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Sparse Traffic Grooming and Performance Analysis of Backbone Network

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Abstract: *Traffic grooming issue is important to reduce the network design cost and improve network operational performance. In full grooming network services provided to users are costly due to their throughput; same nearly performance will be achieved by grooming some nodes called as "sparse grooming network". In this paper we design heuristic approach for selection of G-node based on Max-connectivity nodes in Optical Mesh network. Our work mainly focus on dynamic traffic connection request .Simulation results show that blocking performance of Sparse Grooming Network similar with as full grooming Network.*

Keywords: *OXC - Optical Cross Connect, OC-Optical carrier, RWA-Routing & wavelength assignment, WDM - wavelength division multiplexing, G-Fabric - Grooming Fabric, G-Node – Grooming Node, G-OXC – Grooming Optical Cross Connect, W-Fabric - wavelength-switching fabric.*

1. INTRODUCTION

The backbone network is mostly a mesh network with optical fibers. Optical fiber technology gives very high speed transmission speed because of its potentially limitless capabilities, a huge bandwidth (over 50 terabits per second (Tbps)). On the other hand, only a fraction of customers are expected to have a need for such a high bandwidth. Due to large cost of the optical backbone infrastructure it is necessary 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 network switching, technique called as "Traffic Grooming".

In WDM mesh networks, it is assumed that every network node has traffic-grooming capability, which may not be practical or cost-effective in a nationwide WDM backbone network. In a WDM mesh network not all nodes need to have grooming capabilities. A network with only a fraction of nodes having grooming functionalities, called as a Sparse Grooming network. A node which has traffic -grooming capability is called as grooming node (G-Node). This sparse grooming network must give the performance of nearly equals to the full groomed network, hence the service provider and the customers will use this type of network. Due to this the problem of designing a sparse-grooming WDM mesh network is a very important and practical problem.

Following Figure shows a sample G-OXC architecture. There are two switching fabrics in this OXC, a wavelength-switching fabric (W-Fabric) and a grooming fabric (G-Fabric). Because a grooming OXC may be more costly than an OXC without grooming capability (i.e., the OXCs which only have the WFabric), and in some optical WDM mesh network, only a few network nodes may have traffic-grooming capability. This type of network a "sparse-grooming network", and a node which has traffic-grooming capability to be a grooming node (G-Node)

Once we design sparse grooming network from given physical optical backbone network, it forms a network with some nodes to be designated as grooming nodes. The grooming nodes along with the non-grooming nodes form a logical or virtual topology of the backbone network. Based on the arrival of call or traffic request the light-paths are established between source and destination nodes. The light paths established are based on the k-shortest path routing, and depending on the availability of wavelength channels. To establish a lightpath in a WDM network, it is necessary to determine the route over which the lightpath should be established and the wavelength to be used on all the links along the route. This problem is called the routing and wavelength assignment (RWA) problem.

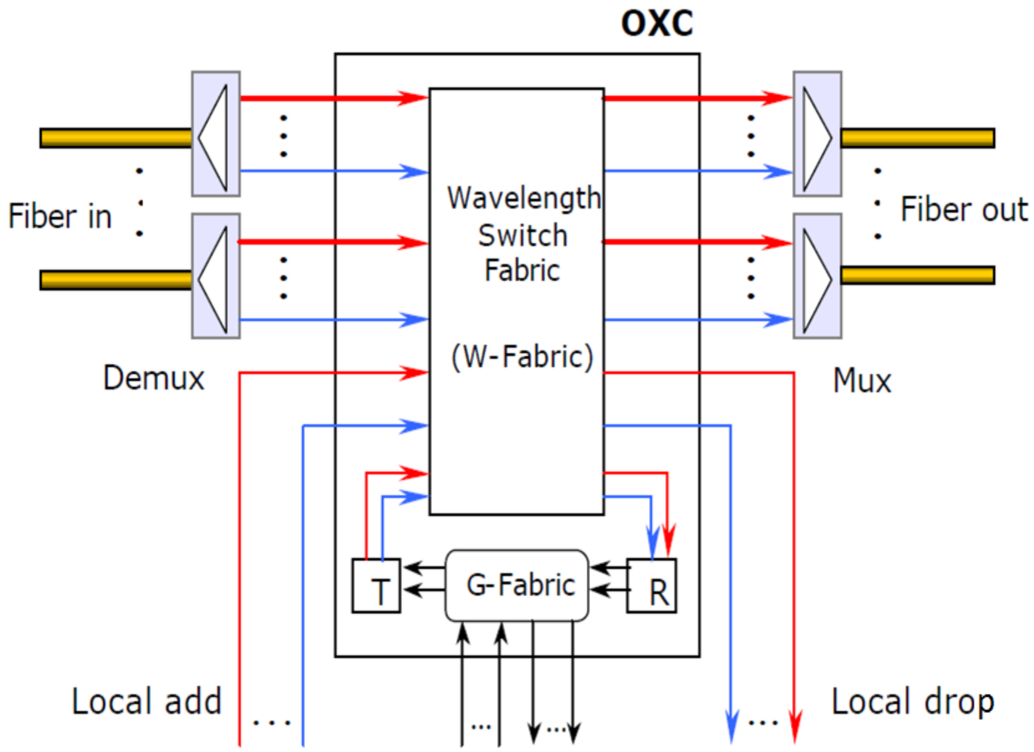
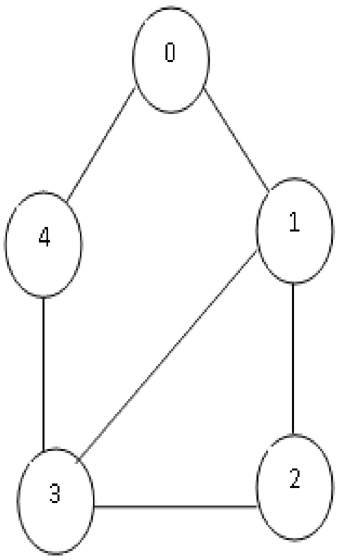


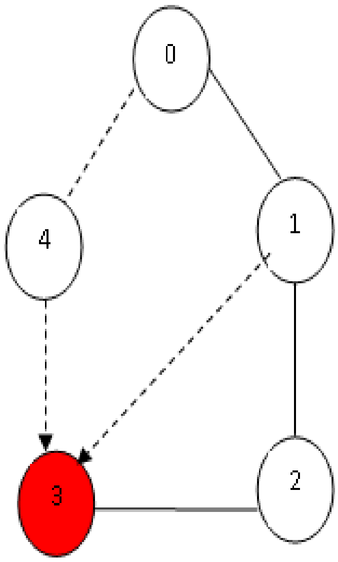
Fig1. *An OXC with a two-level hierarchy and grooming capability*

Most of the research in optical WDM mesh network focused on static traffic arrival in which connection request known in advance and as per requirement lightpaths is established to fulfill the corresponding requirement. Over the period of time many researcher have proposed various heuristics algorithms and compare their performance in terms of blocking probability. Heuristic methods are capable of producing near optimal solutions in acceptable time. Most of the previous work done in grooming on backbone network assume a full grooming network, in which all switching nodes in the network are assumed to have traffic grooming capabilities [1]. Research done in sparse grooming, attempts to find the locations of grooming sites [2]- [10]. They often require the number of grooming nodes as an input parameter. In our work, we select the number of nodes for performing traffic grooming as well as their placement. This approach is more reasonable due to cost considerations.

The rest of the paper is organized as follows. Section 2 includes the heuristic approach to Select Following Diagram Shows an example of designing of sparse grooming network where the network has consists of five nodes and each edge represents a pair of unidirectional fiber links. For sake of convenience each fiber supports two wavelength channels named as $\lambda 1$ and $\lambda 2$. To design a sparse grooming network only one node is allowed to become a G-node. Assume there are four connection requests arrived namely four between node pair (0-3) and one between (1-3).fig. 3 shows a network designed when node 3 is to be a G-node, Dashed line indicates light paths is established between node (0-3) and (1-3) as with this design only three connection request satisfied successfully two between (0-3) and one between(1-3).But With the same design if G-node is node 1 then all connection request satisfied successfully two between node pairs(0-3), two between(0-3) groomed with one request between (1-3) shown in fig 4. So the above example shows that with effective design of sparse grooming network performance of the network can be improved.

Grooming node solve dynamic traffic grooming problem with grooming resources on the nodes having maximum connectivity. Section 3, discusses the performance of our proposed heuristic approach with full grooming network. Section 4 includes the conclusion of the work.





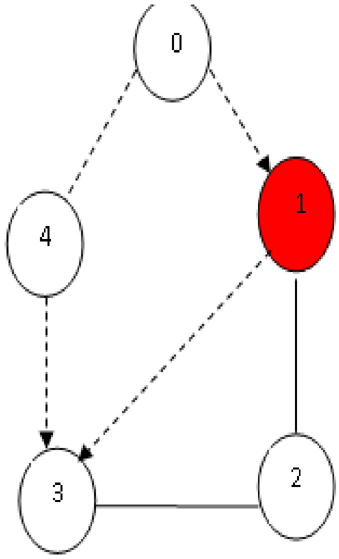


Fig2. *Network with five node* **Fig3.** *Network Design I (node 3 as G node)* **Fig4.** *Network Design II (node 1 as G node)*

2. Heuristic Approach for Sparse Traffic Grooming

In literature basically grooming node selection of optical network based on static traffic load [1]. In this paper we proposed the heuristic approach which selects grooming node on basis of max connecting nodes for a given network design for dynamic traffic grooming. This Approach gives near optimal performance as with full grooming network shown in fig.5.

2.1 Sparse Node Selection Algorithm

Selection of grooming node for given optical WDM network based on Following algorithm.

Step1: *Start*

Step2: *select the max-connectivity node*

Step3: *Sort the nodes according to descending order of max-connectivity*

Step4: *Consider Non traffic grooming algorithm*

Step5: *Calculate the blocking probability of each node, while assigning request*

Step6: *Sort nodes in decreasing order of above step*

Step6: *Finally take intersection of step 4 and 7*

Step8: *Resultant set forms G-node of the network.*

Step9: *Repeat step 2 to 8 till blocking probability is near optimal*

Step10: *exit*

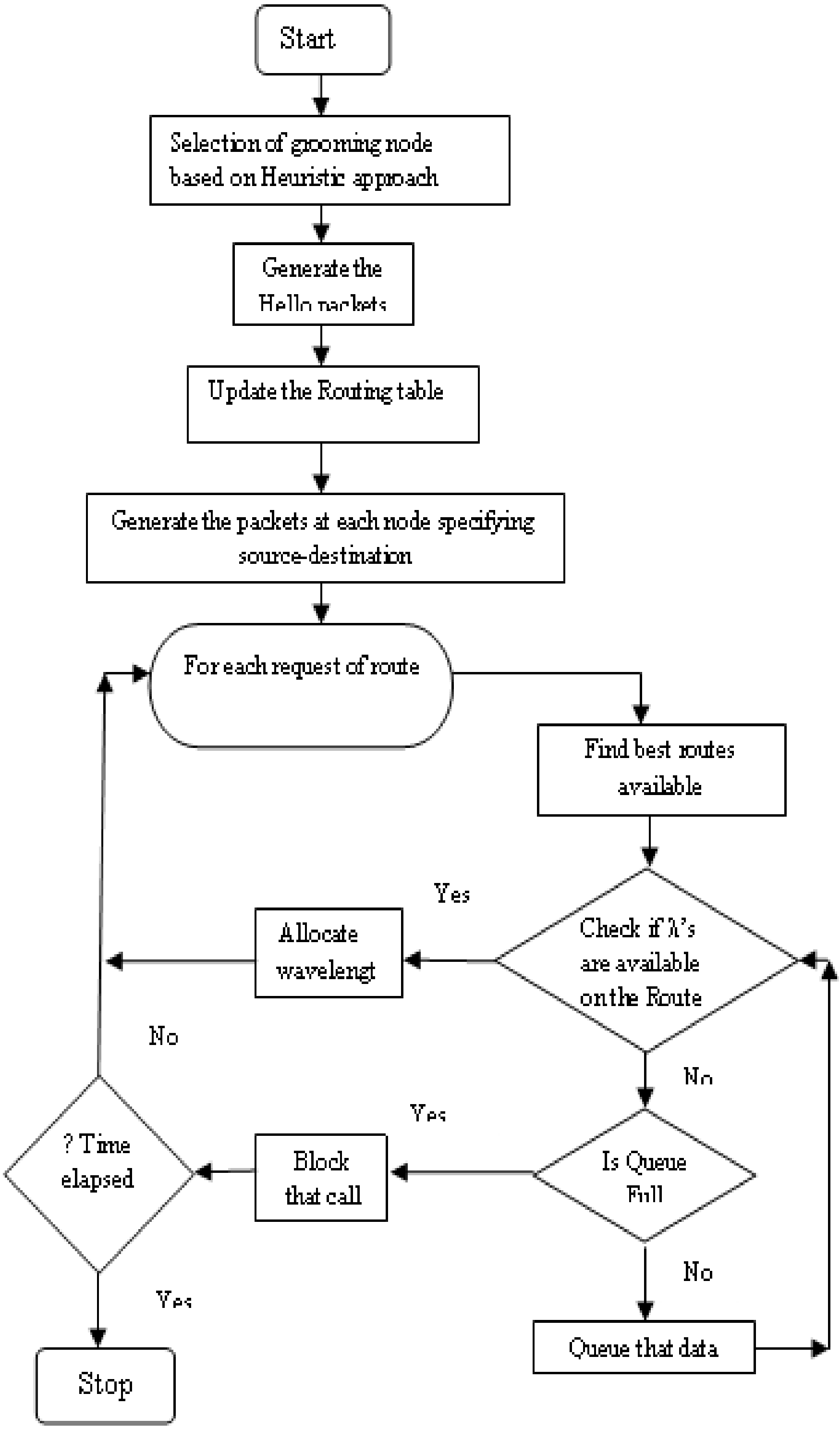


Fig5. *Flowchart of Sparse Traffic Grooming*

2.2 Call Blocking Probability of the Network

Blocking Probability is determined as follows.

$$CBP = \frac{TNC - NCS}{TNC} * 100$$

CBP=call blocking probability

TNC=total number of calls

NCS=Number of calls served

2.3 Total Cost of the Network

Total cost includes the cost of wavelengths used to establish lightpath request from source to destination node plus the cost of all wavelength convertors and traffic grooming devices used by the lightpath requests.

$$CT = NGN * CG + NW * CW$$

$$CT = (NGN + Rc * NW) * CG$$

Where,
CW=cost to support single wavelength channel
CG= cost to employ grooming capability
CT=total cost of Network
NGN=Number of Grooming Nodes
NW=Number of Wavelengths
Rc = Cost ratio

$$Rc = \frac{CW}{CG}$$

3. Results and Discussion

Simulations have been carried out to investigate the performance of the proposed heuristic approach by considering the network topologies illustrated in Fig. 6. For a given network topology and given values of nodes and number of wavelengths we design a heuristic approach which chooses G node and routes the traffic requests to maximize the network throughput.

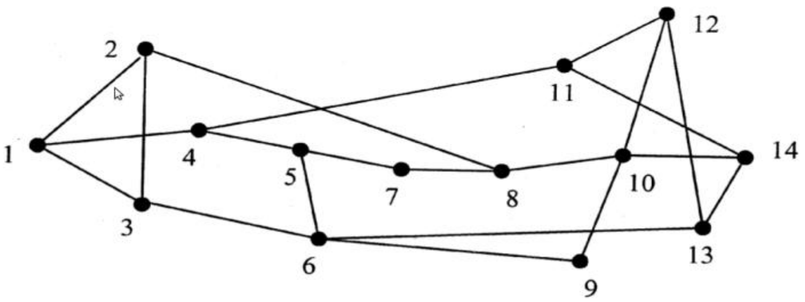


Fig6. *A Sample network used for simulation (NSFNET)*

We have compared our results of max-connectivity node grooming with all node grooming. We found that for a given network if it is to be designed using heuristic approach gives better throughput instead of placing grooming nodes randomly. It is observed from the graph that when number of grooming nodes increases the blocking probability decreases. Whereas at certain point it reaches near to the stability. So we proved that the sparse grooming node in the traffic grooming will achieve the performance of near optimal to the full traffic grooming.

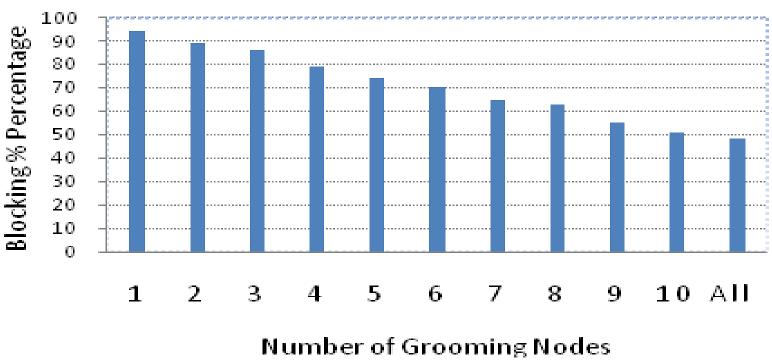


Fig7. *Blocking probability Vs Number of grooming nodes*

As we have used WDM in the Optical mesh network the use of number of wavelengths may affect the performance of the network. That is if the number of wavelengths in use are more then call blocking probability is less as shown in figure 8.

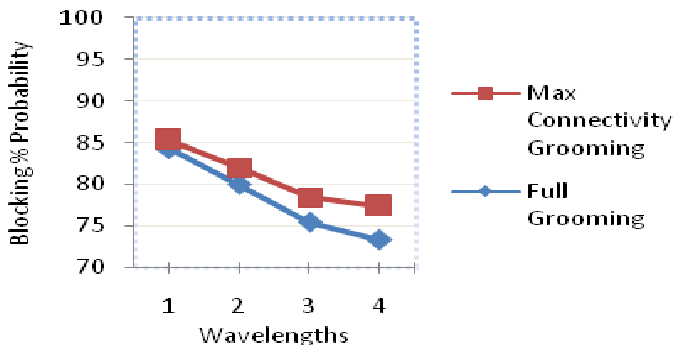


Fig8. *Blocking % probability Vs Number of Wavelengths*

We also have analyzed the system performance for dynamic traffic at the same time. For varying number of packets i.e. the traffic demand goes on increasing the blocking probability also increases. This analysis of the result is shown in figure 9. Where it is observed that the blocking probability for varying traffic demand in sparse traffic grooming and full traffic grooming is nearly same.

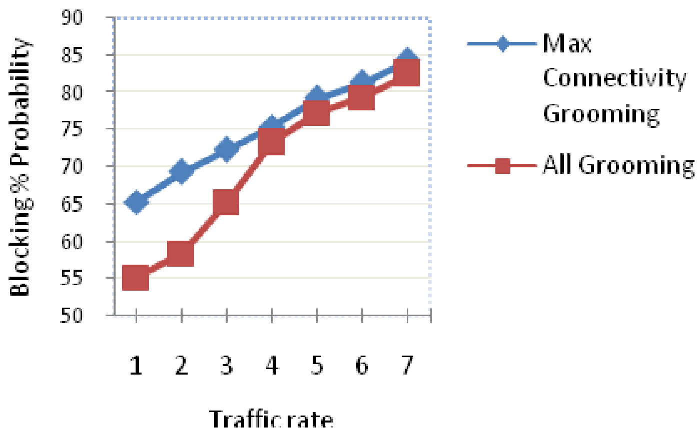


Fig9. *Blocking % probability Vs traffic rate*

The two aspects of using wavelengths for assigning to different requests is used one is wavelength continuity and wavelength conversion. Now a day's most of the research is focusing on wavelength conversion capability. In this project we used the wavelength conversion capability but we are comparing the results with wavelength continuity i.e. wavelength non conversion. This is as shown in the figure10.

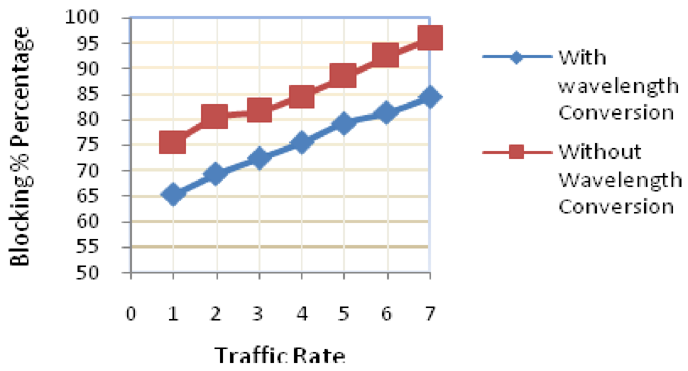


Fig10. *Blocking % probability Vs Traffic rate for wavelength*

4. Conclusion

In this paper, we have developed a heuristic procedure for dynamic traffic grooming in WDM optical mesh networks for finding optimum number of Grooming–nodes based on max-connectivity.

Our simulation results show that the proposed G-node selection approach gives near same performance with full grooming. We have also compared network performance of full wavelength conversion with No wavelength conversion approach and results shows that Full wavelength gives better throughput by reducing number of call blocks.

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