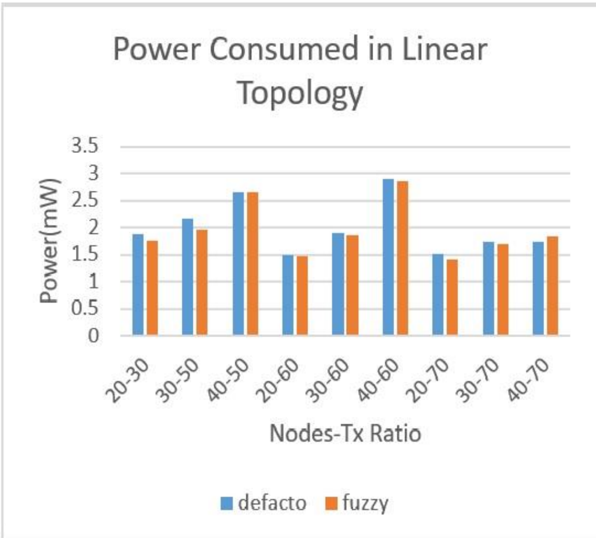

Fig 8(b) Power consumed in Linear

The Power Consumed by is decreased by 4.31% and 2.90% in Random and Linear topology. The overall power consumed is decreased by 3.605% irrespective of topology

6.2 Delay is sum of all delay's like transmission delay, processing delay and computational delay other than the Qdelay. The delay is shown in Fig 9

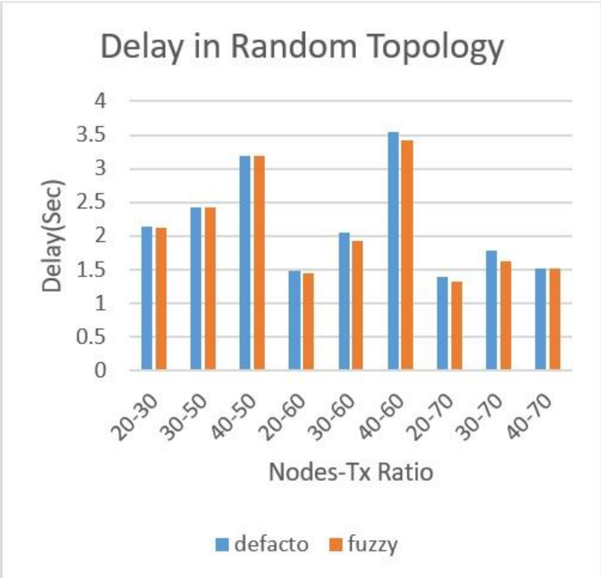

Fig 9(a) Delay in Random

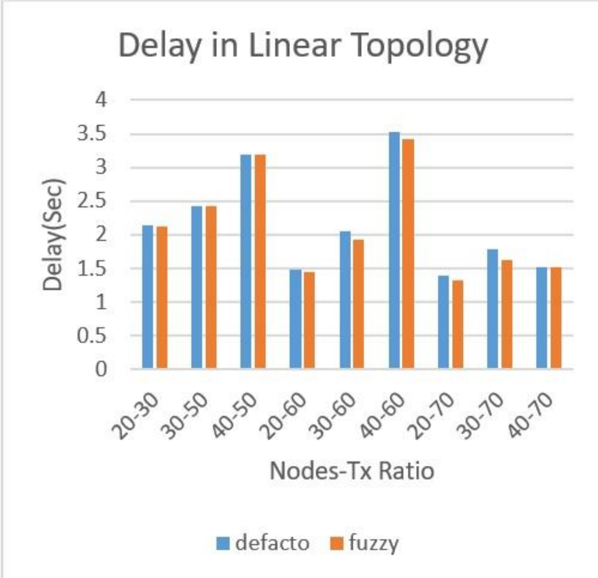

Fig 9(b) Delay in Linear

The delay is decreased by 4.09% and 3.059% for Random and Linear topology and the overall delay is decreased by 3.57% on average irrespective of topology

7. Conclusion and Future Scope

In this paper a fine tuning of de-facto ICMP values of RPL using a soft-computing based fuzzy approach for dynamically changing environment in Real time. Here we considered network density (number of nodes in a network) and Tx Ratio as inputs to FIS for dynamic calculation of ICMP time interval. RPL implementation with fuzzy approach improves the performance of QoS metrics by reducing the power consumption by 3.65% and delay by 3.57% in Random and Linear Topologies.

A further fine tuning of ICMP time interval values by Adaptive Neural Network using ANFIS may assist for enhancement of QoS Metrics.

8. References

[1] Charles, A.S.J. and Kalavathi, P. (2018). QoS Measurement of RPL using Cooja Simulator and Wireshark Network Analyser. *www.ijcseonline.org*, [online] 06(04), pp.283–291.

[2] M. Qasem, H. Altawssi, M. B. Yassien and A. Al-Dubai, "Performance Evaluation of RPL Objective Functions," 2015 IEEE International Conference on Computer and Information Technology; Ubiquitous Computing and Communications; Dependable, Autonomic and Secure Computing; Pervasive Intelligence and Computing, 2015, pp. 1606-1613, doi: 10.1109/CIT/IUCC/DASC/PICOM.2015.242.

[3] W. Mardini, S. Aljawarneh, A. Al-Abdi and H. Taamneh, "Performance evaluation of RPL objective functions for different sending intervals," 2018 6th International Symposium on Digital Forensic and Security (ISDFS), 2018, pp. 1-6, doi: 10.1109/ISDFS.2018.8355323.

[4] S.Pallam Shetty, P.Srikanth, "Investigate the impact of ICMP on the performance of RPL routing protocol for IOT" International Journal of Scientific Research in Engineering and Management (IJSREM) Volume: 05 Issue: 08 | Aug – 2021

[5] Raman, C. and Setty, S. (2017). FUZZY LOGIC BASED TORA TO ENHANCE THE QOS IN MANETS. [online] (4), pp.2394-0697. Available at: http://troindia.in/journal/ijcesr/vol4iss7part4/72-77.pdf [Accessed 22 Aug. 2021].

[6] Rao, C & Setty, s.Pallam. (2019). Improved Real Time Communication Using Star Routing Protocol In Manets Influenced By Fuzzy Logic. International Journal of Control and Automation. 12. 1-12. 10.33832/ijca.2019.12.10.01.

[7] L. Lassouaoui, S. Rovedakis, F. Sailhan and A. Wei, "Evaluation of energy aware routing metrics for RPL," 2016 IEEE 12th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), 2016, pp. 1-8, doi: 10.1109/WiMOB.2016.7763212.

[8] Kamgueu, P., Nataf, E., Djotio, T. and Festor, O. (n.d.). *Fuzzy-based Routing Metrics Combination for RPL*. [online] . Available at: https://www.scitepress.org/Papers/2014/48776/48776.pdf [Accessed 22 Aug. 2021].

[9] Kamgueu, P.-O., Nataf, E. and Ndie Djotio, T. (2015). *On design and deployment of fuzzy-based metric for routing in low-power and lossy networks*. [online] IEEE Xplore. Available at: https://ieeexplore.ieee.org/document/7365929 [Accessed 22 Aug. 2021].

[10] Gaddour, O., Koubâa, A., Baccour, N. and Abid, M. (2014). *OF-FL: QoS-aware fuzzy logic objective function for the RPL routing protocol*. [online] IEEE Xplore. Available at: https://ieeexplore.ieee.org/document/6850321 [Accessed 22 Aug. 2021].

[11] datatracker.ietf.org. (n.d.). *rfc6550*. [online] Available at: https://datatracker.ietf.org/doc/html/rfc6550 [Accessed 22 Aug. 2021].