Dynamic Traffic Grooming At Max Connectivity Nodes with Grooming Resources in WDM Optical Network

K. APARNA, P. KRISHNA KUMARI

***Abstract*—** Wavelength division multiplexing (WDM) optical networks with traffic grooming routes and consolidates sub-wavelength Connections onto light paths, to improve network usage and to reduce its Cost. It can be classified into dynamic or static depending on its connections that are given in advance or randomly arrive in/depart out. In this paper, an analytical model is developed for dynamic traffic grooming, allowing asymmetric data rates for sub-wavelength connections, arbitrary alternate routing in both physical and dynamic topologies, and arbitrary wavelength conversion. We propose Max Connectivity grooming in WDM mesh networks under Dynamic traffic light path connection requests. The wavelength and grooming conversion resources are placed at the nodes having maximum connections which are most cost effective compared to other grooming. We propose a heuristic genetic algorithm (GA) model which has to solve grooming problems with routing and wavelength assignment. To optimize the cost of grooming and wavelength conversion resources the GA algorithm has been used. The blocking probability was investigated under different light path connections. The performance of Max Connectivity grooming has been compared with other grooming policies. Our results in this paper indicate the improvement in resource utilization which has minimum blocking probability.

Keywords: wavelength division multiplexing (WDM), static and dynamic traffic grooming, genetic algorithm (GA), Max Connectivity grooming

I. INTRODUCTION

Network applications now-a-days provides users to interact, sharing of data and communicating with other members all over the network. As with the increasing data rates between the end users in the network, the electronic domain components are not able to support the wavelengths with high speed and are failing to support efficient multiplexing, thus the networks at the present generation are being replaced by the optical domain.

Manuscript received Nov, 2014.
K. APARNA, E.C.E, JNTUA College of Engineering, Pulivendula, Andhrapradesh.
P. KRISHNA KUMARI, E.C.E, JNTUA College of Engineering, Pulivendula, Andhrapradesh

Traffic grooming is defined as the technique used to combine low-speed traffic streams onto high-speed wavelengths in order to minimize the network- wide cost in terms of line terminating equipment and/or electronic switching. Now-a-days, the number of users is becoming more and more. So in order to sustain all users without any problems in communicating, the wavelength converters are placed at the nodes of the WDM network.

Thus the main objective of wavelength conversion with traffic grooming in dynamic is to minimize the network cost, maximize network throughput and thereby reducing the blocking probability of sessions.

1.1 TRAFFIC GROOMING:

Traffic grooming is the process of grouping many small telecommunications flows into larger units, which can be processed as single entities. There are two types of traffic grooming: static and dynamic traffic grooming.
Let us consider an example for traffic grooming as shown in figure below.

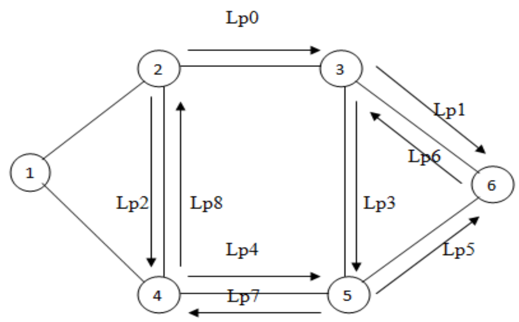

Fig 1: An example for grooming

In the above example, there are six nodes which are connected as shown. The lightpaths are assumed to have the data to flow from the requested traffic demand. The priority of lightpaths requests is assigned in which they have the high demand.

The physical topology of the above 6- node network and Table below contains the traffic demand matrix that we wish to handle. Here we have to design a logical topology with a minimum number of lightpaths that can handle all the traffic requirements.

The routing information is tabulated in table below

Table 1: Routing information for the given example

Lightpaths	Link(s)
Lp0	2-3
Lp1	3-6
Lp2	2-4
Lp3	3-5
Lp4	4-5
Lp5	5-6
Lp6	6-3
Lp7	5-4
Lp8	2-4

In the figure for physical topology above, the number near each arrowhead denotes the distinct link number assigned to the link associated with the arrowhead. The traffic matrix table is as shown below.

Table 2: Traffic matrix

Nodes	2	4	3	5	6
2	0	OC-3x2 OC-12x2	OC-6x3 OC-24x1	0	0
4	OC-3x1 OC-12x1	0	0	OC-3x4 OC-24x1	0
3	0	0	0	OC-6x4 OC-12x2	OC-6x4 OC-12x2
5	0	OC-3x2 OC-24x1	0	0	OC-12x1 OC-24x1
6	0	0	OC-3x2 OC-12x1	0	0

From the above traffic matrix, we create a commodity set Q as in Table 2 below, where every commodity is a triplet corresponding to a request, consisting of the source, the destination and the volume of data communication using the OC-n notation.

1.2 WAVELENGTH CONVERTERS

A device that converts data from one incoming wavelength to another outgoing wavelength is termed as wavelength converter. A device that can change the carrier wavelength of the channel without affecting its bit pattern that contains the information being transmitted.

Importance of Wavelength Converter

1. When the wavelength of the transmitted data from one network to the other network is not compatible, then converter is used on the boundaries of the different networks to make the connection possible.
2. Converter is used to increase the utilization of the network by using all the wavelengths in the network (if there is no wavelength continuity constraint).

2 GROOMING POLICIES

There are three grooming policies based on the placement of wavelength converters.

1. All grooming: The wavelength converters are placed at all nodes
2. Edge grooming: The wavelength converters are placed at edge nodes
3. Max Connectivity grooming: The wavelength converters are placed at Max Connectivity nodes

In the presence of wavelength converters at max-connectivity nodes, there exists more blocking probability compared to all grooming and less compared to edge grooming. But, the number of wavelength converters is reduced in order to reduce the cost of the network. Hence we prefer max- connectivity grooming than the all and edge grooming.

The LTE's and wavelengths for different sessions in the 8- node network by considering the request of four wavelengths can be studied as follows:

Table 3: LTE's and wavelengths for different grooming policies

Sessions	All grooming		Edge grooming		Max-connectivity grooming	
	LTE	WL	LTE	WL	LTE	WL
2	4	1	5	2	4	1
4	6	1	6	2	6	1
6	8	2	9	3	8	1
8	8	4	12	7	10	2
10	10	8	26	16	18	7
15	16	10	45	22	36	10
20	24	12	62	37	41	15

From the simulation result, the overall number of LTEs and wavelengths are required for different grooming policies are shown in figure below. The results of these simulations are shown in table above.

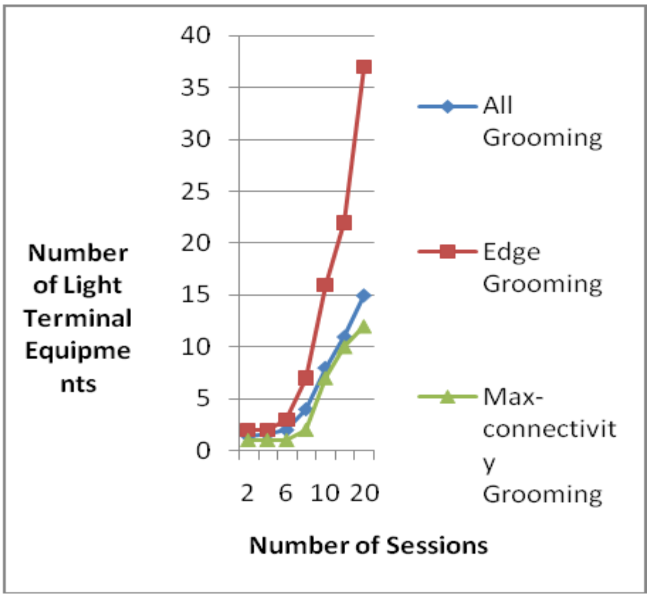

Figure 1: Variation of Number of LTEs with Number of sessions

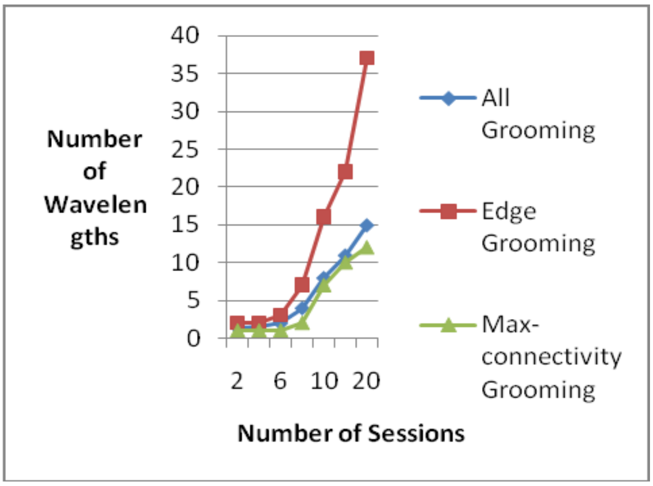

Figure 2: Variation of Number of wavelengths with Number of sessions

By observing the above figures, we notice that the LTE's are less in number in all grooming but it is not preferable because of more number of wavelength converters. In edge grooming, the LTE's and also wavelengths are more. In max- connectivity grooming, the LTE's and wavelengths are preferably less compared to both all and edge grooming.

2.1 Blocking probability:

Blocking probability= (Total ligthpath requests- Successfully established lightpaths)*100/ Total ligthpath requests

Table 4: Blocking probability for the given lightpaths

Total lightpath requests	Successfully established lightpaths	Blocking probability
3	2	33
3	2	33
4	3	25
6	5	16
8	7	12
10	9	10

3 DESIGN IMPLEMENTATION

In dynamic traffic grooming, traffic is not uniform and the nodes are changing the connections dynamically. We formulate the GRWA problem with dynamic traffic using a simple heuristic procedure explained later in the paper. The physical topologies involved in dynamic traffic grooming consist of two mesh WDM optical networks.

3.1 Assumptions:

The following assumptions have been considered to solve the GRWA problem:

i. All links in the network are bidirectional.

ii. Traffic demands are dynamic. Traffic requests vary with time.

iii. Any type of wavelength on the fiber can be tuned with the help of transceivers in a network.

iv. Number of wavelengths available per fiber is limited.

v. Any node can provision lightpath requests maximum up to the number of transceivers installed on that node.

vi. Network nodes have wavelength conversion capability.

So, a lightpath may use different wavelength along its path from source to the destination node.

With the above assumptions, the dynamic traffic grooming in WDM mesh networks having wavelength conversion capability maintains the network in an efficient manner. By using a heuristic approach, dynamic traffic grooming problem is solved.

Our proposed heuristic tries to improve the blocking performance with the minimal use of grooming resources. However, the procedure focuses on the successful establishment of connection requests as much as possible on the expense of wavelength conversion and grooming devices reducing the blocking probability in the network.

3.2 ALGORITHM STEPS:

The algorithm steps for dynamic traffic grooming are given below:

1. Initially the required terms flag, success and hop count are set to null

2. Grooming and wavelength conversion resources are placed at the required nodes

3. Generate a set of uniform source- destination lightpath requests

4. Locate source- destination pair
5. Find a shortest path using first fit algorithm
6.If the wavelength or the shortest path is available, then assign wavelength using first- fit algorithm and flag is set to ‘1’ or else go back to step 5
7. The variables hop count and success is incremented by ‘1’ and flag is set to 1
8. If flag is not ‘1’ then the connection is blocked. Repeat the process from step 4
9. If flag is ‘1’ then evaluate blocking probability & average hop count
10. Number of successfully established lightpath requests and the devices used are returned
11. Display the results and stop the process

The flow chart for heuristic procedure is as shown

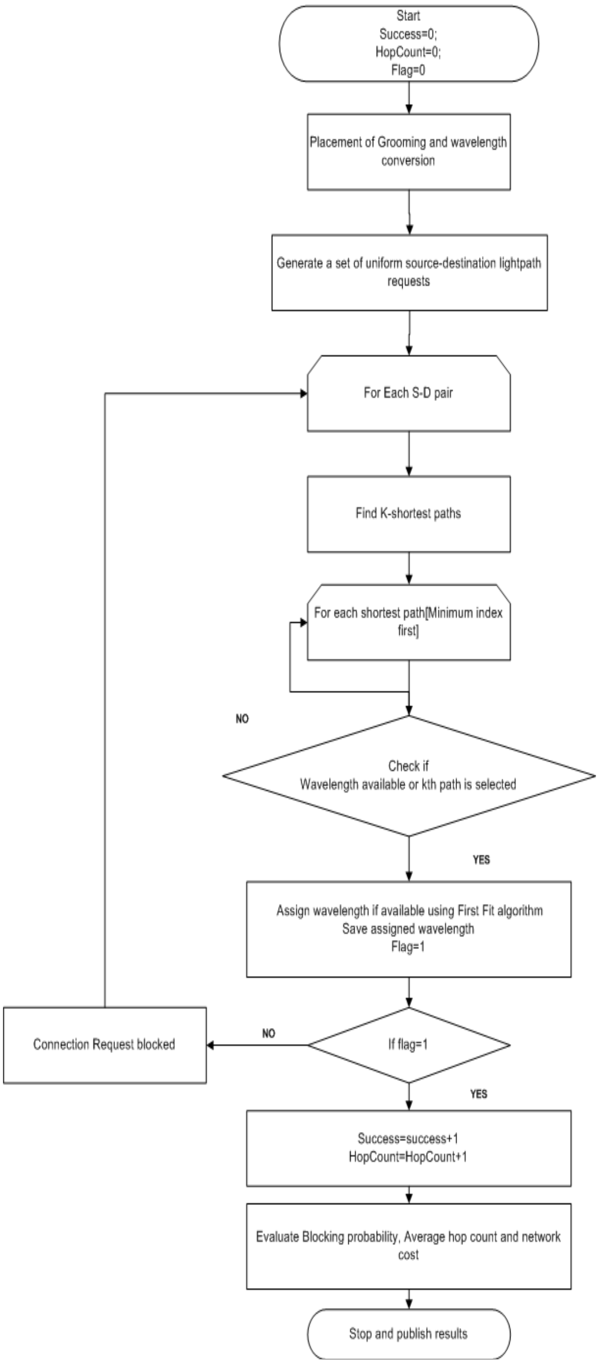

Figure 3: Flowchart for Heuristic Procedure

Fig above shows a flowchart of the proposed heuristic. The proposed scheme is simple and has good performance. The result from the flow chart evaluates the blocking probability, average hop count, and network cost.

This shows the improvement of blocking probability from static to dynamic with the wavelength converters in max- connectivity nodes.

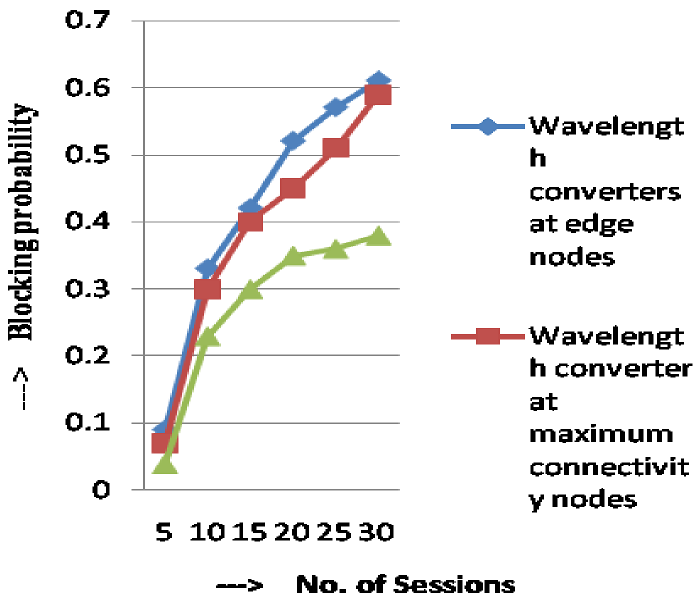

Figure 4: Blocking probability Vs No. of sessions (for full wavelength conversion, wavelength converters at edge nodes and wavelength converters max- connectivity nodes)

4 CONCLUSIONS:

In this paper, a heuristic procedure for dynamic traffic grooming in WDM optical mesh networks with grooming devices on max-connectivity nodes is developed. Based on this, we have presented the simulation results for different grooming schemes and have found that placement of grooming devices on maximum connectivity nodes is efficient and cost effective than other grooming schemes. We have shown the results with comparison of blocking probability. The network with wavelength conversion capability shows much better performance in terms of blocking probability.

REFERENCES

1. Massimo Tornatore, Andrea Baruffaldi, Hongyue Zhu, Biswanath Mukherjee, and Achille Pattavina, " Holding-Time-Aware Dynamic Traffic Grooming", IEEE Journal On Selected Areas In Communications, Vol. 26, No. 3, April 2008

2. A. Rajkumar and Dr.N.S. Murthy Sharma, "A distributed priority based routing algorithm for dynamic traffic in survivable WDM networks", IJCSNS International Journal of computer Science and Network Security, Vol.8 No.11, November 2008

3. Andr´e C. Drummond and Nelson L. S. da Fonseca, "On-Line Dynamic Traffic Grooming Algorithms for WDM Mesh Networks", IEEE Communications Society, IEEE ICC, 2009

4.Chunsheng Xin, "Resource Planning for Dynamic Traffic Grooming in WDM Optical Networks", Journal Of Lightwave Technology, Vol. 27, No. 7, April 1, 2009

5. Andr´e C. Drummond and Nelson L. S. da Fonseca, "Fair and Efficient Dynamic Traffic Grooming Algorithm for WDM Mesh Networks", IEEE Communications Society, "GLOBECOM", 2009

6. M. Masud Hasan, Farid Farahmand, Ankitkumar N. Patel, and Jason P. Jue, "Traffic Grooming in Green Optical Networks", IEEE Communications Society, IEEE ICC, 2010

7. Partha Paul, Balbeer Singh Rawat and S.K. Ghorai, "Traffic grooming in WDM optical network with grooming resources at Max Connectivity nodes, article in Opt. Fiber Technol. (2012)

8. Xin Wan, Yanwei Li, Hanyi Zhang, and Xiaoping Zheng, "Dynamic Traffic Grooming in Flexible Multi-Layer IP/Optical Networks", IEEE Communications Letters, Vol. 16, No. 12, December 2012

9. Mr.Anurag Anant Mishra and Prof. Sanjay Sharma, "Examining of Blocking Probability Computation in Optical Network", *International Journal of Advanced Computer Research, Volume 2 Number 1March 2012*

10. Fernanda S. H. Souza, Daniel L. Guidoniy and Geraldo R. Mateus, "Formulations for the RWA problem with Traffic Grooming, Protection and QoS in WDM Optical Networks", IEEE 2012

11. Hamada Alshaer, and Jaafar M. H. Elmirghani, "Multilayer Dynamic Traffic Grooming with Constrained Differentiated Resilience in IP/MPLS-over-WDM Networks", Ieee Transactions On Network And Service Management, Vol. 9, No. 1, March 2012

12. Yukinobu Fukushima, Takahiro Ooishi and Tokumi Yokohira, "A Wavelength and Converter Assignment Scheme Using Converter Usage History in Wavelength-Routed Networks", International Journal of Computer Networks & Communications (IJCNC) Vol.5, No.4, July 2013

13. Yongli Zhao, Jie Zhang, Jiawei Zhang, Wanyi Gu , "Analysis of Blocking Probability For OFDM-based Bandwidth-variable Optical Networks", 7th International ICST Conference on Communications and Networking in China (CHINACOM), 2012

14. Shuqiang Zhang, Charles Martel, and Biswanath Mukherjee , "Dynamic Traffic Grooming in Elastic Optical Networks", IEEE Journal On Selected Areas In Communications, Vol. 31, No. 1, January 2013

15. K.Pushpanathan and Dr.A.Sivasubramanian, "Traffic Grooming With Blocking Probability Reduction In Dynamic Optical WDM Networks", *International Journal of Emerging Trends & Technology in Computer Science (IJETTCS),* Volume 2, Issue 4, July – August 2013

First Author *K. APARNA, E.C.E, JNTUA College of Engineering, Pulivendula, Andhrapradesh.*

Second Author *P. KRISHNA KUMARI, E.C.E, JNTUA College of Engineering, Pulivendula, Andhrapradesh.*

