

# A Review of Network Survivability in Optical Networks

Neeraj Mohan and Gauravpreet Singh

**Abstract**—The survivability of optical networks is very important issue to address. It is critical because of the fact that these networks are high speed networks and they can handle a large volume of data. Link failures or path failures are very common in optical networks. These failures may cause a huge loss in term of data, time and revenue. To minimize this loss the failed network need to be restored as early as possible. The effect of failure may be minimized if the link is restored to reroute the affected traffic accurately and quickly using the available network resources. The different survivability mechanisms are used as per the need and volume of the network. The main focus is to handle the single link failures and multiple link failures. Multiple link failures may contribute toward the path failure. We have critically reviewed the existing network survivability schemes. Most of these schemes are either network protection schemes or network restoration schemes.

**Keywords**—Network Survivability and Optical Networks.

## I. INTRODUCTION

**O**PTICAL networks provide very high speed for network communication. Failure in a network system is a very common. It may happen due to various reasons. Any failure may result in to loss of data, revenue and time. A small failure may cause disturbance to millions of applications. It may result in tremendous data and revenue loss to both end users and network operators. The downtime of a leased connection in the industry is not acceptable. A downtime of more than 5 minutes per year is not acceptable in real time industry [1]. So the protection of communication system and data is very important. Link failures are very common. The basic objective of network and data protection is to provide reliable and uninterrupted communication to all the users. In case of failure, a restoration method is required to restore the data. These restoration schemes may be divided as reactive and proactive schemes. Further, these schemes can be link based or path based [2].

### Survivability Schemes:

Link failure is very common failure in case of optical networks. Mainly two approaches are there to deal with link failures. These approaches are protection and restoration. In protection approach backup routes are pre planed, and these are used in the event of a link failure. These routes are already designed and required resources are allocated to them.

Whereas, in restoration approach the backup paths are not pre planned. These paths are calculated as and when some failure is actually occurs by locating free wavelength channels. Protection and restoration approaches have their advantages and disadvantages for different parameters such as speed of recovery, resource utilization and the use of spare capacity. [3]

### Protection:

In this approach backup resources are reserved in advance before failure. Backup routes that are to be used in the event of a failure are pre planned. This approach is commonly used to address link failures in optical networks. If protection is implemented in a capacity efficient manner then it can offer much faster recovery from failure. Although some resources are wasted using this approach. Protection approach can be applied for link failures and path failures [4].

### Link Protection:

In this approach the alternate backup path between each node pair of each link is pre calculated. This backup path is always used to retransmit data when a failure is detected on a particular link. So each link has a specified and dedicated backup path which is to be used I case of link failure.

### Path Protection:

In this approach the entire route of backup path is pre planned. All the traffic of failed path is retransmitted using this pre calculated back up path. This flexibility in path protection could lead to lower protection capacity but requires that all failed paths affect their recovery independently. Each path is completely protected by the backup path [5].

### Restoration:

It is the other alternative for network survivability. In this method spare resources are not pre allocated. The backup resources are arranged in online manner after the failure. Restoration based recovery always takes some time to discover a new back up route after the failure. So no resources are wasted just for sparing them for backup path. Restoration may be link restoration, path restoration or sub path restoration.

### Link Restoration:

In case of a failure, the failed link is identified. The end nodes of the failed link do participate in a distributed algorithm so that a restoration path can be discovered dynamically. A new route around the failed link is discovered and the traffic is transmitted using that link. Time taken to decide the backup route is very crucial in the recovery.

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#### Path Restoration:

In the path restoration method, each source destination pair of each connection independently discovers a backup route on an end-to-end basis. These backup paths can be on a different wavelength channels. This backup path is used to transmit data between the source destination pair.

#### Sub-Path Restoration:

In this approach, whenever a link fails, the upstream node of the failed link detects the failure and discovers a backup route from itself to the corresponding destination node for each disrupted connection [6].

## II. LITERATURE SURVEY

Ajeeth Singh et.al [7] have studied the dual failure occurrence in the real time optical networks. These failures are becoming more important for consideration while designing a network and its transmission. A new method has been proposed to provide dual failure survivability using double p-cycle. A p-cycle is associated with each link. Whenever a link is failed, the network will automatically select the best possible route of p-cycles for backup. Data is not diverted randomly in route of p-cycles. Data is retransmitted on backup path based upon the priority criteria. The highest priority packets are retransmitted using shortest distance route of p-cycles whereas lowest priority data packets are retransmitted using longest distance route of p-cycles. So the recovery will be p-cycle priority based.

Sun-il Kim et.al [8] have introduced the reconfiguration method for broken and blocked shared path. This method can be used for recovery from failure. It improves the recovery ratio by up to 19% in the Lata 'X' network. The protection reconfiguration along with recovery algorithm can provide robustness which is very close to the optimal for any network topology. Dynamic reconfiguration can be implemented with little additional capacity compared to the network without reconfiguration.

Xing wei Wang1 et.al [9] have proposed a new algorithm for single fiber link failure in multi-domain optical networks. A Multi Domain Hamiltonian Cycle Protection (MHCP) has been proposed. A Local Hamiltonian Cycle (LHC) is devolved in each single domain to protect the intra link failures and Global Hamiltonian Cycle (GHC) is devolved in multi domains to protect inter link failures. It has been proved using the simulation results that MHCP can obtain better resource utilization ratio and lower blocking probability for optical networks.

D.A. Schupke [10] has analyzed a restoration scheme using p-Cycles. This approach is attractive alternative for restoration for WDM network protection because of its high capacity, more efficiency and fast protection switching time. Due to above mentioned reasons this approach is a good option for WDM network survivability. The survivability of any single link failure guaranteed using p-cycles. Dual failures are less probable but still exist in larger networks. The performance of p-cycles in case of dual failure is also important.

Biswanath Mukherjee et.al [11] have studied and analyzed the various approaches of optical networks. The current WDM deployment strategies and development trends on WDM optical networks have been analyzed. Optical fiber technology can be considered as our savior for networks due to many reasons. Some of the common reasons are limitless capabilities, huge bandwidth, low signal attenuation, low power requirement and low cost of the networks.

Shaveta Rani et.al [12] have proposed a proactive restoration method for WDM optical network. This method optimizes the resource utilization and further reduces the blocking probability of the network. A backup lightpath is established corresponding to each primary lightpath. Primary lightpath is first established for each connection request.

Lu Ruan et.al [13] have proposed a survivability approach for optical networks. This approach is a hybrid of protection and restoration technique. This approach has been proposed for two link failures. The second link failure occurs before the recovery of first failed link. Primary path and backup path are established using the path length. The shorter path is used as working path and longer path is reserved as backup path.

Bowen Chen et.al[14] have proposed a survivability algorithm. It was named as Dynamic Load Balancing Shared Path Protection (DLBSPP). DLBSPP was used to compute primary and link disjoint shared backup paths. First fit (FF) and random fit (RF) schemes employed to search and assign the available spectrum resource. Traffic Aware Restoration (TAR) mechanism was adopted in the DLBSPP algorithm to compute new paths for carrying the traffic affected by the multi-link failures.

Ankit kumar N. Patel et. al [15] have proposed a method for survivable traffic grooming in optical WDM networks. Survivability of network in provided either using dedicated or shared path protection schemes. An auxiliary graph-based algorithm was proposed that addresses Traffic grooming, network protection and impairment constraints are addressed as a single problem. Regenerators and other equipment are placed in the network with the goal of minimizing the network equipment cost.

Anteneh Beshir et. al [16] have analyzed the survivable traffic grooming problem. The motive is to minimize the total number of transceivers required for assigning link disjoint primary and backup lightpaths for each request. A heuristic approach was proposed to solve the NP-hard problem. The capital expenditure of network is minimized by reducing the number of transceivers. Operational expenditure is also decreased because of the significant decrease in power consumption and heat dissipation.

S. Ramamurthy et.al [17] have examined the different techniques to protect a mesh WDM optical network from failures. These survivability techniques are based on path protection or path restoration and link protection or link restoration. Path and link survivability has been studied and examined separately. Results have been simulated for multiple link failures. It can be concluded from the results that there is a tradeoff between the capacity utilization and the susceptibility to multiple link failures.

Dongyun Zhou et.al [18] have analyzed the survivability of networks where the throughput is huge. The faster recovery from failure is the most important feature of a computer network. This feature even becomes more significant if the data is in order of gigabits and terabits per second.

Burak Kantarci et. al. [19] have proposed a restoration framework. It is implemented on Wireless Optical Broadband Access Network (WOBAN). This approach selects the optimum number of protection clusters for the WDM Passive Optical Network (PON) segments at the backend of WOBAN.

Bel-en Meli-ana et.al [20] have proposed a formulation to handle the problem of locating and sizing wavelength division multiplexing (WDM) and optical cross-connect (OXC) equipment of optical network. This problem has been solved by limiting the number of paths for each demand. The results obtained from this method are compared with the results provided by meta-heuristic method which was previously developed to solve this problem. If the demand generated for bandwidth in a fiber optical network exceeds the current capacity then problem become complex. But the wavelength division multiplexing (WDM) is able to expand the capacity of a fiber optic network without the additional optical fiber. A cost-effective combination of WDM equipment and optical fiber has to be taken for optimal results so that additional demands for bandwidth can be handled.

Navid Ghazisaidi et. al. [21] have analyzed the survivability issues for Next Generation Passive Optical Networks (NGPONs) and emerging hybrid Fiber Wireless (FiWi) networks. These networks can provide failure-free connections if survivability scheme is implemented properly. A number of all optical and mixed optical-wireless networks were analyzed. The performances of various schemes were compared to select optical network units (ONUs). It is observed that the choice of selected scheme has a significant impact on the survivability of NGPONs and FiWi networks.

Amir Askarian et. al [22] have suggested a cross layer technique to improve the survivability of all-optical networks. This technique is suitable for link failures. The blocking probability of network and the vulnerability of the network to failures have been decreased using various algorithms. Two protection schemes were also proposed with low blocking probability and having a moderate vulnerability ratio and time complexity.

Yoshiyuki Yamada et. al. [23] has proposed an algorithm for survivability of hierarchical optical networks. It offers wavelength path protection. The source destination pair Cartesian product space has been in the proposed algorithm. It is based on the concept of aggregation of closely located traffic demands. It reduces the network cost significantly.

### III. CONCLUSION

A number of survivability schemes have been studied and critically analyzed. The most appropriate survivability schemes are either network protection or network restoration. These schemes can be used independently or jointly for the survivability of optical networks. Although a number of efficient survivability schemes are there but still considerable

improvements can be done to improve the survivability of optical networks.

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