Demonstration of Hybrid Mechanism for 10-GPON Using Artificial Neural Network

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Abstract- This research has been conducted to develop a mechanism to reduce power consumption during periods of various link utilization cases which helps to maintain the link status without quality degradation,by maintaining vital functions of network in order to support residual network traffic.This has been done by forming different classes of network traffic defined by upper and lower thresholds and re-routing the traffic along the respective receiver based on its capacity.This mechanism is done intelligently based on traffic pattern by machine algorithm(Neural Network).It is a traffic aware energy/power saving scheme. Significant amount of energy is saved in the network that runs on full capacity(even if it uses the ALR approach). The idea is to detect when UNI is not active, calculation of the total payload of the particular ONU and co-ordinating to the receiver it needs to send sleep and active commands.In simple words it is the Link-State co-ordination with network traffic pattern using neural networks.

Keywords – DSL,PON,GPON,OLT ,ONU,ANN,ALR

I. Introduction

In today's broadband access network, energy efficiencies are currently drawing a lot of attention. The concern is not only to reduce green house gas emission, but also to increase the operational efficiency of the network equipments. Studies have indicated that access networks (fixed and mobile) are the major users of network energy consumption [4]. This primarily is due to the involvement of large number of elements. Replacing DSL (Digital Subscriber Line) based wired access networks with optical network has the potential of reducing the energy per bit consumed by the networks. Passive Optical Networks (PONs), particularly GPONs (Giga bit Passive Optical Networks), because of their certain advantages like no mess of fibers in the central office, use of passive optical splitter (unlike point to point access networks which use active electronics in the field) which require no cooling and powering and is therefore extremely stable. It has been found that within PONs, CPE (customer premises equipment) or ONUs (optical network units) are the energy hungriest devices [1]. In a given network their number is large and most of these because of low utilization of the PON capacity and the shared medium architecture are often idle but "always on".

The rest of the paper is organized as follows. Proposed are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. Proposed Algorithm

A hybrid mechanism involving sleep and adaptive link rate (ALR) control functions to reduce the power consumption of optical network units (ONUs) in 10 Gb/s asymmetric Ethernet passive optical network (10GEPON) systems showed effective power management of ONUs on the basis of the traffic conditions as compared with its component functions in isolation at the expense of a slight increase in queuing delay [11]. Power consumption in GPON, depends upon the traffic flow, which in turn depends upon number of active users at a given instance, bandwidth of ONUs, payload data etc. The present study suggests a step wise procedure for developing a neural network based machine learning algorithm within GPON that can help conserve energy. The idea is to develop a

neural network based algorithm which can act as a traffic controller or supervisor, who, on the basis of traffic flow can intelligently decide which Rx or Tx should remain active and for how long.
In our study we have used Optical Fiber Toolbox for laying of optical fibers to conduct simulations, besides this we have used Statistics Toolbox of MATLAB 2011b and Neural Network Toolbox of MATLAB 2011b. The data set that has been used is video data.

Implementation

Step 1 – The first step in our simulation was to develop network traffic model of video data based upon Poisson distribution. Payload data model was based upon bit-error rate.

Step 2 – Selection of a classifier; Artificial neural networks have been successfully used as classifiers in numerous fields. As such we have used neural networks as classifiers for the traffic data which is non stationary and non linear in nature for our work. It will be of interest of to use it for sending intelligent commands (Sleep and Active) to the receiver for analysis and classification.

Step 3 – Selection of real valued input feature vectors; Since, power consumption in GPON depends upon the traffic flow, which in turn depends upon number of active users at a given instance, number of active ONUs, number of active OLTs. These vectors are therefore used as input vectors.

S.No	Attribute	Description
1	Bandwidth	Amount of Data Flow
2	No Of Active ONU	How many ONU are using Power
3	No Of Active OLTs	How many ONUs are using Power
4	No of Users	How many UNI are connect and sending data

Table 1

Step 4 – Normalization of Input Database; In order to equalize the size or magnitude of the variability of these features, we applied three normalization procedures to the video traffic data. The normalization of the data set ensures that variables measured in large valued units will not dominate the computed dissimilarity and that the variables that are measured in small values will not contribute very little.

Step 5 – Neural network hidden layer number detection;

A major problem in designing a neural network is about establishing the optional number of hidden layers. Reading the input and output these are normally clear and easy but showing the hidden layer is designing issue of the classifiers to get the accurate result. We used 'Grow up' process for designing the hidden layer.
In this process 'Grow up' a layer is added after performing empirical testing of neural network for achieving better level of results. We designed the optimal architecture of a neural network with different architecture and making them learn on the set of input dataset created by simulating the video traffic data until the performance criteria was fulfilled. The structure with minimized dimensions which ensures the use of least amount of computational resources is selected.

Step 6 – Initializing of weights; The Mersenne Twister has been optimized for use with Monte Carlo simulations in a number of fields, including simulating complex biochemical pathways,photon migration,genome coalescence,cellular biology, and computational finance.
The Mersenne twister is the default random number generator for Python, Ruby, PHP,MATLAB and also available in C++ since C++11, therefore we choose this random generator for giving weights to our neural network classifier. However for our research work, all the weights and biases are set to small real random values between 0 and 1.

Step 7 – Pattern Learning Method; Supervised learning method was adopted in our study. The efficacy of classifications was evaluated by using Confusion matrix.

Step 8 – Output layer design; Based upon the number of Rx types or classes, the design of the output layer is given in table 2.

Target	Description	Target Code
Class A	Signifies Commands send to Rx1 for Activation	1 0 0 0 0 0
Class B	Signifies Commands send to Rx2 for Activation	0 1 0 0 0 0
Class C	Signifies Commands send to Rx3 for Activation	0 0 1 0 0 0
Class D	Signifies Commands send to Rx4 for Activation	0 0 0 1 0 0

Table - 2

Step 9 – Design of optimized classifier

About 12 designs were developed to find out the design which utilized the minimum resources, was most optimized, accurate. A screen shot of the running neural network is given in figure 1.

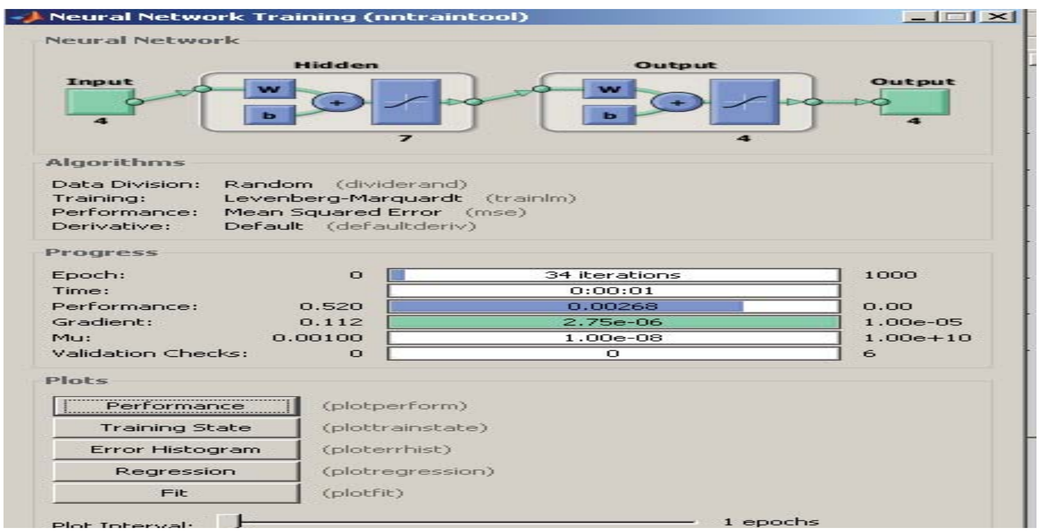

Figure – 1

Analysis of neural network classification algorithm experiments (table 3) indicate that algorithm at serial number 3 [Levenberg-Marquardt (trainlm)] is the most effective with overall accuracy of 98.5%.

S.No	No. of neurons in hidden layer	Training function used	Overall Accuracy in percentage
1	3	Trainlm	68%
2	5	Trainlm	74%
3	7	Trainlm	98.5%
4	15	Trainlm	66%
5	3	Traingd	10%
6	5	Traingd	68%
7	10	Traingd	69%
8	15	Traingd	14%
9	3	Traingdm	19%
10	5	Traingdm	68%
11	10	Traingdm	69%
12	15	Traingdm	15%

Table 3

III. EXPERIMENT AND RESULT

Threshold values were calculated and conditions specified for allocation of Rx. Schematic representation of the process is as under:

If [Bandwidth, No. of active ONUs, No. of active OLTs, no. of users] ≤ Threshold 1
Send traffic to Rx1
If [Bandwidth, No. of active ONUs, No. of active OLTs, no. of users] ≤ Threshold
Send traffic to Rx2
A predefined data set was used to test the efficacy of the algorithm and then confusion matrix was created to validate the results.The classification matrix is shown below in fig no 5.1. it can be seen from the matrix below that the lower triangular matrix shows the no of misclassifications, while the upper triangular matrix shows the correctly classified decision on sleep and activation. In fact , for calculating the true positive rate. We some up the total no of observations that fall diagonally along this matrix. For each other phase (training, testing and final simulation).
We have drawn this classification matrix (Confusion Matrix) for each phase and the accuracy values as shown below in the table.

Training Phase :

Validation Phase :

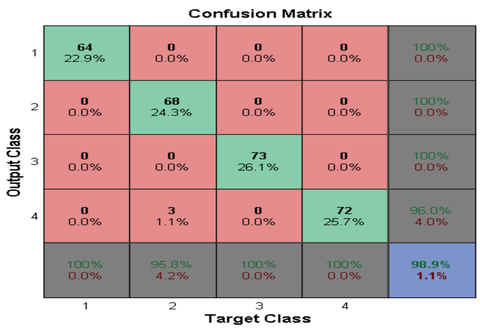

Table 4.1

Table 4.2

Testing Phase :

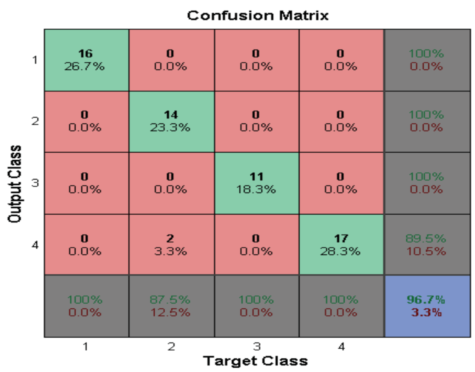

Table4.3

Performance Graphs:

As shown below, we can observe that the best validation performance is 0.0083 at epoch 25. In simple terms this means that the neural network does not need to learn about the decision making on sleep /awake commands for each Rx further than 34 iterations. Since the objective of neural network is to run simulation until it reaches the minimum possible mean square error. We can apparently observe that there is not much variation of mean square error beyond 34 epoch. It is more or less study graph after that.

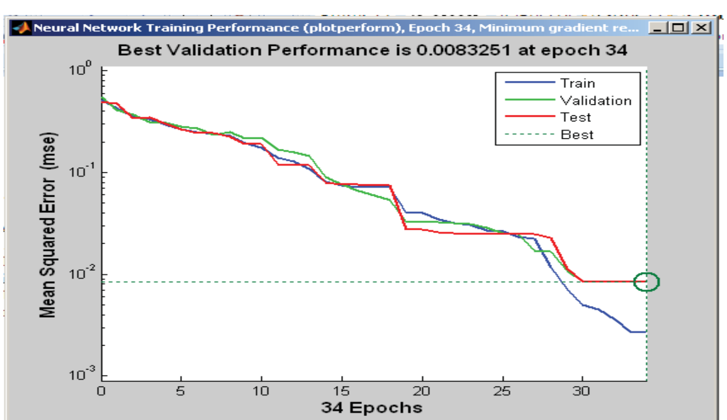

Figure 3

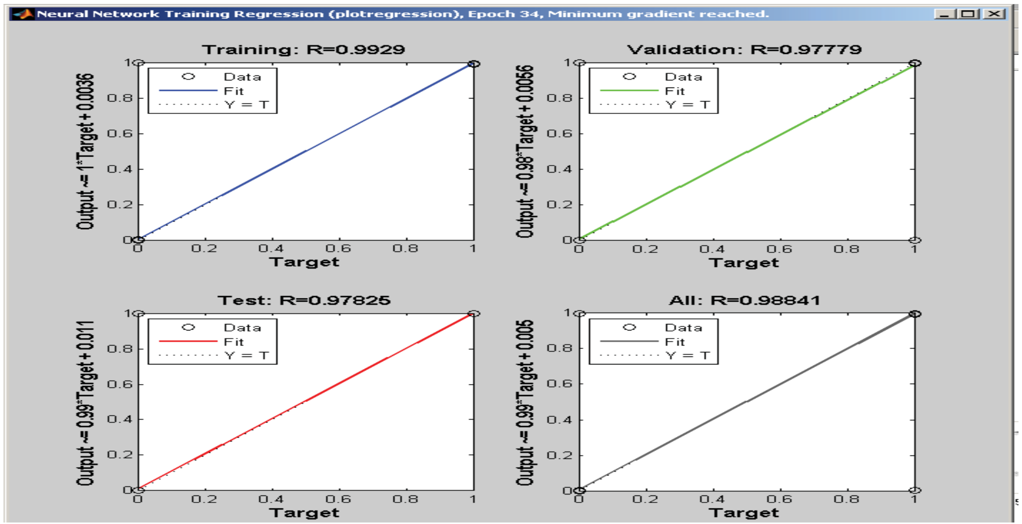

Figure 4

IV.CONCLUSION

The strength of our algorithm is that it identifies nature of defect classification errors as well as their quantities so that the round truth is properly matched with the dedicated results. Once this frame work is put into practice. Therefore after designing multiple classifiers with various possible parameters of input observations, hidden layers and fixed no. of output classes. We have tried to build a low computational resource intensive as well as less time consuming framework to detect the various types of possible decision making commands (Sleep , Awake) for Rx .The selection of parameters for the design of classifier has been meticulously and empirically found after many experiments. The appropriate selection of initial weights for the learning function was found by using trustier random algorithm. So that the coverage is maximum and it occurs rapidly (-0.5 and +0.5). If initial weights are too small then net input to hidden or output unit will approach 0 which would have led to slow learning but if weight were too large the initial input signal to each hidden or output unit would fall in the saturation region where the derivative of the activation function (sigmoid) would have very small value 0.

The selection of learning rate was also done keeping in mind changes in weight factor must be small in order to reduce oscillations or any deviation. For deciding the training and testing patterns. We developed disjoint sets of training and testing datasets and got these validated using K4 cross validation method. In all the various deigns of classifiers the major focus was also to identify the no of hidden units care was taken that no unnecessary additional computational resource usage comes into play for each additional hidden layers.

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