Routs Comparison Concept for New Request Static Link Proactive Survivable Wavelength Division Multiplexing Routing algorithm for Optical Fiber Networks

Anil Kumar Kamboj, Paramjeet Singh, Shaveta Rani

Abstract: Here, we proposed the algorithm which is being used to compare the Integrated route cost of all available routes in NRSL algorithm [1] get designed by us. It finds out the best two routes from all the available routes. Out of these two, the best is selected as the primary path and second one as backup path. Finally, we alleviated the overall network cost to improve the Cost effectiveness of Optical Fiber networks by minimizing the required capacity, or wavelengths, needed for a given demand. We put our concern to decide the classic optimization parameters of any optimization problem.

Keywords: WDM, Survivability, Restoration, Cost Effectiveness, Resource optimization, OEO.

I. Introduction

The main parameters that influence the cost of the optical network are number of wavelengths, degree of the network nodes, number of transit nodes, availability of manpower, the length of the fiber etc. [2]. We review different multiplexing techniques. Wavelength Division Multiplexing (WDM) technique is less complex as compared to other multiplexing techniques. WDM is the technique which transports the large amount of data through optical fiber network. In this, the different signals in the form of light beams get different wavelengths on the same fiber. Fig.1 presents a diagram of a WDM transmission system.

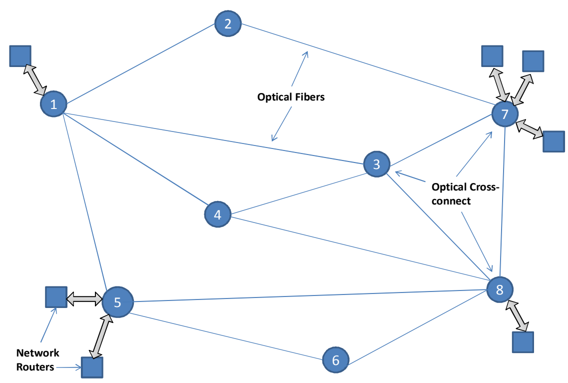

Fig.1: Architecture of a Wavelength-Routed Partially Mesh Optical Network

Manuscript Received on September 2013.

Anil Kumar Kamboj, CDLM Govt. Engineering College, Panniwal Mota, Sirsa, Haryana, India

Dr. Paramjeet Singh, Associate Professor, Deptt. Of CSE, GJSPTU Campus, Bathinda, Punjab, India

Dr. Shaveta Rani, **A**ssociate Professor, Deptt. Of CSE, GJSPTU Campus, Bathinda, Punjab, India

WDM enables carriers to significantly increase transport capacity while leveraging existing fiber-optics equipment [3] and used to enhance the overall transmission capacity for better communication. So in this paper we used this technique.

Different research works have been performed to enhance the different factors responsible for enhancing the performance of WDM optical networks. Because of heavy traffic load on each link in optical network, failures can result in a large loss of data [4]. So we have considered that survivability is more important in optical fiber networks. Survivability is the ability of the network to maintain continuity of service against failures [5, 6]. As this paper used WDM based network, so the restoration concept for survivability is being used. Restoration is defined as the process of changing the route of data traffic to new lightpath from the route on which a failure occurs. It is classified as Reactive methods and Proactive methods In reactive methods, the search operation to find new ligthpaths, starts only after the failure of the existing path. Due to this, the load on network remains low for the time during which no failure occurs. But the major disadvantage is that some time recovery of new path, after failure, may be failed. To solve the disadvantage of reactive methods, the concept of proactive methods is get used. In these methods the backup light paths are get identified in the starting and put them in offline mode as reserved paths. This increased the restoration guarantee to hundred percent. Restoration guarantee refers to the guarantee with which a failed path finds its backup path readily available upon a failure [3]. These reserved paths can be used as a substitute in case of a failure on the primary light path. Because of this, the restoration time gets reduced in proactive methods as compared to reactive methods.

In NRSL algorithm [1], we used the proactive survivability concept. To access the performance of different survivability mechanisms, we have considered various parameters as *degree of survivability, Restoration time, cost effectiveness, resource optimization, and fault tolerance*. Several research works [8-14] have been reviewed to find the importance of these parameters.

A. Degree of Survivability is the ratio of restored traffic that was get affected by the amount of the total traffic affected. Higher the degree of survivability, the better is the system. It is desired that the degree of survivability should be 100% [7].

B. Restoration Time is the time taken by the system for restoration after failure. It is required to keep the restoration time minimum to enhance the overall performance of the network.

C. Fault tolerance is defined as the network's ability to reconfigure itself and re-establish communication upon a component failure. Better the fault tolerance better is the system.

D. Cost Effectiveness is to use the given cost for designing the maximum survivable network or to establish a network with specific survivability criteria by using minimum cost. In both cases the specific recovery scheme has to be designed to achieve the given target even in the form of cost factor or in the form of survivability factor. This scheme should be cost effective to the maximum level.

E. Resource optimization: There are different devices in the networks which get displaced with time. The concept of resource optimization is to use these devices whenever required or to share devices by backup paths which are having different primary paths i.e. these devices were not being used in primary paths of these backup paths. The purpose of this concept is to reduce the cost of networks.

II. PROPOSED ALGORITHM

Here we proposed the pseudo code of the algorithm get used with NRSL algorithm [1] to find the best two routes out of all the available routes from source to destination for every new request. This concept reduces the increments of load on nodes because of each new request. The purpose of this reduction in load is to increase the performance of the Proactive Survivable WDM Optical network. In these type of algorithms, the first operation is to search two routes- one for transmitting the signal in best way and second to keep it reserved for backup path which may be used at the place of earlier route in case of any failure. The different algorithms use different topologies to establish the routes for communication. The proposed concept gets the integrated cost of the routes to be compared and handed over the Primary & secondary routes to NRSL algorithm. It is performed by comparing the integrated cost of all the available routes from source node to destination node in sets of two routes at one time, starting from the initial side. By Integrated cost we mean the cost evaluated by considering different factors of the WDM Optical Network. These factors play the important role in calculating the overall performance of WDM Optical networks. Because of this reduction of load, the Survivable WDM Optical network using NRSL algorithm will perform better by considering the cost factor.

A. Motivation:

To enhance the optical network in developing countries, especially in poor countries, the cost of optical network has to be reduced and the cost effectiveness has to be enhanced. The cost of expensive devices, such as wavelength converters and O-E-O regenerators should also be optimized[11]. For design of optical networks in these countries, the economic considerations often play a more important role than technical consideration. So we will try to alleviate the overall network cost by minimizing the required capacity, or wavelengths, needed for a given demand and to put minimum load possible at once on each link. But we have to pay little attention to the impact of other devices such as wavelength converters and OEOs on the network cost.

B. Algorithm for Comparison of the Integrated cost:

The NRSL algorithm decides the route for the primary and backup paths by considering the different functions which are depended upon the different factors to decide their value and play important role to evaluate the overall cost of the route in Proactive Survivable WDM Optical networks. As shown in NRSL algorithm [1], the operation of comparison of the integrated cost ($C_I(R)$) of routes is required by the destination node in third section of the algorithm. Through this comparison the algorithm has to update the information, if required, about the primary route and backup route. It has to select always the best two routes which are having the lowest integrated cost. Better the comparison operation better will be performance of NRSL algorithm. To enhance this comparison operation, a specific comparison concept gets designed. The algorithm used to perform this operation is shown below:-

Notation: Let

R_P be the Primary route.
R_s be the Secondary route.
R_X be the route X.
R_Y be the route Y.
$C_I(P)$ be the Integrated cost of Primary route.
$C_I(S)$ be the Integrated cost of Secondary route.
$C_I(R_X)$ be the Integrated cost of rout X.
$C_I(R_Y)$ be the Integrated cost of rout Y.

Algorithm:

Start

1. Compare Integrated route cost $C_I(R_X)$ with $C_I(R_Y)$
2. If $C_I(R_X) \le C_I(R_Y)$ then
3. Start
   i. Compare Integrated route cost $C_I(R_X)$ with $C_I(P)$
   ii. If $C_I(R_X) < C_I(P)$ then
   Start
      a. Compare Integrated route cost $C_I(R_Y)$ with $C_I(P)$
      b. If $C_I(R_Y) < C_I(P)$ then
      Start
      - Set the Integrated route cost $C_I(P)$ equal to $C_I(R_X)$.
      - Set the Integrated route cost $C_I(S)$ equal to $C_I(R_Y)$.
      - Set R_X as primary path R_P.
      - Set R_Y as backup path R_s .
      End.
      c. Otherwise
      Start
      - Set the Integrated route cost $C_I(S)$ equal to $C_I(P)$.

- Set the Integrated route cost $C_I(P)$ equal to $C_I(R_X)$.
- Set R_P as backup path $R_{S.}$
- Set R_X as primary path R_P .

End.

End.

iii. Otherwise

a. Compare Integrated route cost $C_I(R_X)$ with $C_I(S)$

b. If $C_I(R_X) < C_I(S)$ then

Start

i. Set the Integrated route cost $C_I(S)$ equal to $C_I(R_X)$,

ii. Set R_X as backup path R_s

End.

End.

4. Otherwise

Start

i. Compare Integrated route cost $C_I(R_Y)$ with $C_I(P)$

ii. If $C_I(R_Y) < C_I(P)$ then

Start

a. Compare Integrated route cost $C_I(R_X)$ with $C_I(P)$

b. If $C_I(R_X) < C_I(P)$ then

Start

- Set the Integrated route cost $C_I(P)$ equal to $C_I(R_Y)$,
- Set the Integrated route cost $C_I(S)$ equal to $C_I(R_X)$;
- Set R_Y as primary path R_P,
- Set R_X as backup path R_s

End.

Otherwise

Start

- Set the Integrated route cost $C_I(S)$ equal to $C_I(P)$
- Set the Integrated route cost $C_I(P)$ equal to $C_I(R_Y)$
- Set R_P as backup path R_s
- Set R_Y as primary path

End.

End.

iii. Otherwise

Start

- Compare Integrated route cost $C_I(R_X)$ with $C_I(P)$
- If $C_I(R_Y) < C_I(S)$ then

Start

  - Set the Integrated route cost $C_I(s)$ equal to $C_I(R_Y)$
  - Set R_Y as backup path R_s

End.

End.

End.

III. EVALUATION

The above shown pseudocode given for comparison operation is gets used to evaluate the NRSL algorithm [1]. For the evaluation purpose, the different values are being assigned to the parameters in NRSL algorithm. Here the value of 'λ' is to be considered 0.2. The φ is assumed to be 0.25. The value of ε, ζ, η, κ is to be 1.

The evaluation was get performed by comparing the results of NRSL algorithm[1] with the results of LRCR algorithm [15] and CFPR algorithm [16]. The performance was get evaluated by comparing the results in terms of *new source destination pair request v/s the increment in load*, *new source destination pair request v/s blocking probability* and *number of wavelengths v/s blocking probability*.

The Table: 1 gives the data for the number of signals generated at the stage of verification of routes per each new source-destination pair request. Through this we get that by NRSL algorithm[1], the load increases two times the number of new source destination pair request i.e. if 'n' is the number of new source-destination pair requests, then the number of signals generated at stage first for the searching of routes will be '2*n'. But in case of LRCR algorithm and CFPR algorithm, the signals generated at stage first for the searching of routes will be about the number of new source-destination pair requests multiplied by the number of possible routes i.e. 'm*n' where 'm' is the average possible routes for each source- destination pair.

New source destination pair request	No. of new routes used at stage 1		
	LPCR	CFPR	NRSL
1	9	8	2
2	18	16	4
3	27	24	6
4	36	32	8
5	45	40	10
6	54	48	12

Table-1: Data for the number of signals generated at the stage of verification of routes per new source-destination pair request

However, it may be possible that for the different source destination pair, the different number of possible routes is available there. So we have considered for simulation the average number of possible routes for new source-destination pair request. The fig: 2 shows that the increment in load for new source destination pair request is too less in NRSL algorithm as compared to LRCR algorithm and CFPR algorithm. This figure depends upon the data shown in table 1.

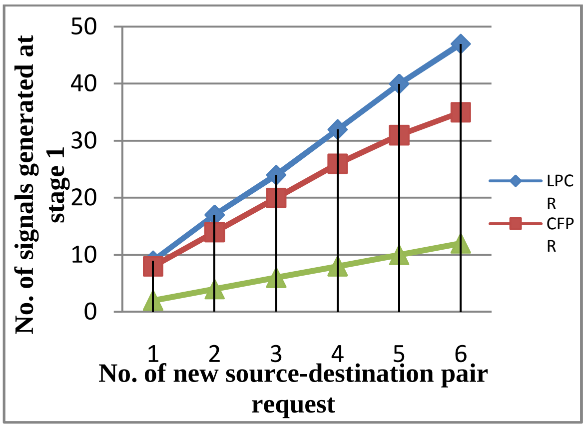

Figure-2: Number of signals generated at the stage of verification of routes per each new source-destination pair request

It shows that the load increment in new source-destination pair request may vary in LRCR algorithm and CFPR while in the proposed NRSL algorithm the load increases constantly with the increase in new source-destination pair request.

The Table: 2 gives the data related to the increment in blocking probability due to new source destination pair request.

New source destination pair request	Blocking Probability		
	LPCR	CFPR	NRSL
5	0	0.01	
10	0.05	0.1	0
15	0.18	0.35	0.05
20	0.45	0.6	0.11
25	0.67	0.76	0.2
30	0.81	0.86	0.37
35	0.9	0.95	0.58
40	0.94	0.97	0.69

Table-2: Increment in blocking probability due to new source destination pair request

The fig. 3 shows the result of new source-destination pair request v/s the blocking probability factor. The blocking probably is the major factor which has to be considered for the performance evaluation of all the algorithms used for computer networking. It shows that with the increase of number of new source-destination pair request, the blocking probability increases more rapidly in LRCR algorithm and CFPR algorithm as compared to the proposed NRSL algorithm. It can also be understand by the factor that the blocking probability increases as the load increases. It happens in all the algorithms used for networking of computers. So the load is a major factor for blocking probability. As the request signals generated for route search are less in NRSL algorithm as compared to the LRCR algorithm and CFPR algorithm, so the load increments are less in NRSL algorithm. Hence the ratio of blocking probability v/s new source-destination pair request is better in NRSL algorithm as compared to LRPR algorithm and CFPR algorithm.

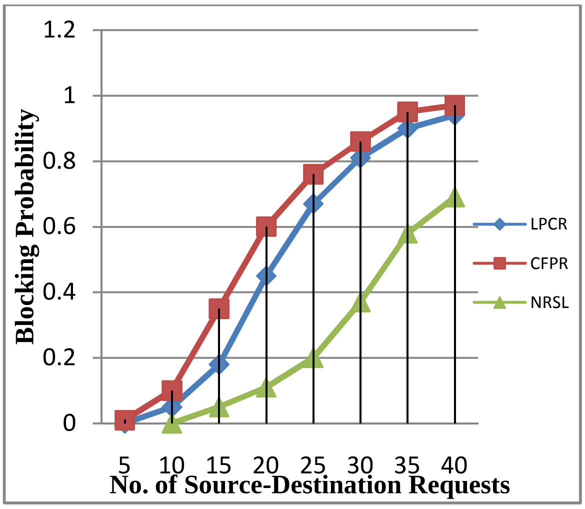

Figure-3: Increase in blocking probability with the increase of number of new source destination pair request

The fig. 4 shows the result of simulation in terms of number of wavelength v/s blocking probability. By this figure we analyze that the NRSL algorithm provide the better service even in less number of wavelengths per fiber in optical fiber network. As the number of wavelengths increased the blocking probability reduced in all algorithms compared for simulation, but in NRSL algorithm the blocking property decreased more rapidly as compare to LPCR and CFPR algorithms. Due to this the number of required wavelengths per fiber was less in NRSL algorithm compared to LPCR and CFPR algorithms for the same result in blocking probability.

Number of wavelength	Blocking Probability		
	LPCR	CFPR	NRSL
2	0.95	0.98	0.78
4	0.76	0.83	0.61
6	0.55	0.61	0.38
8	0.36	0.41	0.22
10	0.23	0.27	0.12
12	0.13	0.15	0.03
17	0.05	0.06	0
16	0	0	

Table-3: Effect of number of wavelengths on blocking probability.

However the time delay in the selection of primary and backup route was more in NRSL algorithm as compared to LPCR and CFPR algorithms. It happened because the proposed NRSL algorithm sent the request only on two possible routes at a time i.e. in two by two groups of routes for one new source-destination pair request. But in the same case LPCR sent the request to all possible routes at once and select the best path for primary routes and second best path for backup route. At the same time CFPR algorithm first searched shortest path without wavelength conversion for primary route and then with wavelength for backup route. Due to all this, the NRSL algorithm took more time to select the paths for primary and backup routes while the LPCR algorithm took less time for the same operation. The CFPR algorithm took somewhat less time for this operation as compared to NRSL algorithms.

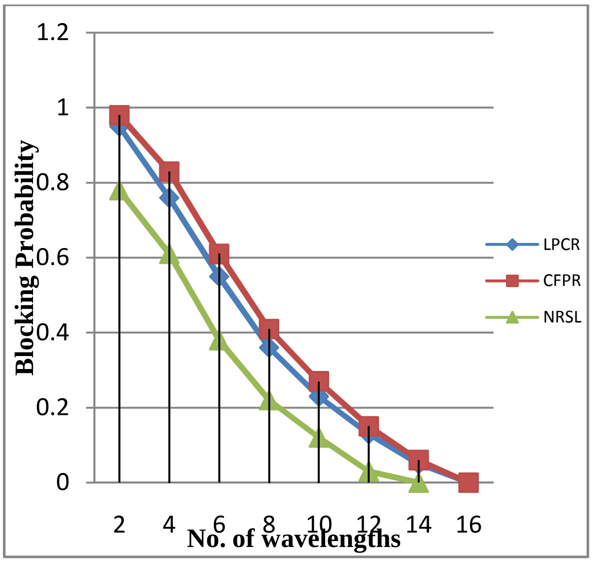

Figure-4: Performance analysis in term of blocking probability with effect of the increment on no. of wavelength

IV. CONCLUSION

The comparison graphs of the throughputs of the test performed is presented in fig.5. The graph shows that the average blocking probability is higher in LPCR algorithm and CFPR algorithm as compared to NRSL algorithm by using the proposed specific comparison concept. It has been

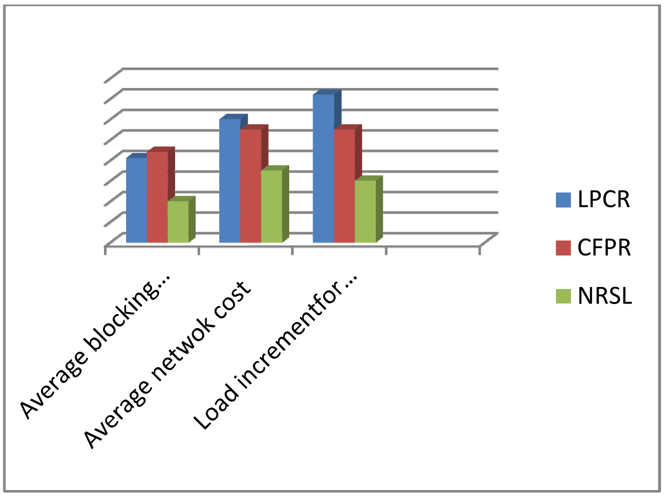

Figure-5: Comparison graph

concluded that this better performance of NRSL algorithm is due to less increment in load in NRSL algorithm with the increase in new source-destination pair request. So the NRSL algorithm is better to use by using the proposed specific comparison concept, for a network where it is required that the load should not be increased rapidly for new source-destination pair request.

This also shows that the number of wavelengths per optical fiber required for the same performance are much lower in NRSL algorithm as compare LPCR and CFPR algorithms. The number of wavelength in optical fiber affects the cost of network because the cost of optical fiber also depends upon the number of wavelengths available in each fiber. As the number of wavelength increases the cost of the optical network also increases. This is shown in fig.6.

The another factor of discussion is that the blocking probability increases in a working network whenever new source-destination pair request is added. In case of LPCR and CFPR algorithms the load on links increases much due to new source-destination pair request as compare to NRSL algorithm as shown in the simulation. This enable the optical fiber networks with low capacity using NRSL algorithm to work better in case of new source-destination pair request enters rapidly. So in poor countries there is less requirements of frequently changing the optical fiber networks with low capacity in case the users increases.

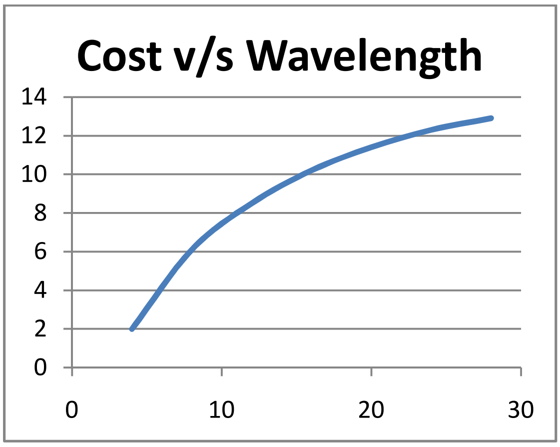

Figure. 6: Effect of number of wavelengths on the cost of optical network

The factor that the NRSL algorithm do not increases the performance much is resolved by the point that in poor countries of the world the cost matters much as compared to the other factors. The first factor for these countries which must be considered is the cost of the system which has been reduced by NRSL algorithm for the same performance of network. The NRSL algorithm keep the full stress on this point and performs well for providing the optical network with almost same capacity at a low cost as compare to LPCR and CFPR algorithms.

So it has been concluded that the use of NRSL algorithm is better in poor countries of the world where we have to provide the services at lower cost.

V. FUTURE SCOPE

It has get concluded by using the proposed specific comparison concept with NRSL algorithm, we reduce the overall network cost by minimizing the required capacity, or wavelengths, needed for a given demand and to put minimum load possible at once on each link. But we paid little attention to the impact of other expensive devices such as wavelength converters and O-E-O regenerators. But these devices also play a major role on the overall cost of optical networks. Hence for better enhancement of the optical network in developing countries, especially in poor countries in future, the cost or the requirement of these expensive devices should also be optimized.

The other major factor is that as the number of users increases, NRSL algorithm takes more time to decide the path i.e. time consumption increases and it is useful for the low capacity optical network. In future, the number of users and high capacity networks will increase in developing as well as poor countries also. So it requires putting further attention toward the time consumption with keeping the cost of network at low.

VI. REFERENCES

[1] **Anil K. Kamboj, Paramjeet Singh, Shaveta Rani,** "Wavelength Division Multiplexing Routing Algorithm for Optical Fiber Networks Proactive Survivability", IJCSITRE, vol. 3, Issue-3, May-June-2013 .

[2] **Kefei Wang,** "Resource Optimization and QoS for WDM Optical Networks".

[3] **C. Murthy and M. Guru Swamy,** "WDM Optical Networks", Prentice Hall PTR.

[4] **Tianjian Li,** "On Optimal Survivability Design in WDM Optical Networks under Scheduled Traffic Models", *Doctor of Philosophy,* Wright State University, March, 2007.

[5] **Ramamurthy, S., Sahasrabuddhe, L. and Mukherjee,** B. (2003). Survivable WDM mesh networks. *Journal of Lightwave Technology* **21**:870-883.

[6] **Zhou, D. and Subramanian, S.** (2000). Survivability in optical networks. *IEEE Networks* **14**:16-23.

[7] **R. Ramaswami and K. N. Sivarajan**, "Optical networks: a practical perspective", 2nd ed. San Francisco, Calif.: Morgan Kaufmann, 2002.

[8] **Shaveta Rani , Paramjeet Singh, Ajay K. Sharma, "**Distributed control based survivability strategy for WDM optical networks" *Seventh International Conference on Optoelectronics, Fiber Optics and Photonics, (PHOTONICS-2004)* p2.112.

[9] **Manoj Sivakumar and Krishna M. Sivalingam,** "A Routing Algorithm Framework for Survivable Optical Networks Based on Resource Consumption Minimization", *Journal of Lightwave Technology*, vol. 25, no.7, pp. 1684-1692, July 2007.

[10] **Vishal Anand and Chunming Qiao** "*Effect of Wavelength Conversion* in Survivable Wavelength Routed Optical WDM Networks with Alternate Routing" 2002.

[11] **Byungkyu Kang** "Design of Survivable WDM Network Based on Pre-Configured Protection Cycle". *Thesis of Master of Science*, EDITH COWANN University, Western Australia, August 2006.

[12] Albert Dirk Gazendam, "The design of Physical and Logical Topologies for Wide Area WDM Optical Network". *Thesis of Master of Engineering*, University of Pretoria, Pretoria, December, 2003.

[13] **Ji Li,** "Design and Analysis of Survivable WDM Mesh Network" *Doctor of Philosophy,* University of Hong Kong, April, 2007.

[14] **Paramjeet Singh**, "Investigations on Routing and Wavelength Assignment Algorithms in WDM Optical Networks".

[15] **Manoj Sivakumar and Krishna M. Sivalingam**, "A Routing Algorithm Framework for Survivable Optical Networks Based on Resource Consumption Minimization" Journal of Lightwave Technology, vol. 25, no. 7, July 2007.

[16] **S. Gowda and K. M. Sivalingam**, "Protection mechanisms for optical WDM networks based on wavelength converter multiplexing and backup path relocation techniques" Proc. IEEE INFOCOM, San Francisco, CA, Mar. 2003, pp. 12–21