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A survey on protection and restoration methods in Optical Networks

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Abstract: optical networks working on WDM (Wavelength Division Multiplexing) are prone to component failures. As these networks carry huge amount of information, fault management has become vital in maintaining survivability of high speed optical networks. In WDM networks failure of networks, failure of network element may cause the failure of several optical channels, thereby leading to large data losses. Lea In this paper, existing protection and restoration methods proposed for optical network are critically reviewed and analyzed. The operation of various methods and their performance also presented.

Keywords: optical networks, protection, restoration, survivability, WDM.

I. INTRODUCTION

Wavelength division multiplexing (WDM) divides the vast transmission bandwidth available on a fiber into several non -overlapping wavelengths bands, and thus allowing multiple wavelength channels to co-exist on a single fiber. An access station may transmit signals on different wavelengths, which are coupled into fiber using wavelength multiplexers. An optical signal passing through a wavelength-selective cross connect may be routed from an input fiber to an output fiber without undergoing optoelectronic conversion. An optical signal passing through a wavelength-interchange cross-connect may be converted from the input wavelength to different wavelength at the output port [1].

These and another network elements are prone to failure may result in huge amount of data loss and revenue loss. This gives high importance to the issue of survivability of optical network. It refers to ability of a network to recover affected traffic in failure environments and to provide different services continuously. Survivable network architectures are based either on reserving backup resources in advance called protection or on discovering spare backup resources in an online manner called restoration [2]. This paper is organized as follows. In section II, We begin by presenting existing protection and restoration methods. Section III concentrates related work in this field. Various Comparative analyses presented in section IV. Finally, concluding remarks and future scope are presented in section V.

II. EXISTING PROTECTION AND RESTORATION METHODS

2.1 Protection Techniques

Optical network protection methods are classified by Guido Maier, AchillePattavina, Simone De Patre and Mario Martinelli [3]. They described preplanned protection and left provisioning part for future work as shown in Fig: 1. Protection can be implemented in optical channel sublayer (OChS Protection) and in optical multiplex sublayer (OMS Protection). Different protection schemes are used ring network and mesh networks.

2.1.1 Path Protection in Ring Networks- OChDPRing(Optical Channel Dedicated Protection Ring)/1+1 Dedicated Protection

For path protection OCh-DPRing scheme is applied. As shown in fig.2 this is applied to the rings that use two fibers to propagate the signal in opposite direction. Path protection is designed using both the fibers to establish two counter propagating light paths around the ring [3]. The source node transmits on both the working and protection links simultaneously. Exact failure localization is not important. This scheme will become problematic, when more light paths are involved in failure.

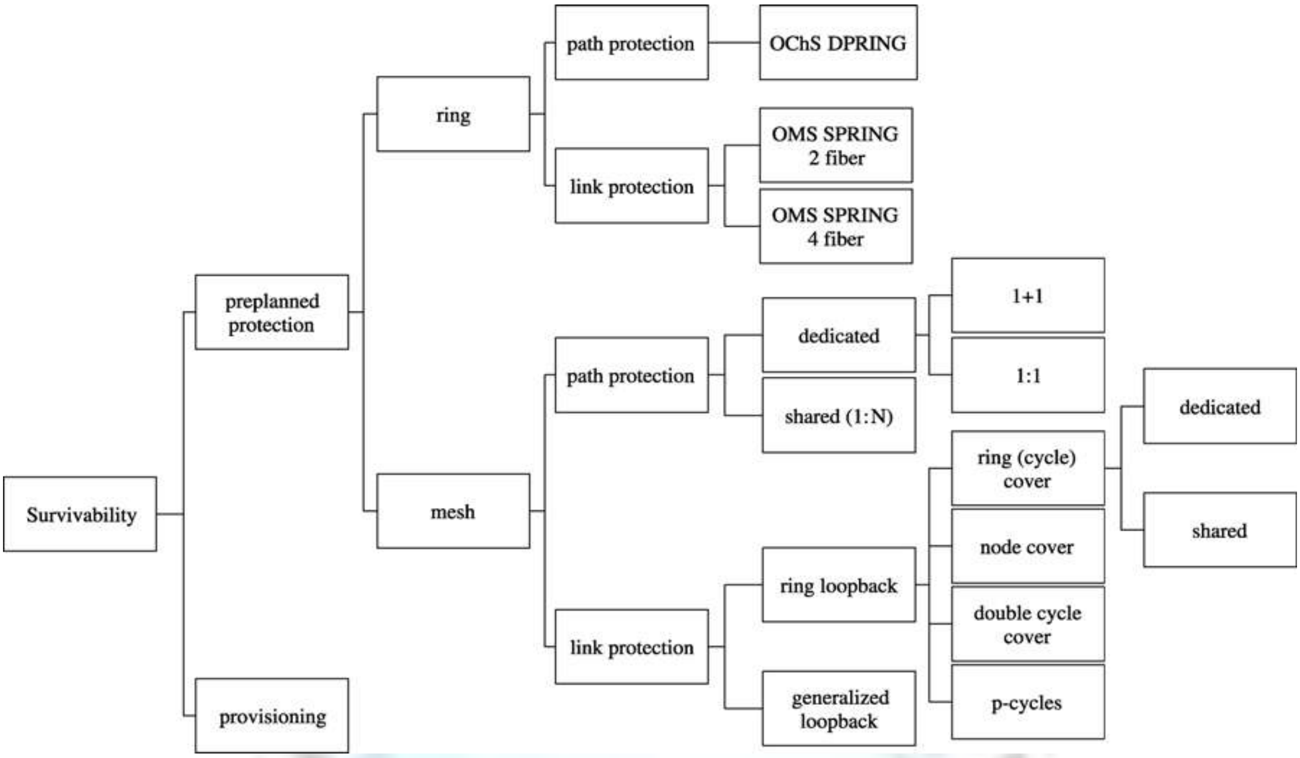

Figure 1: Classification of the protection techniques implementing survivability in the WDM layer [3]

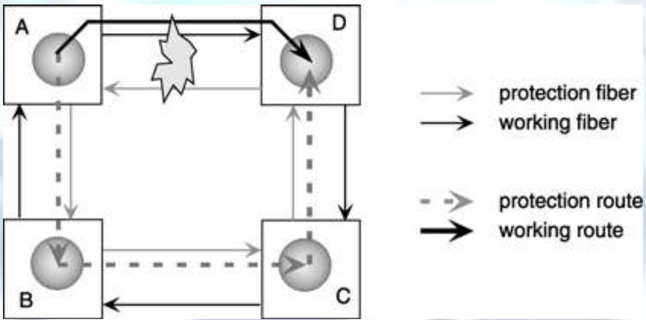

Figure 2: OCh-DPRing 1+1 path protection of the lightpathAD[3]

2.1.2 OMS link Protection-OMS-SPRing(Optical Multiplex Section-Shared Protection Ring)

This is also called as line or link protection , all the WDM channels crossing the failed fiber are rerouted together. An idle alternative path must be available. They can be further classified as two fiber or four fiber mode. In four fiber mode for each fiber pair, second pair is reserved for backup traffic. In two fiber system, on each fiber from a couple of fibers in one direction, half are used as spare resources to protect some other link [3].

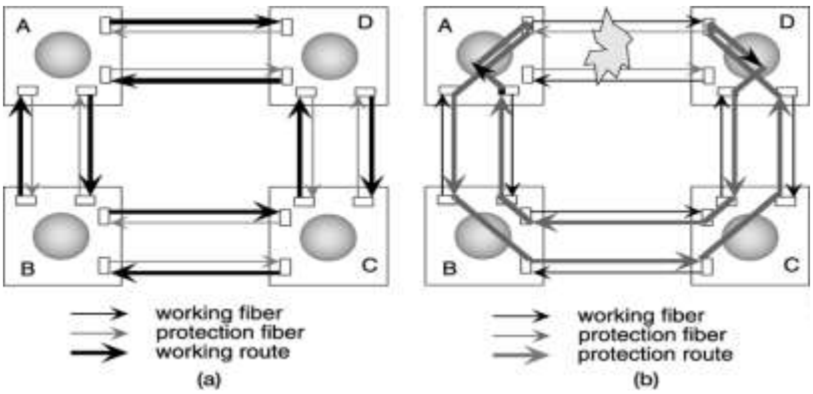

Figure 3: OMS Shared Protection Ring, four -fiber implementation the ring is represented in failure condition (a) and after a loopback (b) [3]

2.1.3 Dedicated Path Protection Mesh Networks

In WDM mesh networks dedicated path protection is possible in both 1+1 and 1:1 types. In 1+1 protection the optical signal is physically split at the transmitter and routed onto two different paths. The receiver receives both the signal and selects the best one. Its protection path is always in use. In 1:1 protection the working lightpath is switched on the protection path only when a failure occurs. Protection resources can be used by the low priority traffic in normal condition.

2.1.4 Shared Path Protection /1: N

A single protection path is used to protect a set of N paths. The working lightpath is switched onto protection path only when a failure occurs. In this case the amount of resources reserved for protection is decreased.

2.1.5 Ring Loopback (Link Protection in Mesh Networks)

The three most notable ring based protection techniques for mesh networks are ring covers, cycle double covers, and p-cycles (pre-configured protection cycles). The main goal of the ring cover technique is to find a set of rings that covers all the network links and then use these rings to protect the network against failures. Cycle double covers technique provides one protection fiber for each working fiber. The p-cycle technique is based on the property of a ring to protect not only its own links, but also any possible links connecting two non-adjacent ring nodes called chordal links.

2.1.6 Generalized Loopback Technique

Generalized loopback technique can be included under ring based approaches. Although its not strictly, considered as one of the mesh-based ring protection techniques.

2.2 Restoration Methods

Fault tolerance refers to the ability of the network to reconfigure and reestablish communication upon failure, and is widely known as restoration [4]. A restoration scheme may be either centralized or distributed control. For large networks, distributed control is preferred over the centralized control. The restoration schemes differ depending on the functionality of the cross-connects, traffic demand, performance metric, and network control. The traffic demand can be either static or dynamic. In static traffic demand, the set of demands is given in advance. The objective is to assign lightpaths with restoration capability to all the demands to minimize spare resources required. This problem is relevant for the capacity planning phase to determine the capacity needed in near future based on current and expected demands [5]. Ultimate aim is to satisfy large number of demands with less number of resources. Fig. 4 shows the classification of the restorations methods

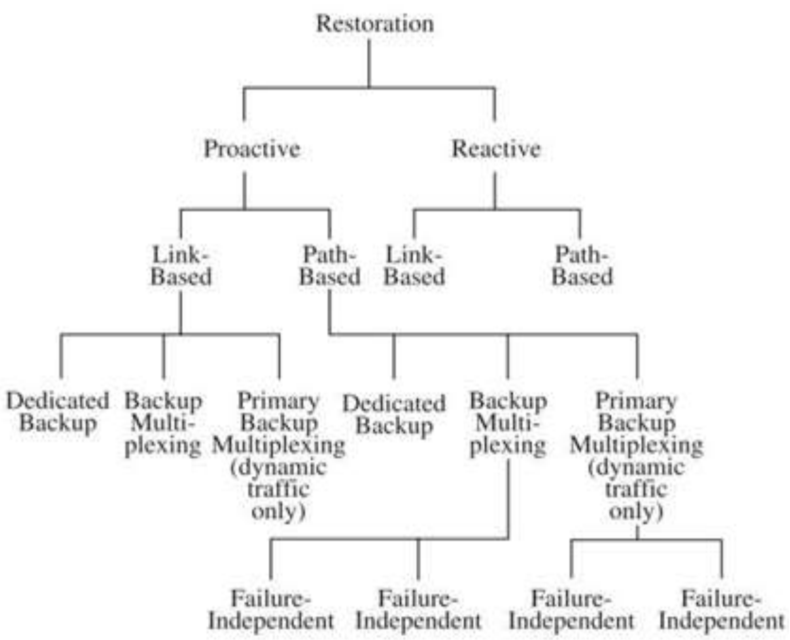

Figure 4: classification of restoration methods[5]

2.2.1 Proactive Restoration

In this method backup lightpaths are reserved at the time of planning primary lightpaths. So they provides hundered percentage gaurantee in restoration

2.2.2 Reactive Restoration

The reactive method no backup path is reserved but search is initiated when the primary path fails to find out spare resources. So this method is able to provide hundered percentage gaurantee in restoration of failed path.

2.2.3 Link Based Restoration

In this method ,whenever failure occurs in network the rerouting is done around the failed link in the network.

2.2.4 Path Based Restoration

A complete new path is used as alternate path. This include the usage of the dedicated reserve backup route.

2.2.5 Dedicated Backup

A proactive restoration method may use a dedicated backup lightpath for a primary lightpath. This is known as dedicated backup reservation method.

2.2.6 Backup Multiplexing

As resouce is vital in optical communication, all efforts are being done in this direction as in backup multiplexing lightpaths can share a wavelength channel.

2.2.7 Primary Backup Multiplexing

In dynamic traffic scenario, a proactive method can employ primary backup multiplexing to further improve resouce utilization.

2.2.8 failure dependent

In failure-dependent method, associated with the failure of every link used by a primary lightpath, there is a backup lightpath. A backup lightpath use any link except the failed link.

2.2.9 failure independent

In failure- independent method, a backup lightpath link-disjoint with primary lightpath.

III. RELATED WORK: SURVEY

M. Alanyaliet al. [4] they addressed restoration network design problem for multifiber wavelength selective network. The work considers a proactive failure-dependent path- based restoration scheme. Two design methods were proposed, and their performance was evaluated through simulation. S. Baroniet al. [7] provisioning multifiber network was considered for both wavelength converting and wavelength selective networks. they also proposed three proactive restoration methods. These were path based failure independent and failure dependent and link-based methods. Amir Askarianet al. [8] implemented cross layer techniques for improving the survivability of all optical networks by decreasing both the blocking probability and the susceptibility of the network to failures. Gurusamy Mohan and siva Ram Murthy [9] presented a comprehensive survey related to lightpath restoration in WDM optical networks. Sunil Gowda et al.[10] they implemented algorithm conversion free primary routing in backup paths and backup path relocation schemes.

IV. COMPARISON

The above explained restoration methods can be compared in respect of spare resources required, cost of cross-connects and algorithm complexity. Wavelength selected networks were considered in [11]. Wayne D. Grover and D. Stamatelakis analyzed P-cycles prove to have speed like ring networks and efficiency like mesh networks when used in optical network survivability [12]. O. Crochatand J. Y. Le Boudec dealt with a wavelength division multiplexing (WDM) network on which virtual paths (VP) serving a higher layer are overlaid. Since a single link failure can cause the simultaneous loss of service on several VPs, a design algorithm called Disjoint Alternate Path (DAP) is presented [13]. Yasuhiro Miyao and Hiroyuki Saito an integer programming based protection scheme is presented It attempts to assign working paths and the corresponding link-disjoint protection paths so that the total facility cost including the cost of fibers and OXCs is minimized. It assumes that wavelength conversion is available in each OXC, and no wavelength is released if a working pathfails. Restoration is rapidly performed with the help of an operation, administration, and maintenance (OAM) channel between the end nodes of the working path [14].

V. CONCLUSION AND FUTURE SCOPE

In this paper, we presented a survey on light path restoration in WDM optical networks. Some key attributes are restoration time, resource utilization, cost, efficiency needs to be taken into consideration while using different restoration schemes. It is expected that in future real life networks, there will be a formation hybrid form of resilience schemes. A Restoration method further needs improvement by looking demand of dense wavelength division multiplexing (DWDM) technology.

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