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Virtual Topology Reconfrigation of WDM Optical Network with Minimum Physical Node

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Abstract

This paper review the reconfiguration of high capacity WDM optical Network, messages are carried in all optical form using light paths. The set of semi-permanent light paths which are set up in the network may be viewed as a virtual topology by higher layers such as SONET, ATM and IP. Reconfiguration is to charge in virtual topology to meet traffic pattern in high layers. It provides a trade off between objective value and the no. of changes to the virtual topology. In another study Objective is to design the logical topology & routing Algorithm on physical topology, so as to minimize the net work congestion while constraining the average delay seen by source destination pair and the amount of processing required at the nodes. Failure handling in WDM Networks is of prime importance due to the nature and volume of traffic, these network carry, failure detection is usually achieved by exchanging control messages among nodes with time out mechanism. Newer and more BW thirsty applications emerging on the horizon and WDM is to leveraging the capabilities of the optical fiber Wavelength routing is the ability to switch a signal at intermediate nodes in a WDM network based on their wavelength. Virtual topology can be reconfigured when necessary to improve performance. To create the virtual topology different from the physical topology of the underlying network, is the ability of wavelength routing WDM.

Keywords: WDM, Physical Topology, Virtual Topology and Reconfiguration

1. INTRODUCTION

Advances in optical technology have made it possible to develop systems that are capable of providing a large bandwidth. Systems using wavelength routing switches and optical cross-connects enabled data to be switched entirely in the optical domain from source node to destination node. An optical signal passing through an optical switch may be routed from an input fiber to an output fiber without undergoing through optoelectronics conversion.

The Wavelength Division Multiplexing (WDM) optical network is composed of optical nodes and optical fiber links, typically forming a mesh topology. The WDM divides the tremendous bandwidth of a fiber into many non- overlapping wavelengths called WDM channels. Each channel can be operated asynchronously. Due to the huge transmission bandwidth of the optical fiber the WDM optical network is used as the transport infrastructure. The major role of WDM optical network is to interconnect client networks like IP, ATM and serves as a national or international backbone to transport client traffic. An access node may transmit signals on different wavelength which are coupled into the fiber using wavelength multiplexers. The WDM optical network utilizes wavelength routing to provision optical connections, called light paths.

The light path occupies one dedicated wavelength on each traverse link in the WDM optical network. One Light path interconnects two client nodes across a WDM optical network and is treated as a logical link. A lightpath would occupy the same wavelength on all fibers links that it traverses; this is referred as wavelength continuity constraints. The wavelength continuity constraint results in inefficient use of the wavelengths available. The wavelength conversion technique is used to overcome it. The wavelength converters translates input optical signal from one wavelength to another wavelength at the output. Either a full wavelength conversion or the limited wavelength conversion is adopted. When wavelength converters are present at switches a light path may switch between different wavelengths on the route from source to destination.

The issue in transporting client calls using light paths is that client calls have data rates which are generally much smaller than the light path capacity. To address this issue traffic grooming techniques is used to combine low speed traffic stream on to high speed light paths.

In metropolitan and wide area networks, most connections are multi hop, i.e., most of the traffic is processed by intermediate electronic routers between the source and destination. Currently, WDM systems are still limited by costs of electronic components. Electronically processing each wavelength at each network node is still prohibitively expensive as well as inefficient since much of the traffic traveling through a node may be destined for a downstream node. Optical add/drop multiplexers (ADMs) and cross-connects may be used to allow individual wavelength signals to be either *dropped* to the electronic routers at each node or to pass through the node optically.

The passive or configurable optical nodes and their fiber connections constitute the *physical topology* of the network. The *logical topology* describes the light paths between the electronic routers and is determined by the configuration of the optical ADMs and transmitters and receivers on each node. Configurable components allow the logical topology of the network to be reconfigured. This capability can be used to reduce the traffic load on the electronic routers in accordance with the traffic pattern.

2. EARLY RECONFIGURATION PROCESS APPROACHES

Early research in a reconfiguration process has been studied in two different contexts: a broadcast optical network and a wavelength-routed optical network. They are slightly different in objectives and constraints by nature of the network types. A broadcast network is mostly applied for LAN or MAN network in a passive star topology while a wavelength-routed network is applied for a transport backbone network in a mesh topology. Therefore a reconfiguration in a broadcast network is performed more frequently in terms of packet-by-packet basis and requires faster turning receivers (or transmitters) than those of a wavelength-routed network. There are plenty of heuristic approaches in a reconfiguration problem of broadcast optical networks.

1. Consider a reconfiguration as a transition diagram that disrupts the traffic minimally through a sequence of branch exchange operations. The problem of finding the shortest sequence is equivalent to the problem of finding a decomposition of auxiliary graph algorithms. The shortest sequence provides the minimum duration of reconfiguration phase. At each step, two links are disrupted (exchanged) on the ring topology. [9]
2. A similar algorithm called the Dynamic Single- Step Optimization (DSSO) is introduced. The DSSO has been proposed for load balancing that tracks rapid changes in a traffic pattern using branch exchange sequence. [10]
3. It focuses on the cost-benefit analysis to reduce a reconfiguration cost. Their Merge Split Reconfiguration (MSR) algorithm reduces the number of light paths that need to be reconfigured while keeping the network congestion as low as possible. [11],[12].
4. Consider a reconfiguration problem as a trade-off between the number of receiver returning and the degree of load balance. [13]
5. It presented a new algorithm that attempts to construct the new wavelength assignment in a way that simultaneously achieves both objectives. [14], [15].
6. A technique which was developed the Most and Least Loaded Channel Balance (MLLCB) algorithm such that the demand on most loaded channel is reduced by exchanging one node with the least loaded channel. In a wavelength-routed optical network reconfiguration, the existing research attempts to maximize the performance and to minimize the number of changes in a virtual topology. The performance in the wavelength-routed optical network can be measured by various metrics including the average propagation delay of a lightpath, the average hop-distance of traffic, the success traffic throughput, the maximum load offered to any lightpath (congestion) and the utilization of traffic over the lightpaths. [14],[15].
7. A technique was formulated the reconfiguration problem using linear programming. Their performance objective is to minimize the average packet hop distance in the network. In the first step, they search for the optimal value of the performance objective under a new demand and a new virtual topology. In the second step, they minimize the number of changes in the virtual topology using the optimal performance objective in the next step as a constraint. It extend the objective to minimize the average number of packet hops in the network, minimize the total number of lightpaths, minimize the hops as well as the number of physical links or the sum of these objectives. [16]'[17].
8. Since the reconfiguration problem is proved as an NP-hard problem, the linear programming approaches do not scale well for a large network. A technique was proposed a two-phase heuristic for a reconfiguration problem such that the performance objective is to minimize the average weighted hop count. The heuristic is designed to maintain the near-optimality of the virtual topology, to provide a compromise between the trade-off objectives and to quickly and the lightpaths to be reconfigured. Although the algorithm scales well for a large network, the solution relies on the setup parameter i.e., the bound on the number of changes. focus on the virtual private network such that the traffic demand is in the term of wavelengths required and the performance objective is to minimize the average propagation delay of the lightpaths. [18],[19],[20].
9. A Balanced Alternate Routing Algorithm (BARA) based on a genetic algorithm to solve the reconfiguration problem. They use the weighted combination of trade-of objectives when applies to a (single objective) genetic algorithm. [20]
10. It focuses on the sequence of reconfiguration process in order to minimize the disruption or maximize

the network availability. They propose four heuristic algorithms including Longest Lightpath First (LPF), Shortest Lightpath First (SPF), Minimal Disrupted lightPath First (MDPF) and Tree Search (TS) algorithms. The LPF and SPF result in a low performance. The TS and MDPF provide good performance but both have computational complexity. [19]

11. The other heuristic approach is introduced. They consider an adaptation mechanism for reconfiguration. The proposed algorithm redesigns the virtual topology according to an expected traffic pattern. It detects the imbalances of the network by high and low watermark parameters on lightpath loads and reacting promptly (by adding or deleting lightpath one at a time) to balance the loads.[21].

Early reconfiguration policy approaches the reconfiguration process has an overhead cost that interrupts traffic and rearranges the lightpaths. Therefore frequent reconfiguration is costly. However, in frequent reconfiguration will downgrade the performance. The policy guides us when is the best time to perform a reconfiguration process and what level of reconfiguration to be performed. There are few studies in the reconfiguration policy. Some of them are described below.

I It detects the best time to perform reconfiguration when the overall average network utilization goes beyond the specified threshold or when a link runs out of capacity. This method is known as a threshold approach which is difficult to define the threshold value, and may not result in the optimal outcome. [22]

II It propose the reconfiguration policy on the broadcast optical network using the Markov Decision Process (MDP) to obtain optimal outcome. They define the reward and cost functions to calculate the optimal outcome. This is an approximate model, the outcome depends on how close of the state transition probabilities and the reward/cost functions are to the real network. Usually the model parameters are obtained from the simulation or real network. [12].

3. RECONFIGURATION PROBLEM

Objective is to design the logical topology & routing Algorithm on physical topology, so as to minimize the net work congestion while constraining the average delay seen by source destination pair and the amount of processing required at the nodes. We have used minimum physical medium with the help of logical topology.

Problem Definition of The Reconfiguration Process We assume that our reconfiguration problem is a centralized optimization problem which acquires a global view or status of the network. The reconfiguration is activated or triggered by the changes in a traffic demand, neither the failure of equipment nor the changes in a physical topology. The reconfiguration process is a multi-objective problem that consider not only the network performance but also the number of changes in the virtual topology. The problem formulation is different from the ordinary virtual topology design in that it requires another objective (to minimize the changes in virtual topology) besides the performance objective. Therefore, it requires both the new traffic demand and the previous logical topology as inputs.

4. RESULT AND DISCUSSION

A,B,C,D and E are the five traffic station and 0,1,2,…… represent the weight of matrix

Now

AA=1 BA=4 CA=3 DA=2 EA=1
AC=4 BC=3 CB=2 DB=3 EB=2
AD=5 BD=2 CD=4 DC=5 EC=3
AE=1 BE=2 CE=3 DE=4 ED=8

Now adjust it in decreasing order →

ED=8
AD=5
DC=5
DE=4
CD=4
BA=4
AC=4
EC=3
DB=3
CE=3
CA=3
BC=3
EB=2
CB=2
BE=2
BD=2
EA1
AE=1
AB=1

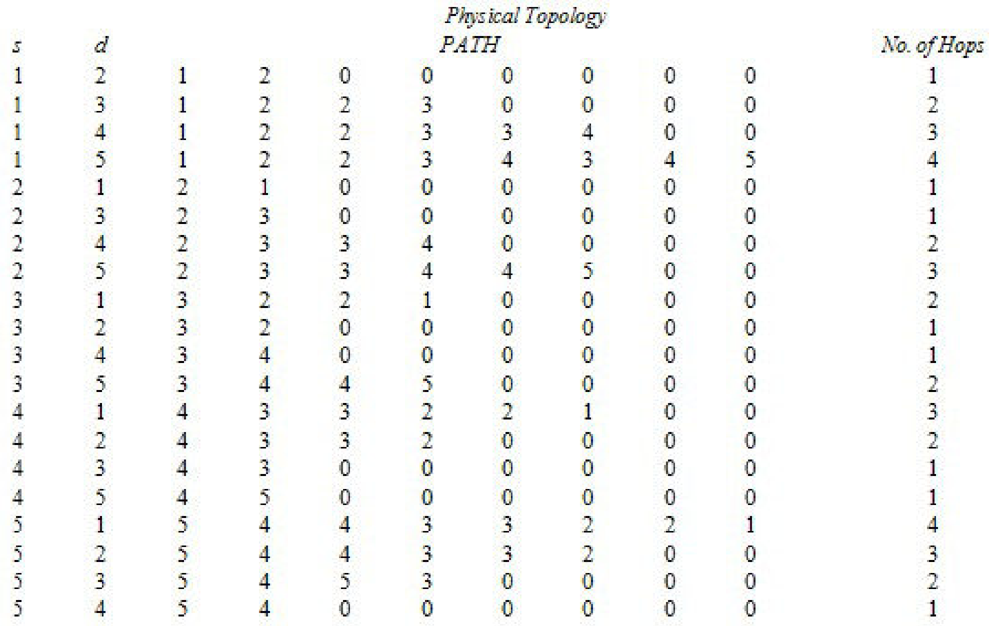
DA=2

If paths are established between node pairs with high traffic between them, then routed traffic reduces and hence the average weighted hope count would also be reduced. Our algorithm used this idea to find out the light paths to be established to decrease the objective function value.

Physical topology → any given node in the LAN will have one or more link to one or other nodes in the network and mapping of these links and nodes on to a graph result in a geometrical shape that determine the physical topology in the network. Where 0 represent not connected and 1 represent path between two stations available directly. Matrix of physical topology in 5*5

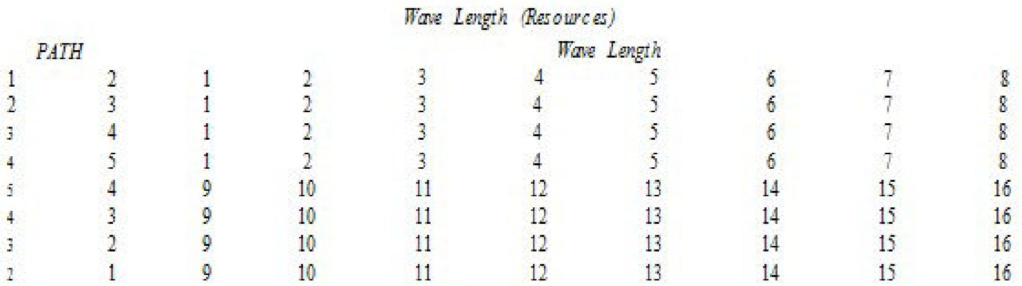
Virtual topology: → The mapping of data flow in the network between nods determines the logical topology or virtual topology of network, now we take a matrix of 5*5 of traffic, where

Result 1



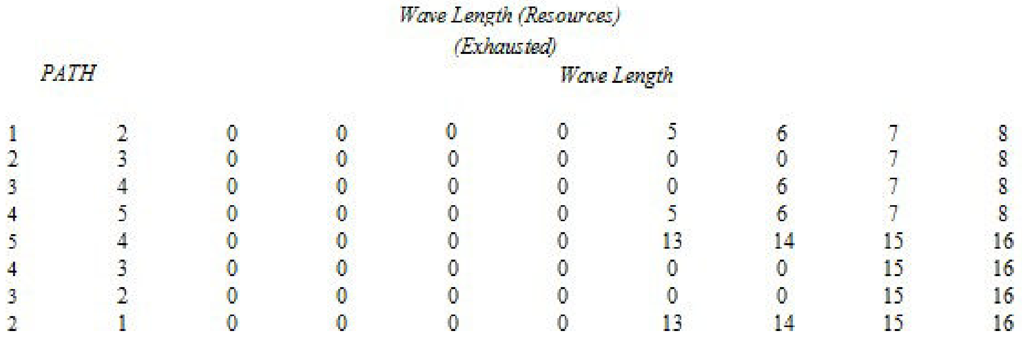
Physical Topology

s	*d*	*PATH*								*No. of Hops*
1	2	1	2	0	0	0	0	0	0	1
1	3	1	2	2	3	0	0	0	0	2
1	4	1	2	2	3	3	4	0	0	3
1	5	1	2	2	3	4	3	4	5	4
2	1	2	1	0	0	0	0	0	0	1
2	3	2	3	0	0	0	0	0	0	1
2	4	2	3	3	4	0	0	0	0	2
2	5	2	3	3	4	4	5	0	0	3
3	1	3	2	2	1	0	0	0	0	2
3	2	3	2	0	0	0	0	0	0	1
3	4	3	4	0	0	0	0	0	0	1
3	5	3	4	4	5	0	0	0	0	2
4	1	4	3	3	2	2	1	0	0	3
4	2	4	3	3	2	0	0	0	0	2
4	3	4	3	0	0	0	0	0	0	1
4	5	4	5	0	0	0	0	0	0	1
5	1	5	4	4	3	3	2	2	1	4
5	2	5	4	4	3	3	2	0	0	3
5	3	5	4	5	3	0	0	0	0	2
5	4	5	4	0	0	0	0	0	0	1



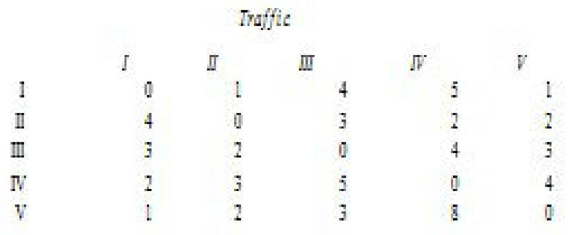
Wave Length (Resources)

PATH		*Wave Length*							
1	2	1	2	3	4	5	6	7	8
2	3	1	2	3	4	5	6	7	8
3	4	1	2	3	4	5	6	7	8
4	5	1	2	3	4	5	6	7	8
5	4	9	10	11	12	13	14	15	16
4	3	9	10	11	12	13	14	15	16
3	2	9	10	11	12	13	14	15	16
2	1	9	10	11	12	13	14	15	16



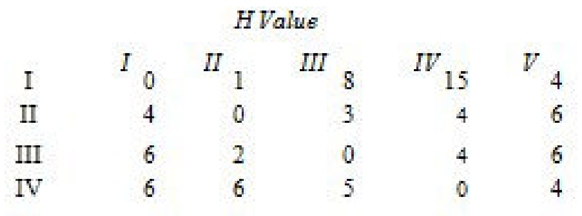
Wave Length (Resources)
(Exhausted)

PATH		*Wave Length*							
1	2	0	0	0	0	5	6	7	8
2	3	0	0	0	0	0	0	7	8
3	4	0	0	0	0	0	6	7	8
4	5	0	0	0	0	5	6	7	8
5	4	0	0	0	0	13	14	15	16
4	3	0	0	0	0	0	0	15	16
3	2	0	0	0	0	0	0	15	16
2	1	0	0	0	0	13	14	15	16



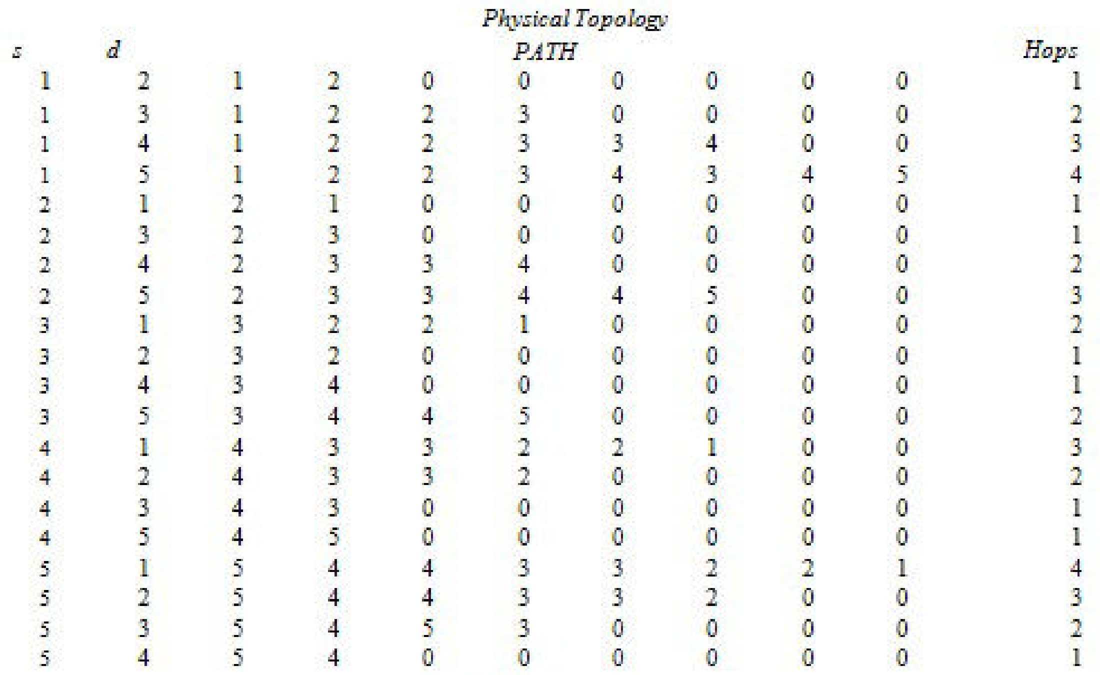
Traffic

	I	*II*	*III*	*IV*	*V*
I	0	1	4	5	1
II	4	0	3	2	2
III	3	2	0	4	3
IV	2	3	5	0	4
V	1	2	3	8	0



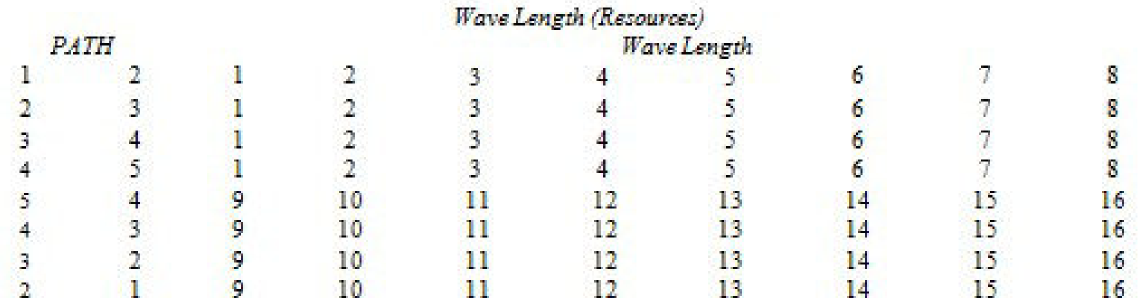
H Value

	I	*II*	*III*	*IV*	*V*
I	0	1	8	15	4
II	4	0	3	4	6
III	6	2	0	4	6
IV	6	6	5	0	4



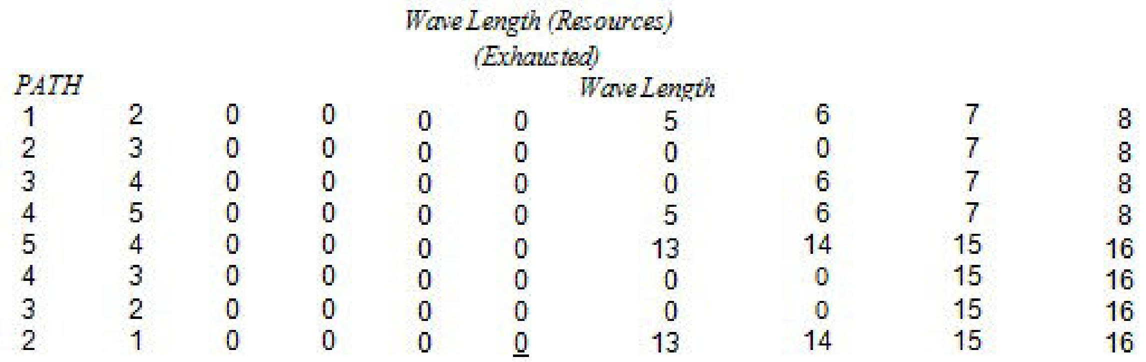
Physical Topology

s	*d*	*PATH*								*Hops*
1	2	1	2	0	0	0	0	0	0	1
1	3	1	2	2	3	0	0	0	0	2
1	4	1	2	2	3	3	4	0	0	3
1	5	1	2	2	3	4	3	4	5	4
2	1	2	1	0	0	0	0	0	0	1
2	3	2	3	0	0	0	0	0	0	1
2	4	2	3	3	4	0	0	0	0	2
2	5	2	3	3	4	4	5	0	0	3
3	1	3	2	2	1	0	0	0	0	2
3	2	3	2	0	0	0	0	0	0	1
3	4	3	4	0	0	0	0	0	0	1
3	5	3	4	4	5	0	0	0	0	2
4	1	4	3	3	2	2	1	0	0	3
4	2	4	3	3	2	0	0	0	0	2
4	3	4	3	0	0	0	0	0	0	1
4	5	4	5	0	0	0	0	0	0	1
5	1	5	4	4	3	3	2	2	1	4
5	2	5	4	4	3	3	2	0	0	3
5	3	5	4	5	3	0	0	0	0	2
5	4	5	4	0	0	0	0	0	0	1



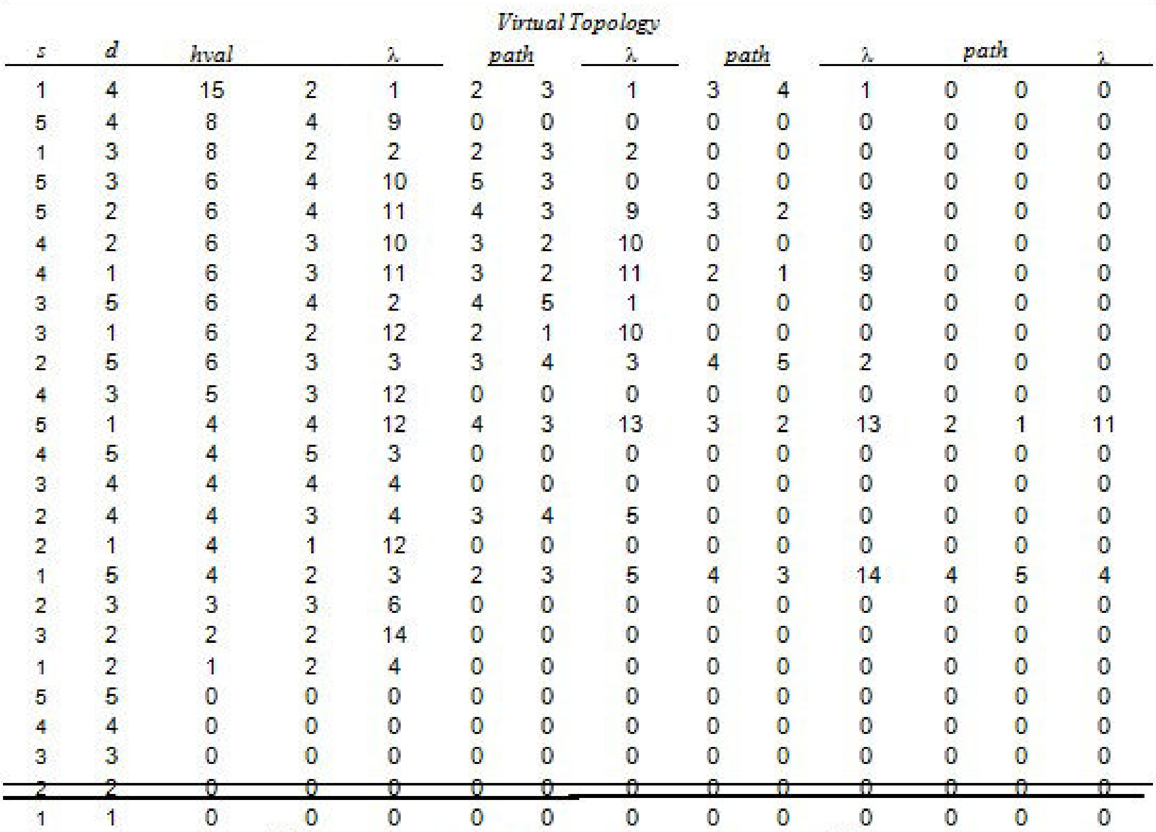
Wave Length (Resources)

PATH		*Wave Length*							
1	2	1	2	3	4	5	6	7	8
2	3	1	2	3	4	5	6	7	8
3	4	1	2	3	4	5	6	7	8
4	5	1	2	3	4	5	6	7	8
5	4	9	10	11	12	13	14	15	16
4	3	9	10	11	12	13	14	15	16
3	2	9	10	11	12	13	14	15	16
2	1	9	10	11	12	13	14	15	16



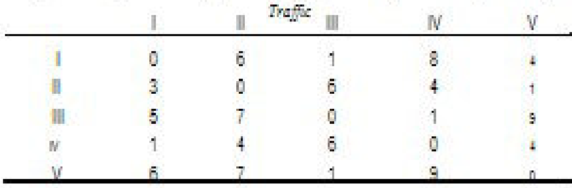
Wave Length (Resources)
(Exhausted)

PATH		*Wave Length*							
1	2	0	0	0	0	5	6	7	8
2	3	0	0	0	0	0	0	7	8
3	4	0	0	0	0	0	6	7	8
4	5	0	0	0	0	5	6	7	8
5	4	0	0	0	0	13	14	15	16
4	3	0	0	0	0	0	0	15	16
3	2	0	0	0	0	0	0	15	16
2	1	0	0	0	0	13	14	15	16



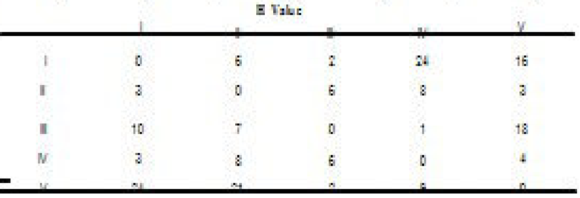
Virtual Topology

s	*d*	*hval*		λ	*path*		λ	*path*		λ	*path*		λ
1	4	15	2	1	2	3	1	3	4	1	0	0	0
5	4	8	4	9	0	0	0	0	0	0	0	0	0
1	3	8	2	2	2	3	2	0	0	0	0	0	0
5	3	6	4	10	5	3	0	0	0	0	0	0	0
5	2	6	4	11	4	3	9	3	2	9	0	0	0
4	2	6	3	10	3	2	10	0	0	0	0	0	0
4	1	6	3	11	3	2	11	2	1	9	0	0	0
3	5	6	4	2	4	5	1	0	0	0	0	0	0
3	1	6	2	12	2	1	10	0	0	0	0	0	0
2	5	6	3	3	3	4	3	4	5	2	0	0	0
4	3	5	3	12	0	0	0	0	0	0	0	0	0
5	1	4	4	12	4	3	13	3	2	13	2	1	11
4	5	4	5	3	0	0	0	0	0	0	0	0	0
3	4	4	4	4	0	0	0	0	0	0	0	0	0
2	4	4	3	4	3	4	5	0	0	0	0	0	0
2	1	4	1	12	0	0	0	0	0	0	0	0	0
1	5	4	2	3	2	3	5	4	3	14	4	5	4
2	3	3	3	6	0	0	0	0	0	0	0	0	0
3	2	2	2	14	0	0	0	0	0	0	0	0	0
1	2	1	2	4	0	0	0	0	0	0	0	0	0
5	5	0	0	0	0	0	0	0	0	0	0	0	0
4	4	0	0	0	0	0	0	0	0	0	0	0	0
3	3	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0



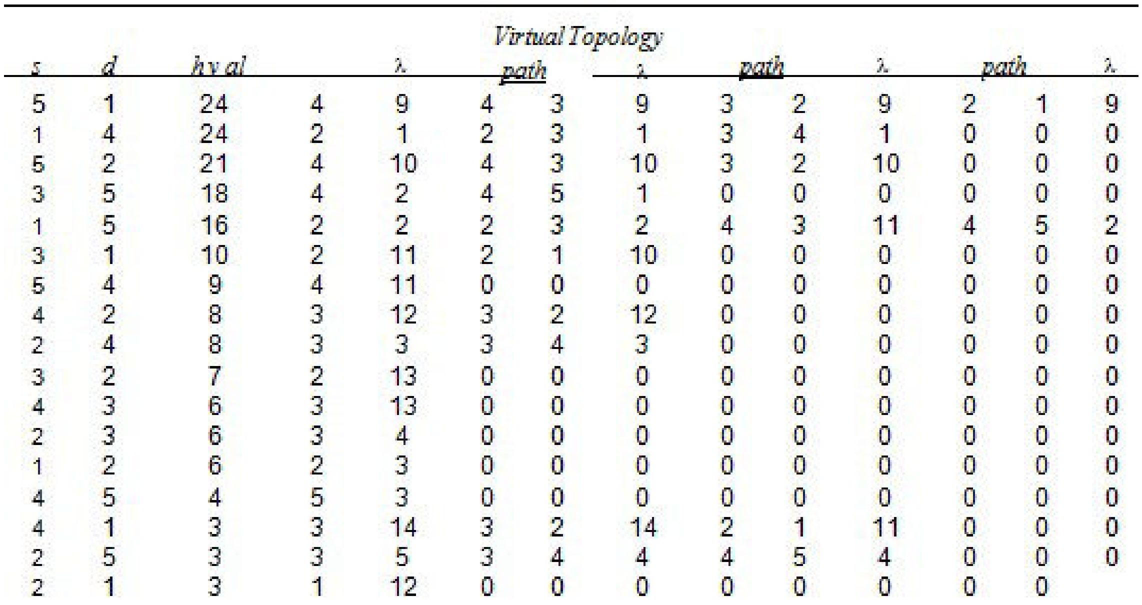
Traffic

	I	II	III	IV	V
I	0	6	1	8	4
II	3	0	6	4	1
III	5	7	0	1	9
IV	1	4	6	0	4
V	6	7	1	9	0



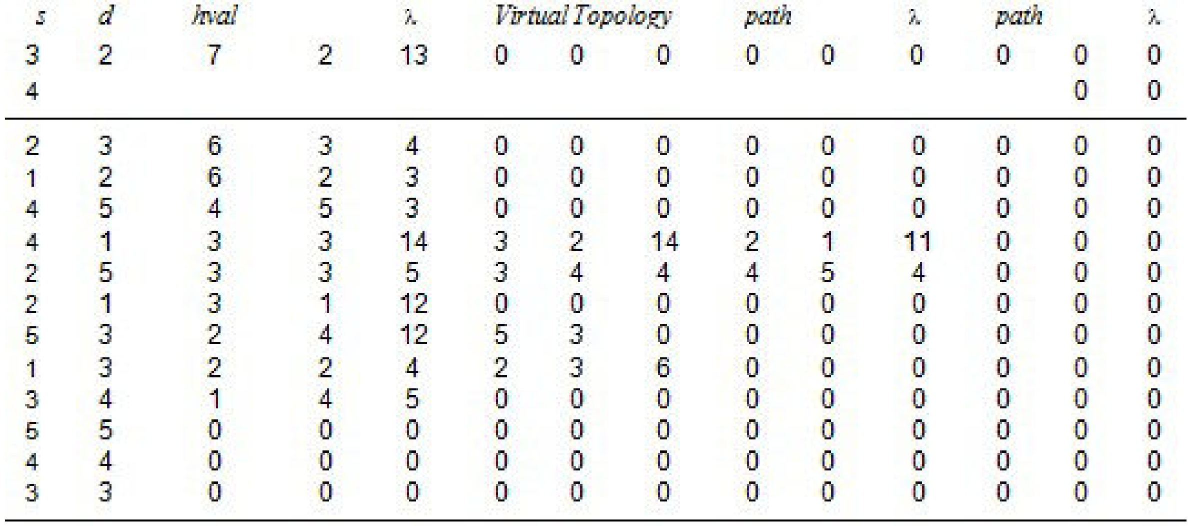
H Value

	I	II	III	IV	V
I	0	6	2	24	16
II	3	0	6	8	3
III	10	7	0	1	18
IV	3	8	6	0	4
V	24	21	2	6	0



Virtual Topology

s	*d*	*h v al*		λ	*path*		λ	*path*		λ	*path*		λ
5	1	24	4	9	4	3	9	3	2	9	2	1	9
1	4	24	2	1	2	3	1	3	4	1	0	0	0
5	2	21	4	10	4	3	10	3	2	10	0	0	0
3	5	18	4	2	4	5	1	0	0	0	0	0	0
1	5	16	2	2	2	3	2	4	3	11	4	5	2
3	1	10	2	11	2	1	10	0	0	0	0	0	0
5	4	9	4	11	0	0	0	0	0	0	0	0	0
4	2	8	3	12	3	2	12	0	0	0	0	0	0
2	4	8	3	3	3	4	3	0	0	0	0	0	0
3	2	7	2	13	0	0	0	0	0	0	0	0	0
4	3	6	3	13	0	0	0	0	0	0	0	0	0
2	3	6	3	4	0	0	0	0	0	0	0	0	0
1	2	6	2	3	0	0	0	0	0	0	0	0	0
4	5	4	5	3	0	0	0	0	0	0	0	0	0
4	1	3	3	14	3	2	14	2	1	11	0	0	0
2	5	3	3	5	3	4	4	4	5	4	0	0	0
2	1	3	1	12	0	0	0	0	0	0	0	0	



s	d	hval		λ	Virtual Topology			path		λ	path		λ
3	2	7	2	13	0	0	0	0	0	0	0	0	0
4												0	0
2	3	6	3	4	0	0	0	0	0	0	0	0	0
1	2	6	2	3	0	0	0	0	0	0	0	0	0
4	5	4	5	3	0	0	0	0	0	0	0	0	0
4	1	3	3	14	3	2	14	2	1	11	0	0	0
2	5	3	3	5	3	4	4	4	5	4	0	0	0
2	1	3	1	12	0	0	0	0	0	0	0	0	0
5	3	2	4	12	5	3	0	0	0	0	0	0	0
1	3	2	2	4	2	3	6	0	0	0	0	0	0
3	4	1	4	5	0	0	0	0	0	0	0	0	0
5	5	0	0	0	0	0	0	0	0	0	0	0	0
4	4	0	0	0	0	0	0	0	0	0	0	0	0
3	3	0	0	0	0	0	0	0	0	0	0	0	0

Program for the above analysis has made in Mat Lab. We have used heuristic algorithm. We have taken matrices 5x5 for physical topology as well as traffic. Initially we made a virtual topology, next step by step we change 10% in traffic matrices up to 100 %. And observed the respective change in VT. We have considered no. of hopes and traffic weight. The average weighted hop count is used as the objective function, which is to be minimized. It is composed as follows:

$$h_{avg} = \copyright 1 / \;_{sd}\;_{sd}t \;^{x}\copyright \;_{sd}\;_{sd}t \; x \; h_{sd}$$

where t_{sd} denotes traffic from source s to destination *d*, and h_{sd}denotes the no. of hopes from s to d in the VT.We have evaluated eleven result and few of them have shown above.

5. CONCLUSION AND FUTURE ENHANCEMENT

The traffic grooming is applied to groomed low speed traffic to high speed light paths to share the resources in optical layer there by utilizing the network resources and reducing the overall cost of network. For each incoming call it is necessary to find a path consisting of logical links. The process of finding paths to consolidated client calls over logical topology is called traffic grooming. Efficiently grooming low-speed connections onto high capacity light paths will improve the network throughput and reduce the network cost.

In this paper we have examined the problem of finding virtual topologies which minimize the maximum or average hop distance from a source node to a set of destination nodes. Such a virtual topology can be used for either standard multicast communication, in which the source node sends the same data to all destination nodes, or personalized multicast communication, in which the source node may send Different data to different destination nodes. We have shown that a simple time construction simultaneously minimizes the maximum and average hop distance in paths and rings. Moreover, for the more general case of minimizing the weighted average (or maximum) hop distance in paths and rings, a polynomial-time dynamic programming algorithm can be employed. Finally, we note that some optical switches have the capability of splitting a lightpath to multiple output ports. Using this functionality, a single lightpath may be "tapped" by multiple nodes. The number of nodes that can tap a lightpath is bounded, however, since the lightpath experiences some loss of power each time it is tapped

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