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Survivability Strategy for Large and Scalable WDM Optical Networks

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Summary

The restoration control strategy can be either centralized or distributed. In centralized control, there is a central controller to keep track of the state of the network. It is also responsible for selecting the path for data transmission. Most of the work done in this field is based on centralized control. For large networks, distributed control is preferred over centralized control because of low control overhead. Distributed control strategy requires exchange of control messages among nodes. The distributed control generally results in the possibility of resource reservation conflicts among simultaneous path establishments and poor resource utilization. In this paper, we have proposed one distributed control based strategy that avoids the problem of resource reservation conflicts along with the efficient utilization of resources. The resource utilization is enhanced by using backup multiplexing technique i.e. there can be resource sharing between backup lightpaths. The proposed strategy is based on proactive approach i.e. the backup lightpath is established along with primary lightpath to avoid time delay in searching the alternate path for affected traffic after failure to avoid data loss.

1 Introduction

Survivability is one of the very important issues in optical networks. It is greatly effected by the provisioning which deals with resource allocation [1]. It deals with re-establishing communication upon failure. The restoration can be categorized as proactive and reactive techniques. Proactive techniques are those techniques in which the resources for backup lightpath are reserved, when the connection request arrives. Reactive techniques are those techniques in which backup lightpath are searched after failure occurrence. Restoration techniques can be categorized as link based and path based [2]. In link based restoration, a new path is selected between end nodes of failed link only. In path based restoration, a new path is searched between the source and the destination. The path based restoration can be further categorized as failure dependent and failure independent. In failure dependent method, associated with each failure, a backup lightpath is there. The backup lightpath need not to be link and node disjoint with the primary lightpath. In failure independent approach, there is only one backup lightpath. In it, both lightpaths need to be link and node disjoint. Resources for backup lightpath can be reserved in three ways: primary backup multiplexing, dedicated backup lightpath and backup multiplexing. In primary backup multiplexing technique, a primary lightpath and one or more backup lightpath can share the resources [3], in dedicated backup lightpath, there is one dedicated backup lightpath i.e. the resources allocated to backup lightpath are not shareable. But in backup multiplexing, the resources allocated to one backup lightpath can be shared by other backup lightpaths. In this paper, we have proposed a distributed control based survivability strategy because it is the only solution for large and scalable networks. It can be used for critical applications as it provides 100% degree of survivability and very low restoration time proactive in nature. Although it reserves the resources in advance, the resources are utilized very efficiently due to the backup multiplexing. The distributed control mostly results in resource reservation conflicts but the proposed scheme resolves the conflicts.

2 The proposed strategy

The strategy works in the proactive manner and it is based on the concept of path based failure independent restoration and single failure model. It can work for both node and link failure. Backup multiplexing technique for resource reservation has been used to efficiently utilize the resources and to reduce the blocking probability. The lightpaths established will be wavelength continuous. There is one link information table corresponding to each link in the network. The link information table has three columns and one row entry corresponding to each reserved wavelength on that link. The entry in the first column shows the number of the wavelength that has been allocated; second column shows the primary route(s) for

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the source destination pairs which are using this wavelength. There will be only one route in the second column, if the wavelength is reserved for primary lightpath, otherwise it may have more than one route. The entry in the third column shows whether this wavelength is used for primary (*P*) or backup (*B*) lightpath establishment. The degree of survivability achieved through this strategy is always 100% for all the connections accepted. Shortest path algorithm is used to find a route based on the hop count because it results in the selection of a route that uses minimum number of links. As less number of links are used, so resources are used more efficiently and blocking probability reduces.

For each source destination pair, perform the following steps:-

i. Find a route between the given source and destination using shortest path algorithm. Let this route be R.
ii. For i = 1 to N (N is total number of wavelengths per fiber.)
iii. Flag = 1
iv. For j = start link to last link on route R
v. If there is an entry in the link information table corresponding to link j for wavelength i
   Then
   (I) For k = j-1 to start link Step -1
   (II) Delete the row entry in the link information table corresponding to link k for wavelength i.
   (III) End of for loop for k
   (IV) Flag = 0 (V) Break out of the loop for j.
   Else
   (I) Add one row in the link information table for link j which contains the wavelength i in 1st, route R in 2nd and 'P' in 3rd column.
   (II) If (j = last link), go to step (viii).
vi. End of for loop for j
vii. End of for loop for i
viii. If (flag = 0)
   Then
   (I) Reject the connection request.
   (II) Perform steps starting from step (i) for another s-d pair.
ix. Take a network similar to the given network except that it does not have the links and nodes used by R.
x. Find the shortest route considering the network from step (ix). This route is Q.
xi. For wavelength w = 1 to N
xii. Flag = 1
xiii. For link j = start link to last link on the route Q
xiv. If the wavelength w is free on link j
   Then
   (I) Add a new row in the link information table by putting w in 1st, R in 2nd and 'B' in 3rd column.
   (II) If (j = last node), go to step (xvii).
   Else If third column entry for wavelength w in the table is 'P'
      Then
      (I) For k = j-1 to start link on route Q Step - 1
      (II) Delete row corresponding to wavelength w.
      (III) End of For loop for k
      (IV) Flag = 0
      (V) Break out of the loop for j.
   Else If the route(s) in second column for wavelength w and the route R are link and node disjoint
      Then
      (I) Add R in the 2nd column.
      (II) If (j = last node), Then go to step (xvii).
      Else
      (I) For k = j-1 to start link on route Q Step -1
      (II) Delete the row corresponding to wavelength w from the table if it has only one entry in 2nd column, otherwise delete R from 2nd column.
      (III) End of For loop for k
      (IV) Flag = 0
xv. End of For loop for j
xvi. End of For loop for w
xvii. If (flag = 0)
   Then
   (I) For j = last link to start link on route R Step – 1
   (II) Delete the row entry for wavelength i from link information table for link j.
   (III) End of For loop for j
   (IV) Reject the connection request.
xviii. Start from step (i) for another s-d pair till end.

3 Results

The network shown in Fig. 1 is taken as the example network. Three wavelengths per fiber have been assumed and the following source destination (s-d) pairs for connection establishment have been taken:
(1 – 4), (2 – 10), (1 – 3), (5 – 4), (6 – 10), (6 -7), (2 – 6), (1 – 8), and (8 – 10).

Table 1 gives the overview of all the connection requests. The 1st column in it indicates the s-d pair, the 2nd shows R, 3rd shows the wavelength used for primary lightpath, 4th indicates Q, 5th shows the wavelength to be used for backup lightpath and the last column indicates whether the connection has been accepted or dropped. There is one row entry corresponding to each s-d pair. Tables 2(a) to 2(b) are two of the fourteen link information tables generated one corresponding to each link.

This strategy if modified to look through various routes will although result in acceptance of the connection request for (5-4) s-d pair, but on a longer route and increase in the connection establishment time which will increase blocking probability and also will increase connection establishment time which is undesirable. The connection requests for s-d pairs: (6-10), (2-6), (1-8), (8-10) has been accepted just due to backup multiplexing.

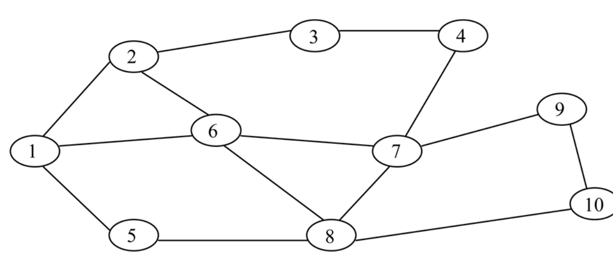

Fig. 1: The 10-node 14-link network.

Table 1: Overview of all the connection requests

s-d Pairs	Primary route	Primary λ number	Backup route	Backup λ number	Status
1 - 4	1-2-3-4	1	1-6-7-4	1	Accepted
2- 10	2-6-8-10	1	2-3-4-7-9-10	2	Accepted
1 - 3	1-2-3	3	1-6-7-4-3	2	Accepted
5 – 4	-------	--	------	--	Dropped
6– 10	6-8-10	2	6-7-9-10	1	Accepted
6 – 7	6-7	3	6-8-7	3	Accepted
2 – 6	2-6	2	2-1-6	2	Accepted
1 – 8	1-5-8	1	1-6-8	3	Accepted
8 - 10	8-10	3	8-7-9-10	3	Accepted

Table 2 (a): Link information table for link 1-2

Wavelength	Route	P \ B
1	1-2-3-4	B
2	1-2-3 and 2-6	B
3	1-5-8	B

Table 2 (b): Link information table for link 1-6

Wavelength	Route	P \ B
1	1-2-3-4	P
3	1-2-3	P
2	2-6	B

4 Conclusions

The proposed strategy results in an efficient utilization of resources as backup multiplexing technique is used. Distributed control which is preferred for large and scalable networks, generally results in resource reservation conflicts. But this problem has been resolved in this strategy by reserving the resources by making entry in the link information table. It makes the system reliable as it gives 100% degree of survivability for all the connections accepted. So this strategy can be used for large and/or scalable networks handling critical data.

References

[1] S. Rani, A. K. Sharma, P. Singh: “Restoration approach in WDM optical networks”; Int. Journal of Optics (2006), accepted for publication

[2] C. Ou et. al.: “Subpath protection for scalability and fast recovery in optical WDM mesh networks”; IEEE Journal on Selected Area in Comm. 22 (2004) 9, 1859-1875

[3] R. Ramaswami, K. N. Sivarajan: “Optical Networks – A Practical Perspective”; 2nd edition, Morgan Kaufmann (2002)