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Optimization of Network Traffic Routing and Handling of Network Congestion Using Artificial Nerual Network

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Abstract: A novel generalized algorithm is designed and developed to obtain optimal path traffic routing for communication network. An algorithm is presented by considering the routing design metrics distance between the hops, number of hops, hop failure and congestion. The selected network for the generalized algorithm is capable of handling a network of any structure with any number of hops. One of the main objectives in communication network is to reduce the communication cost to reach the destination that can be obtained by reducing the number of hops to reach the destination. Also considering minimum number of hope in data transfer from source to destination will reduce the traffic and congestion in the network link. Further to enhance the efficiency algorithm designed by considering the metrics number of hops, hop failure and congestion. The developed algorithm is tested and presented with a typical example. In this study the author present the performance measure of network congestion with Single Server Queuing model using Artificial Neural network.

Key words: Routing, optimal path, hop failure, congestion, queuing

INTRODUCTION

The problem of finding efficient routing algorithms has been a fundamental research area in the field of data network.[1-4]. Routing is the act of moving information across an internet from a source to destination and along the way at least one intermediate node typically is encountered. Routing perform the basic activities, such as determining optimal routing paths and switching. Optimal path is obtained using different metrics. A metric is a standard of measurement used in design of routing algorithm. Routing protocols use metrics to evaluate what path will be the best for a packet to travel[5-9]. To aid the process of path determination routing algorithms initialize and maintain routing Tables, which contain route information. Route information is varying with respect to the routing algorithms. Switching algorithms is relatively simple, it is the same for most routing protocols. In most cases a host determines the path that it must send a packet to another host. Having acquired a router's address by some means the source host sends a packet addressed specifically to a router's physical address[10-16].

ROUTING ALGORITHMS

The design goals of the routing algorithms are the characteristics such as Optimality, Simplicity and low overhead, Robustness and stability, Rapid convergence, Flexibility.

Optimality refers to the capability of the routing algorithm to select the best route, which depends on the metrics and metric weights used to make the optimal. Simplicity and low over head in routing algorithms are designed to be as simple as possible and also it must offer its functionality efficiency, with a minimum of software and utilization over head. Efficiency is particularly important when the software implementing the routing algorithm must run on a computer with limited physical resources. Routing algorithms must be robust, that they should perform correctly in unforeseen circumstances, such as hardware failures, high load conditions and incorrect implementation. In addition routing algorithms must converge rapidly. Convergence is the processes of agreement by all routers on optimal routes, when a network event causes routes to either go down or become available.

Routers have to distribute routing up date message, stimulating recalculation of optimal routes and causing all routers to agree on these routes. Routing algorithms should also be flexible, which means that they should quickly and accurately adapt to a variety of network circumstances. Routing algorithms have used many different metrics to determine the best route. Sophisticated routing algorithms can base route selection on multiple metrics, combining them in a single metric. The listed metrics have been used in design. Path length, Number of hops, Reliability, Congestion, Delay, Band Width, Load, Communication cost[17]. This study is

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focused to obtain optimal path by considering the matrices as distance between hops, number of hops, failure of hops and congestion at hops.

CONGESTION

When too many packets are present in the subnet, its performance will be reduced. This situation is called congestion. When the number of packets dumped into the subnet by the hosts is within its carrying capacity, they are all delivered and the number delivered is proportional to the number sent. However as traffic increases too far the router are begin losing packets. This tends to make matters worse. At very high traffic, performance collapses completely and almost no packets are delivered.

Congestion can be brought about by several factors. If all of a sudden streams of packets begin arriving from three or four input lines and all need the same line, a queue will build up. If there is insufficient memory to hold all of the packets, the packet will be lost. Slow processors can also cause congestion. Congestion tends to feed upon itself and become worse, if a router has no free buffers. Congestion control leads to two groups, open loop and closed loop. Open loop means the solutions attempt to solve the problem by good design in essence to make sure it does not occur in the first place. Once the system is up and running midcourse corrections are not made. In contrast closed loop solutions are based on the concept of a feedback loop[18-25].

This study focused when the closed loop congestion established at any one of the nodes in the network, leaving that node, the data will take an alternative optimal path to reach the destination.

PROBLEM STATEMENT

The objective is to formulate a generalized optimal algorithm to obtain an optimal path for any number of hops with any structure by considering the following metrics say distance between the hops, number of hops, block, congestion and failure of hops.

A typical 7 node network as shown in Fig. 1 is considered. Assuming node, 1 as source node and 7 as destination node. Processing is done by applying Critical path method to the network.

The critical path algorithm involves two phases[26,27]. The first one is the forward phase which determines the earliest occurrence of the hop and the second one is backward phase which calculates the latest occurrence of the hop. The technique is recursive in nature. The same Procedure is repeated for all the nodes. Fixing the node in

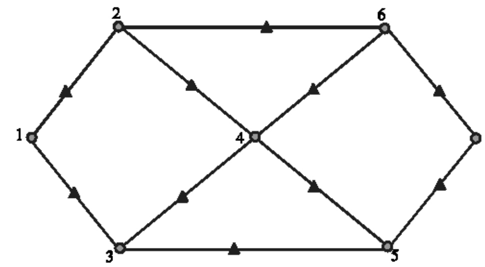

Fig. 1: Network with 7 nodes

Table 1: Distance matrix

Node	1	2	3	4	5	6	7
Node 1	0	2	4	0	0	0	0
Node 2	-2	0	0	3	0	5	0
Node 3	-4	0	0	3	2	0	0
Node 4	0	-3	-3	0	3	3	0
Node 5	0	0	-2	-3	0	0	1
Node 6	0	-5	0	-3	0	0	2
Node 7	0	0	0	0	-1	-2	0

the network which is having same value of earliest occurrence and latest occurrence. Now this selected location of the node is in the short path. Similarly selecting the location of all this type of nodes. The sequence of all this nodes are listed. Minimum number of nodes constraint is applied. The result is the required optimal path. Then verifying whether any of the node in the optimal path is congested. If it is congested entire procedure is repeated and an alternative optimal path is obtained.

Optimization algorithm: The number of nodes and structure of the network, distance between the nodes in the network are taken. Processing are carried out according to the various steps in the Critical path algorithm. The various steps involved in critical path algorithm to optimize the routing is as follows.

Step1: Fix the direction of the links of the given network starting from node 1 to node 2 and similarly to all links.

Step 2: Set the earliest start of node 1 to be zero. Initialize input number of nodes and distance to be zero

Step 3: Formulate distance matrix as shown in as shown in Table1.

Step 4: Follow the forward pass rule to obtain the earliest occurrence of all nodes.

Step 5: Set the latest finish to last node to equal to the earliest start of same node.

Step 6: Follow the backward pass rule to obtain the latest occurrence of all other nodes.

Step 7: Compare the value of earliest and latest occurrence, form the shortest path.

Step 8: Apply the minimum number of node constraint.

Step 9: Check whether the node in the shortest path is congested.

Step 10: Compute the optimal path.

QUEUING MODEL

Queuing model is one of the tool to analyze network congestion. This study focused the performance measure of network Single server Queuing model using Back-Propagation network Algorithm.

MATERIALS AND METHODS

An infinite Buffer Single Server queue with Poisson message packet arrivals takes an exponentially distributed amount of time to service each packet. Packets are processed in first in, first out order[27]. Different models in queuing theory are classified by using standard notations described initially by D.G.Kendall in 1953 in the form a/b/c. Later Am.Lee in 1966 added the symbols d and e to Kendall notation.

In the Literature of queuing theory the standard format used to describe the main characteristics is (a/b/c): (d/e).

Where a-arrival of data distribution.
b-service of data distribution.
c-number of servers.
d-maximum of servers of data allowed in the system.
e-queue service.

Single server model is represented as (a/b/1): (8/FCFS). Proposed model is based on the following certain assumptions.

- Poisson distribution of arrivals of data.
- Single waiting line with no restriction on length of queue.
- Queue discipline is first – come first served.
- Single server with exponential distribution of service time.

With above assumptions performance measurer of the model and outputs 1,2,3,4 and 5 are[27]

1.Expected number of data in the system
(LS) = a/(b-a) (1)
Where a-arrival rate of data in Mbps.
b – Service rate in Mbps.
2.Queue length (LQ) = a * a/b(b-a) (2)
3.Waiting time for a data in the queue
(WQ) = a/b(b-a) (3)
4.Waiting time for a data in the system
(WS)= 1/(b-a) (4)
5. Traffic intensity (T) = a/b (5)

NEURAL MODEL FOR QUEUING

In recent years application of Artificial neural network has emerged as a promising area of research. ANN is one of the most powerful mathematical tool to solve many problems. Back Propagation Network (BPN) algorithm is used to solve the model.

For the selected Single server Queuing model Neural network is framed with 2 input neuron with 5 hidden neuron and 5 output neuron. The learning of 0.6 and momentum factor is 0.9 have been used.

The training of an artificial neural network involves two passes. In the forward pass, the input signals propagate from the network input to the output. In the reverse pass the calculated error signals propagate backwards through the network where they are used to adjust the weights. The calculation of output is carried out layer by layer in the forward direction. The output of one layer in weighted manner will be the input to the next layer in the reverse pass the weights of the output neuron layer are adjusted first since the target value of each output neuron is available to guide the adjustment of associated weights[28].Back propagation algorithm is used to analyze the Queuing model

BPN Algorithm is used in this study has the following steps:

Step 1: Normalize the input and outputs.

Step 2: Assume the number of neuron in the hidden laye.

Step 3: Initialize the weights to small random Values.

Step 4: Input to the input layer.

Step 5: Comput the inputs to the hidden layer.

Step 6: Compute the input to the output layer.

Step 7: Calculate error.

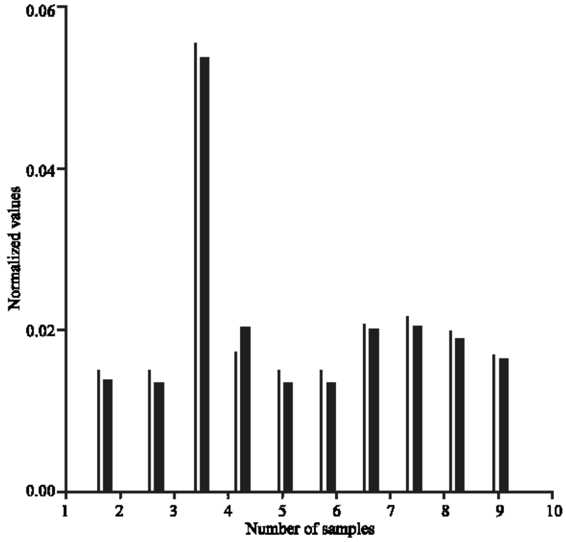

Fig. 2: Output 1 of test data

Table 2: Optimal path

Source node	Destination node	Metric	Optimal path
1	7	Distance between the hops and number of hops	1-3-5-7
1	7	Distance between the hops, number of hops, Failure and congestion at node 3	1-2-6-7
1	7	Distance between the hops, number of hops, Failure and congestion at node 2 and 3	No path to data transfer

Step 8: Repeat the steps 4-7 until the convergence in the error rate is less then the tolerance value. The training data and testing data have been normalized so that inputs and outputs are with in the range of 0-1.

SIMULATION AND RESULTS

The generalized optimal critical path computation algorithm is developed. Taking source node as 1 and destination node as 7 and distance between the nodes of the network from the Table 1, the optimal path is obtained by applying the proposed algorithm. The results are recorded as shown in Table 2.

The optimal path computed by considering distance between the hops and the number of hops is shown in Fig. 4.

The optimal path computed considering distance between the hops the number of hops, failure and congestion at node 3 is shown in Fig. 5.

If there is a Failure and congestion at node 2 and 3 the result will show Data can not be transfer. There is no path to data transfer shown in Fig. 6. This technique could be extended to any real world problems such as Transporting problem, Planning and Communication problems.

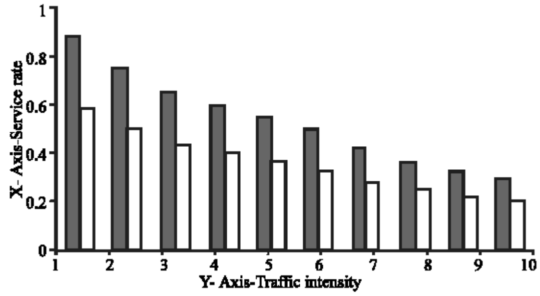

Fig. 3: Comparisons of traffic intensity with different arrival data

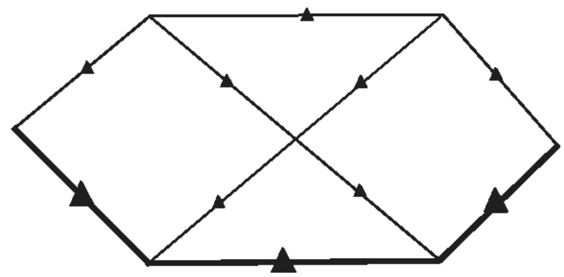

Fig. 4: Optimal path without congestion

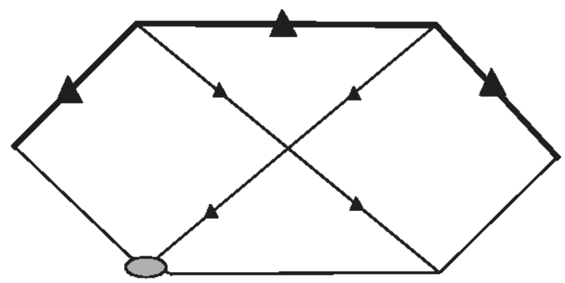

Fig. 5: Optimal path with node3 congested

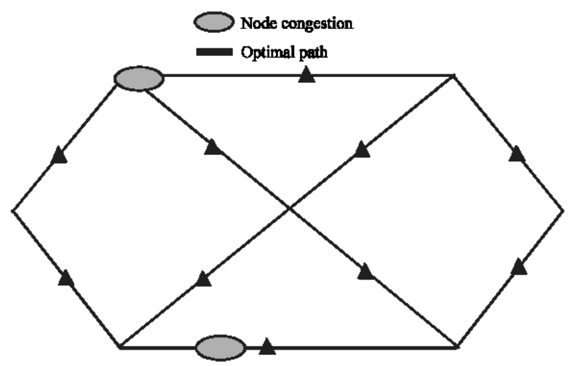

Fig. 6: Optimal path with 2 and 3 congested

Table 3: Comparison of Test data for the output 1

Sl No.	Expected number of data in the system actual y	Expected number of data in the system BPN y'	y'-y = Error
1	0.0469	0.0429	-0.0047
2	0.0467	0.0411	-0.0056
3	0.1740	0.1677	-0.0063
4	0.0540	0.0638	0.0098
5	0.0456	0.0395	-0.0061
6	0.0200	0.0281	-0.0081
7	0.0640	0.0626	-0.0014
8	0.0675	0.0640	-0.0035
9.	0.0625	0.0584	-0.0041
10	0.0533	0.0505	-0.0028

Table 4: Comparison of test data. for the output 2, 3, 4 and 5

Sl No	Output	Actual value	BPN value
1	Queue length	0.0374	0.0588
		0.0553	0.0337
		0.0529	0.0528
2	Waiting time of a data in the queue		
		0.0515	0.1891
		0.2155	0.0501
		0.1856	0.2116
3	Waiting time of a data in the system		
		0.2000	0.2500
		0.3333	0.2055
		0.2445	0.3251
4	Traffic intensity		
		0.7882	0.8222
		0.8202	0.7651
		0.8287	0.8248

Table 5: Comparisons of traffic intensity with different arrival data

Sl. No	Service rate in Mbps	Traffic intensity a/b[1]	Traffic intensity a/b[2]
1	1.7	0.8823	0.5882
2	2	0.7500	0.5000
3	2.3	0.6521	0.4347
4	2.5	0.6000	0.4000
5	2.7	0.5555	0.3703
6	3	0.5000	0.3333
7	3.5	0.4285	0.2857
8	4	0.3750	0.2500
9	4.5	0.3333	0.2222
10	5	0.3000	0.2000

RESULTS AND DISCUSSION

The test data have been normalized so that inputs and outputs are within the range of 0-1. Comparison of the test data for the output 1 is given in the Table 3. Figure 2 shows a close resemblance between the predicted and actual values. Table 4 Shows the comparison of the various outputs using BPN network and it is concluded that the developed BPN network had good performance convergence.

Various arrival rates and service rate are assumed Table 5 shows that the comparisons of traffics for various arrival rate. Traffic intensity[1] obtained with arrival rate of 1.5 Mbps and Traffic intensity[2] obtained with the arrival rate of 1Mbps for different service rate. Table 5 and Fig. 3, 7 shows the variations of Traffic intensity with the

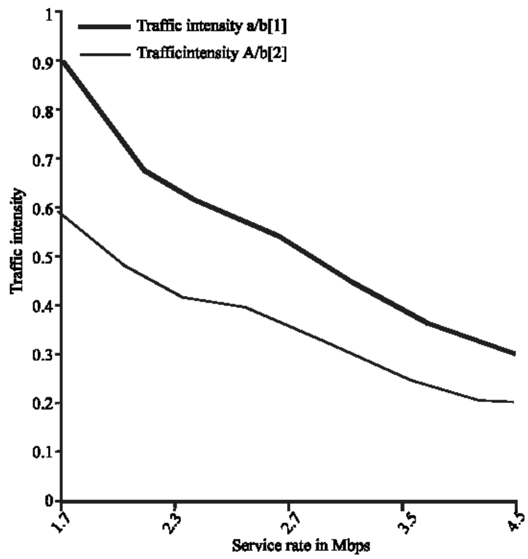

Fig. 7: Traffic intensity comparisons

arrival rate of the data in Mbps. The traffic intensity is reduced with the arrival data is shown in Table 5.

CONCLUSION

The generalized software for the optimal path for various metrics is developed for any number of hops of any structured network. The results are verified using various number of nodes with different network configurations. This technique can be apply to various practical problems such as network analysis, designed to assist in the network planning, network scheduling and controlling of large complex network projects.

The algorithm can be extended to the real world practical problems such as to optimize the cost and resource allocation in construction of a bridge, highway, power plant, repair and maintenance of an oil refinery, design, development and marketing of a new product, research and development works. This can be extended to multi optimal path in network accounting either one or more number of matrices.

ANN based single server queuing model is discussed and the developed model is more efficient to address the problem of the network congestion. Practical designers are well aware that the choice of least delay path takes to account of the delays imposed by congestion. The generalized performance of various parameters in network congestion using single server queue model Neural network is analyzed. Obtained maximum traffic intensity without loss of the data, without congestion for the arrival rate and service rate is shown in Table 5. From the above results throughput of the system is increased to the maximum value.This bringing the phenomenon out of designer frame work in network congestion. Using the above model the network congestion eliminated completely with maximum throughout with out loss of the data's. This can be extended to any number of server systems with any network.

The proposed neural model combines many features, such as quick convergence and an ability to operate in real time and to adopt changes in network topology and link. From the simulation results, it can be concluded that the proposed model is both efficient and effective in handling of network congestion. This study proposes a simple approach for Queuing modeling using BPN algorithm. This technique has potential future in the field of communication network.

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