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Performance Evaluation of Routing Algorithm for WDM Optical Network under Congestion Aware Strategy

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ABSTRACT

WDM optical networks being high speed networks provide very high data rate for transmission. In WDM technology, the data is carried from source node to destination node as a wavelength signal. Many such signals are multiplexed and transmitted through fibers. At the other end the signals are demultiplexed. WDM technology and routing algorithm is backbone of optical fiber which has huge information carrying capacity. In current paper, a comparative analysis of various routing algorithm used in optical network has been performed. The strategies investigated are Shortest Path (SP), Congestion Aware (CA1) and Weighted Congestion Aware (CA2) routing algorithm. We evaluated their performance by performing simulation in MATLAB environment under the various network parameters such as number of demands, blocking probability and number of wavelength on the regular network topologies like NSFNET and EON. Based on result, it has been conclusively established that Weighted Congestion aware Routing Algorithm (CA2) is having fewer Network blocking probability.

Keywords: WDM Optical Network, Routing Algorithm, Congestion aware, Weighted Congestion aware, Blocking Probability, Matlab environment.

1. INTRODUCTION

Optical networking uses light for communication among various nodes. It is consists of a light source such as lasers or LED, an optical amplifier for amplification and WDM technique to transmit large data through fiber optic cables. As it can have high bandwidth, can be used for internet and other communication networks to transmit human and machine-to-machine information. The main problem in optical communication is to find route for lightpath and assigning wavelength for that path which is referred as Routing and Wavelength Assignment problem (RWA).

The network should uses minimum amount of network resources and ensure that same wavelength is not assigned to the same lightpath. The RWA problem can be considered fewer than two different traffic assumptions. The static RWA problem applies to the case in which the set of connections is known in advance, and a light path must be established for each connection. In the dynamic RWA problem, connections are established dynamically and then get departed because of which lightpath has to establish dynamically. In both the static and dynamic RWA problems, the routing component and the wavelength assignment component of the problem are often decoupled into two separate sub problems in order to make the problem more tractable.

Dynamic routing in WDM (Wavelength Division Multiplexing) networks has been evolving keen interest due to the expected traffic growth for future optical networks [1]. In dynamic routing the routes are determined in accordance with the current state of the networks that depends on the active connections. The route to traffic data between the request nodes are decided dynamically on the basis of the current traffic status and available resources (wavelength). In static routing requests are known in advance, and the routing and wavelength assignment operations are performed off-line [2]. The most straight forward approach to routing connection is to always choose the same fixed route for a given source-destination pair for example fixed shortest-path routing [3].

2. RELATED WORK

Seb J.Savory et. al have analyzed the blocking probability of congestion aware routing in a nonlinear elastic optical network and demonstrated its efficiency for the NSFNET reference network (14 nodes, 22 links) [4]. Greedy heuristics for the wavelength-assignment problem for a static set of light paths typically involve ordering the wavelengths, and assigning the same wavelength to as many light paths as possible before moving on to the next wavelength is discussed in [5]. In [4], the author have proposed shortest-hop path between source-destination pair that is randomly chosen considered individually, and the route for the pair of nodes is switched to an alternate shortest-hop path that results in a reduction of load on the most heavily loaded link in the original shortest-path route. In [6], an approach similar to that in [4] is considered; however, the objective is to minimize the number of fibers in a multi-fiber network, and the set of alternate paths includes routes which may be longer than the shortest-hop routes.

Mitra et. al. presented an algorithm for assigning a wavelength optimally in a tree topology to maximize on-hop traffic [1]. They have shown that in case of a general graph where multiple wavelengths are available, this heuristics scheme performs better than one of the best known existing heuristic algorithms with respect to maximizing on-hop traffic. Mukherjee et. al reviewed various strategies for the routing and wavelength assignment (RWA) in wavelength-routed optical WDM networks. Most of the attention is devoted to such networks operating under the wavelength-continuity constraint. In which light paths are set up for connection requests between node pairs, and single light path must occupy the same wavelength on all of the links that it spans [2]. Li et. al. have investigated Forward Error Correction (FEC) used in optical communication systems to compensate for the degradation of the received optical signal to noise ratio (OSNR). Current optical networks tend to use the same type of FEC for all the light paths even though light paths with higher OSNRs can be established by FECs with lower overhead. This paper proposes an adaptive approach to choose the most efficient FECs for different light paths based on their individual OSNRs [7].

In order to estimate the network blocking probability (NBP), the author of paper [8] have proposed the methodology of sequentially loading the network with bi-directional demands between randomly selected pairs of nodes in the network. Praphan et. al. have proposed a routing and wavelength assignment scheme for the WRMD mesh network that minimizes the number of required wavelengths for light path establishment [9]. Yabin Ye et. al. [10] have developed a technique to setup light paths and turn down dynamically to free some of the transceivers in optical nodes. These spare transceivers can also be used for regeneration or wavelength conversion.

3. PROBLAIM DOMIAN

In Optical Network communication systems, when the signal is transmitted from sender to receiver, it suffers from many phenomenon like wavelength assignment, routing algorithm, and most importantly selection of path between sources to destination based on various routing algorithm used. Normally in the simple routing algorithm for optical network which are based on Dijkstra, which may be considered is the effect of congestion while travelling in the optical network which is basically the increase of blocking probability. All these are most serious contaminants to our signal which affects our optical network blocking probability. It affects the reliability of transmission. So the important parameters of simulator requires such as the number of nodes, number of wavelengths per link, connection requests etc. All these parameters are been initialized before running the simulations to obtain results for a given selection of parameters. Network Blocking Probability (NBP) defines that how much data can be achieved while wavelength or demand is fixed. It is also related to routing algorithm efficiency when it is used in optical network.

4. PROPOSED SOLUTION

We have discussed about the problems and the paper is focused to overcome these problems. Congestion Aware Routing Algorithm (CA1) and Weighted Congestion Aware Routing Algorithm (CA2) are implemented and compare with Dijkstra algorithm. This two algorithm is used to overcome the effect of Network Blocking Probability. Shortest Path (SP) Routing is first allocate the optical spectrum than two congestion aware CA1 and CA2 variants are applied. CA1 algorithm selects the shortest path implemented with Dijkstra's algorithm where the edge weight for the most congested path has been replaced by infinity. In CA2 Routing Algorithm, the shortest path through a weighted network, where the weight of an edge joining nodes i and j is given by $W_{ij}= L_{ij} /\eta_{ij}$where $L_{ij}$is the physical length and $\eta_{ij}$is the proportion of the total spectrum which is still available on that edge.

Shortest path (SP) routing algorithm first selected shortest path between source to destination node by Dijkstra Algorithm. After that path is created, data is transfer from source to destination. Because of only one path is available for all data transformation so its Network blocking Probability is high while the traffic is high in between source to destination node.

Congestion aware (CA1) routing algorithm work when the traffic is high in between source to destination node, then alternate route is create from source to destination node. This alternate route is based on hope count and Dijkstra algorithm. Due to this route, its Network blocking Probability is low as compare to SP. CA2 routing algorithm work when the traffic is high in between source to destination node and then alternate route is create that result NBP lower as compare to SP and CA routing algorithm.

5. RESULTS AND ANALYSIS

Following assumptions has been made for developing an efficient Routing Algorithm for WDM optical network.

- Each link in the network is bidirectional.
- Each node has the same number of wavelengths.
- Point-to-point traffic.
- A Set of random request is generated.
- For each possible source-destination request path is create.

The simulation is done in MATLAB in which input parameters are number of nodes, number of wavelengths per node, connection requests etc. and network blocking probability is taken as output parameter. All these parameters are been initialized before running the simulations to obtain results for a given selection of parameters. The two basic network topologies NSFNET (National Science Foundation Network) (14node, 22links) and EON (European Optical Network) (11node, 25links) Network are taken, on which various routing algorithm strategies such as SP, CA and WCA are tested and analyzed. NSFNET and EON topology is shown in figure 1 and 2 respectively.

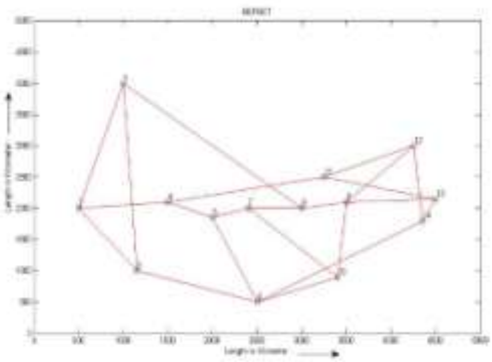

Fig. 1: NSFNET Topology

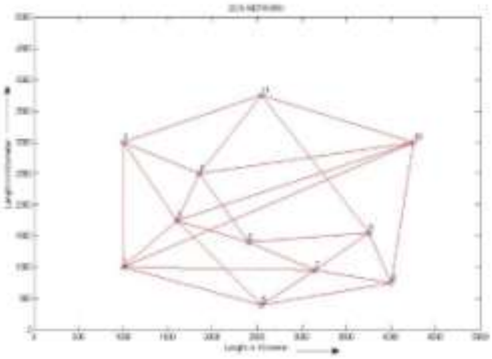

Fig. 2: EON Topology

5.1 By Varying Wavelength

In this case, the wavelength is vary by keeping the demand at a value of 50, 100 and 150 for both the topologies.Figure 3 and 4 shows that NBP versus wavelength for both the network with demand of 50 at node. It is observed that as the wavelength is increases at a node, the blocking probability is decreases for both the topology. The blocking probability of CA2 is less as compared to other strategies.

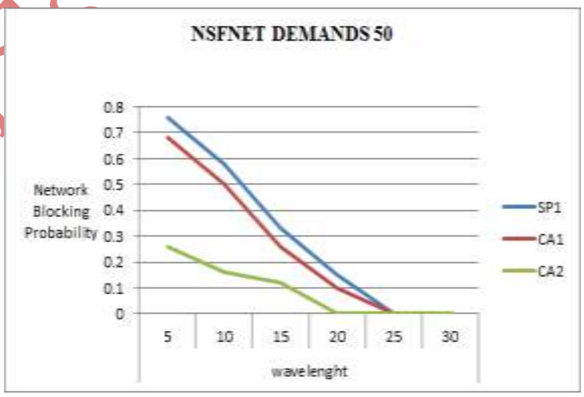

Fig. 3: Blocking probability verses wavelength per node for NSFNET Network with 50 demand

Fig. 4: Blocking probability verses wavelength per node for EON Network with 50 demand

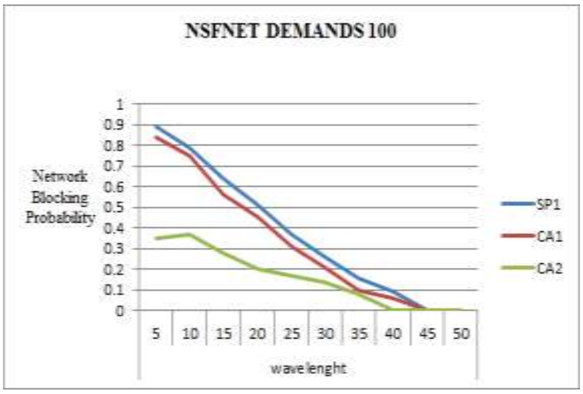

Fig. 5: Blocking probability verses wavelength for NSFNET Network with 100 demand

Figure 5 and 6 shows the blocking probability for both network with demand 100 while figure 7 and 8 with demand 150. The results shows that NBP for CA2 is less with varying wavelength.

Fig. 6: Blocking probability verses wavelength for EON Network with 100 demand

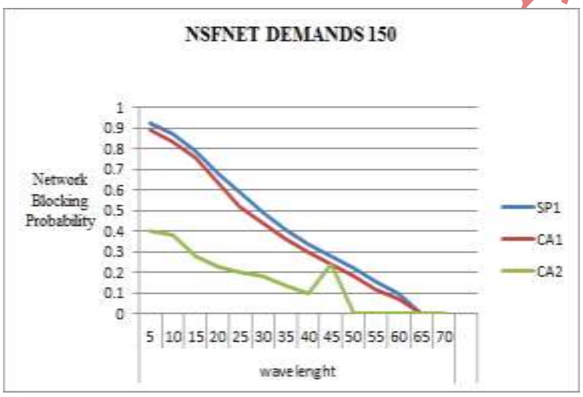

Fig. 7: Blocking probability verses wavelength for NSFNET Network with 150 demand

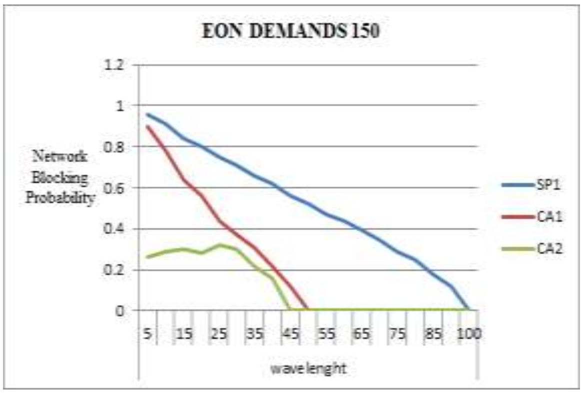

Fig. 8: Blocking probability verses wavelength for EON Network with 150 demand

5.2 By Varying Demand

Here the demand is vary by keeping the wavelength at values of 50, 100 and 150 respectively. Figure 9 and 10 shows the NBP versus number of demands for 50 wavelength for both the network. Also the blocking probability increases with the increase in the number of demands. The performance of CA2 is better among the other two algorithms.

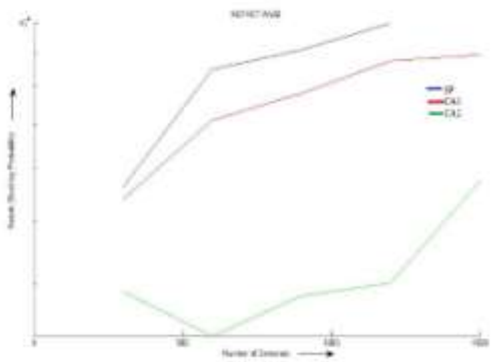

Fig. 9: Blocking probability verses demands for NSFNET Network with 50 wavelength

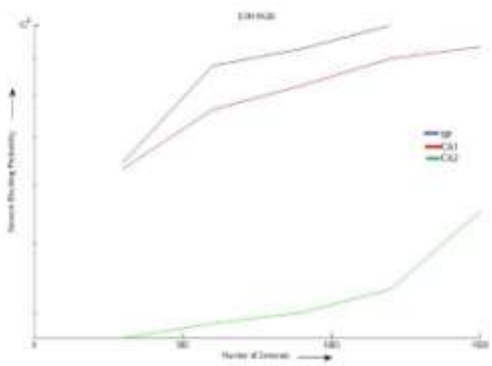

Fig. 10: Blocking probability verses demands for EON Network with 50 wavelength

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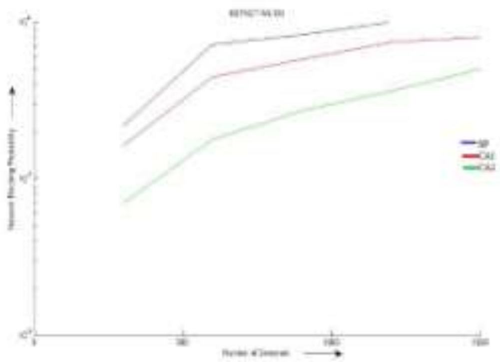

Fig. 11: Blocking probability verses demands for NSFNET Network with 100 wavelength

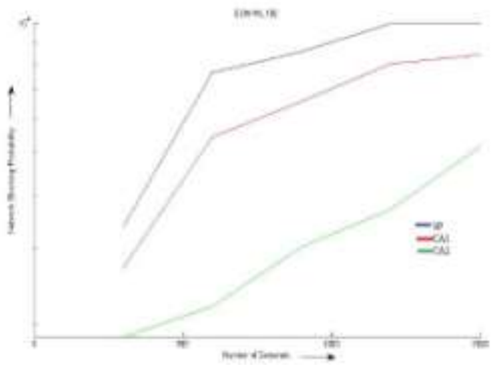

Fig. 12: Blocking probability verses demands for EON Network with 100 wavelength

Figure 11 and 12 shows the NBP versus number of demands with 100 wavelength while figure 13 and 14 for 150 wavelength for NSFNET and EON network. It is observed the NBP of CA2 is showing best performance as compared to SP and CA1.

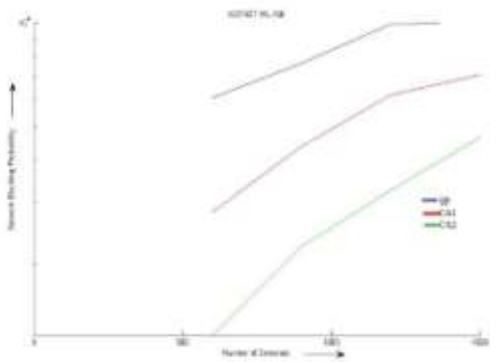

Fig. 13: Blocking probability verses demands for NSFNET Network with 150 wavelength

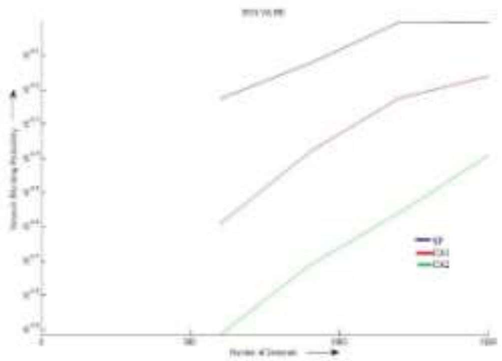

Fig. 14: Blocking probability verses demands for EON Network with 150 wavelength

6. CONCULSION AND FUTURE SCOPE

Based on the simulation result, it is concluded that Weighted Congestion Aware (CA2) Routing Algorithm is having least Network Blocking Probability while Shortest Path Routing Algorithm showing worst Network Blocking Probability in case of varying wavelength as well as varying number of demands.

The above discussed strategies can be investigated for other real networks such as ARPANET (11 node, 23 links), NJLATA (11 node, 23 links), USA (24 nodes, 43 links) and other optical networks.

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