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Proactive Fast Connection Recovery Scheme for a Failure in Elastic Optical Networks

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ABSTRACT: This paper presents a proposed link based fast connection recovery scheme for a failure in elastic optical network (EON). In this scheme a backup path is reserved in advance and re-route the traffic immediately after the failure happens in the network. This recovery scheme required large backup capacity. We analyse three network parameters such as bandwidth blocking probability (BBP), recovery time (RT), and network capacity utilization ratio (NCU) for randomly generated source to destination request for three topologies that is COST239, ARPANET and NSFNET and compare the results for shared link protection (SLP), dedicated link protection (DLP), and our proposed link based recovery scheme (PLBRS). Our proposed scheme shows the minimum RT compared to other two strategies.

Keywords: Elastic optical networks, Frequency slots, shared link protection, Dedicated link protection, and proposed link based recovery scheme.

Abbreviations: BBP, Bandwidth blocking probability; DLP, Dedicated link protection; EON, Elastic optical networks; FS, Frequency slots; ILP, Integer linear programming; NCU, Network capacity utilization; RAFF, Re provisioning after the first failure; RT, Recovery Time; PLBRS, Proposed link based recovery scheme; SLP, Shared link protection; WDM, wavelength division multiplexing.

I. INTRODUCTION

As reported by cisco [1] the number of internet users increases three fold from last few years correspondingly the requirement of higher bandwidth is also increases. The different applications like video conferencing, cloud computing, high definition television (HDTV), and online gaming etc. required very high bandwidth. The optical network plays an important role for the transmission of more information online.

The existing Optical networks used the wavelength division multiplexing (WDM) for the transmission of 40Gbps or 100Gbps. But this WDM scheme is infeasible to transfer more than 100Gbps. This WDM scheme based on the fixed bandwidth spectrum of 50GHz channel spacing and fixed modulation formats [2]. This fixed grid cannot meet the demand of higher bandwidth. The EON is a new paradigm in optical network, used to provide variable bandwidth as required by the users [3]. EON provides a granular fine frequency slots (FS) multiple of 6.25 GHz. EON consider the FS continuity and contiguity constraint. The routing and spectrum assignment problem is also considered in EON [4] . The survivable networks have the ability to quickly restore the failure in EON [5]. This can be done by providing a spare capacity in existing optical network. In literature the survivability is categorized into pre-protection and restoration schemes. Protection scheme reserve the alternate route for connection failure in advance, whereas the restoration scheme dynamically search the backup after failure happened in the network. This scheme is more efficient than protection scheme [6].

Many studied have been done for the protection of single link failure and double link failure. Guaranteed survivability has been provided [7]. Dual link failure recoverability is proposed [8]. Protection schemes for two link failure are designed [9] [10] where the link disjoint alternate routes are available. All these schemes provide guaranteed protection [11]. However, they require large amount of backup capacity. Other approach to handle the two link failure is re provisioning after the first failure (RAFF) [12]. In RAFF, every request is allocated a alternate route in the spare capacity for a link failure in the network.

After the recovery of the first failure, the new backup alternate routes are provided for unrecoverable failure. In this way the affected request can restore quickly using new alternate backup route, when the second failure happened. In [13] p-cycle network proposed, where the RAFF spare capacity can reconfigured dynamically.

The ILP model provided two cases, first is whole cycle reconfiguration and other is additional cycle configuration. Hence, alternate backup route provisioning after the recovery of the first failure and before the second failure occurs. Thus, all connection demand whose primary paths are affected by first failure need to have a provisioned of alternate backup route.

Here, We present a new proactive protection scheme to handle the single link failure [14]. Despite as the protection scheme in which a request require two backup routes for connection recovery, our proposed scheme require only one backup route for each demands to save the spare capacity in the network. Our schemes compute the backup route for all requests which not protected after the second failure happened. The main idea of our proposed scheme is as follows: Each request has to assigned single backup route. The spare capacity is reserved to ensure the entire request whose working path is affected by second link failure and can be restored using the pre planned backup path. Second is for those request whose working and backup route are affected by the second link failure, the dynamic restoration is used for the second link failure.

Our proposed scheme, uses a pre-planned protection strategy to provide a recovery to the single link failure in EON. For initial connection request, that are not recovered by the pre-planned protection, can be recovered by using dynamic restoration scheme if the spare capacity is available on the alternate route. Our proposed scheme has the advantage of fully pre-planned backup path for each request. Also our backup path reserved capacity exploit the backup path sharing under double link failure. Each primary path have a protection path. Our simulation results show that the PLBRS provided better recovery as compared to SLP.

This paper is organized as follows. Section II explained the proposed protection scheme for single link failures. Section III presents the simulation results, and Section IV provides the conclusion of this paper.

II. PROPOSED and EXISTING STRATEGIES

In this paper, we discuss the shared link protection (SLP), dedicated link protection (DLP) and our proposed link based recovery scheme (PLBRS) schemes.

A. Notations Used

Here, failure of the link detecting by the adjacent nodes. The different network parameters are used for the switching protection, such as message processing time, optical cross- connects and the propagation delay in the optical network etc. are given as follows.

- The processing time of the message m_p at the nodes is 10 µs.
- The delay due to signal propagation p_d for each signal is 400 s, which corresponding to 80 km length [15].
- Optical cross-connects, c_x takes any value that is 10 s, 10 ms, 10 ns and 500 s.
- The time to detect the failure f_d, is about 10 µs.
- l_b be the no. of links, for the backup path from source to the destination node.

Let G (N, L, f_s) represents the network topology (Nodes, Links and wavelengths) and different notations are as follows:

n	Set of the nodes ∀ nϵN
l	Set of the Links ∀ lϵL
f_s	Set of FS for each link
t_s	Transmitting node
d_s	Destination node
r	Connection request ∀ r ϵR , that is {(s1, d1), (s2, d2)….(si, di)} where ∀(s,d)ϵV, ∀s≠d, ∀iϵV.
p_r	Primary route of the i^{th} connection request where ∀iϵR.
b_r	Backup route of the i^{th} connection request where ∀iϵR.

B. Shared Link Protection (SLP)

In SLP, the nearest node of the failed link detect the failure of the link [16] and immediately itself established the connection with the receiving node by the alternate backup route. Here, the backup FS is reserved in advance. In SLP the optical cross connects c_x are not allowed for the sharing of backup FS. The destination nodes send acknowledgement when it receives connection setup message from the source node. The total time taken for connection establishment is

$$F_d+(l_b+1)\times c_x+2\times l_b\times p_d+2\times(l_b+1)\times m_p \qquad (1)$$

C. Dedicated Link Protection (DLP)

In this scheme, the nearby node establishes the connection between the failure link after detecting the failure by using advance reserved FS. The response of DLP is slower than our proposed link protection scheme (PLP).

The switching time for the DLP is

$$F_d+2\times l_b\times d_p+2\times(l_b+1)\times m_p \qquad (2)$$

D. Proposed Link Based Recovery Scheme (PLBRS)

In this scheme, the nearby node immediately establishes the connection between the transmitting and receiving nodes. This scheme share the backup resources as SLP. The recovery time for the proposed scheme is given by

$$RT_{plbrs}=t_c+t_a \qquad (3)$$

RT_{plbrs} be the recovery time for proposed scheme and t_c and t_a be the connection setup time between the adjacent node to the receiving node and acknowledgement time from receiving node to the source node. We assume $n_{l\text{-}r}$ be the nodes on the backup route between link nodes to receiving node. $T_{r\text{-}s}$ and $T_{r\text{-}s}$ be the connection establishment time from link node to the receiving node and receiving node to the source node. T_c is the total connection setup time from link node to the receiving node and back to source node.

$$T_{l-r}=(m_p\times c_x)+l_{l-r} \qquad (4)$$

$$T_{r-s}=n_{r-s}\times m_p+l_{r-s} \qquad (5)$$

$$\text{Hence, } T_c=(T_{l-r}+T_{r-s}) \qquad (6)$$

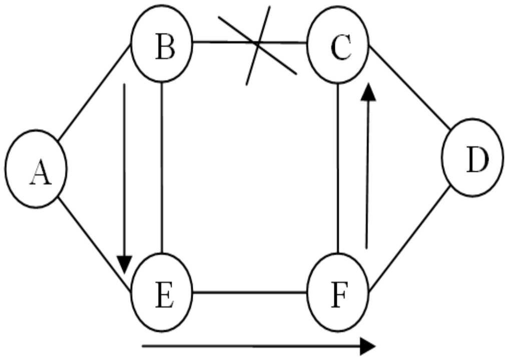
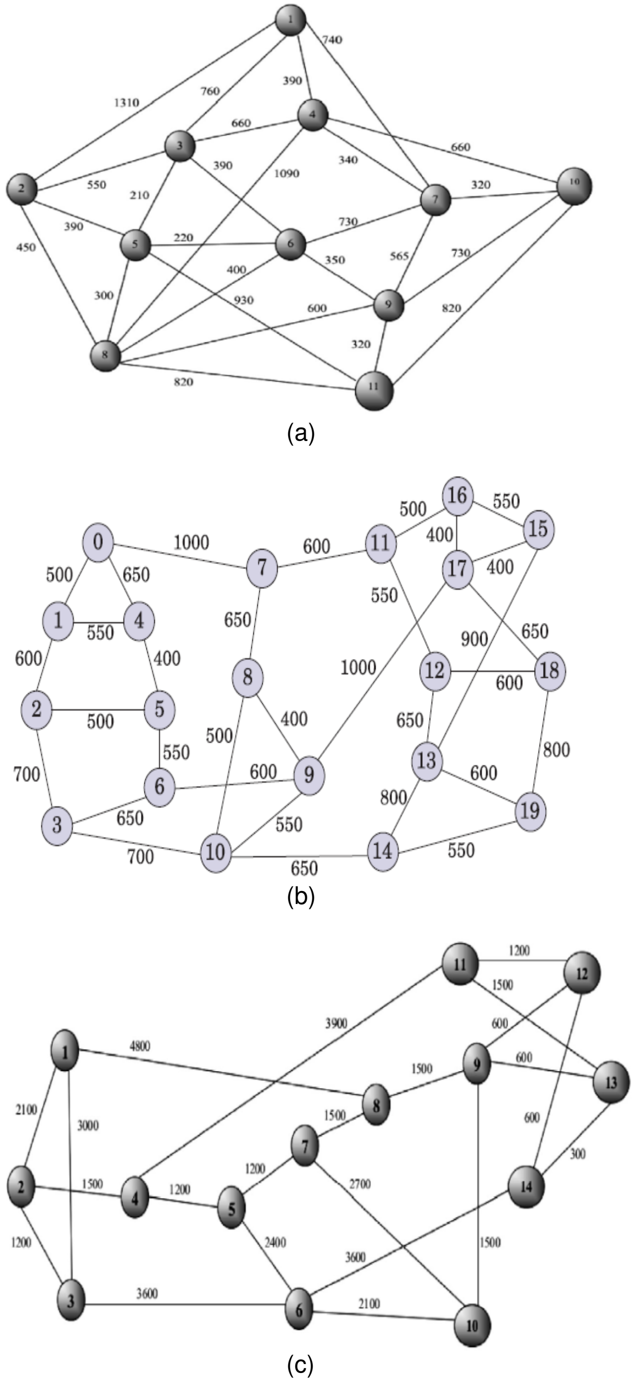


Fig. 1. A-B-C-D is primary route, if B-C and alternate backup route B-E-F-C assignment.

Here, we consider six nodes in Fig.1 A-B-C-D be the primary route, if link B-C fails then the backup route is provided through B-E-F-C. For backup route the FS is reserved in advance. The recovery setup message is generated at the link source node immediately after the detection of the failure of link at link source node to the receiving link node.



(a)

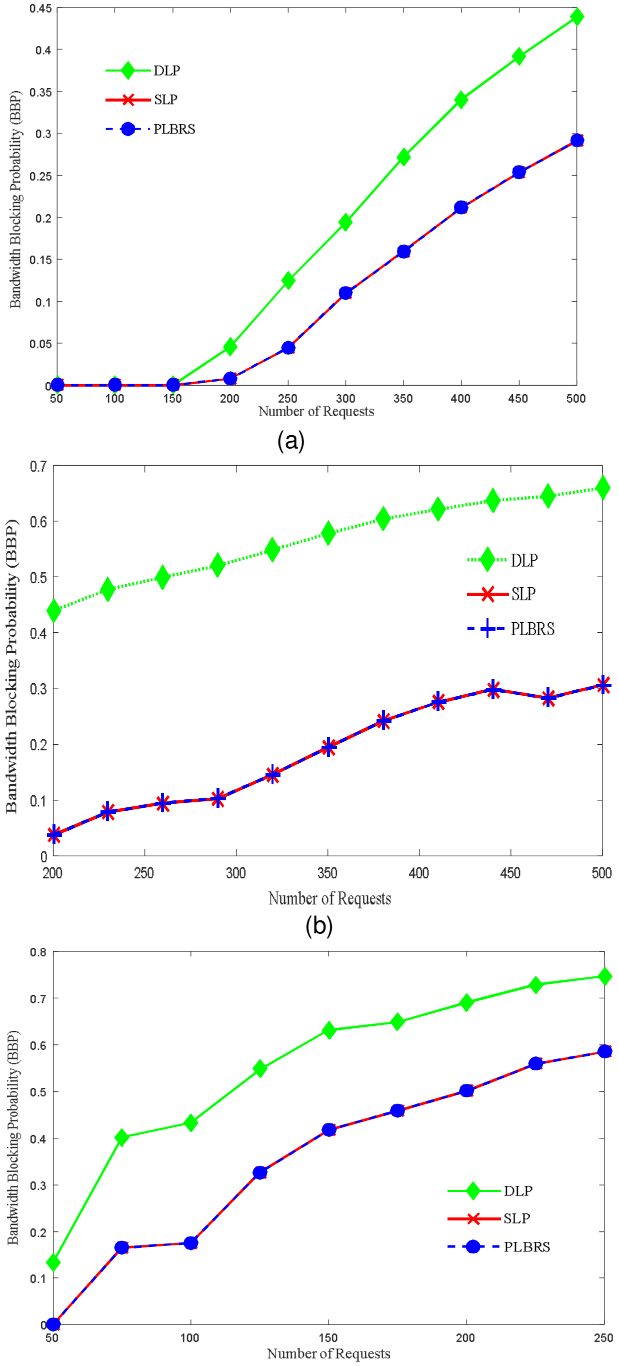
(b)

(c)

Fig. 2 (a) COST 239 (11Nodes, 26 Links) (b) ARPANET (20 node, 32 links) (c) NSFNET (14 Nodes, 22 links).

III. RESULTS AND DISCUSSION

Here, we consider three different topologies as given in Fig. 2 (a), (b) and in (c) that is COST 239, ARPANET and NSFNET. And evaluate the performance of different network parameters in MATLAB 2015 on i5, 7400 intel core processor with 3GB system and 8 GB RAM by randomly generated source and destination demands/request.

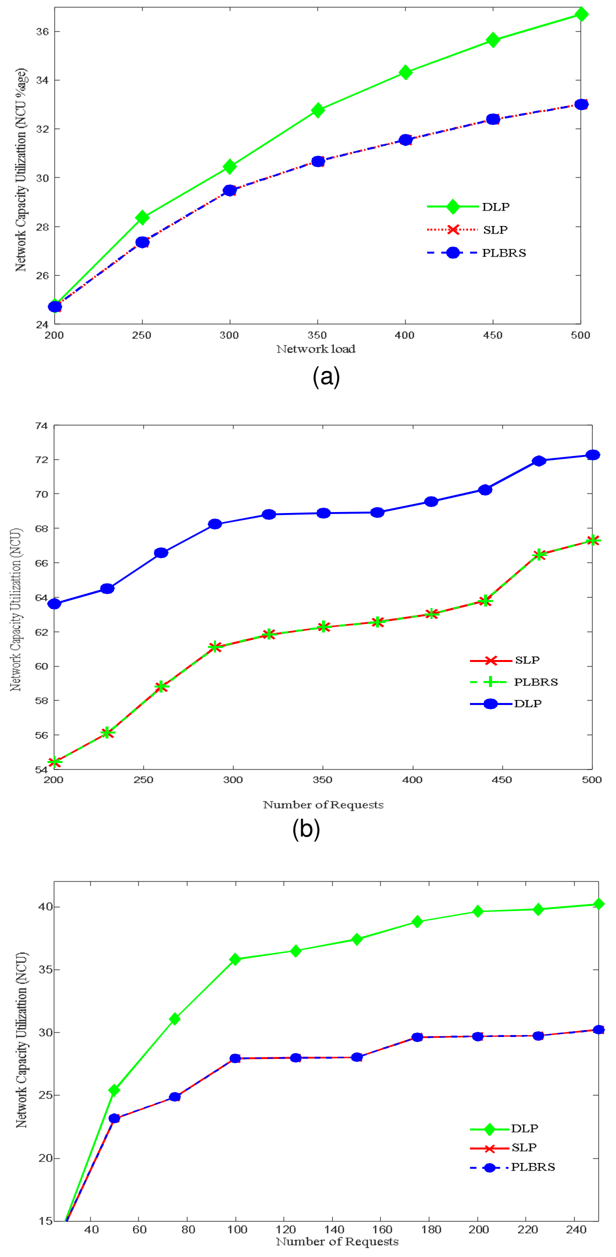


(a)

(b)

(c)

Fig. 3 (a) Shows Bandwidth Blocking Probability vs. Number of requests for COST 239 and (b) represents the Bandwidth blocking probability vs. Number of requests for ARPANET (c) shows the Bandwidth blocking probability vs. Number of requests for NSFNET.



(a)

(b)

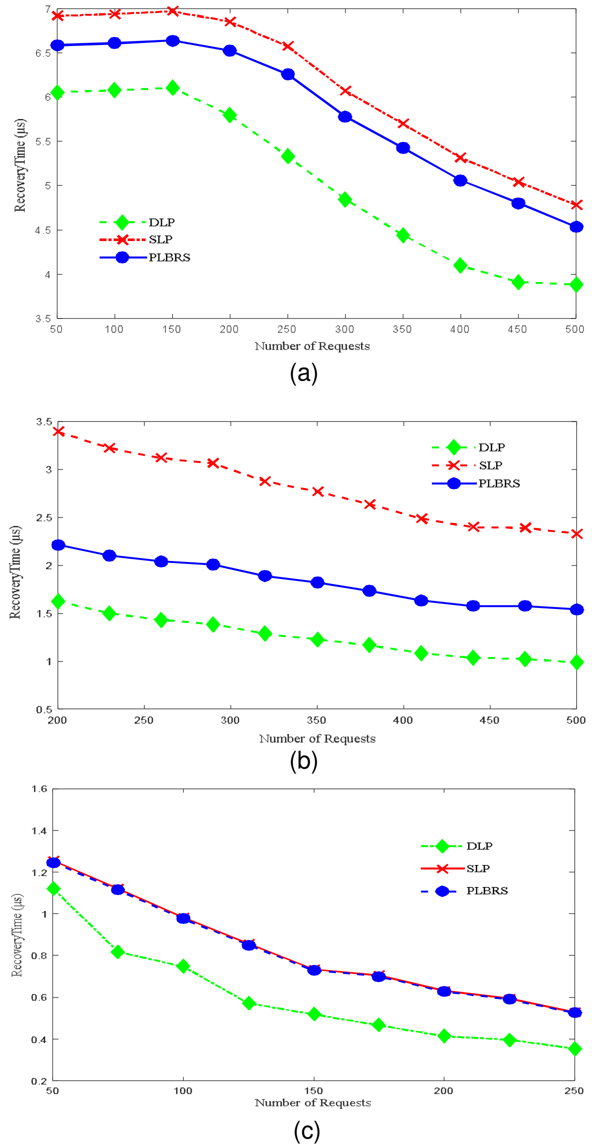
(c)

Fig. 4 (a) Shows Network Capacity Utilization vs. Number of requests for COST 239 and (b) represents the Network capacity utilization vs. Number of requests for ARPANET (c) shows the Network capacity utilization vs. Number of requests for NSFNET.

A. Bandwidth Blocking Probability (BBP)

The BBP is the number of bandwidth demand rejected to the total bandwidth demanded [17]. It has been noticed from Fig. 3(a), (b) and (c) the BBP of our proposed strategy is very less as compared to the SLP. Hence, in our PLBRS scheme the large number of source-destination requests accepted as compared to SLP.

The mean BBP for our proposed strategy DLP, SLP and PLBRS are 0.18, 0.1078, and 0.1078 respectively for COST239 are 0.56, 0.18, and 0.18 for ARPANET and for NSFNET are 0.49, 0.31, and 0.31 for DLP, SLP and for PLBRS respectively. The rejections of the connection request in DLP and SLP are more than our PLBRS scheme. The mean values for different parameters are provided above in Table 1.



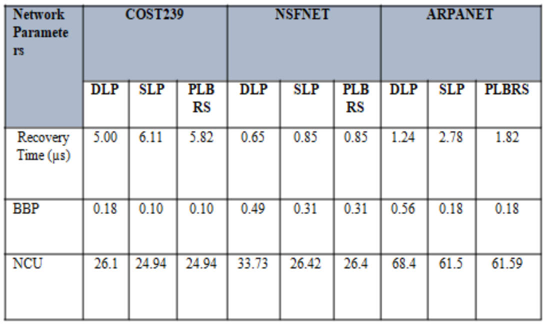
(a)

(b)

(c)

Fig. 5 (a) Shows Recovery Time vs. Number of Requests for COST 239 and (b) represents the Recovery Time vs. Number of requests for ARPANET (c) shows the Recovery Time vs. Number of requests for NSFNET

Table 1: The mean values of different network parameters for different Strategies.



Network Parameters	COST239			NSFNET			ARPANET		
	DLP	SLP	PLB RS	DLP	SLP	PLB RS	DLP	SLP	PLBRS
Recovery Time (µs)	5.00	6.11	5.82	0.65	0.85	0.85	1.24	2.78	1.82
BBP	0.18	0.10	0.10	0.49	0.31	0.31	0.56	0.18	0.18
NCU	26.1	24.94	24.94	33.73	26.42	26.4	68.4	61.5	61.59

B. Network Capacity Utilization (NCU)

The network capacity utilization is defined as the total spectrum used to the total number of request accepted in the network. The average NCU for COST 239 is 24% 26% and 26% for DLP, SLP and for PLBRS as given in Fig. 4 (a) and (b) &(c). The average NCU for ARPANET is 68%, 61% and 61% for DLP, SLP and for PLBRS respectively and for NSFNET are 26%, 33% and 33% for DLP, SLP and for PLBRS. If NCU [18] is more than 70% then slowdown will occur in-network traffic, if this remains for a long time than a long queue of traffic will occur in the optical network, which causes a stoppage in the traffic. In COST239 the traffic is less as compared to ARPANET and NSFNET.

C. Recovery Time

The recovery time, is the time from where the recovery process is started and the confirmation message received from the receiving end to the source. For fast recovery, a recovery time constraint is required to introduce. The Recovery time is shown in fig. 5 (a) (b) and (c) for all three topologies that is Cost239, ARPANET and for NSFNET in our PLBRS scheme is less than SLP and above than DLP as shown in Fig. 5 (a) for COST239 (b) for ARPANET and (c) for NSFNET. The average of RT for DLP, SLP and PLBRS for COST239 are 5.00, 6.11 and 5.82 and for ARPANET are 1.24, 2.78 and 1.82 and for NSFNET are 0.65, 0.85 and 0.85 for DLP, SLP and for PLBRS respectively.

IV. CONCLUSION

Here, we proposed link based recovery scheme for a failure in EON. Our proposed scheme shows the recovery time between SLP and DLP. We evaluate the network parameters like BBP, NCU and recovery time for three topologies viz. COST239, ARPANET and for NSFNET. Our purposed PLBRS strategy shows optimized performance when compared to other strategies. In the future, we proposed a recovery scheme for a multiple failure in EON.

Conflict of Interest: Nil

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