An Intelligent Fuzzy Neural Routing Scheme for Improving Computer Network

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Abstract: The growing usage of computer networks is requiring improvements in network technologies and management techniques so users will receive high quality service. Determining the best route through a wide area network (WAN), requires the routing algorithm to obtain information concerning all of the nodes, links, and devices present on the network. The most relevant routing information involves various measures that are often obtained in an imprecise or inaccurate manner, thus suggesting that fuzzy reasoning is a natural method to employ in an improved routing scheme. Fuzzy reasoning and neural networks, when combined together provide a very effective routing algorithm for computer networks. Computer simulation is employed to prove the new fuzzy routing algorithm outperforms the Shortest Path First (SPF) algorithm 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 fuzzy routing algorithm are apparent when considering the dynamic nature of modern computer networks.

Keywords: wide area network (WAN), Shortest Path First (SPF)

I. INTRODUCTION

Effective routing algorithms use various techniques to determine the most appropriate route for transmitting data as more individuals transmit data through a computer network, the quality of service received by the users begins to degrade. A major aspect of computer networks that is vital to quality of service is data routing. A more effective method for routing data through a computer network can assist with the new problems being encountered with today’s growing networks.

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Path First (SPF) algorithm 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 fuzzy routing algorithm are apparent when considering the dynamic nature of modern computer networks.

II LITERATURE REVIEW

Adaptive routing uses frequently updated information to determine an appropriate route while considering traffic conditions on the WAN. Every node on an asynchronous transfer mode (ATM) or packet switched network performs adaptive traffic routing. Thus far, many different schemes have been proposed to address adaptive routing. Among the more common approaches are neural networks (Hiramatsu 1989; Rauch and Winarske 1988; Matsumoto 1992; Jensen, Eshera and Barash 1990; Wang and Weissler 1995) expert systems (Flikop 1993) and math programming (Hashida and Kodaira 1976; Key and Cope 1990).

Two very common and simple criterion used in selecting a WAN route are the minimum-hop route and the least-cost route. Both of these methods are applied to adaptive routing situations as well as deterministic approaches that use static routing table. The minimum-hop method uses routing tables to determine the route having the least number of hops to reach the destination node. A hop refers to a data packet traveling from one device to the next and represents a single link between two devices. The least-cost method finds the route having the least cost, where cost is based on data rate (Stallings 1990). Other metrics are also commonly used, such as reliability, travel delay, available bandwidth, load of the resources, allowable packet size and communication cost (Cisco 1995). Efficient routing schemes have been thoroughly researched in regard to traditional telephone networks. Therefore, much of the literature concerning network routing is specific to telephone networks. Although the routing process for telephone networks is similar to that of computer networks, there are characteristics specific to computer networks that need to be considered. Mitra and Seery (1991) analyze some of the more popular telephone routing techniques based on alternate routing. These techniques are similar in that each call is provided with a list of possible routes to use. The differences are found in the algorithms used to select alternate routes when the first choice is unavailable.

Krasniewski (1984) suggests a fuzzy approach to alternate routing in a telephone network. A fuzzy membership function is used to assign each alternate path a value between 0 and 1 to indicate the relative selection order of the path.

III FUZZY ROUTING

The new routing algorithm and an analysis concerning the strengths and capabilities of the new design. This entire process can be divided into tasks and sufficiently described in four sections. This work involves designing a simulation model to represent the detailed routing process found in a computer network.

A) FUZZY ROUTING SETS

Once the raw values were obtained using the random routing model described above, the fuzzy sets were defined. The fuzzy sets were structured in reference to the particular network being modeled, and therefore apply to the hypothetical network.

The Distance metric is described using three fuzzy sets: distance low, distance medium, and distance high (Figure 1). There is significant overlap between these three sets because of the small range in "distance" values. Having only twelve nodes and seventeen links in the WAN causes the distance between any two nodes (number of hops) to range from zero to seven. Congestion is also described with three fuzzy sets: congestion low, congestion medium, and congestion high (Figure 2). Compared to the distance metric, there is much more variation in congestion. Therefore, the congestion sets are sparser with less overlap. The maximum throughput for any link in the hypothetical network is 8000 bytes per second; therefore, the throughput values range from 0 to 8000. This range is also divided into three fuzzy sets: throughput low, throughput medium, and throughput high (Figure 3). Failure measures were also divided into three fuzzy sets: failure low, failure medium, and failure high (Figure 4). Although the majority of observations had a failure of
zero, there were instances with failure measures up to 100.
After defining the fuzzy sets, the next step was to convert the raw observations in the training and testing sets to fuzzy membership grades. The next phase involved designing and training the neural network. This was achieved using the software package NeuralWorks Professional II.

IV) EXPERIMENTAL DESIGN

This study is designed to compare the new routing algorithm to the commonly used OSPF shortest route algorithm. When considering only the distance from the source node to the destination node, shortest route is expected to generate the best routing path under stable and predictable conditions. This is because shortest route was designed to optimize the path of travel based on only one measure, usually distance. As discussed previously, there are many factors that seem imperative to determining which path will be the most successful. This suggests that an algorithm considering additional network characteristics will be more effective. In this study, we hypothesize that of the relevant factors, the congestion levels and failure rates will have the most prominent affect on observing the advantages of the new algorithm. For this reason, the experimental design is centered on these two factors. The experimental design has four different scenarios to be tested, as indicated in Table1. Each scenario tests a combination of failure and congestion levels and will be tested at the $\alpha = 0.10$ significance level. As mentioned earlier, the definitions of low and high are network dependent. Many factors have helped determine the specific values for low and high in this study. The size of the network, the structure of the network, and the length of the sample times all support these values. These values are provided and explained in detail in the next section.

The expectation is that for scenario one where low congestion and low failures is present, shortest route will perform well. If the analysis supports this expectation, it will contribute to overall validation of and confidence in the models. As we move to scenarios two, three, and four, the new algorithm with its adaptive capabilities should show superiority.

<table>
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<tr>
<th>Low Congestion</th>
<th>Low Failure</th>
<th>High Failure</th>
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<td>Scenario 1</td>
<td>Scenario 2</td>
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A) SCENARIO ONE

The first scenario was designed to be the most stable configuration having low congestion as well as low failure. This scenario depicts the most steady of the three; therefore, it is expected that the new algorithm will have no significant advantages over shortest route in this initial scenario. The sampling process was conducted such that both sets of runs utilized an identical ordering of message creation; therefore, the forty means collected are actually twenty pairs. This suggests the presence of paired differences. There are two sets of statistical tests that can be used for paired data; parametric and nonparametric. However, before any statistical testing could begin the normality of the data needed to be established to determine which tests would be most appropriate.
B) SCENARIO TWO
The second scenario was expected to exhibit some significant advantage of implementing the new algorithm. It was designed similar to the first, but with a higher failure rate and the same low congestion. This scenario was expected to demonstrate that the new algorithm has a significant advantage over shortest route under these conditions. The mean times collected for each algorithm are listed in Table 3.
The four analyses provided rather satisfying results for the new algorithm. It was expected that as failures and congestion levels increased, the advantages of the new algorithm would become more prominent. The most stable of the four scenarios exhibited the least amount of effectiveness from the new algorithm, while the most chaotic experienced the largest benefits. The p-values for the four
scenarios are listed in Table 4

<table>
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<th>Table 4. P-values for all tests</th>
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<td><strong>Low Congestion</strong></td>
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<td><strong>Low Failure</strong></td>
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<td><strong>High Failure</strong></td>
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The p-values indicate the new algorithm outperforms the shortest route algorithm in effectively transmitting data through the network. The superiority exhibited increases as the network becomes more unstable and less predictable, thus suggesting it to be more suitable for the changing environment of today’s computer networks. These p-values exhibit statistical significance, but the practical efficiency (as seen in scenario four) is an improvement of 2.497 percent. The significance of this improvement should be obvious considering today’s high-speed networks and the underlying need for data transmissions to be performed in the quickest and most efficient manner.

V. REFERENCES


