Network Elements Controlled by Artificial Neural Network

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Abstract: This paper describes the comparison between the well-known Network Element in the converged network with classical sequence data processing and the new designed advanced switch controlled by Artificial Neural Network. Simulation programme Opnet Modeler is used for the simulation. The main problem is priority keeping. It is known, that modelling of nonlinear and complicated systems contains problems of process describing and algorithm development. Systems can be very complicated and mathematical description gets near next to impossible. Artificial Neural Networks solve this problem fast and well-arranged.

Key-words: Artificial Neural Network, ANN, Network Element, NE, Converged Network, Delay, Jitter

1 Introduction

An Artificial Neural Network (ANN) will be used for control of Network Elements (NE), in our case of a Switch (SW). Classical sequence data processing is substituted by parallel [2,3]. This paper comes out from [1] and points main results from this reference.

An artificial neuron is a fundamental of every ANN. The network contains known number of these neurons. The number of neurons is given by number of inputs and outputs of ANN topology in the course of ANN mathematical model [2,16]. One neuron contains limited number of inputs, outputs are multiplexed and all carry the same value.

ANN are suitable for converged communication network [2,3]. This network provides users services, especially multimedia services in real time as videoconferences, Voice over Internet protocol (VoIP) and other.

The most frequent development of Hopfield network is optimization problem solution by iteration process [1]. It is a problem solution by sequential repeating and sequential approximation to a result. Hopfield ANN minimizes a power ANN function [5,6,13].

The Hopfield networks need large memory, they contain buffers and control units [7]. The main advantage of the Hopfield networks is beginning stability of output vector. The main disadvantage is high number of connections, frequent network overflow and moderate instability.

A Kohenen ANN is created by one layer of input neurons and second layer of Kohenen neurons, which are connected every with every [1]. The connections of all input neurons come to every Kohenen neuron and for every is given a vector of synaptic weigh. The inputs are multiplexed by synaptic weights and weight space is identical to input space [7,13,19].

The main difference between Kohenen and Hopfield network is in the learning phase. The Kohenen network learns all time, in its traffic. The Hopfield network has first learning phase and then using phase.

2 Problem Formulation

A Hopfield ANN is represented as continue or discrete system [2,3]. Every neuron is connected with all others and this connections are symmetric [14,19]. Converged networks represent convergence of telecommunication and computer networks. Classical sequence data processing contains central processor unit (CPU). When CPU buffer is overcharge packets are thrown away and data loss and delay increase. Parallel data processing is alternative [2,3,14] and neural network using is suitable for it [1].

A network learning is the first step for Hopfield or Kohenen ANN. The learning can be initial or gradual, both must solve the optimization task [14,16] fast and effectively. The number of valid solutions increases with problem exponentially. Time for optimal solution increases then also exponentially [1]. For ANN is optimization
stochastic process and optimal solution may not be founded.

The basis communication protocols as Internet Protocol IP and Ethernet protocol do not contain arrangement for control of priority reservation in communication channels with FIFO (First In First Out) queue. The Network Element NE itself must set the priority as a solution of this problem. The active NE controlled by ANN must therefore set itself packet priority [1]. This priority is set by the time point, when packet incomes and by packet size and type and by groups of packets streams [2,14]. ANN sets from these parameters if packet will be sent out of order (services VoIP) or if the delay is possible (services FTP - File Transfer Protocol). This arrangement influences a Quality of Service (QoS).

The main function of the switch is to send data from the input port to the output port. If data from more input ports directed to one output port the blocking would be possible. Therefore every data stream has its own output [2].

Kohenen network seems to be good solution for the problem above.

3 The main model of the switch controlled by ANN

The requests to the elements in converged networks grow up. Elements, like switches, must be equally fast for data transmission together with QoS cover for all connected terminals [1].

The requests further grow up with higher data transmission by IPv6 protocol and standards IEEE 802.3ae and IEEE 802.3z. These standards have higher data streams then IEEE 802.3a to IEEE 802.3y 10/100Mbit/s [2,14,16].

Basic switch model controlled by ANN is on the Fig.1 [1,2,14,16]. Data from inputs ports are immediately send to the input buffers. Input buffers have two functions.

a) sending of packets parameters to the block ANN. Overhead from the packets IPv4 and IPv6 are sent to the block ANN where is decided which of packets have higher priority.

b) data sending to the switch. Data from IP packets are from the buffers sent directly to the switch area. Paths in the switching area are activated to the output port by ANN controlling.

Switch outputs can for better traffic contain also buffers.

ANN – Artificial Neural Network, SW – Switch, MANN – Memory ANN

Fig.1 Basic switch model controlled by ANN

For next switch simulation by Opnet Modeler was Fig.1 transformed to Fig.2 [1]. This transformation is important for program environment for changing of classical switch model to the switch controlled by ANN. ANN control is separated to single ports, because otherwise the calculation is overly slow-paced.

ANN – Artificial Neural Network, SW – Switch

Fig.2 The switch model controlled by ANN in Opnet Modeler program

4 Opnet Modeler simulation

We compare classical switch and the switch controlled by ANN [1]. The switch has four ports and own QoS control. Kohenen ANN add own symbols DSCP (Differentiated Services Code Point) to IP packets. Allocation of these symbols is separated for every port. Selected services are by it preferred. Control topology works by Fig.2 [1]. Kohenen ANN was selected, because calculation
time and error number is for Kohenen network minimized [13,16].

Created topology for two switches comparison is on the Fig.3 [1]. Switch is for the first classical controlled, for the second is controlled by ANN.

![Fig.3 Opnet Modeler topology](image)

All equipments connection is set by 1 Gbit/s (1000BaseT). Services load the network by these parameters:
- FTP – file downloading to 4 MB, HTTP (HyperText Transfer Protocol) – internet pages browsing on HTTP Server and text pages displaying (till 30 kB), VoIP – connection by H.323 protocol and codec G.729 loaded by connection with VoIP Server and clients from 1 to 3 each other.

QoS is set by DSCP marking on the switch with ANN and on the router on the classical. These rules are used for DSCP marking:
- FTP AF11 – class 1 (AF – Assured Forwarding) – quiet packets throw away
- HTTP AF21 -class 2 (AF – Assured Forwarding) – quiet packets throw away
- VOIP EF-class 5(EF – Express Forwarding) stress to low delay.

Classical switch and switch with ANN are compared by:
- Speed of services FTP, HTTP, VoIP
- Total network delay
- Delay on the switch ports
- Single buffers load

Comparison for the HTTP services is on the Fig.4 [1]. The HTTP service has higher rate growth for the switch with ANN. It is given by smaller HTTP service limiting on the switch ports.

![Upper – with ANN, lower - classical](image)

The FTP service is in this network with QoS on the last place by transmission preference. Average curve on all network is on the Fig.5 [1]. Switch with ANN has three time higher transfer then classical. This service is not limited.

![Upper – with ANN, lower - classical](image)

Next important parameter is network packet delay, we can see it on the Fig. 6 [1].

TCP packets in this network create the higher representation. Services HTTP and FTP use full it, VoIP partially. VoIP use TCP packets for telephone signaling, selecting subscribers availability and control network transport. Initial value is for the switch with ANN high, after state fixation goes to 24 ms. Classical switch delay is approximately 30 ms.

For VoIP service is important not only network delay, but also jitter. Jitter for the switch with ANN is half to the jitter for the classical switch.
Sometimes can be the switch with ANN without jitter. Next parameter is delay on the single ports. For the switch with ANN is on the single ports no delay, the classical switch has small, but some delay.

Upper – classical, lower – with ANN
Fig.6 TCP delay

The last parameter is usage of input buffers. ANN usages this buffers approximately same but a little more then classical. For the traffic it has no negative influence.

5 Conclusion

We simulated by Opnet Modeler and compared the classical switch and the switch controlled by ANN. The switch with ANN is possible to use and it has better results for HTTP, VoIP and FTP services. Bandwidth is without problem for both switches, delay and jitter are better for ANN.

The switch with ANN has higher request for buffers, but it is not critical. As our conclusion we can claim, that NE controlled by ANN is better then classical NE.

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References