DEVELOPMENT OF NEURAL OPEN SHORTEST PATH FIRST (NOSPF) ROUTING PROTOCOL FOR WIDE AREA NETWORK (WAN) SYSTEM

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Abstract

Routing Protocols are used by routers to dynamically determine the path of a packet (user information) through an internetwork. This is an important subject to understand in today's Information Communication System, since it pertains to all routers and configurations that use Internet Protocols (IP). IP Routing is a key technology for connecting LANs in a Wide Area Network (WAN). This paper studies the underlying concepts widely used in routing protocols. Various techniques are used by effective routing protocols to determine the most appropriate route for data transmission. The most relevant routing information involves various measures that are often obtained in an imprecise manner, hence proposing that neural routing is a natural method to employ in an improved routing scheme. This adaptive artificial intelligence method enables the Wide Area Network (WAN) learn easily once the neural network is initially designed. This technique, neural networks, provides a very effective routing algorithm for computer networks. Computer simulation is employed to prove the new Neural Open Shortest Path First (NOSPF) outperforms the Open Shortest Path First (OSPF) in most computer network situations. The benefits increase as the computer network migrates from a stable network to a more variable one. The advantages of applying this neural routing protocol are apparent when considering the dynamic nature of modern computer networks.

Keywords: Neural Network, Neural Open Shortest Path First, Routing Protocol

2. Introduction

Internetwork enables systems on multiple networks to communicate, as it composes of every aspect of connecting computers together in order for resources to be shared (Cisco, 2012). The enhancement of Internetworks has provided enormous assistance for the requirements of communication for different end-system. Cisco (2012) asserts that "An internetwork requires many protocols and features to permit scalability and manageability without constant manual intervention."

According to (Brande, 1997), "One of the goals of Open System Interconnection (OSI) Reference Model in internetwork is performance management. Performance management inspects or observes the network to ensure its Quality of Service (QoS) so that users may competently, utilize it." As Internetwork grows, issues such as congestion, bottlenecks, hardware failures and poor response time often results in unacceptable Quality of Service (QoS). The task of providing efficiently proactive utilization of access to the network is challenging. Traditionally, the connection of Wide Area Network (WAN) System has been characterized by relatively low throughput and high delay in an unstable network condition, due to the use or choice of inappropriate routing protocols (Tannenbaum, 2003).

2.1. Objectives

The aim of this work is to design a Wide Area Network (WAN) System that will provide optimal Quality of Service (QoS) of the routing protocol by the use of Artificial Neural Network. The specific objectives include, to design a Wide Area Network (WAN) that covers Five (5) Local Area Networks (LANs), to develop a System that Interconnects the nodes of each Local Area Network (LAN) over approximated distance and to explore the routing aspect of the network configuration.

3. Literature Review

Wide Area Network (WAN) is a system that is made up of different interrelated components, which perform different functions to reach their design goals. One of the components of Wide Area Network (WAN) System is Routing Protocol, which performs routing. Routing refers to the movement of packets from source to destination or one network to another. A routing protocol specifies the method of communication between routers in order to select the best route to the destination network (Sirak, 2015). Routing occurs at the network layer of the OSI Reference Model and the internet layer of TCP/IP network reference model using Routing Protocols. Routing Protocols determine the path of a packet through an internetwork (Cisco, 2005). Open System Interconnection (OSI) Reference Model has implemented the principle or theory of Technology Standards and Network Effects, which states according to Laudon (2014) that "technology standards are specifications that establish the compatibility of products and the ability to communicate in a network (Stango, 2004)" In those days, before the advent of OSI Reference Model there existed only homogenous network of computers. Some routing protocols have been designed to implement Metcalfe's law, which states that that the value or power of a network grows exponentially as a function of the number of network members (Laudon, 2014) because they have features that make them to be scalable. The scalability feature of Neural Open Shortest Path First (NOSPF) Routing Protocol is explored in this work using the Markov's Chain Rule, which is expressed mathematically as:

- - - Equation (1)

$$\frac{\partial E_{to}}{\partial w_1} \quad L_{O1} = \frac{1}{1 + e^{-S_{O1}}} \quad - \quad * \; \frac{\partial S_{O1}}{\partial w_1}$$

- - - Equation (2)

$(Sh1) = w1 * i1 + w2 * i2 + b1 * 1$ - - - Equation (3)

$(So1) = w2 * Lh1 + w4 * Lh2 + b2 * 1$ - - - Equation (4)

$Etotal = \sum \frac{1}{2}(\text{Real Output} - \text{Apparent Output})2$ - - - Equation (5)

Where, Etotal = mean square error function,

Real Output = Threshold function

Lo1 = Apparent Output = Sigmoid function

Lh1 = Output at the hidden layer

So1 = Summation function at the output layer

Sh1 = Summation function at the hidden layer

w1, w2, w3, w4 = Weight

i1, i2 = Input

b1, b1 = Bias

3.1. Empirical Review

Pradeep K.W. Abeygunawardhana, (2014) introduced an adaptive routing algorithm to be used on Wide Area Network (WAN) based on the Cognitive Packet Network (CPN) architecture to enhance the Quality of Service (QoS) delivered to end users. However, when QoS goal weights are set 100% to the minimum delay and 0% to the minimum packet loss though it result in lowest delay among all the test cases it also result in the worst packet loss. Mohd Zahid, M. Soperi M. Haider Kamarulnizam Abu Bakar, (2011) explored the effectiveness of scheduling OSPF RTC using Generalized Regression Neural Network (GRNN) to determine suitable values for hold time. The values are determined based on three parameters: LSA-inter arrival time, the number of important control messages in queue, and CPU utilization of the router. However, the network instability is confined to single area in the network, which the neural network did not cover. Will Newton, (2002) researched on a routing algorithm, which attempts to solve some of the problems faced in dynamic, unreliable, and congested networks is suggested, but the neural network failed to converge in all situations. Nenad Kojic, Irini Reljin and Branimir Reljin, (2012) research uses Packet delivery ratio, Throughput, End-to-end delay, Average hop count, and Blocking iterations as metrics to compare the performance of the routing protocols. However, the routes with minimal hop count are not optimal from the point of all the observed network parameters. Chiadikobi (2016) designed a Wide Area Network (WAN) that enhanced Classless Inter – Domain Routing by the use of Open Shortest Path (OSPF). However, OSPF routing protocol have a serious drawback which is the difficulty involved in configuring OSPF and its being a technique used for conventional system network.

4. Analysis and Design

4.1. Analysis of the Proposed System

The Wide Area Network (WAN) System is analyzed using the Data flow Diagram (Level 1) shown in figure 1

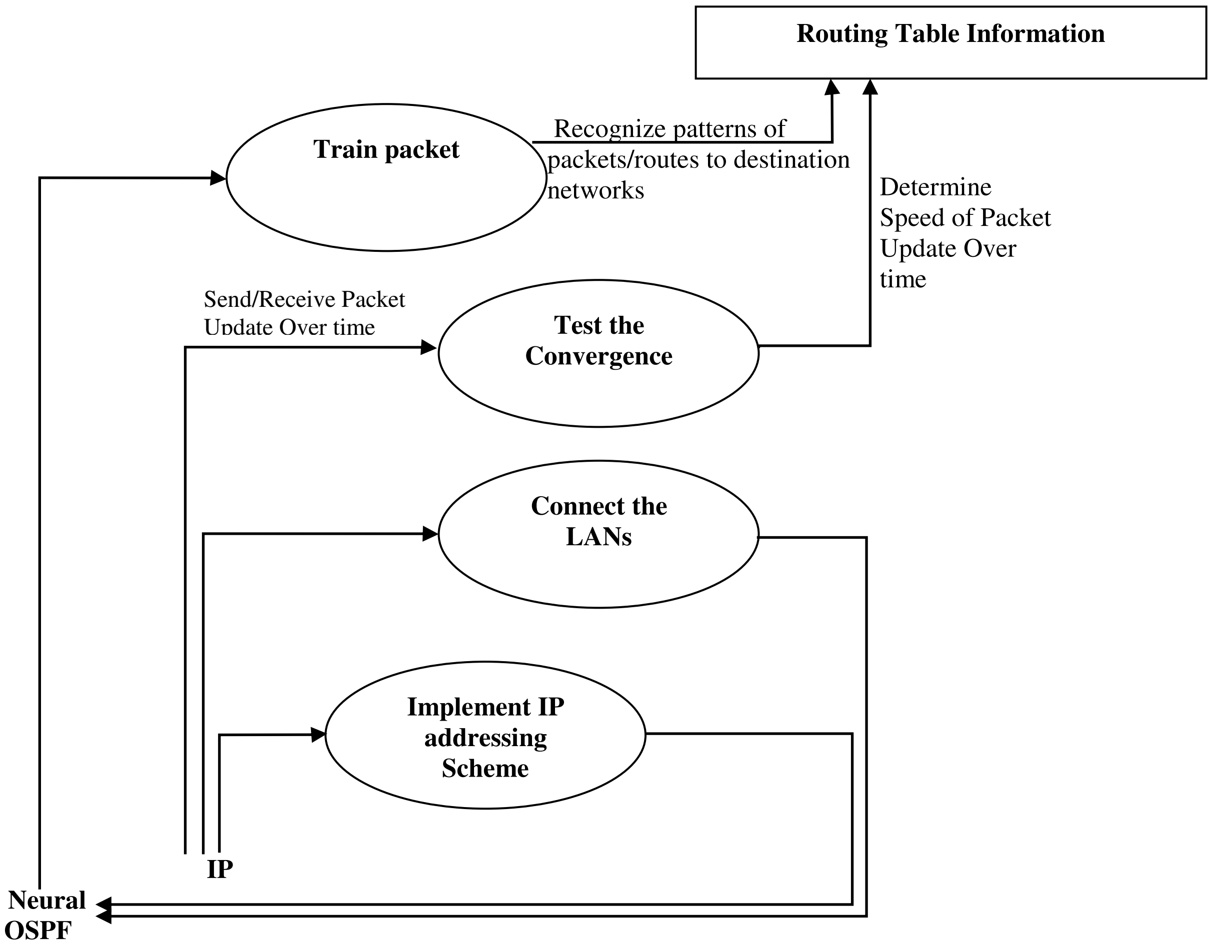

Figure 1: Level 1 Data Flow Model of the design Proposed System

4.2. Simulation Design

A supposed network, which is the Wide Area Network (WAN) System, is established (Figure 3.2) before developing a simulation model to analyze the proposed routing protocol because the network depends on the proposed routing protocol. In this work, network routing metrics used are distance (delay), throughput, congestion and failure. Once the simulation model was designed, it was used to obtain training data for the neural network. Each observation in the training data set was to represent an individual packet traveling from the first source neuron to a destination neuron.

The Neural Network was designed with three layers, which are the input layer, hidden layer and output layer. The input layer consisted of an Input Neuron (IN) (represented by Neuron 1). The hidden layer contained a Hidden Neuron (HN) (represented by Neuron 2). The output layer contained an Output Neuron (ON) (represented by Neuron 3). It was used to signify the expected time to arrive at the destination. The Neural Network was also developed with two Bias Input Neurons (BN1 and BN2) (represented by Neuron 4 and Neuron 5). The bias input neurons are characterized by network congestions and failures, which are rated as low or high. Figure 2 shows the Neural Wide Area Network (WAN) System design that covers the five (5) Local Area Networks (LANs).

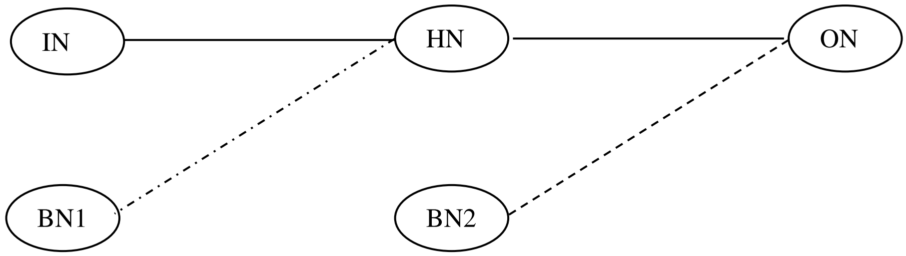

Figure 2: Neural Network Block Diagram for Wide Area Network (WAN) System

The goal of back propagation is to optimize the weights (distance) so that the neural network can learn how to correctly map arbitrary inputs to outputs. To achieve this:

A. The Forward Pass (Feed Forward)

We fed those inputs (distance and throughput) together with the biases (network congestion and network failure) forward through the network, thereby figuring out the Summation Function (S) at the hidden and output layer neurons, and related each Summation Function (S) to the Logistic Function (L) to get the Apparent Outputs (Neural Open Shortest Path First), which was compared with the Real Outputs (Open Shortest Part First) to get their differences. We calculated the error for the output neuron using the Squared Error Function and sum them to get the total error:

B. The Backwards Pass (Feed Back)

Our goal with back propagation is to update each of the weights in the network so that they cause the apparent output to be closer the real output, thereby minimizing the error for each output neuron and the network as a whole by applying the Chain Rule.

5. Results and Discussion

5.1. Convergence Testing

This work is designed to compare the proposed Neural Open Shortest Path First (NOSPF), which implements the Back - Propagation routing algorithm to the commonly used Open Shortest Path First (OSPF), which implements the shortest route algorithm. In this design, four different situations are to be tested with respect to the level of network failure and network congestion. The network defines the situation as low or high.

5.2. Discussion

The outcome of the Neural Wide Area Network (WAN) System design, which provides answer to the Research Objective raised in section 1.1 is as follows:

1. The features, which indicates the performance of the Wide Area Network (WAN) System is its convergence, which is rated as slow, normal or fast under unstable network condition such as network congestion and network failure, which are rated as low or high.

2. The logical and physical design of the existing system differs from that of the proposed system in terms of their routing protocol requirements. The existing system requires OSPF for updating and maintaining the routing table of routers and routing packet from source to destination, while the proposed Wide Area Network (WAN) System requires Neural OSPF to train packet in order to recognize route to destination by their patterns and as such interconnect the Local Area Networks (LANs) in the Wide Area Network (WAN) System over approximated distance by predicting its time of packet arrival (convergence).

3. The routing protocols used during the design and configuration and simulation of the Wide Area Network (WAN) System have been tested with respect to four different situations based on its convergence with respect to level of network failure and network congestion, which determines optimality of the routing protocol and the result (Figure 4.1).

4. The first situation was designed to be the most stable configuration having low congestion as well as low failure. This situation depicts the most steady of the four; therefore, we expect that the new protocol does not have significant advantages over OSPF in this initial situation. The mean output transit times collected for each protocol under this arrangement are shown in Figure 4.1a

5. We expect the second situation to reveal some significant advantage of implementing the proposed protocol. It was designed to be similar to the first situation, but with a higher failure rate and the same low congestion. This situation was expected to demonstrate that the new protocol has a significant advantage over shortest route under these conditions. The mean output times collected for each protocol are shown in Figure 3

6. A third situation emulated a WAN, which has low failure but high congestion; all other factors remained the same. The mean output times collected for each protocol are shown in Figure 3c

7. The last situation described the WAN during a very hectic period of time output, which has a high failure probability and a high congestion rate. The information received is given in Figure 3d and figure 3 has the convergence times in each situation illustrated in chart.

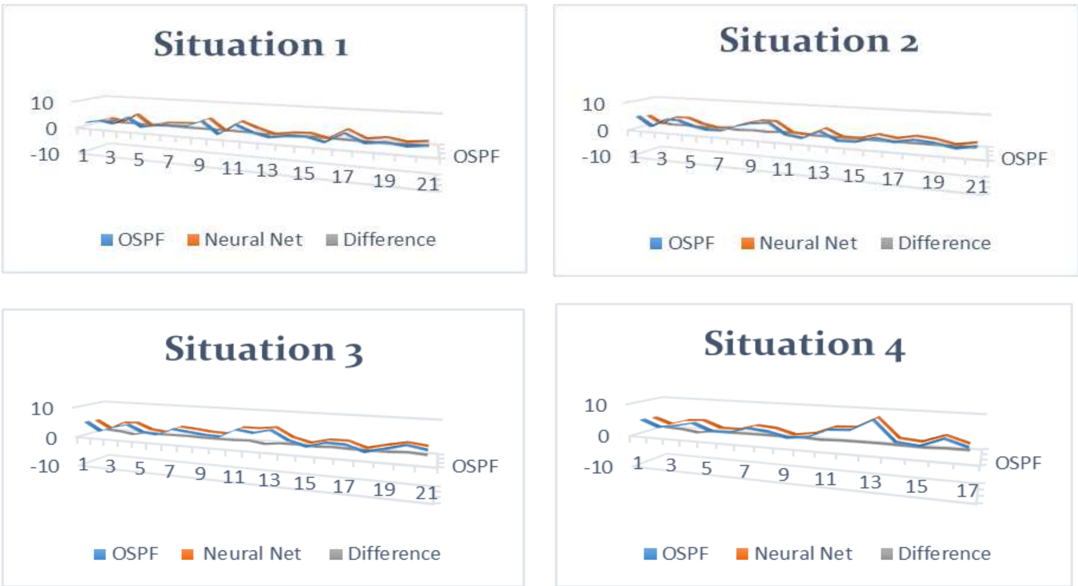

Figure 3: Convergence time for each network **situation**

5. Summary and Conclusion

5.1. Summary of Findings

One outstanding check for the validity of this design is the Routing Protocol, Average Round Trip Time (in millisecond), and Convergence Speed at unstable network condition. The computer simulation employed proves the new Neural Open Shortest Path First (NOSPF) outperforms the Open Shortest Path First (OSPF) in most computer network situations. The benefits increase as the computer network migrates from a stable network to a more variable one.

5.2. Conclusion

As various concepts and principles have been employed in the design and configuration of Wide Area Network (WAN) System, it can be seen clearly that there is a relationship within routing protocols in terms of their features. Therefore, Neural Open Shortest Path First (NOSPF) provides more features which makes it an optimal routing protocol in an unstable network situation than Open Shortest Path First (OSPF).

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