SURVIVABILITY IN OPTICAL MESH NETWORKS DURING SINGLE LINK FAILURE

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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.

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.

IV.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.

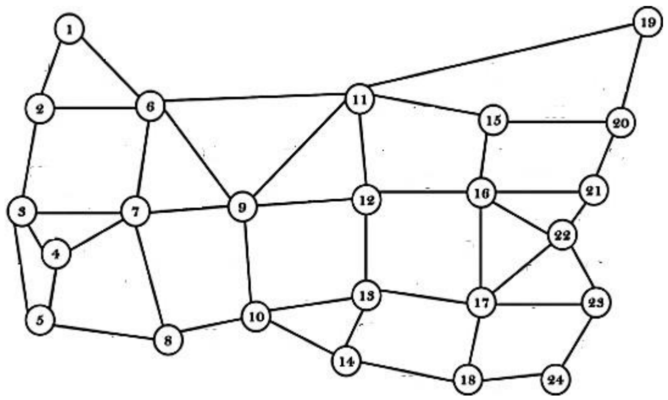


Fig 3: A typical 24-node Network [13]

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

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

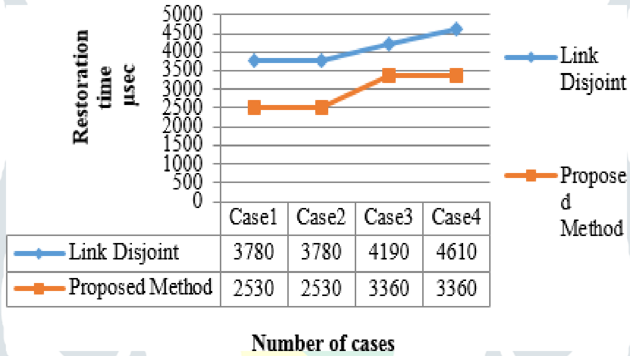
Cases	**Restoration Time Required**	
	Existing	**Proposed**

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**.**

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.

V. 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.

REFERENCES

[1] "History of Fiber Optics," *http://www.timbercon.com/history-of-fiber-optics/*. .

[2] M. Arumugam, "An Overview of Optical Communication," *Journal of Physics*.

[3] N. Mohan, "Link Failure Recovery in WDM Networks," vol. 1, no. 5, 2014.

[4] S. Ramamurthy, L. Sahasrabuddhe, and B. Mukherjee, "Survivable WDM mesh networks," *J. Light. Technol.*, vol. 21, no. 4, pp. 870–883, Apr. 2003.

[5] M.Keshtgary and A. H. Jahangir, "Survivable Network Systems: Its Achievements and Future Directions," *International Journal of Information Science and Management (IJISM)*, vol. 5, no. 2. pp. 11–34, 16-Jul-2015.

[6] D. Zhou and S. Subramaniam, "Survivability in Optical Networks," *IEEE Netw.*, vol. 14, no. December, pp. 16–23, 2000.

[7] A. Bhandari and J. Malhotra, "A Review on Network Survivability in Optical Networks," vol. 5, no. 12, pp. 97–101, 2015.

[8] N. Jindal, "Wavelength Division Multiplexing," *Opt. Commun. Essentials*, vol. 1, pp. 466–470, 2012.

[9] H. Saini and A. K. Garg, "Protection and Restoration Schemes in Optical Networks : A Comprehensive Survey," *Int. J. Microw. Appl.*, vol. 2, no. 1, pp. 5–11, 2013.

[10] H. T. Mouftah, "Future trends in the design of survivable optical networks," in *Proceedings of 2005 7th International Conference Transparent Optical Networks, 2005.*, vol. 1, pp. 52–52.

[11] A. Tzanakaki, K. Georgakilas, K. Katrinis, L. Wosinska, A. Jirattigalachote, and P. Monti, "Network performance improvement in survivable WDM networks considering physical layer constraints," in *2009 11th International Conference on Transparent Optical Networks*, 2009, pp. 1–4.

[12] S. Ramamurthy, L. Sahasrabuddhe, and B. Mukherjee, "Survivable WDM mesh networks," *J. Light. Technol.*, vol. 21, no. 4, pp. 870–883, Apr. 2003.

[13] G. Ellinas, A. G. Hailemariam, and T. E. Stern, "Protection cycles in mesh WDM networks," *IEEE J. Sel. Areas Commun.*, vol. 18, no. 10, pp. 1924–1937, Oct. 2000.

[14] T. Jakab and Z. Lakatos, "Protection and restoration based resilience in Automatic Switched Optical Networks Control plane." *IEEE J. Sel. Areas Commun.*, vol. 25, 2013.

[15] A. Todimala, A. Todimala, and B. Ramamurthy, "A Scalable Approach for Survivable Virtual Topology Routing in Optical WDM Networks A Scalable Approach for Survivable Virtual Topology Routing in Optical WDM Networks," *IEEE J. Sel. Areas Commun.*, vol. 25, 2007.