LINK FAILURE SURVIVABILITY IN OPTICAL MESH NETWORKS

Abhay Bhandari[1], Jagjit Malhotra[2], Tanuj Mishra[3]

[1] *Department of Electronics and Communication, LPU, Phagwara, Punjab, India*

[2] *Department of Electronics and Communication, DAVIET, Jalandhar, Punjab, India*

[3] *Department of Electrical, LPU, Phagwara, Punjab, India*

ABSTRACT

In this work, a recovery strategy is planned which utilizes reactive way to deal with single connection failure. This Proposed technique uses Dijkstra's calculation to locate the most shortest way between two nodes in a given system and if there should arise an occurrence of failure of any connection on the working connection all the adjoining cycles between end nodes of the fizzled connection are determined. From the discovered contiguous cycles the shortest nearby cycle is discovered which comprises of the source and destination nodes of the fizzled connection. At that point the neighboring nodes relating to the fizzled connection changes from the fizzled connection to the recently discovered working connection to re-set up the system. After reclamation of fizzled connection every contiguous node of the fizzled interface refresh their cycles. Rebuilding time is likewise figured to discover time required to reestablish fizzled connect. The proposed strategy is tried in MATLAB by contrasting aftereffects of proposed method and existing link disjoint method.

Keywords- Dijkstra's Algorithm, Link disjoint, Survivability, Single link failure, restoration.

I. INTRODUCTION

Earlier metallic and non-metallic waveguides were used for optical signal transmission but due to large losses during transmission from this kind of medium so they were not suitable for transmission of optical signal. Tyndall discovered that through optical fibers light could be transmitted by a phenomenon known as total internal reflection, it has water as a medium to show that light rays bend. In his experiment, a container filled with water was used to allow the water to escape from the horizontal surface. A glass container was used to collect the water that was flowing through a parabolic path, by this experiment Tyndall**[1][2]** proved that light can move through a cured path and it could bend also according to the path. During 1950, endoscopes employing optical fibers were used to see the inner parts of human body, these optical fibers were having diameters of 1mm or 2 mm. In 1960, Khao and hockman introduced the use of waveguides or optical fibers made of glass to avoid signal losses due to atmospheric constraints. However, initially the signal attenuation was very large about 1000db/Km and while in coaxial cables it was only 5 to 10 dB/Km. Further improvement in the manufacturing processes of optical fibers during 1973 to 1977 reduced the attenuation loss to 5 dB/Km as shown in Fig1.

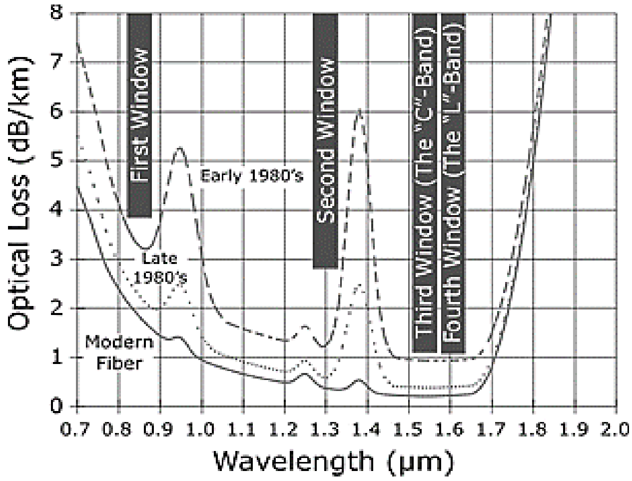

Fig1: Evolution of optical Fibers [1]

Therefore the optical fiber communication developed into an engineering realism. With the recent development in internet the demand for internet and services offered by internet is rapidly growing, so with this development the transmission capacity necessity requirement is also growing**[3]**, so it is the key task of the engineers to meet these high capacity requirements at minutest cost.

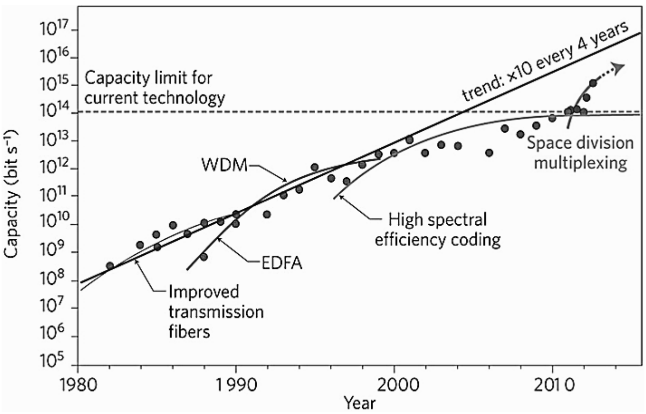

Fig2: Increase in transmission capacity with the advancements in optical technology [1].

Optical fibers are proved as best solution for these expanding needs and future system services. These fibers have low weight than the traditional electrical cables and the signal transmitted is in the form of light which is immune to electrical interferences and hence signals can travel long distances with minimum attenuation, thus having low bit error rates and are fit for supporting transmission capacity of 50 THz. Optical network are also subjected to failure which can cause a loss of sensitive and valuable data so survivability plays a very important role in overcoming such network catastrophe. One important feature of survivability is to provide important or essential services in case of a failure occurrence, so these four properties should be exhibited by these survivable systems these are**[4][5]**:

- **Resistance to Attack:** This means the ability of a network to overcome attacks which can steal important information. Various approaches for resistance consist of firewalls, encryption, authentication etc.

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ISBN: 978-93-86171-48-1

- **Recognition of Attack:** Recognition means the ability to identify attacks. Without recognition adaptation is not possible.
- **Recovery after Attack:** Recovery means the ability of a network to restore the normal functionality after failure. It also involves providing the essential services at the time of failure. The recover approaches used today are duplication of important information, use of fault tolerant methods and also involves the use of backup systems.

II. FAULT MANAGEMENT SCHEMES FOR SURVIVABILITY

For an optical network the technique for survivability can be divided into two methods depending on allocation of spare capacity[6]:

- **Protection**

Protection method involves preserving the network resources during design time of the network which involves reserving of spare capacities. These resources are utilized once a failure is detected in a network otherwise these resources remain ideal. The protection approach has faster recovery time but it leads to the wastages of resources as the resources remains ideal in other words this technique is having low resource utilization. Protection approach is applicable on both link failures as well as path failures[7].

- **Restoration**

Restoration is also known a dynamic restoration this is a reactive approach, which means to react when the failure has occurred. Like in protection method the resources are no pre planned but a search is done and using the available network resources restoration is done. The advantage of this this method is better resource utilization with was relatively low as in case of protection scheme.

III. LITERATURE SURVEY

Neeraj Jindal *et.al* [8] studied a reliable routing method for creating primary and backup paths. For establishing primary path this method uses load balancing in which estimation of cost metrics on the base of current load is done. The routing of traffic is done on links which are having light load instead of heavier loaded links. In the setting up of backup path a small fraction of probe packets are sent by the source, then the feedback is monitored at the destination whether it is positive or negative. Using this feedback the blocking probability of the network is calculated.

Himanshi Saini *et al* [9] have surveyed various papers based on protection and restoration techniques to achieve survivability and discussed about the speed and capacity benefits of P-cycles and concluded that P-cycles have better survivability because they combine together the benefits of both ring and mesh networks.

Mouftah, H.T. et al [10] listed various advantages and disadvantages of both the survivability techniques related to time complexity or restoration speed of an impaired network and he concluded that protection techniques have a better restoration speed but it causes wastage of resources as compared to restoration techniques so restoration schemes are an attractive alternative.

Anna Tzanakaki *et.al* [11] focused on survivable optical networks and studied in detail that how network performance can be improved by considering two parameters network resilience and physical layer constraints.

She presented simulation results using COST239 network using proactive approach based on path based shared protection and showed improved in blocking probability in case of network failure.

S.Ramamurthy *et.al* [12] has examined various techniques based on path protection and link protection for surviving failures in optical networks and analysed that shared path protection is having a more capacity utilization than the dedicated path protection and shared link protection.

Georgios Ellinas *et.al* [13] have suggested an for WDM networks. This approach uses arbitrary mesh topologies which uses APS for restoration of failed links. \In situation of failure of a link, automatic restoration is implemented. The data is transmitted to the destination by means of protection fiber and switches. The restoration process from failure is automatic and self-directed. Real-time restoration is done without relying on centralized database.

T. Jakab *et.al* [14] Studied that innovative and effective resilience methods of optical communication have been probable since the introduction of switching abilities and signaling based distributed intelligence of optical networks. Both permanent optical channels & switched optical channel transport services were supported by automatic switched optical network.

VI. PROBLEM FORMULATION

In this section, we develop restoration based approach for the formulations of proposed technique and compared with link disjoint schemes to protect against single-link failures. We assume that the network topology and a cost matrix (comprising of the number of connection will be set up between every node) are given. The objective of this paper is to propose technique to survive single link failure in optical WDM network while transmitting data from source to destination. Our proposed utilizes Dijkstra's algorithm to locate shortest path between source and destination nodes. The Dijkstra's Pseudo code is as follows:

```
function Dijkstra(G, X, Y):
   for each vertex v in G:
      dist[v] := infinity ;
      previous[v] := undefined ;
   end for
   dist[X] := 0 ;
   N := the set of all nodes in Graph G ;
   if B is not empty:
      s := vertex in B with smallest distance in dist[] ;
      remove s from B ;
      for each neighbor v of s:
         alt := dist[s] + dist_between(s, v) ;
         if alt < dist[v]:
            dist[v] := alt ;
            previous[v] := s ;
            decrease-key v in B;
```

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ISBN: 978-93-86171-48-1

```
        end if
      end for
    end if
  return dist[dest];
```

In case of connection failure happens on the primary path all the adjacent free free cycles are determined out of every autonomous cycles the shortest cycle which will comprise of both the end nodes of the fizzled connection will be discovered, then the end nodes will change to the recently discovered working path. The reestablished time will likewise be ascertained to discover the time taken in seeking working path. The proposed algorithm is evaluated in MATLAB and the outcomes are contrasted and compared with the current connection disjoint method to discover enhancements. The proposed algorithm uses the following steps

- Calculate the shortest path between source and destination using Dijkstra's algorithm.
- If a link failure is detected by a node on the primary path, then adjacent cycles containing the source and destination nodes of failed link are determined
- Shortest path from these adjacent cycles is determined.
- Then the node by which the failure is detected, send the setup message to source using backup path.
- Then affected traffics are retransmitted along the selected new backup path.
- Then all the nodes on adjacent cycle to the failure link just update their affected cycle.

V. PERFORMANCE ANALYSIS

The proposed technique was applied to the following n/w design as shown in Fig 3. Restoration time is calculated to compare with the existing link disjoint method.

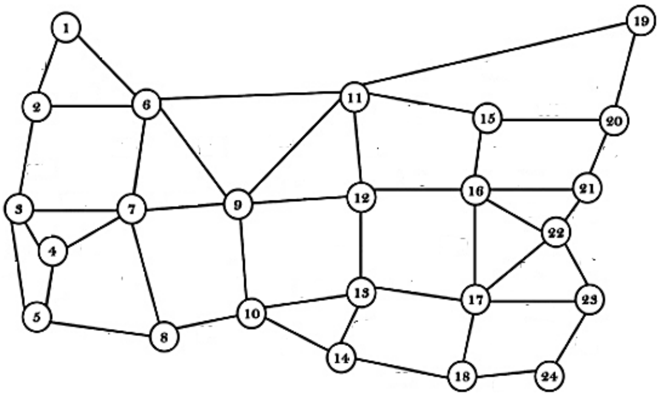


Fig 3: A typical 24-node Network [13]

Serval assumptions were made before calculating results:

- The message-handling time at a hub is 10 s, relating to the execution of 10 000 instructions on a 1-GHz CPU.
- The propagation delay on each connection is 400 s.
- The time to arrange, test, and set up an OXC is 10 ns.
- The time to detect a link failure is 10 s.
- The number of hops from the link source to the destination node of the connection are considered.

Four cases of link failures were taken and the results of both the proposed and the link disjoint technique were compared to find out adjacent cycles for link restoration and selecting the shortest cycle among them and calculating the number of nodes in the backup route from the source (link-source) node to the destination (link-destination) node in case of both link disjoint and proposed method.

Four cases are discussed which shows four shortest paths and the scenario in which a link fails on the determined shortest path. The Table 1 shows the four cases in which shortest paths are determined from the source to destination node and the cases if a link fails on the primary data transmission path. The table shows the determined FNM (Failure notification message) paths for the four cases in case a link on primary path fails.

Table 1: FNM path for the failed links for four cases.

Cases	Shortest path	Failed Link	FNM Path	
			Link Disjoint Method	Proposed Method
1	1->6->9->12->13	6->9	9->7->3->2->1	9->7->6->1
2	2->3->5->8->10	5->3	5->4->7->6->2	5->4->3->2
3	5->8->10->14->18	10->14	14->13->12->9->7->4->5	14->13->10->8->5
4	2->6->9->11->19	6->7	11->12->9->7->3->2	9->7->6->2

Table 2 shows the paths chosen for the retransmission of packets after link failure has occurred in both the cases using link disjoint and proposed method. Link Disjoint is an intuitive method to determine two shortest link-disjoint paths between a pair of source and destination while the proposed method determines the adjoining cycles between the nodes of the failed link and determines the shortest cycle among them for the restoration of the failed link and for retransmission of the failed packets to the destination node.

Table 2: Retransmission path for Link Disjoint and proposed Method

Cases	Path for retransmission of packets	
	Link Disjoint Method	Proposed Method
1	1->2->3->7->9->12->13	1->6->7->9->12->13
2	2->6->7->4->5->8->10	2->3->4->5->8->10
3	5->4->7->9->12->13->14->18	5->8->10->13->14->18
4	2->3->7->9->12->11->19	2->6->9->11->19

ISBN: 978-93-86171-48-1

After the link failure is overcome using the proposed and link disjoint method using the determined paths for retransmission of packets the number of nodes in both the cases are determined as shown in table 3. It can be interpret that the number of nodes required for retransmission of packets in case of link failure is less using the proposed technique as compared to link disjoint technique.

Table 3: Total Number of nodes required for failed link restoration

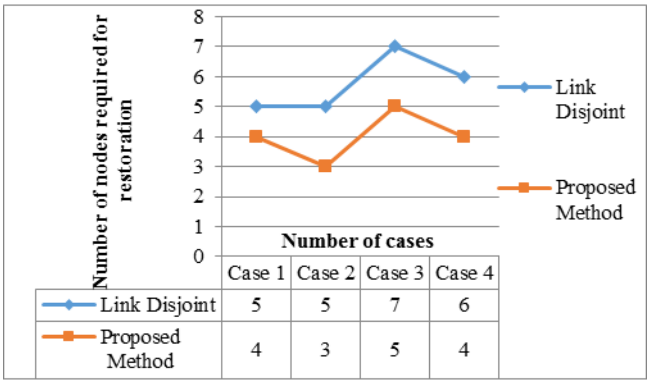
Total number of nodes for restoration of failed link	
Link Disjoint Method	**Proposed Method**
5	4
5	3
7	5
6	4

The link restoration time was calculated using the various assumption as shown in Table 4

Table 4: Time required to restored failed link

Cases	Restoration Time Required	
	Existing	**Proposed**
1	3780 µs	2530 µs
2	3780 µs	2530 µs
3	4190 µs	3360 µs
4	4610 µs	3360 µs

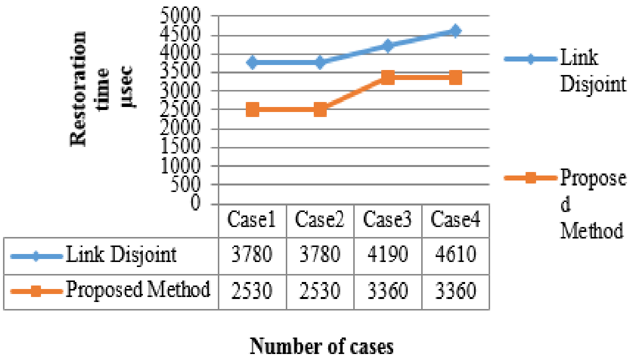
The graph 1 shows the comparison of link disjoint method and proposed method on the basis of number of nodes required for retransmission of packets in case of failure. The proposed methods proves to be efficient as compared to link disjoint as number of nodes required are less.



Graph1: Comparison of Link disjoint technique and proposed technique on the basis of number of nodes required for restoration**.**

ISBN: 978-93-86171-48-1

While the graph 2 shows the comparison of Link disjoint technique and proposed technique on the basis of time required to overcome link failure. As the required time should be as low as possible as is one of an important objective of survivability. The improvements can be seen using the Graph 2.



Graph2: Comparison of link disjoint and proposed technique on the basis of time taken for restoration from failed link.

VI. CONCLUSION

- The proposed technique determines the shortest path from all the adjacent cycles found which are required to overcome link failure and thus proves to be more efficient as compared to the conventional Link Disjoint Method.
- The objective of the proposed method is to keep number of nodes required to overcome failure to minimum and time to restore link have to be as minimum as possible.
- This work can further be extended for a network were large number of nodes are there. While we have only considered only restoration of link failure, future work can integrate other parameters like dual link failures. While proposing our technique we have considered only single link failures, because they are prime cause of failures in optical networks.

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