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Research Article

ANFIS Based Back of Transmission for WSN in enhancing the performance and Network Lifetime

M Janardhan[1], Prof S Pallam Shetty[2], Prof PVGD Prasad Reddy[3]

[1,2,3] CSE Department, AUCE(A),Visakhapatnam

Abstract

The Digital world is stacking up with smart objects, indefinitely embedded with sensing objects. Sensing objects are resource constrained devices with limited energy, less bandwidth and less computational capabilities which needs to connect among themselves using WPAN/WLAN. WLAN/WPAN are low data rate networks uses IEEE 802.15.4 protocol for optimum energy utilization. Buffer Size, Beacon Interval and Back of Transmission are essential factors for energy and delay minimization in a network implementing IEEE 802.15.4 protocol. This paper articulates the implementation of ANFIS based Back of transmission in IEEE 802.15.4 for energy minimization and optimization of network life expectancy. This technique makes use of existing Fuzzy Inference System. Experimental results obtained from Cooja Simulator using MATLAB specifies power and delay decreased by 11.51% and 12.87% respectively, PDR increased by 1.51%

Keyword: IEEE 802.15.4, Buffer Size, Beacon Interval, Back of Transmission

Introduction

Wireless Personal Area Networks (WPANs) and Wireless Local Area Networks (WLANs) are quickly getting more popular in the real world as a means of preserving public web connectivity. IEEE 802.15.4 plays a key role in WLAN and WPAN short-range communication along with its low bit rate, low interference, and low power consumption.

IEEE 802.15.4 is a crucial component of the cross-layer design strategy that bridges the MAC and Network layers. Until the link between the nodes is established, it is named IEEE 802.15.4. Once the link is made, it is called ZigBee up to the application layer. To maintain low bit rate and low energy consumption, the Cross Layer Design method utilizes Logical Link Control (LLC) and Service Specific Convergence Sub-Layer (SSCS).

For non-interfering data, IEEE 802.15.4 uses the DSSS (Direct Sequence Spread Spectrum) modulation. Implementing the two elements will cut power usage while also extending the network's life. There are two ways to allocate channels in MAC: a. beaconing mode and b. non-beaconing mode.

Use the Non-Beaconing Mode with the Un-slotted ALOHA in IEEE 802.15.4. Implementation of Un-slotted ALOHA with respect to a non-specific time interval may result in data collision, causing the data Grable to be retransmitted. At the MAC Sublayer, the CSMA/CD method is utilised to prevent data retransmission.

Literature Review

Gezer, A et al [1] WPAN's efficiency is reduced since it uses the IEEE 802.15.4 protocol with a defacto back of transmission. They introduced the ACAMRO approach, which uses a Buffer size of 20KB to improve results by 120 percent.

Choudary et al [2] IEEE 802.15.4e is a modification for Industrial Applications, as previously stated. Markova's model for IEEE 802.15.4e, which used DSME and TSCH mode, compared performance to IEEE 802.15.4.

Chew et al [3] For wireless IoT, IEEE 802.15.4 and Zigbee thread specific protocols are being used. They claimed that IEEE 802.15.4 uses the physical and MAC Sub-layers, while Zigbee (at the upper layers) uses IEEE 802.15.4 at the bottom.

Sonali et al [4] The protocols Zigbee, Z-wave, Thread, and HART have been used in IEEE 802.15.4, and it's a basic for WPANs at the physical and MAC Sub-layers.

Manikanta, P et al [5] mentioned that using the Taguchi approach to find out the most appropriate factor that suits for Mobile Adhoc network in DYMO routing protocol.

Durga et al [6] The power consumption of IEEE 802.15.4 was studied using an algorithmic approach for sensitive and insensitive approaches, and the DMSE model was shown to be superior than the TSCH model in IEEE 802.15.4e.

Muhammad et al [7] They are determining the channel capacity for CSMA/CA in the MAC layer for ACK and without ACK, as mentioned. The capacity of a channel is regulated by the network's delay and packet loss.

Sajid et al [8] No mechanism for channel sharing between data packets and control data packets is mentioned, which leads to network congestion. By incorporating a cost function into the a hybrid scheduling algorithm, a network's throughput and packet dropping can be increased.

3. IEEE 802.15.4 Protocol

The IEEE 802.15.4 protocol is designed for low-rate personal area networks (PANs) used for sensing (monitoring) and actuating (controlling) in extend the network's life. The IEEE 802.15.4 protocol's low data rate is a promising feature for power dissipation. In general, the IEEE 802.15.4 protocol is used at the physical layer, MAC+LLC (Logical Link Control), and SSCS (Service Specific Convergence Sublayer), and will be advanced to the upper layers.

The IEEE 802.15.4 protocol utilized DSSS (Direct Sequence Spread Spectrum) Modulation to operate as an ISM (Industrial, Scientific, and Medical) protocol. The protocol is highly tolerant of noise and channel interference when using the DSSS. Using the same channel a significant number of times might generate interference, which can result in data collision and loss. Data loss can occur in retransmission of data, increasing network congestion and raising the risk of data collision. At the MAC level, the concept of CSMA/CD is used to resolve data collision. Figure 1 demonstrates the IEEE 802.15.4 protocol.

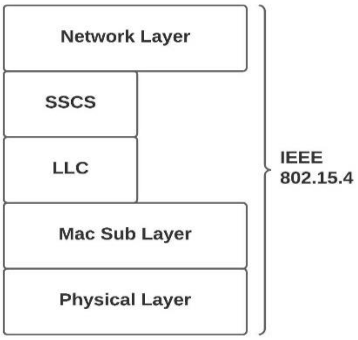


Figure 1 IEEE 802.15.4 Protocol

Related to network channelization, the IEEE 802.15.4 Protocol is divided into two categories: a) Beaconing Networks and b) Non-Beaconing Networks.

The slotted ALOHA is being used in beaconing networks, while a un-slotted ALOHA has been used in non-beaconing networks, although the IEEE 802.15.4 protocol employs non-beaconing networks. On the basis of functionality, IEEE 802.15.4 is divided into two categories.

FFD (fully function device) b) RFD (reduced function device) (RFD)

FFD can connect with any device and use any protocol, whereas RFD can only communicate with FFD because of its low power consumption. In a network beacon interval in connectivity to the back of transmission, IEEE 802.15.4 performs a crucial function.

ANFIS Based IEEE 802.15.4

IEEE 802.15.4 implementation using the de-facto parameter value of Back of transmission is not adaptable dynamic networks. Here we are using a soft computing approach in calculating the dynamic back of transmission values is shown in Fig 2

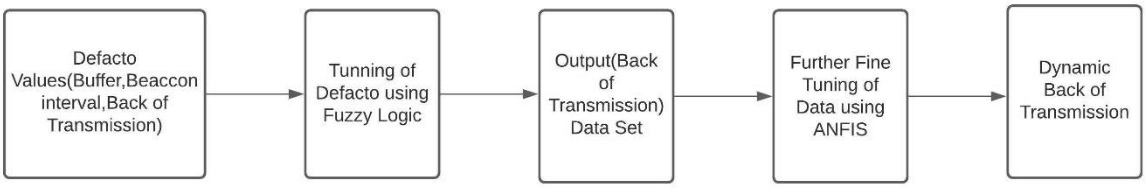


Fig 2 Block Diagram for IEEE 802.15.4 using ANFIS

The flow chart demonstrates the implementation of ANFIS modelling on the data set generated with FIS is shown in Fig 3

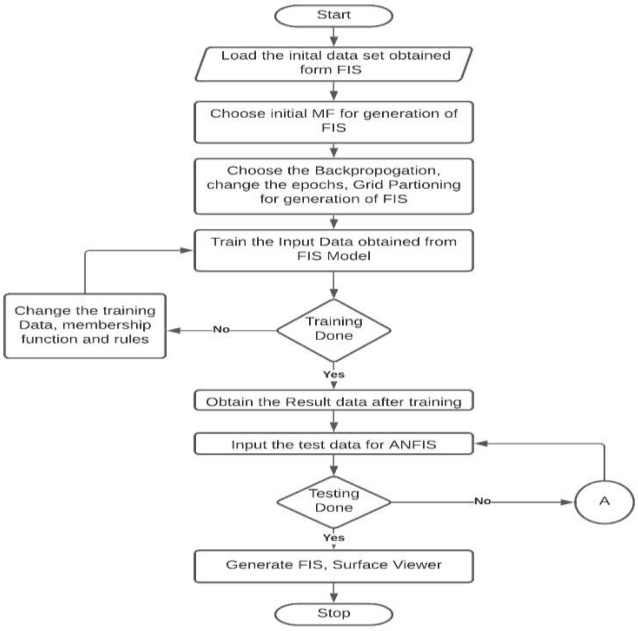
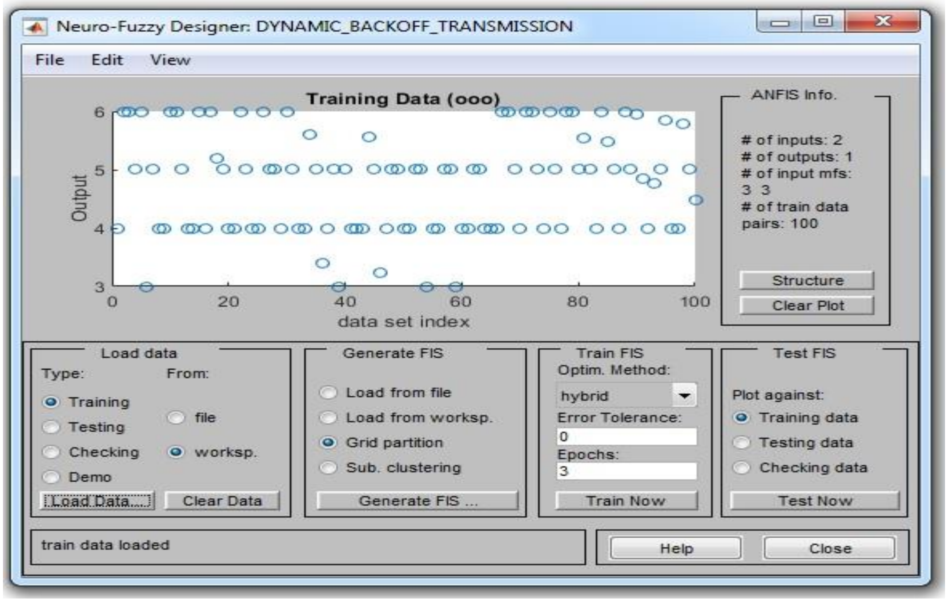


Fig 3 Flow Diagram for ANFIS

Adaptive Neuro Learning technique analogous to Neuro Fuzzy training in a certain data is provided as input to the neurons and weights were applied to the connections between the input layer and the hidden layer and the hidden layer to the output layer. The summation function is being used in the output layer, while the bias function is used in the back propagation algorithm to modify the weights.

The FIS information set is generated by loading data from a workspace that has two inputs: Buffer Size, Beacon Interval, and Back of Transmission. In Figure 4, each input is comprised of three triangle membership functions, an epoch value of 200, and an error tolerance.



# of inputs: 2
# of outputs: 1
# of input mfs:
3 3
# of train data pairs: 100

Type: ● Training ○ Testing ○ Checking ○ Demo

From: ○ file ● worksp.

○ Load from file
○ Load from worksp.
● Grid partition
○ Sub. clustering

Optim. Method: hybrid

Error Tolerance: 0

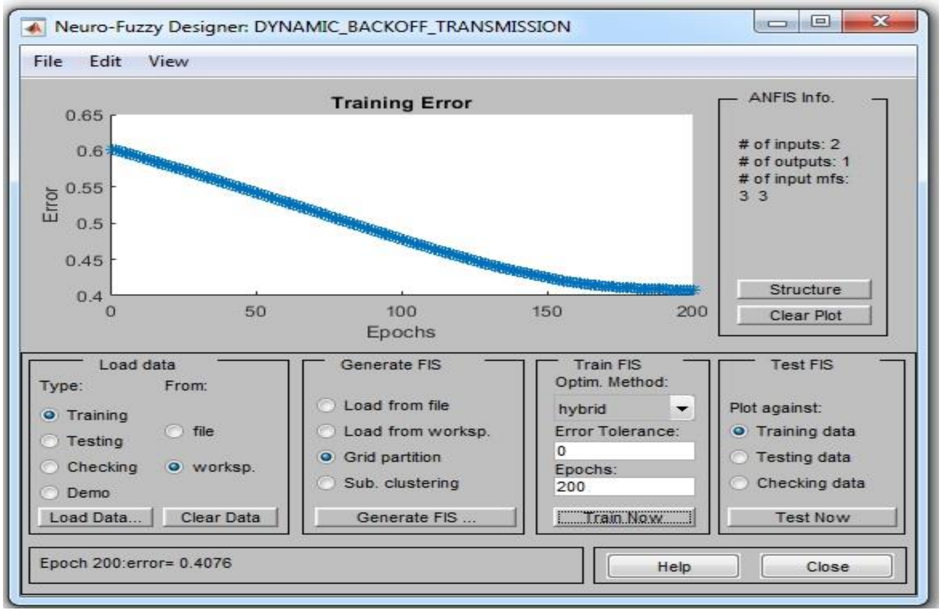
Epochs: 3

Plot against: ● Training data ○ Testing data ○ Checking data

train data loaded

Fig 4 Data Loaded from Workspace

Adaptive Neural Networks are used to train the data given as input by minimising the error, as seen in Fig 5.



# of inputs: 2
# of outputs: 1
# of input mfs:
3 3

Type: ● Training

From: ● worksp.

● Grid partition

Optim. Method: hybrid

Error Tolerance: 0

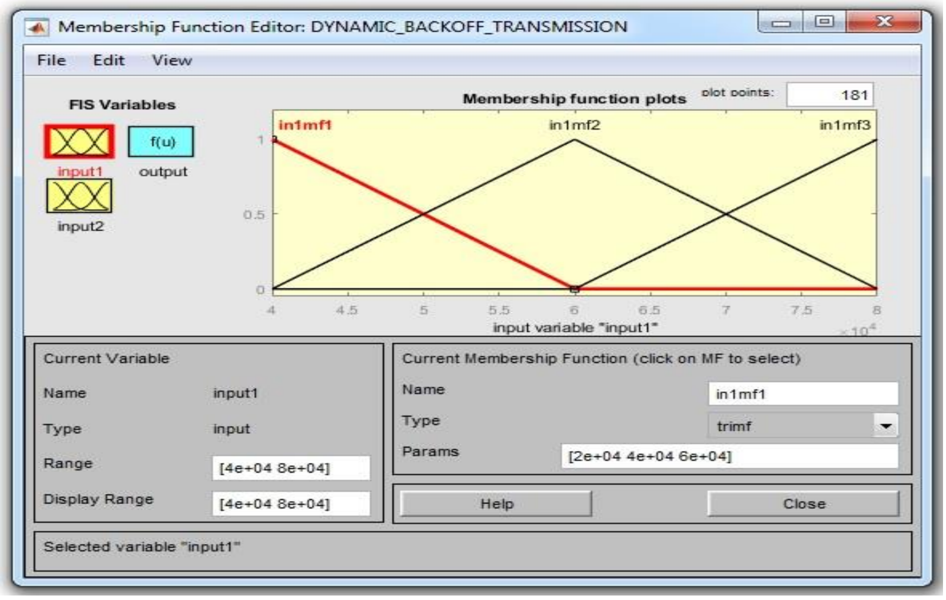
Epochs: 200

Plot against: ● Training data

Epoch 200:error= 0.4076

Fig 5 Training the Network

The Buffer Size is the first input, and it has three triangle membership functions that range from 40000 to 80000. The Beacon interval has three triangle membership functions ranging from 1 to 5. The input 2 represents the Beacon interval. Both inputs are taken into account when creating the output dynamic. Figure 6 depicts the back of transmission with nine membership functions ranging from 3 to 6.



plot points: 181

Current Variable

Name input1

Type input

Range [4e+04 8e+04]

Display Range [4e+04 8e+04]

Current Membership Function (click on MF to select)

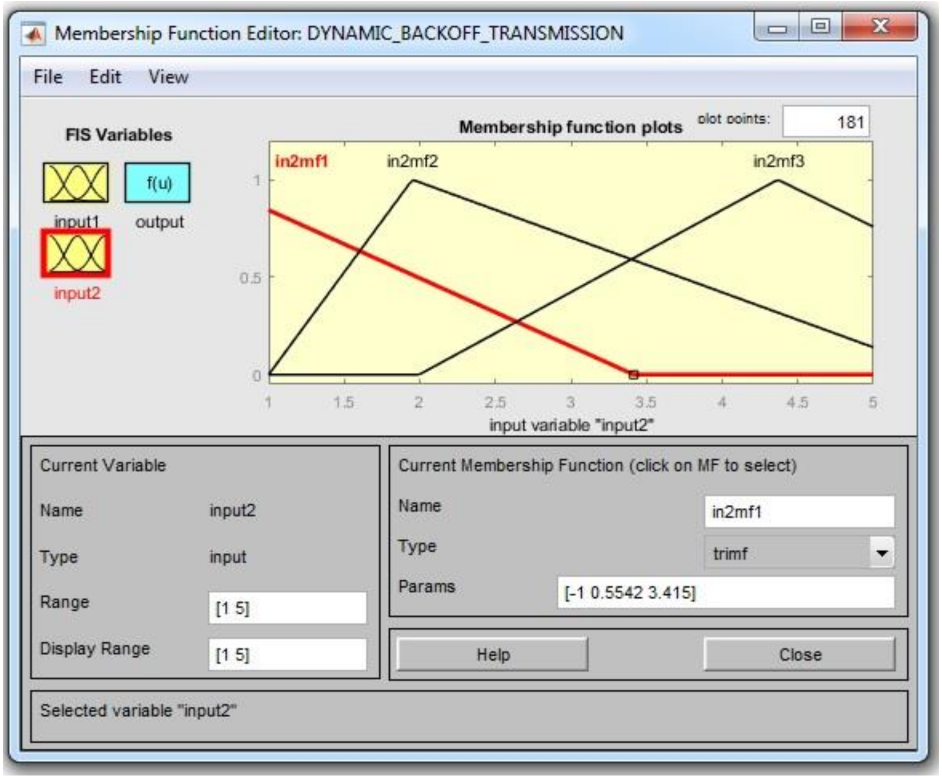
Name in1mf1

Type trimf

Params [2e+04 4e+04 6e+04]

Selected variable "input1"

Fig 6(a) Input 1 is Buffer Size with three triangular functions of membership



Membership Function Editor: DYNAMIC_BACKOFF_TRANSMISSION

plot points: 181

Current Variable

Name input2

Type input

Range [1 5]

Display Range [1 5]

Current Membership Function (click on MF to select)

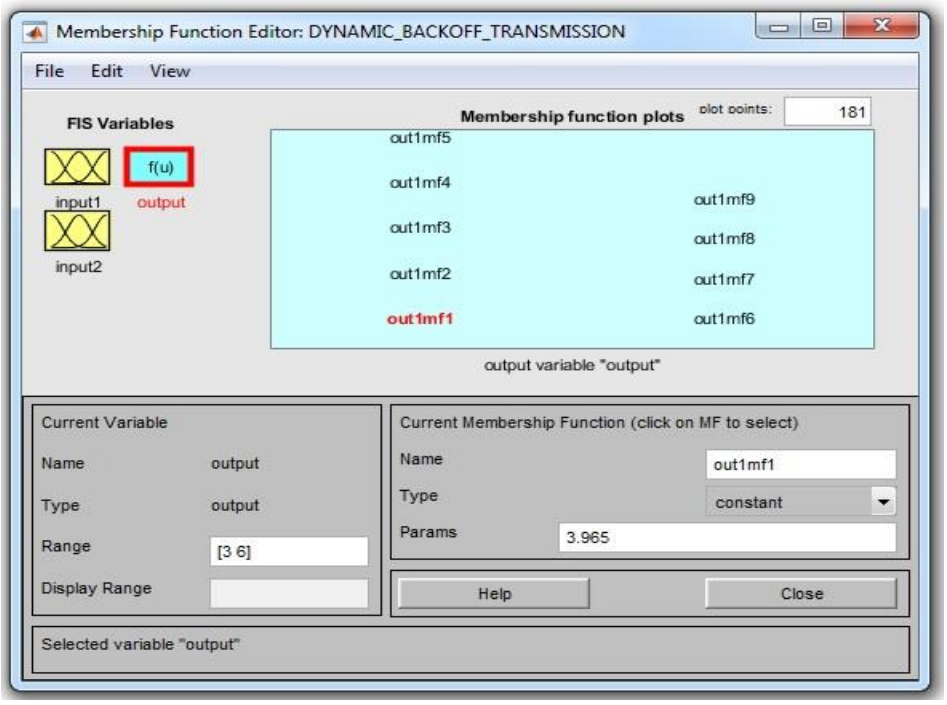
Name in2mf1

Type trimf

Params [-1 0.5542 3.415]

Selected variable "input2"

Fig 6(b) Input 2 is Beacon Interval with three triangular functions of membership



Membership Function Editor: DYNAMIC_BACKOFF_TRANSMISSION

plot points: 181

Current Variable

Name output

Type output

Range [3 6]

Display Range

Current Membership Function (click on MF to select)

Name out1mf1

Type constant

Params 3.965

Selected variable "output"

Fig 6(c) Output Back of Transmission with nine functions of membership

The ANFIS outputs will be derived using the FIS Rule viewer generated by the Adaptive Neural Network, with further fine tuning of the output data set obtained using fuzzy logic as shown in Fig 7.

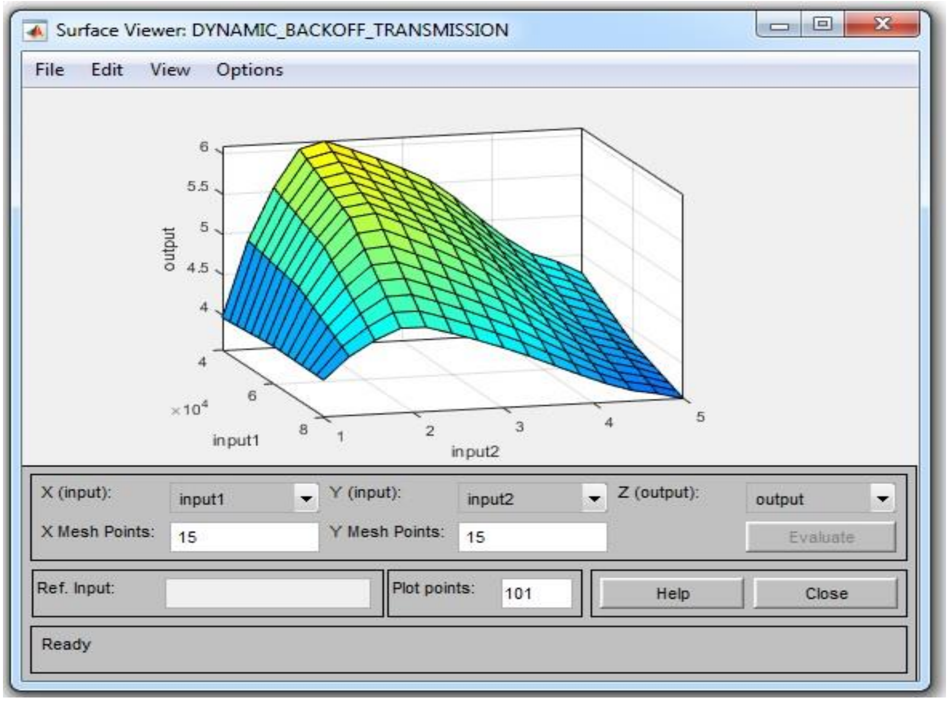
Input: [6e+04;3]

Plot points: 101

Ready

Fig 7 FIS Viewer for ANFIS

Figure 8 shows the 3D Surface viewer's input1 (Buffer Size), input2 (Beacon Interval), and output(Back of Transmission).



X (input): input1

Y (input): input2

Z (output): output

X Mesh Points: 15

Y Mesh Points: 15

Ref. Input:

Plot points: 101

Ready

Fig 8 3D Surface Viewer of ANFIS

Simulator Used

Cooja, a java-based simulator that runs on the Contiki operating system (version 2.7), is well-suited to IoT applications. Cooja is made up of three components: Skymote, Tmote, and Zoletria, all of which enable the real-time environment and are written in native C code to handle numerous protocols. Table 1 lists the simulation parameters.

Parameters	Values
Environment	UGDM
Seed	Random
Mode	Sky Mote
Topology	Ecllipse
Area	100X100
Speed Limit	No Speed
Beacon Interval	1 to 5
Buffer Size	40000 to 80000
Back of Transmission	3 to 6

Table 1 Simulation Prameters

Result Analysis

Power: The power consumed by 10,20 and 30 nodes shown in Fig 9

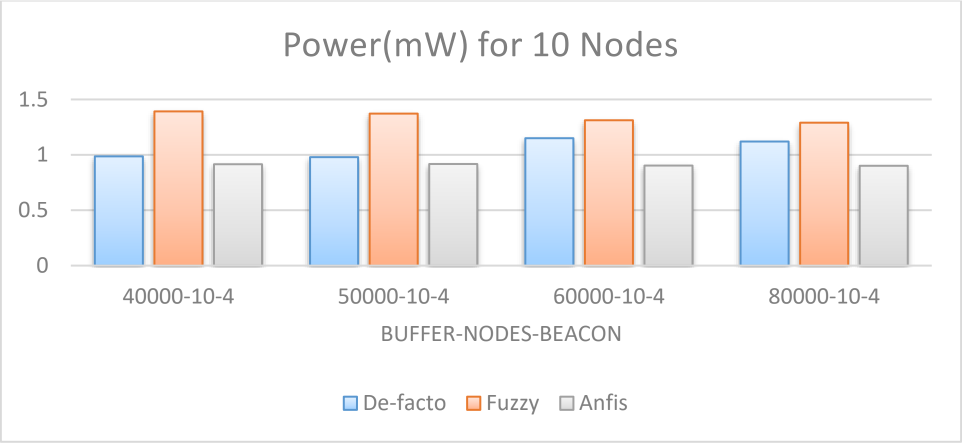


Figure 9(a) Power Consumed for 10 Nodes

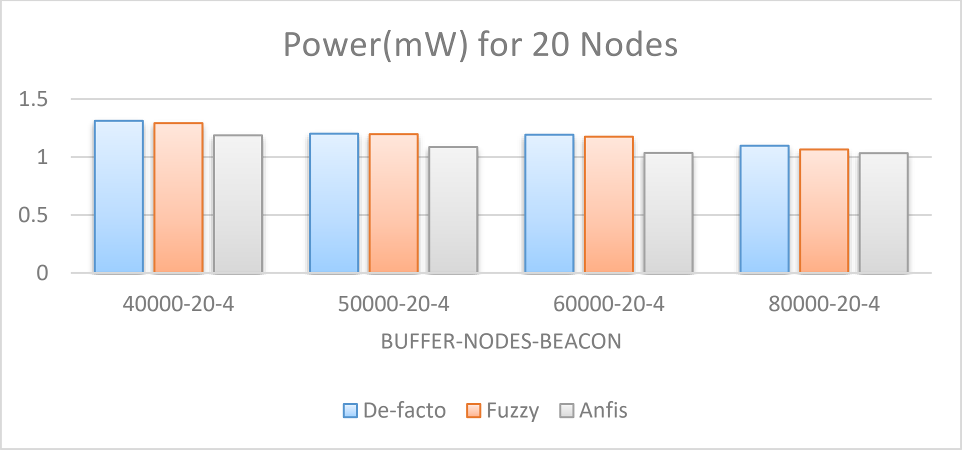


Figure 9(b) Power Consumed for 20 Nodes

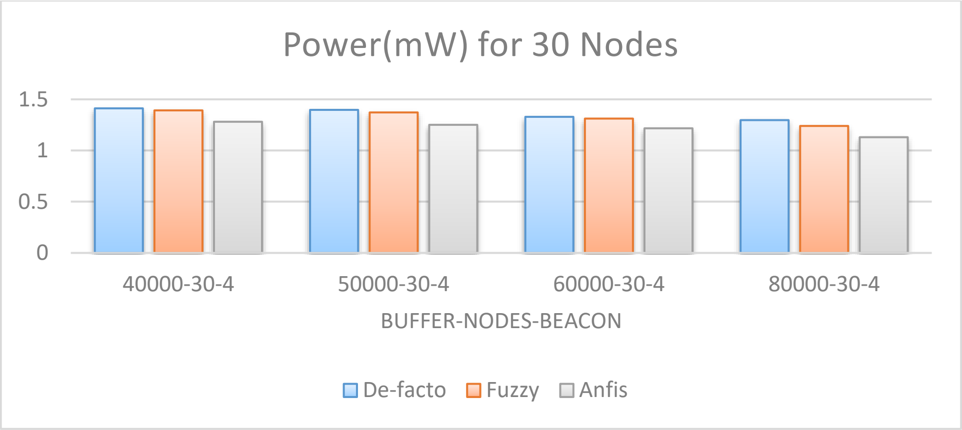


Figure 9(c) Power Consumed for 30 Nodes

In the small size network with 10 nodes the power consumed is decreased by 12.38% . In the medium size network with 20 nodes the power consumed is decreased by 8.88%. In the large size network with 30 nodes the power consumed is decreased by 13.28%. The power consumption decreased on overall is 11.51% in various network topologies.

Packet Delivery Ratio The PDR for different nodes is shown in Fig 10

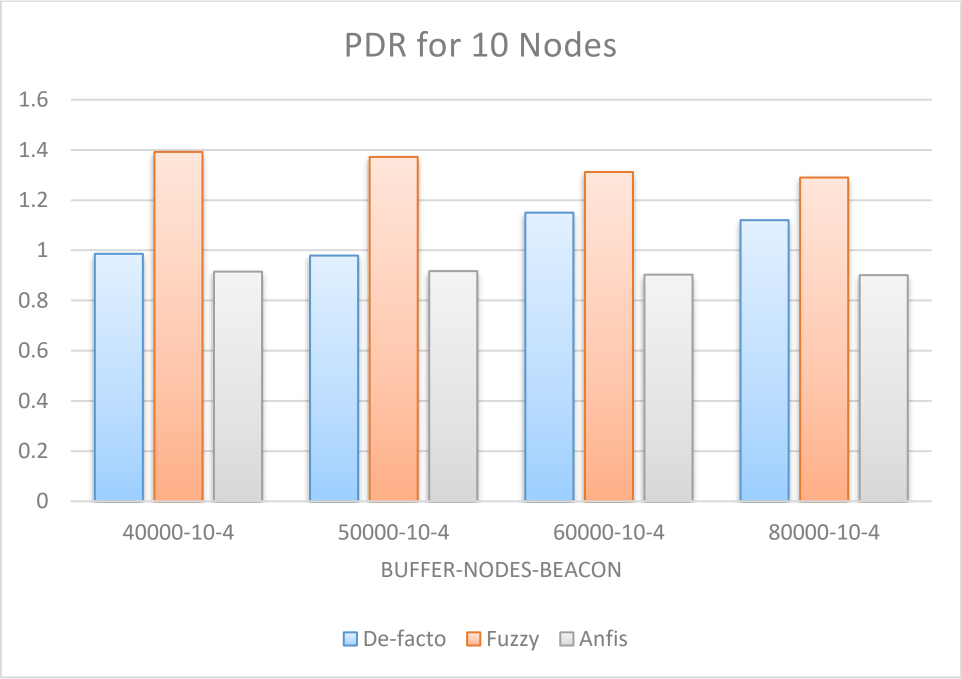


Figure 10(a) PDR for 10 Nodes

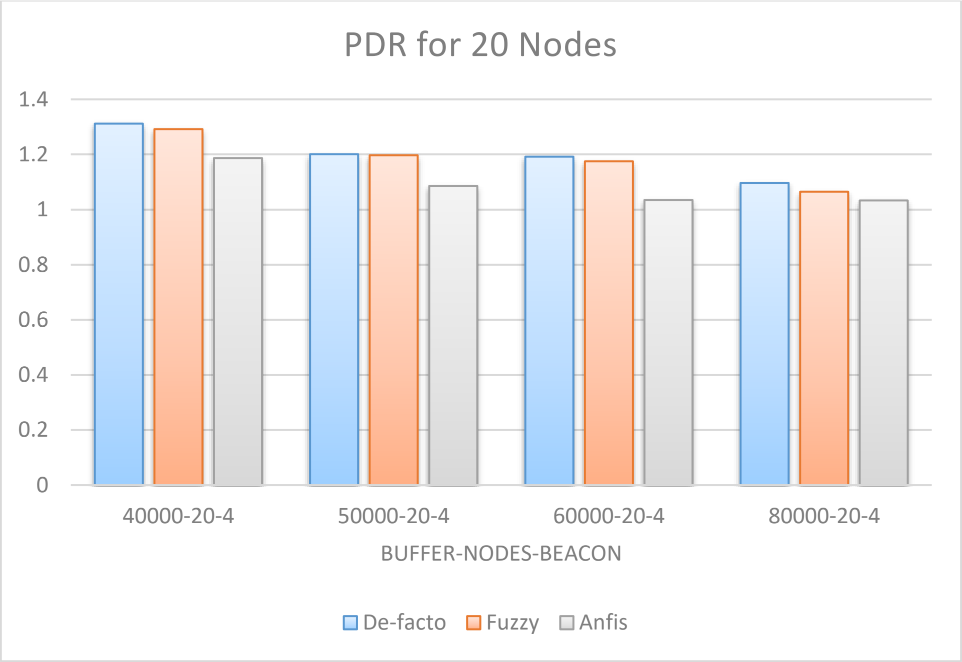


Figure 10(b) PDR for 20 Nodes

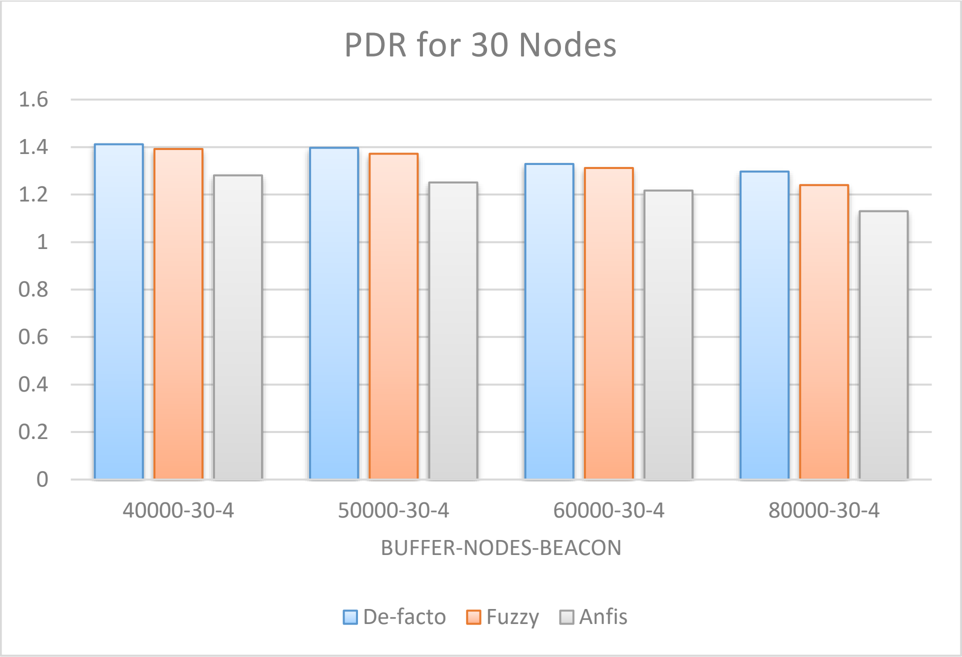


Figure 10 (c) PDR for 30 Nodes

In the small size network with 10 nodes the PDR is increased by 0.8%.In the medium size network with 20 nodes the PDR is increased by 1%.In the large size network with 30 nodes the PDR is increased by 1.2%.The pdr on overall is increased by 1.51% in various network topologies.

Delay The Delay at various nodes is shown in Fig 11

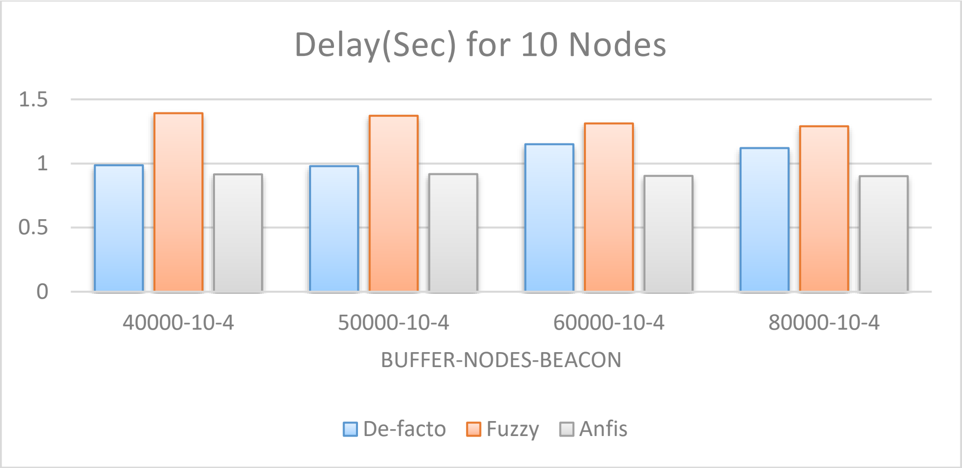


Figure 11(a) Delay for 10 Nodes

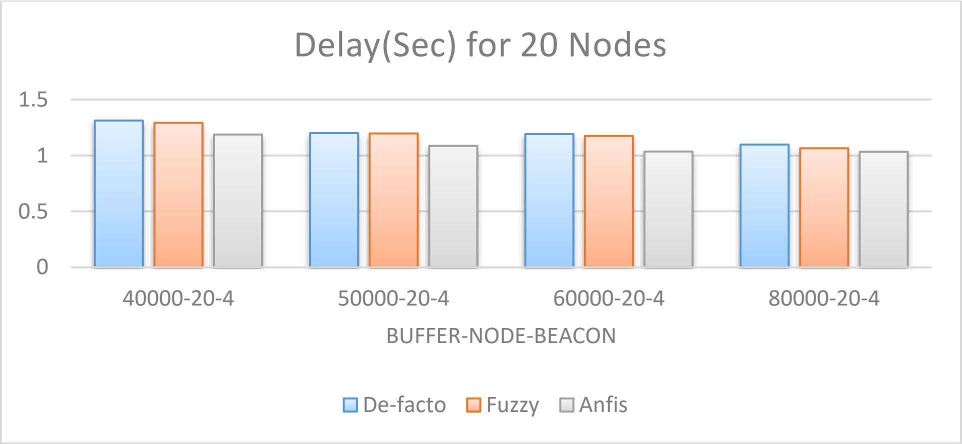


Figure 10 Delay for 20 Nodes

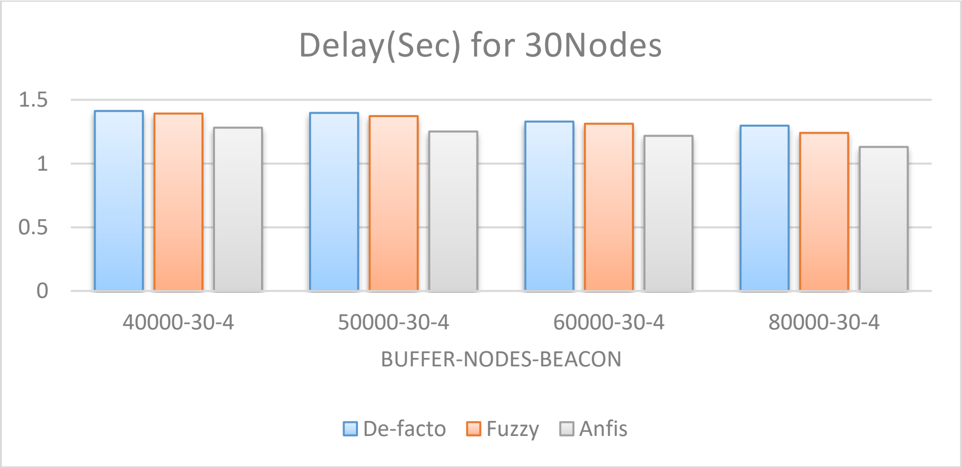


Figure 11 Delay for 30 Nodes

In the small size network with 10 nodes the delay is decreased by 16.54%. In the medium sized network with 20 nodes the delay is decreased by 10.62%. In the large sized network with 30 nodes the delay is decreased by 11.46%. The end-to-end delay decreased on overall is 12.87% in various network topologies.

Conclusion

The goal of this article is to use an adaptive neural network (ANFIS) approach to fine-tune the de-facto parameter values of the Back of Transmission for IEEE 802.15.4. IEEE 802.15.4 with ANFIS reduces power, latency, and PDR by 11.51 percent and 12.87 percent, respectively, and boosts PDR by 1.51 percent. IEEE 802.15.4 transmission backbone based on ANFIS and adaptive to a dynamic real-world environment.

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