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EFFICIENT NETWORK RESOURCE UTILIZATION SURVIVAL STRATEGIES FOR OPTICAL NETWORK

Prafful Dubey*[1], Prof. Vijay Chauhan[2]
*[1,2]Department of Electronics and Communication Engineering
Lakshmi Narain College Of Technology,Indore
praffuldubey@gmail.com

Abstract

If the light path is disrupted, huge volume of traffic loss occurs. Failure of connection may be due to fibre cut or node failure in the network.Survivability, the ability of a network to withstand and recover from failures, is one of the most important requirements of networks. Its importance is magnified in fibre optic networks with throughputs on the order of gigabits and terabits per second. In this paper survivable strategies are Dynamic Path Protection, Shared Path Protection and Hybrid Connection Approach.These strategies are compared on the basis of blocking probability,Resources Utilization Ratio and number of wavelength link used for the establishment of connection request.The network topologiesNATIONAL and NSFNET have been used for simulation on MATLAB environment. The result demonstrates that among all the strategies HCA establish maximum number of connections; avoid congestion and uses minimum network capacity.

Index Terms- Routing and wavelength Assignment, light path, opticalnetwork, optimization, protection, protection-switching time,restoration, survivability, wavelength routing.

1. Introduction

The extensive growth of the Internet and the introduction ofnew services and applications, which require high networkbandwidth and availability have prompted many telecommunication operators to extensive deployment ofWavelengthDivision Multiplexing (WDM) networks. In WDMaccess technology, several high bandwidth wavelength channelsare multiplexed in one optical fibre with point-to-pointcommunications. Thus, network capacity expansion andphysical extension of mesh networks are made easier andcost-effective. Thanks to its huge transport capacity, WDMremedies to the transmission bottleneck faced by metropolitanand backbone optical transport networks, but, at the sametime, poses the challenge of protecting the large amounts oftransported traffic. Survivability inWDMnetworks is consequentlya crucial issue that has already received considerable research interests.

Two survivability paradigms have been proposed in survivableWDM networks, namely the reactive and the proactiveones. Within the reactive approach, known asrestoration, a search for link (node) disjoint backup paths is Initiated only when a failure occurs in the network. With the Proactive approach, known as protection, backup-protection
paths are pre-configured (pre-determined and all the requiredresources along the path are reserved) at the same time as the working path is established. As backup resourcesare reserved ahead of network failures, the proactive approachguarantees the recovery of the failed link/path within a shortrestoration delay.While the proactive approachmayconsumeless spare capacity, and thus achieves higher spare capacitysaving, it cannot always guarantee successful recovery andmay take longer time to recover from a failure.may take longer time to recover from a failure.

In wavelength routed network data flows at a very high rate(in Tb/s). Here different wavelengths are combined by a multiplexerand simultaneously transmitted over a single fiber usingwavelength division multiplexing. Hence, wavelength divisionmultiplexing (WDM) enhances the capacity of the optical networks.Each wavelength can support data rate up to several hundreds ofGbps for alightpAlight path is an optical route between the twonodes in the network. There are two types of lightpaths: the primarylightpath and the backup lightpath. The lightpath that carriestraffic during normal mode of operation is known as primary (activeor working) lightpath. Since most of data flows over primary lightpath,it must be the shortest path among all the available routes.When primary lightpath fails, the traffic is rerouted over a newlightpath, known as backup (reserved) light path. In wavelengthrouted network two types of connection requests, either offline oronline arrive. In offline connection requests, variables such as theset of source to destination pairs, the number of s–d requests, theconnection setup and teardown time are known in advance. This isalso known as scheduled lightpath demand (SLD). In SLD, if setup and tear down time are ignored, it is known as permanentlightpath demand (PLD) or static lightpath demand of the connectionrequests. If connection requests are arrange as per theincreasing or decreasing order of their path length this is known assequential routing in WDM network. In online mechanismconnection requests arrive randomly. This mode is also known asdynamic or random traffic demand.

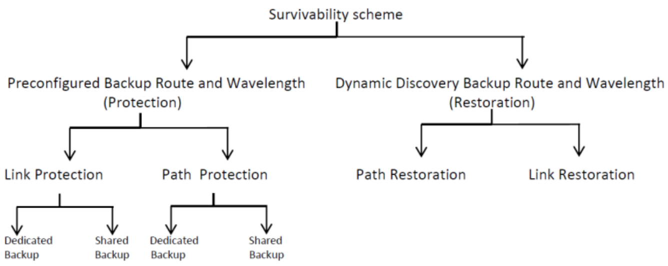


Fig.2 Different schemes of Surviving link failures

I. SCHEME

If the light path is disrupted, huge volume of traffic loss occurs.Failure of connection may be due to fibre cut or node failure inthe network. To make connections survivable redundant capacity is provided within the network. This capacity may be used forrerouting the traffic when a failure occurs. These issues come underthe domain of fault management techniques; and this has beenan area of extensive research during last decade. Fault managementis broadly classified in two types: protection and restorationProtection techniques reserve the redundant route/routes (backuplightpath) during the connection (primary lightpath) setup ;while, in restoration the interrupted request is rerouted afterthe disruption of primary lightpath. In protection mechanism,resource allocation is preplanned and these routes are not useduntil primary path fail. Therefore, protection mechanism provides100% restorable networks. However, in these techniques resourcesare not utilized efficiently. Toward the efficient utilization of theresources, backup lightpaths share the wavelength link, assumingsingle connection failure. This significantly reduces the resourcerequirement in the network. In restoration techniques backuplightpath is searched by considering current status of the network.Backup lightpath may be either link disjoint or path disjoint. In linkdisjoint lightpath, route is searched along the failed link only. Whilein path disjoint lightpath, all the links and intermediate nodesof failed primary lightpath are excluded when searching for thebackup lightpath [1,6].

II. SURVIVABILITY SCHEME

• ***Path protection/restoration:***

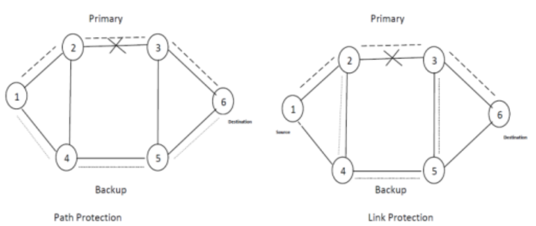


Fig.3 Protection scheme

In path protection, backup resources are reserved duringConnection setup, while in path restoration; backup routesare discovered dynamically after the link failure. When a link fails [illustrated in Fig. 3(a)], the source node and the destination node of each connection that traverses the failed link are informed about the failure via messages from the nodes adjacent to the failed link.

*(1) Dedicated-path protection:*In dedicated-path protection(also called 1:1 protection), the resources along a backup path are dedicated for only one connection and are not shared with the backup paths for other connections.

(2) Shared-path protection: In shared-path protection,the resources along a backup path may be shared withother backup paths. As a result, backup channels aremultiplexed among different failure scenarios (whichare not expected to occur simultaneously), and therefore,shared-path protection is more capacity efficientwhen compared with dedicated-path protection.

(3) Path restoration: In path restoration, the source and destination nodes of each connection traversing the failed link participate in a distributed algorithm to dynamically discover an end-to-end backup route. If no routes are available for a broken connection, then the Connection is dropped.

• ***Link protection/restoration:***

In link protection, backup resources are reserved around each link during connection setup, while in link restoration, the end nodes of the failed link dynamically discover route around the link. In link protection/restoration [illustrated in Fig. 3(b)], all the connections that traverse the failed link are rerouted around that link, and the source and destination nodes of the connections are oblivious to the link failure.

*(1) Dedicated-link protection:*In dedicated-link protection,at the time of connection setup, for each link of the primary path, a backup path and wavelength are reserved around that link and are dedicated to that connection. In general, it may not be possible to allocate dedicated backup path around each link of the primary connection and on the same wavelength as the primary path. For example, Fig. 5 shows a bidirectional ring network with one connection request be-tween Node 1 and Node 5. The backup path around link(2,3), viz. (2,1,8,7,6,5,4,3), and the backup path around link (3,4), viz. (3,2,1,8,7,6,5,4), share links in common and hence cannot be dedicated the same wavelength.2 Since our experience indicates that dedicated-link protection utilizes wavelengths very inefficiently, we will not consider dedicated-link protection in this work.

(2) Shared-link protection: In shared-link protection, the backup resources reserved along the backup path may be shared with other backup paths. As a result, backup channels are multiplexed among different failure scenarios (which are not expected to occur simultaneously), and therefore shared-link protection is more capacity-efficient when compared with dedicated-link protection.
Link restoration:In link restoration, the end nodes of the failed link participate in a distributed algorithm to dynamically discover a route around the link. If no routes

are available for a broken connection, then the connection is dropped.

III. OBJECTIVES

Our aim is to allocate the s–d requests in such a way thatthe acceptance of connection requests is maximized with theuse of minimum number of the network resources (wavelengthlinks).The parameter signifying the utilization of network capacityis the Resource Utilization Ratio [18,21]. Lower value of RURmeans the given strategy has been able to utilize the networkresources efficiently and there exists the maximum sharing ofbackup resources. The objectives of this paper can be givenas:

1. Maximize the number of requests established in the network.
2. Minimize the wavelength-links used by the connection requestsin the network.
3. Minimize the Resource Utilization Ratio (RUR), defined as theratio of the network capacity used to the total connectionrequests holding in the network.

IV. SURVIVAL STRATEGIES

1) Dedicated-path protection (DPP)

In dedicated-path protection (also called 1:1 protection), the resources along a backup path are dedicated for only one connection and are not shared with the backup paths for other connections.

2) Shared path protection (SPP)

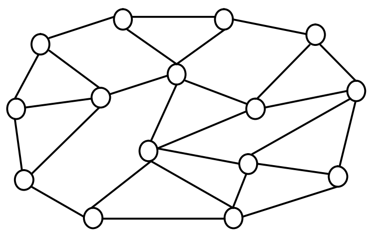
In SPP, corresponding to an arrived connection request, the primarylightpath for the s–d pair is searched based on the shortestpath algorithm; then the first available wavelength is assignedto the pre-determined search route as per the first fit algorithm.After this, the path disjoint backup lightpath is searched. Thebackup lightpaths corresponding to different connection requestsmay share the wavelength on links for the efficient use ofresources.

Hybrid connection strategy (HCA)

In HCA, the same wavelength of each link in the network isreserved for the establishment of the backup lightpaths. For a givens–d request, the primary lightpath is searched in a fashion similar tothe SPP. However, in comparison to SPP, in HCA backup multiplexingis efficiently performed. This results in enhanced availability ofnetwork resources for the primary lightpaths.

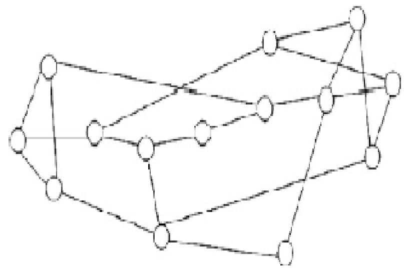
V. TOPOLOGIES

1) NATIONAL:



NATIONAL network topology having 15 nodes and 27 links

2) NSFNET:

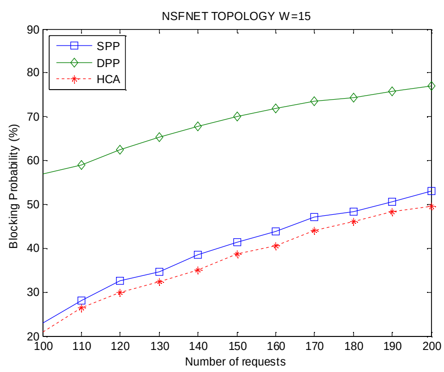


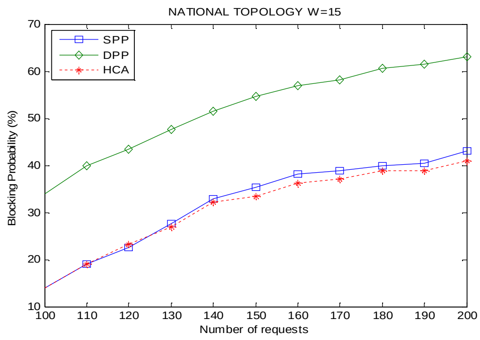
NSFNET topologyhaving 14 nodes and links

VI. SIMULATION AND RESULTANALYSIS

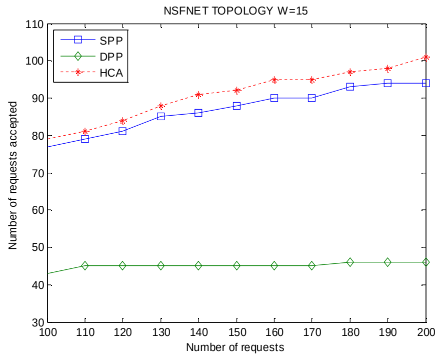
In order to implement these strategies, a simulator has been developed inMATLAB environment. In the simulator, information regarding thenetwork topology is given as input parameters. The network hasbeen assumed to be without the wavelength conversion capabilityand the static traffic is assumed. Different sets of connectionrequests are generated for the simulation. For connection recoverysingle link failure model has been assumed. In simulator, all the simulations have been undertaken considering the protectionpath based recovery for the backup lightpath establishmentand the constraints defined. The static lightpathdemands have been considered. The output of the simulator providesthe following information: the number of requests accepted,the wavelength-links used by accepted connection requests, theResource Utilization Ratio (RUR).

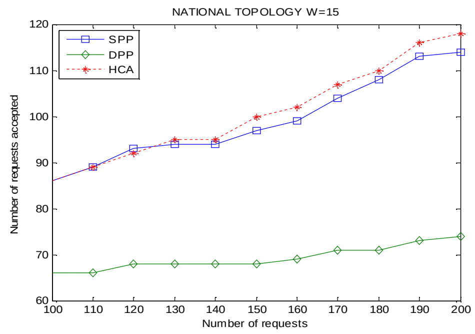
It is defined as the ratio of network capacity used to thetotal connection requests holding in the network. Lower value of RUR means network's capacity is utilized efficiently. This in a wayimplies that sharing of backup resources is high. RUR has a lowvalue, when either the number of connections holding the requestsis high or the network capacity used is low.



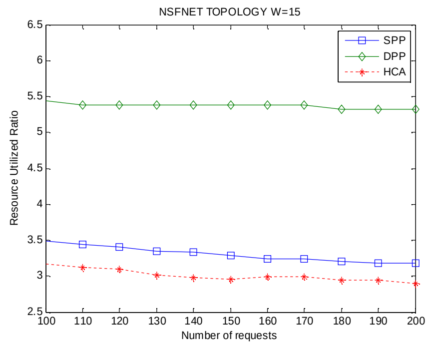


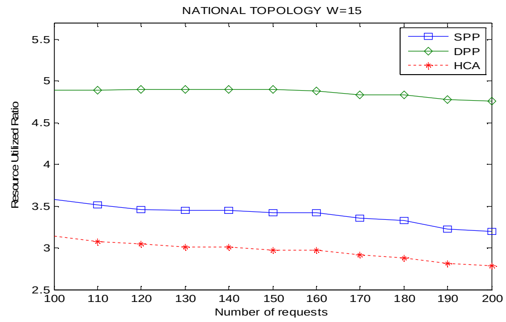
(a) The graph showing variation of 'blocking probability' with the'number of requests arrived' forNSFNET network. (b) The graph showing variation of'blocking probability' with the 'number of requests arrived' for NATIONALnetwork.





(a) The graph showing variation of 'number of requests accepted' with the'number of requests arrived' for NSFNET network. (b) The graph showing variation of'number of requests accepted' with the 'number of requests arrived' for NATIONALnetwork.





(a) The graph showing variation of 'R U R' with the 'number of requestsarrived" for NSFNET network. (b) The graph showing variation of 'R U R' with the'number of requests arrived' for NATIONAL network.

VII. CONCLUDING REMARKS

In this communication, we compare DPP, SPP and HCA survival strategy in WDM optical networks in dynamic traffic environment. Togeneralize the results, study on the network topologies of NSFNET and NATIONAL has been undertaken. The result demonstrates that among all the strategies HCA establish maximum number of connections; avoid congestion and uses minimum network capacity.Based on the investigations and result after simulation we conclude that HCA performs better than existing strategy.

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