Evaluate the Blocking performance for "All Optical wavelength routed WDM networks with and without wavelength converters" using the iterative path decomposition algorithm

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ABSTRACT

Wavelength-routed networks can effectively utilize the bandwidth of the optical fibers. Wavelength converters help to reduce the blocking probability of the network and enhance the fiber utilization. We use the iterative path decomposition algorithm to evaluate accurately and efficiently the blocking performance of 14-node NSFNet with and without wavelength converters. The iterative algorithm analyzes the original network by decomposing it into single-path subsystems. These subsystems are analyzed in isolation, and the individual results are appropriately combined to obtain a solution for the overall network.

Keywords Wavelength-routed optical networks, wavelength converters, path decomposition algorithm, Wavelength Division Multiplexing

INTRODUCTION

Wavelength Division Multiplexing (WDM) is a promising technique to utilize the huge bandwidth of the optical fiber effectively, the next generation of WDM network is referred to as wavelength-routed all-optical WDM network [1], which is very likely to serve as the backbone of the wide-area networks (WAN) and metropolitan-area networks (MAN) by providing lightpath services to the upper network layers, e.g. SONET/SDH, ATM. 10Gb Ethernet or IP. Wavelength conversion technology and wavelength converters play an important role in enhancing fiber utilization and in reducing the overall call blocking probability of the wavelength-routed all-optical WDM network. Wavelength conversion eliminates the wavelength continuity constraint and thus improves the blocking performance significantly [2].

One of the primary design objectives of wavelength-routed all-optical networks is to minimize the blocking probability. In a network without wavelength converter nodes, it is required that data for a call arriving at the input port of a node on one wavelength has to be switched to an output port of the node at the same wavelength. To satisfy such a connection request for a call, it is necessary that the connection path which is setup from the source to the destination has a free wavelength on its entire links. This requirement is called the *wavelength continuity* con*straint* and results in increasing the probability of a call being blocked. On the other hand, it has been shown in [3] that wavelength converters improve the performance of wavelength-routed networks in terms of blocking probability. Wavelength-routed networks can effectively utilize the bandwidth of the optical fibers. Wavelength converters help to reduce the blocking probability of the network and enhance the fiber utilization [4]. Path Decomposition Approach represents a simple and computationally efficient solution to the difficult problem of computing call-blocking probabilities in wavelength-routing networks especially for large mesh networks where arbitrarily long paths expected [5]. The iterative algorithm computes the blocking probabilities by decomposing a path into a series of shorter segments connected in tandem. Once the path subsystems have been analyzed in isolation, the individual solutions are appropriately combined to form a solution for the overall network, and the process repeats until the blocking probabilities converge.

RELATED WORK

Wavelength conversion can eliminate the wavelength continuity constraint and thus improve the blocking performance significantly [6]. Kovacevic and Acampora investigated the blocking performance in WDM networks with and without wavelength converters in [7]. Birman introduced a reduced load approximation scheme to calculate the blocking probabilities for fixed shortest path routing in arbitrary topologies [8], which showed that the blocking probabilities grow with the number of hops much faster than for circuit-switched telephone network due to the wavelength continuity constraint. This result has also been exposed by Barry and Humblet [9]., Harai et al. proposed the fixed alternate routing algorithm [10] and investigated its performance by extending Birman's analytical model. The fixed-alternate routing algorithm can improve the blocking performance by introducing more routes between each pair of nodes. If there is no available wavelength on the primary route, an alternative route will be tried. Thus the traffic potentially can be distributed to more fiber links, and the overall blocking performance can be improved. A new analytical technique for the analysis of all-optical networks without wavelength conversion has been proposed in [11]. This technique is based on the inclusion-exclusion principle from combinatory, and it can also be extended to analyze fixed-alternate routing algorithms. The effect of all optical wavelength converters on the performance is studded in static-routing circuit-switched networks with different topologies. It is shown that there is no significant performance improvement when the optical wavelength converters are used in centralized switch or ring topology networks. However, it also shown that the optical wavelength converters significantly improve performance of large mish networks.

PATH DECOMPOSING APPROACH

We analyze a mesh network by decomposing it into a number of subsystems where each subsystem is a single path. Each subsystem is analyzed in isolation using the algorithms developed in [5]. A path decomposition approach is a simple and computationally efficient solution to the difficult problem of computing call-blocking probabilities in wavelength-routing networks. We study a class of circuit-switched wavelength-routing networks with fixed routing and with random wavelength allocation and apply it to the practical mesh optical network. We use the iterative path decomposition algorithm to evaluate accurately and efficiently the blocking performance of such networks with and without wavelength converters. The first step in analyzing a given network is to decompose it into a set $R^{\backslash} \sqsubseteq R$ of the paths such that: (1) no path $r \in R^{\backslash}$ is contained within a path q∈ R, q≠ r and (2) any path q∈ R either belongs to $R^{\backslash}$ or is completely contained within a path $r \in R^{\backslash}$. These two requirements ensure that a minimal set of sub-systems that includes all possible paths is used. We can construct such a set $R^{\backslash}$ by using the following steps. First, the paths *in R* are stored in a list in order of decreasing length. The first path *r* that are also in the list is removed and inserted in $R^{\backslash}$. Then any sub-paths of *r* that are also in the list are removed from it. The process continues with the next path in the list and is repeated until the list becomes empty. It is straightforward to show that this algorithm will construct a set $R^{\backslash}$ which satisfies the above two properties. Table (1) Determining the Shorts path route for 14-node using Dijkstra Shortest path method which compute path between two edges in a directed/undirected network using the algorithm used by T. E. ***Cormen*** (12). Table (2) shows the Creating the composted route for 14 nodes NSFNET according to above roles.
The simulation in this section has been carried out using Mat lab computer program with the help of a tool box called Blocking computations in WDM networks tool box presented by Przemyslaw.[13]

BLOCKING PERFORMANCE ANALYSIS FOR 14 NODE NSFNET

In this section, we analyze the 14 node NSFNet network by decomposing it into a number of subsystems where each subsystem is a single path. Each subsystem is analyzed in isolation using the algorithm. We will process the blocking simulation for the 14 node NSFNET as the following Simulation steps.

a. Create network and store it in Mat-file
b. Create load for that network(either uniform or non uniform traffic loads
c. Determine the shortest paths using ***Dijketra`s algorithm*** for the loaded network.
d. Use ***Birman*** analytical model to find the blocking of the shortest path.
e. Find the decompose paths and determine its blocking.
f. Draw the blocking performance for a certain decompose path.(e.g. one hope path and two hops path
g. Determine the overall blocking performance using only the decompose paths

Creating a simulated 14 node NSFNET

We use the script given by ***Cormen*** in [12]. First, script asks the user to input simple description about the saved network. Second, it asks to input incident nodes and wages for every NODE in the network. Every input has to be divided by spaces. Wage for a given node has to be given in the same sequence as the corresponding incident node. Both inputs must have same length. It is possible to input only incident nodes without wages (script asks the user if he wants to do such). User cannot input network structure with isolated nodes (each input cannot be empty). Edge inputs have to be positive integers.

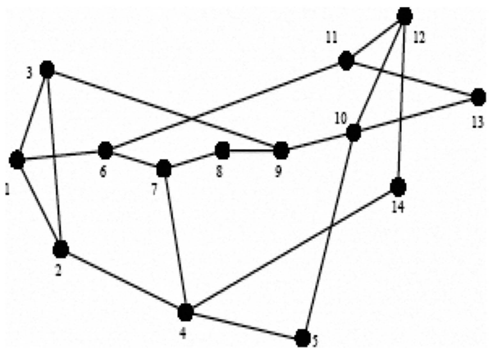

Figure (1.a) 14-Node NSFNet

(Physical topology)

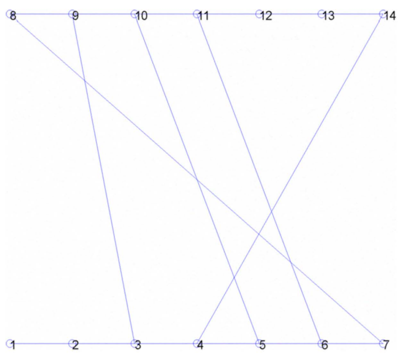

Figure (1.b) 14-Node NSFNet created by Simulation

Determine the shortest path routs for 14 nodes NSFNet

"Dijkstra's Shortest Path Search algorithm is a clever and relatively efficient way to search for shortest paths between nodes. The algorithm finds the shortest paths from a specified start node to any other reachable node (or all reachable nodes) for graphs with positive weights (or costs, or distances) between nodes. After saving the "14-nade NSFNST" network in a Mat file, we use script used by Corman [12] for computing the shortest path between begin and end node using Dijketra`s algorithm.

4. 4Determining the path decomposing approach for the 14 node NSFNET

Table (1) Determining the Shorts path route for 14-node using Dijkstra Shortest path method which compute path between two edges in a directed/undirected network using the algorithm used by T. E. ***Cormen*** (12).

Table (2) shows the Creating the composted route for 14 nodes NSFNET according to above roles.

Determine the blocking probability for composite route for 14 nodes NSFNET

The iterative algorithm analyzes the original network by decomposing it into single-path subsystems. These subsystems are analyzed in isolation. In the case of short paths (three links or less) simulation is used to computes blocking probability using generalized reduced load approximation method first introduced by Kelly [14], extended by Chung et al. and implemented for WDM network by Birman [8] (full and no wavelength conversion) and Tripathi [15] (sparse wavelength conversion) by applying an approximate Markov process model, In the case of longer paths, these subsystems are analyzed by decomposing them into shorter segments. Results from individual subsystems are combined to obtain a solution for the overall network.

After computing the decomposed routes, we can now compute the blocking probability for a certain decomposed path against traffic offered at that route.

Figure (٢.a) show an example for this plot using 3-hope rout (10, 12, 14),

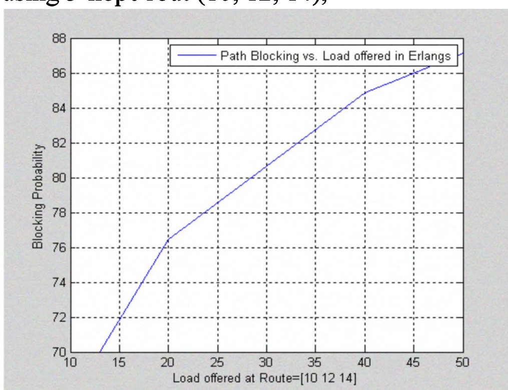

Figure (2.a) 2-hope path blocking for different traffic loads in 14 node NSFNet (route 10 12 14 as example) in the no conversion case

figure (٢.b) show an example for this plot using 2-hope rout (1,3,). We can observe from the figures that increasing the number of nodes in the path increases the blocking probability for the non convertible nods, full convertible nods gives better blocking performance than non convertible nods, we can also observed that calls established over longer paths tend to experience higher blocking probability than calls using short paths. Using converters, the blocking probability is significantly lower than when there is no converter. Both these results are expected

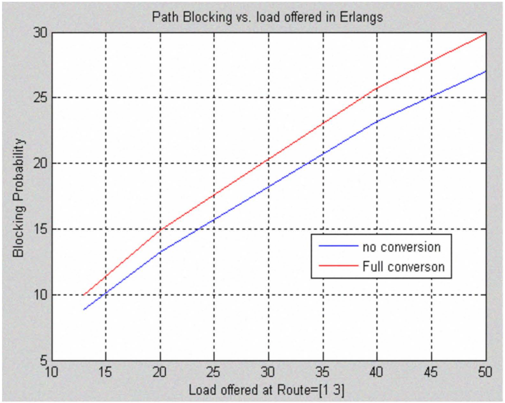

Figure (2.b) 1-hope path blocking for different traffic loads in 14 node NSFNet (route 1 3 as example) in both no conversion and conversion case

OVERALL BLOCKING PERFORMANCE

Each path acts as a sub system in the whole network and its path decomposition blocking is calculating. These subsystems are analyzed in isolation, and the individual results are appropriately combined to obtain a solution for the overall network, Figure (4.11) shows the overall blocking performance for the 14-node NSF Net network using A path decomposition approach, normally we use number of chandelles from 8 to 12 frequency to achieve a good blocking performance .W use one wavelength just for demonstration the simulation needs also a high computational process and needs much time for evaluation

CONCLUSION

We have used a path decomposition algorithm to simulate accurately and efficiently the call-blocking performance of wavelength-routing networks for 14 nodes NSF net. Using this algorithm relax the complicated process for computing the performance of large mesh networks with long paths which needs large processing capabilities.

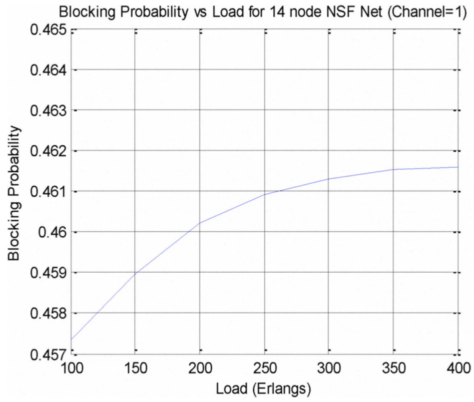

Figure (3) Overall blocking probability for 14 node NSF Net

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Appendix

Route No.	Shortest Path route
1	1 2
2	1 3
3	1 2 4
4	1 2 4 5
5	1 6
6	1 6 7
7	1 6 7 8
8	1 3 9
9	1 3 9 10
10	1 6 11
11	1 6 11 12
12	1 6 11 13
13	1 6 11 12 14
14	2 3
15	2 4
16	2 4 5
17	2 1 6
18	2 4 7
19	2 4 7 8
20	2 3 9
21	2 4 5 10
22	2 1 6 11
23	2 4 5 10 12
24	2 4 5 10 13
25	2 4 5 10 12 14
26	3 2 4
27	3 2 4 5
28	3 1 6
29	3 2 4 7
30	3 9 8
31	3 9
32	3 9 10
33	3 1 6 11
34	3 9 10 12
35	3 9 10 13
36	3 9 10 12 14
37	4 5

Route No.	Shortest Path Route
46	4 5 10 12 14
47	5 4 7 6
48	5 4 7
49	5 4 7 8
50	5 10 9
51	5 10
52	5 10 12 11
53	5 10 12
54	5 10 13
55	5 10 12 14
56	6 7
57	6 7 8
58	6 1 3 9
59	6 11 12 10
60	6 11
61	6 11 12
62	6 11 13
63	6 11 12 14
64	7 8
65	7 8 9
66	7 4 5 10
67	7 6 11
68	7 6 11 1
69	7 6 11 13
70	7 6 11 12 14
71	8 9
72	8 9 10
73	8 7 6 11
74	8 9 10 12
75	8 9 10 13
76	8 9 10 12 14
77	9 10
78	9 10 12 11
79	9 10 12
80	9 10 13
81	9 10 12 14
82	10 12 11
83	10 12
84	10 13
85	10 12 14
86	11 12
87	11 13
88	11 12 14
89	12 10 13
90	12 14
91	13 10 12 14

Table (1) Determining the Shorts path route for 14-node NSFNET

Route R (decreasingly)		R' (Decomposition Routes)
2 4 5 10 12 14	2 4 5 10 12 14	2 4 5 10 12 14
1 6 11 12 14	1 6 11 12 14	1 6 11 12 14
2 4 5 10 12		
2 4 5 10 13	2 4 5 10 13	2 4 5 10 13
3 9 10 12 14	3 9 10 12 14	3 9 10 12 14
4 5 10 12 14		
7 6 11 12 14	7 6 11 12 14	7 6 11 12 14
1 6 11 12		
1 6 11 13	1 6 11 13	1 6 11 13
2 4 7 8	2 4 7 8	2 4 7 8
2 1 6 11	2 1 6 11	3 2 4 5
3 2 4 7	3 2 4 7	3 2 4 7
3 9 10 13	3 9 10 13	3 9 10 13
4 5 10 13		
5 4 7 6	5 4 7 6	5 4 7 6
5 4 7 8	5 4 7 8	5 4 7 8
6 1 3 9	6 1 3 9	6 1 3 9
6 11 12 10	6 11 12 10	6 11 12 10
6 11 12 14		
7 6 11 13	7 6 11 13	7 6 11 13
8 7 6 11	8 7 6 11	8 7 6 11
9 10 12 14		
13 10 12 14	13 10 12 14	13 10 12 14
3 9 8	3 9 8	3 9 8
4 5 10		
5 4 7		
5 10 9	5 10 9	5 10 9
6 11 12		
7 8 9	7 8 9	7 8 9
11 12 14		
12 10 13	12 10 13	12 10 13
1 2		
1 3		
1 6		
2 3	2 3	2 3
11 13	11 13	11 13
12 14		

Table (2) Creating the composted route for 14 nodes NSFNet

Routes (Descendingly)	Blocking % - Load=90
2 4 5 10 12 14	29.356.392.472.402.100
1 6 11 12 14	25.473.622.373.298.100
2 4 5 10 13	25.142.953.595.830.500
3 9 10 12 14	2.375.580.491.796.960
7 6 11 12 14	25.912.033.293.563.800
8 9 10 12 14	2.565.138.141.236.490
1 2 4 5	195.440.433.575.031
1 6 7 8	1.762.234.249.950.060
1 3 9 10	1.834.284.809.275.130
1 6 11 13	19.562.213.793.723.200
2 4 7 8	17.286.814.293.729.900
2 4 5 10	16.301.095.014.316.700
2 1 6 11	18.110.176.836.301.800
3 2 4 5	19.179.435.371.676.300
3 2 4 7	18.943.107.184.337.900
3 9 10 12	13.967.756.961.336.300
3 9 10 13	1.701.098.983.893.940
4 2 3 9	1.860.327.668.094.950
4 5 10 13	18.606.652.373.385.000
5 4 7 6	1.708.094.383.236.380
5 4 7 8	1.824.626.346.334.350
5 10 12 14	1.743.175.736.769.270
6 1 3 9	18.886.269.071.271.600
6 11 12 14	1.868.937.947.724.240
7 6 11 12	16.530.154.440.030.900
7 6 11 13	20.176.767.594.508.100
8 9 10 12	16.086.011.731.202.800
8 9 10 13	1.929.917.173.245.290
9 10 12 14	16.380.037.931.051.400
3 1 6	902.604.813.129.554
5 4 7	9.205.964.396.288.880
6 11 13	8.994.777.344.540.110
11 12 14	8.919.600.489.427.220
1 6	7.361.512.341.500.220
11 12	6.885.969.377.190.760

Table 3 blocking % for only the 35 decomposed route in 14-node NSFNet for overall traffic load =90 Erlnag