Traffic Grooming in Optical WDM Network

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Abstract – Traffic Grooming has become a very important issue on optical Network, as optical networks provide a very high speed data transmission for huge amount of data. A Sparse grooming Network with only a fractional of noes having grooming functionalities may achieve the same performance as the one in which all the nodes are grooming, but with much lower cost. In literature different algorithms, models and techniques have been proposed to design the sparse grooming networks. With Proper assignment of routing and wavelengths in the network reduces the blocking probability ultimately increases the bandwidth of the network. In this paper, we studied and analyzed the different sparse traffic grooming and RWA assignment strategies with its performance metrics for optical mesh networks.

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.

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I. INTRODUCTION

The rapid expansion of the internet in the last decade has been made possible largely by optical networks with high bandwidth and reliability. WDM significantly increases the capacity of a fiber by allowing simultaneous transmission of multiple wavelength channels. A single fiber strand has now over a tera-bit per second bandwidth and a wavelength channel has over ten giga-bit per second transmission speed (e.g. OC-48 has capacity of approx. 2.5 Gbps1). In WDM optical networks, the bandwidth request of a traffic stream can be much lower than the full wavelength capacity.

Traffic Grooming in WDM networks can be defined as the techniques used to combine low-speed traffic streams onto high-capacity wavelengths in order to minimize the network cost in terms of terminating equipment and/or electric switches (Barr, et. al., 2005).It is useful in order to improve bandwidth utilization and optimize network throughput by a procedure of efficiently multiplexing/ demultiplexing different wavelength channels (Barr, et. al., 2005).Grooming is a term used to describe the optimization of capacity utilization in Internet transport systems by means of cross-connections between different transport systems or layers within the same system (Zhu and Mukherjee, 2003).

In the past few decades, computer and telecommunication networks have experienced dramatic growth. With the growth of the Internet technology, there is a huge demand for network bandwidth. This demand is aggravated by the advent of new bandwidth hungry applications, such as multimedia communications e.g. voice mails, video on demand and high data traffic on Internet. The unprecedented growth of internet traffic and rapid advancements in the optical transport technologies have fueled the Internet transport infrastructure to evolve towards a model of high speed IP routers interconnected by intelligent optical networks.

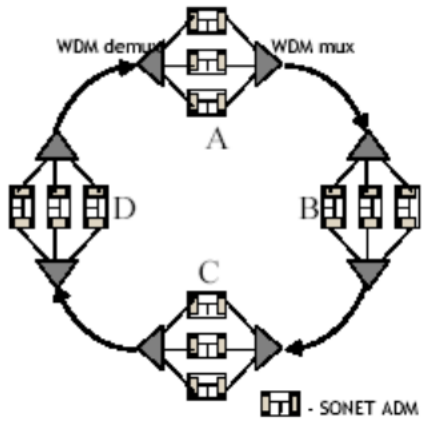
(a) **Optical Transport Network-**Optical transport networks are high-capacity telecommunications networks based on optical technologies and components that provide routing, grooming, and restoration at the wavelength level as well as wavelength-based services. Optical networks, based on the emergence of the optical layer in transport networks, provide higher capacity (in Tbps) and reduced costs for new applications such as the Internet, video and multimedia interaction, and advanced digital services. Optical networks are also being used widely nowadays in backbone networks that spans long distances, e.g., each link could be a few hundreds to a few thousands of kilometers in length., due to their high relatively low cost. The backbone network can be set up to provide nationwide or global coverage. Most telecom backbone networks are deployed today as an interconnection of "stacked" SONET/SDH rings, in which the fibers support multiple wavelengths using WDM transmission equipment. Ring networks, however, are inefficient in using the expensive bandwidth resources of the network. Thus, mesh networks, which consist of an arbitrary interconnection pattern, are being deployed as the backbone of choice for our future telecom networks.

(b) **Optical WDM Network-** With the advancement of Dense Wavelength Division Multiplexing (DWDM) technology, the bandwidth of a fiber has significantly increased. Recent studies indicate that up to 360 DWDM wavelength channels can be sent through a single fiber. Similarly each wavelength channel can also carry up to 100 Gbps, with the advancements in switching equipments, tunable lasers and photo detectors. Even though fibers can offer very high bandwidth, user requests that come to optical fiber networks are of lower bandwidth. The capacity requirement of these low-rate traffic connections can vary in range from STS-1(51.84 Mbps or lower) up to full wavelength capacity.

This requires efficient grouping of individual connections onto the same wavelength as dedicating a unique wavelength for each demand will lead to huge wastage of bandwidth. Intelligent grouping is also required because each wavelength has to be dropped at the source and destination of each of the connections assigned to it. Dropping a wavelength at any node involves conversion from optical to electronic domain, and the equipment for performing this is the main contributor towards the cost of the network. This grouping of connections and assigning wavelengths to these groups, so as to optimize on some objective such as throughput or network cost, is reduced.

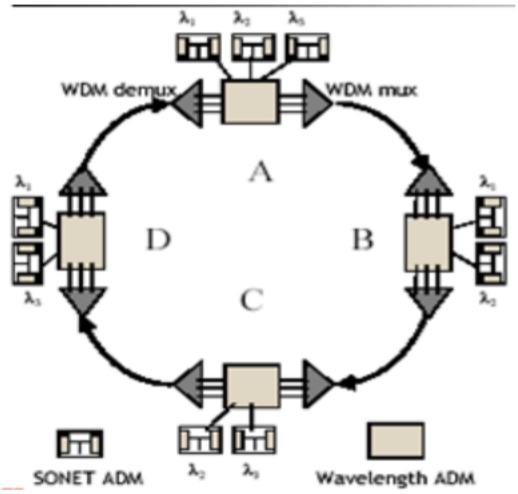
II. MINIMIZING THE NETWORK RESOURCES

The network resources must be used efficiently to achieve high performance. By carefully grooming the low speed connections and using wavelength-division multiplexer (OADM) to perform the optical bypass at intermediate nodes, electronic ADMs can be saved and network cost will be reduced. To reduce the amount of traffic that must be electronically processed at intermediate nodes, future WDM systems will employ WDM add/drop multiplexers (WADMs), which allow each wavelength to either be dropped or electronically processed at the node or optically bypass the node electronics (Modiano and Lin, 2001).The SONET/WDM architecture shown in Fig. 2a is potentially wasteful of SONET ADMs because every wavelength (ring) requires a SONET ADM at every node. A WADM at a given node is capable of dropping and adding any number of wavelengths at that node. Consequently, it is no longer necessary to have a SONET ADM for every wavelength at every node, but rather only for those wavelengths used at that node.



SONET/WDM ring (Ungroomed): Fig 2(a)

The above figure 2(a) shows an ungroomed unidirectional ring network with four nodes A, B, C and D, and 3 wavelengths λ1, λ2 and λ3. Wavelength λ1 carries the traffic between nodes A and D and that between nodes C and B, etc. Therefore, each node would require an ADM on every wavelength for a total of 12 ADMs – which is potentially wasteful of ADMs because every wavelength requires an ADM at every node.



SONET/WDM ring (Groomed) : Fig 2(b)

Assignment2 on Wavelengths

λ1 : A↔B, A↔ C (3 ADMs)

λ2 : B↔C, B ↔ D (3 ADMs)

λ3 : A↔D, C ↔ D (3 ADMs)

- Requires total 9 ADMs