International Journal of Emerging Engineering Research and Technology
Volume 2, Issue 8, November 2014, PP 150-154
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Probabilistic Intelligent Routing Scheme for Optical Networks

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Abstract: *An optical network is a collection of optical nodes hosts forming a temporary network with the aid of centralized ministration or standard support services. In such an environment, routing is one of the most important issues that have a significant impact on the network's performance. An ideal routing algorithm should strive to find an optimum path for packet transmission within a specified time so as to satisfy the Quality of Service. In this paper a probabilistic routing algorithm for solving the routing problem in a distributed optical networking scheme is presented. The algorithm is based on Probabilistic routing Algorithm for the selection of appropriate routes under dynamic traffic conditions.*

Keyword: *Dynamic traffic, Optical Network, Probabilistic routing Algorithm.*

1. Introduction

Optical networks are widely deployed due to their flexible structures, where the energy efficiency is one of the primary metrics of interest since most nodes in -optical optical networks are battery-powered. It is costly and sometimes impossible to replace or recharge the batteries of nodes in some complex scenarios, such as, battlefields and emergency relief scenarios. To this end, nodes in optical networks should be enabled to manage efficiently their energy consumption to prolong the network lifetime. The energy consumption of each node varies according to its communication state: transmitting, receiving, listening or sleeping state [2]. In [3], the authors conducted some measurement on the energy levels consumed during the different nodes communication states. Consequently, the ratios between the listening, receiving and transmitting states are described as: 1: 1.05: 1.4. In [4], the authors described the same ratios as: 1: 1.2: 1.7. Note that the energy consumed for listening the rio environment is not negligible and a node consumes the least energy when it is in the sleeping state, thus putting as many as possible idle nodes (which do not transmit, receive, or forward data) into sleeping state will save energy of these nodes. Optical transmission is solely used in -optical networks [5], therefore the total energy consumed for end-to-end communications increases as a function of both the number of relaying nodes and each individual transmission distance (d), where nodes consume energy in a nonlinear fashion with transmission distance according to dn (n is the power index of the channel path loss and usually $2 < n < 4$). Therefore, if the hop number is small (while the transmission distance is large), the energy consumed for one-transmission increases nonlinearly. Alternately, if the hop distance is small (for the same overall end-to-end distance), the energy consumption will be dominated by the electronic energy cost in the transceivers and therefore the total energy increases almost linearly as a function of the hop number (where the hop number is large). There is a tread off between hop number and transmission range of each hop to get the optimal energy efficient.

In Optical networks, such as the SONET and the Distributed Nodes-optical Networks, routing is one of the most important issues that have a significant impact on the network's performance [1], [2]. An ideal routing algorithm should strive to find an optimum path for packet transmission within a specified time so as to satisfy the Quality of Service (QoS) [2]–[4]. There are several search algorithms for the shortest path (SP) problem: the breth-first search algorithm, the Dijkstra algorithm and the Bellman–Ford algorithm, to name a few [1]. Since these algorithms can solve SP problems in polynomial time, they will be effective in fixed infrastructure optical or wired networks. In this paper, a PR based approach is proposed for solving the SP routing problem. Variable-length sequences have been employed. Their elements represent nodes included in a path between a designated pair of source and destination nodes. The crossover exchanges partial sequences (partial-routes) and the mutation introduces new partial sequences (partial-routes). Lack of positional dependency in respect of crossing sites helps maintain diversity of the population.

2. PROBABLISTIC ROUTING ALGORITHM

The underlying topology of optical networks can be specified by the directed graph, G = (N, A), where N is a set of N nodes (vertices), and A is a set of its links (arcs or edges) [1]–[4]. There is a cost C_{ij} associated with each link (i,j) . The costs are specified by the cost matrix C= [C_{ij}], where C_{ij} denotes a cost of transmitting a packet on link (i,j). S and D denote source and destination nodes, respectively. Each link has the link connection indicator denoted by I_{ij}, which plays the role of a sequence map (masking) providing information on whether the link from node to node is included in a routing path or not. Using probabilistic routing algorithm technique for SP route problem does result in most optimal or even the best possible solution, thus utilizing it efficiently would give a better prospective to the communication modeling.

3. SYSTEM MODEL

A sequence of the proposed PR consists of sequences of positive integers that represent the IDs of nodes through which a routing path passes. Each locus of the sequence represents an order of a node (indicated by the gene of the locus) in a routing path. The gene of first locus is always reserved for the source node. The length of the sequence is variable, but it should not exceed the maximum length, where is the total number of nodes in the network, since it never needs more than number of nodes to form a routing path. A sequence (routing path) encodes the problem by listing up node IDs from its source node to its destination node based on topological information database (routing table) of the network.

An example of sequence (routing path) encoding from node S to D node can be visualized as list of nodes represented as sequence along the constructed path, (S → N1 → N2 → … →N_{k-1} → N_k → D). and l as the total number of nodes forming a path. The fitness function in the SP routing problem is obvious because the SP computation amounts to finding the minimal cost path. Therefore, the fitness function that involves computational efficiency and accuracy (of the fitness measurement) is defined as follows:

$$f_i = \frac{1}{\sum_{j=1}^{l_i - 1} C_{g_i(j), g_i(j+1)}} \tag{3}$$

where, f_i represents the fitness value of the i^{th} sequence, l_i is the length of the i^{th} sequence,$g_i(j)$ represents the gene (node) of the j^{th} locus in the i^{th} sequence, and C is the link cost between nodes.

The decision model can now be formulated, In general, standard deviation can be thought of as the probabilistic “width” or “spre” of distribution of a random variable. Hence, (i.e., the standard deviation of BBs) indicates the “statistical length” or “spre” of fitness values of BBs from their average fitness value; indeed, the factor represents the total average range of fitness changes of all the BBs. In the SP routing problem, only statistical point of view is meaningful since all the domain-dependent variables are time varying due to the changes in network topology consequent on factors such as link failure, congestion, and mobility (power on or off in wired network). Considering the factors the probability of making the correct decision on a single trial is given by:

$$p = \Phi\left(\frac{2}{\sqrt{2m'}\,(\chi^k - 1)}\right) = \Phi\left(\frac{2}{\sqrt{2m'}}\right).$$

Where Φ is the cumulative distribution of a normal distribution with zero mean X is the average cardinality of the alphabet, and k is the average order of BBs and m’ is the total correlated noise.

The PR succeeds when all the n members of the population In the BBs of interest are correct. From a well-known result in the gambler’s ruin (one-dimensional random walk) literature, it follows that the probability $P_{bb}(x_0)$ that the PR eventually succeeds when there are x_0 initial correct BBs is

$$P_{bb}(x_0) = \frac{1-\left(\frac{q}{p}\right)^{x_0}}{1-\left(\frac{q}{p}\right)^{n}}$$

where, q= 1- p is the probability of losing a copy of the BB in a particular competition. The probability that the PR succeeds can be formed by

$$n = -\frac{\chi^k}{2}\cdot\ln(\alpha)\cdot\left(z^{-1}\sqrt{\frac{\pi}{2}}+1\right) = -\frac{\chi^k}{2}\cdot\ln(\alpha)\cdot\left(\frac{\chi^k-1}{2}\cdot\sqrt{\pi m'}+1\right)$$

where $\alpha = 1 - P_{bb}$ is the probability of PR failure.

The possibility of finding a shortest path will be quite high when each node chooses a lowest/best-cost node among its own neighbors as a forward node in a route (as happens in a greedy algorithm). It is well known that locally optimal selections may be misaligned. These reflect interdependence among BBs. The idea is to make an attempt to spread this potential (to mislead) over the average length of sequences, and thereby weaken it. The sequences can then be modeled as independent BBs.

4. IMPLEMENTATION

The objective (as stated above) is to minimize the SP routing problem. To do so, delay at every node is calculated and the node having minimum delay is selected and hence, these routes are utilized to minimize the delay efficiency.

The steps for computation can generalized as:

Step 1 The constraint limits is set for the SP route.

Step 2 Random values are generated between limits.

Step 3 The values of generated routes are put into the objective function

Step 5 The fitness evaluation is done for the various routes selected computed

```
fmax (n, 1) = max (fx (n, 1))
fmin(n,1) = min(fx(n,1)
for i=1:z
   ft(i,1) = (fmax(n,1) - fmin(n,1)) - fx(n,1);
end
ftb = mean (ft);
for i=1:z
   rl (i, 1) = ft (i, 1)/ftb;
end
```

Step 6 The best fit is calculated based on the equation above.

Step 7 Selection based on the roulette wheel concept is done, the values providing the best fit being given a higher percentage on the wheel area so that values providing a better fit have higher probability of producing an offspring.

Step 8 Crossover is performed on strings using midpoint crossover. Crossover provides incorporation of extra characteristics in the off springs produced.

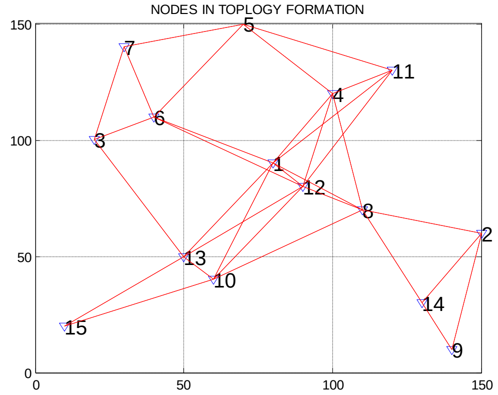
Step 9 Mutation is done if consecutive iteration values are the same

Step 10 The new routes that satisfy the objective of minimization of reactive power loss and the corresponding losses are tabulated.

Where : Fx is the fitness value; ft=normalized fx,

5. RESULTS

The simulation studies involve the deterministic, weighted network topology (with 20 nodes). The optimal path derived is shown below.



With a view to focus exclusively on fair comparison of algorithms on the basis of performance, the population size is taken to be the same as the number of nodes in the network.

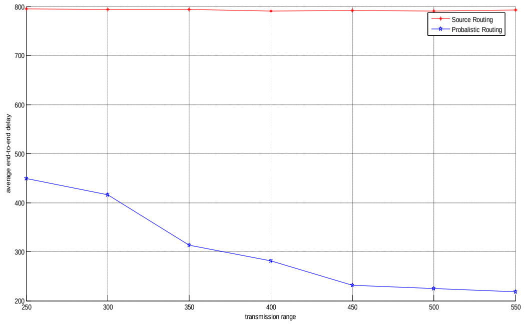


Fig. 6. *Average end to end delivery delay Vs range.*

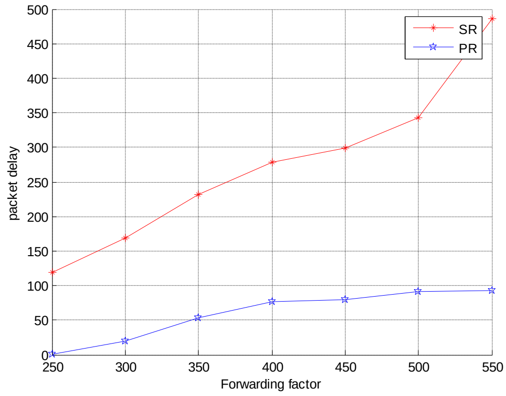


Fig 7. *Packet delivery and Forwarding factor.*

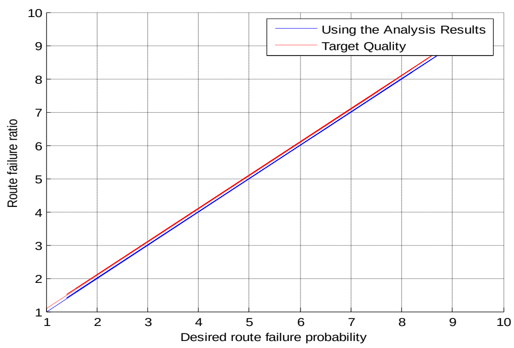


Fig. 10. *Desired route failure probability versus route failure ratio.*

6. CONCLUSION

Optical networks, also known as short-lived networks, are autonomous systems of nodes nodes forming network in the absence of any centralized support. This is a new form of network and might be able to provide services at places where it is not possible otherwise. Absence of fixed infrastructure poses several types of challenges for this type of networking. Among these challenges is routing. This paper presented a probablistic routing algorithm for solving the SP routing problem. The proposed algorithm can search the solution space effectively and speedily compared with other extant algorithms. The population-sizing equation appears to be a conservative tool to determine a population size in the routing problem.

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