Minimizing resource protection in IP over WDM networks: Multi-layer Shared Backup Router

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Abstract: This work compares two resilience strategies on multi-layer network dimensioning: dual-plane protection and Multi-Layer Shared Backup Router. Latter provides a significant reduction (up to 24%) on the required IP equipment in comparison with current approach.
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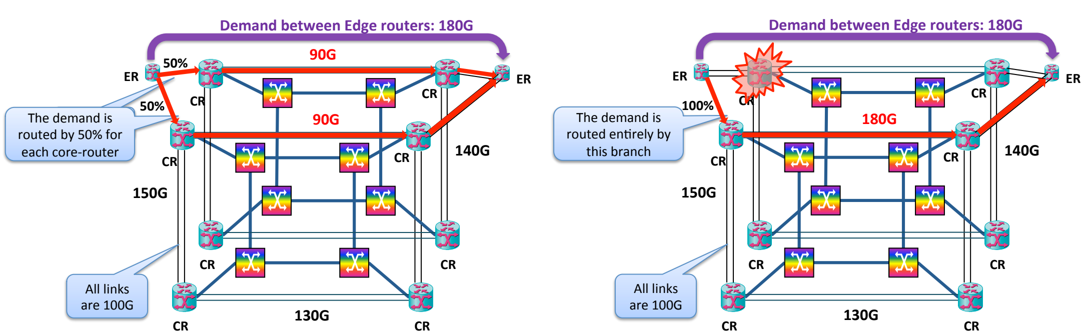
1. Introduction

Multi-layer dimensioning (IP and Optical) can provide important cost reduction in today's core network deployments [1]. Multi-layer restoration has been an extensively researched topic in the past few years. In [2] more cost-efficient architectures are presented as an alternative to current dual-plane protection. However, they have not been sufficiently explored. Building on advanced optical layer capabilities and multi-layer control plane, authors in [3] presented the Multi-Layer Shared Backup Router (MLSBR) concept and compared the availability of MLSBR and traditional dual-plane approach.

The idea behind MLSBR consists on having extra shared backup routers to restore the traffic in case of a failure of an IP router. This technique is compared with the common design of today's networks, where two IP planes are created in order to deal with node failure. This paper presents comparative results to quantify the savings that can be obtained by applying this novel approach. In the present document, for the first time a techno-economic study of MLSBR is done for the Spanish Telefónica core network. The impact of the number of shared backup routers on the overall savings is quantified.

2. Network dimensioning

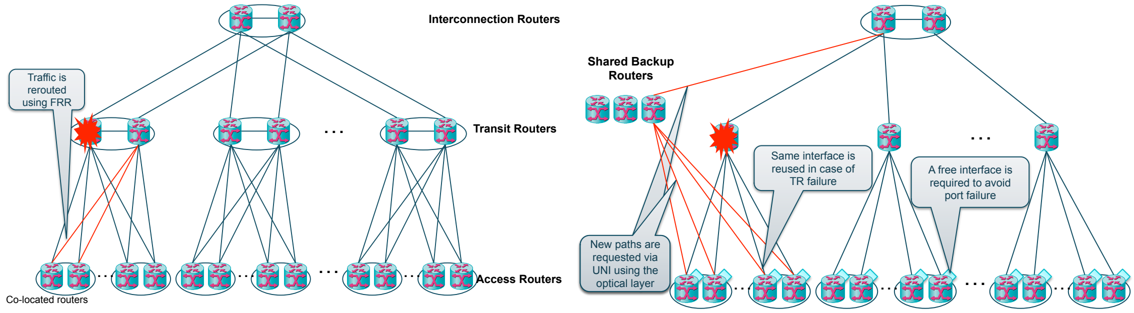
Current core networks consist on a multi-layer topology formed by IP routers and Reconfigurable Optical Add-Drop Multiplexers (ROADMs). IP nodes are connected to the optical nodes to transmit the IP demands over the optical topology. Present IP dimensioning strategy against node failures consists on split the demands in two different equivalent planes, which carry 50% traffic each. Each plane is dimensioned to carry 100% of the traffic, so in case of node failure the other plane can absorb all traffic in the network. Fig.1 illustrates this approach. To avoid any single point of failure, the connection of each core router to the optical mesh is done through different ROADMs. Similarly, in case of a failure in the ROADM, the traffic is rerouted using the backup core router, like in the IP node failure case.



(a) (b)

Fig. 1.Network dimensioning against node failures.

To allow traffic recovery in less than 50ms, all the demands affected by a failure are rerouted through the backup router using Fast Re-Route (FRR), as shown in Fig. 1b. The traffic is duplicated in current network dimensioning for dual-plane, because it requires to have enough capacity to carry all traffic in case of a failure in one plane. This single layer dimensioning approach for node failures does not get any advance of the existence of an underlying optical layer. Thanks to the optical layer, it is possible to reach any node in the network if a new lightpath is created and reconnect to any remote router in case of failure. However, path provisioning may take up to 1 min.



(a) Dual-plane Protection (b) MLSBR

Fig. 2. Resilience schemes in a hierarchical topology.

3. Multi-Layer Shared Backup Router use case

MLSBR use case consists on providing backup routers, which are available in case of a node failure. We assume that there is an optical mesh connection access, transit and interconnection routers. As previously described, the whole IP nodes must be duplicated in order to solve IP router failure. Let us assume a hierarchical architecture with three levels, as shown in Fig. 2a. In this example, the transit routers are duplicated to recover to a transit failure. When using MLSBR, a set of Shared Backup Routers (SBRs) are available so, when there is a failure in the transit routers, the failed transit router configuration is copied and new connections are created to the access and interconnection nodes. This scheme is presented in Fig. 2b. To create the IP/MPLS adjacencies from the access routers to the backup routers, a new path is requested to the optical layer using UNI. The destination back-up router and the path to be requested via UNI is configured beforehand by the access router. The configuration is done similarly from the interconnection to the transit router. As previously mentioned, it is assumed that there is an optical mesh between access and transit nodes. This is why a new back-up path can be provisioned after the failure happens.

Let us remark that the recovery time using dual-plane protection resilient is faster than applying MLBSR, because MLBSR takes similar time to optical restoration. However, as demonstrated in previous work [3], the network availability when using MLSBR approach is better than traditional dual-plane protection.

Table 1 shows the MTTR for protection and MLSBR schemes assuming a MTBF of 3 years in the IP routers for the scenario presented in Fig. 2 with seven locations for transit routers. Based on the results, MLSBR allows increasing the MTTR for the same availability. This means that OPEX can be reduced using this protection scheme.

	Number of Backup Routers					
Availability	**2**	**3**	**4**	**5**	**6**	**Protection**
99,99%	33,0	59,2	86,6	110,7	132,6	11,1
99,999%	14,3	31,9	51,6	72,4	91,0	3,4
99,9999%	6,7	17,6	31,9	47,2	63,6	0,1

Table 1: Comparison between MLBSR and Protection in terms of MTTR (days)

4. Impact on CAPEX reduction

The MLSBR concept is proved in the Core Telefónica Spanish Network (Fig. 3). This network has the structure the exposed in the Fig 2a. It is composed by 6 interconnection routers (IX-Level), 14 transit routers (TR - Level) and several access nodes (AC - Level). For this study only the two upper levels has been taken into account for the numerical results. As depicted in Fig 2b, there is no port saving in the access routers due to this technique. Two ports in the access routers are required to avoid a single point of failure. This numerical study has used the traffic demands of 2012 and a traffic growth per year of 35%, in order to evaluate the same network in five years (2017).

The network dimensioning is done using the dual-plane protection approach using the 20 nodes network in Fig. 3. For the MLSBR mechanism, the dimensioning process is done just for one plane (10 nodes in the network). IP layer is dimension with a maximum occupation of 80% in case of any failure in the network. The number of shared back-up router can vary depending on how many node failures the network is protected. Depending on the number of back-up routers, they are added to the dimensioning problem to get the number of IP ports using MLSBR. The results of the IP-ports savings of compare the dual-plane protection dimensioning approach versus the MLSBR approach are presented in Fig. 4.

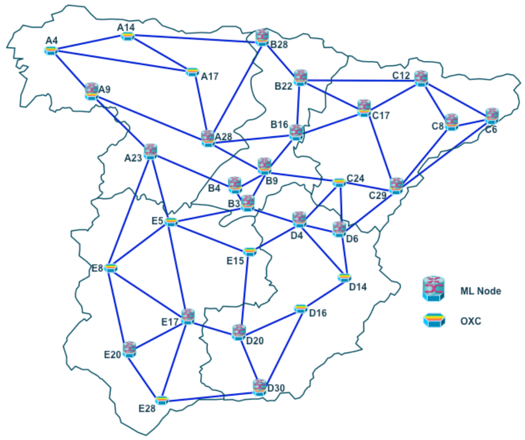


Fig. 3. Telefónica Core Network topology.

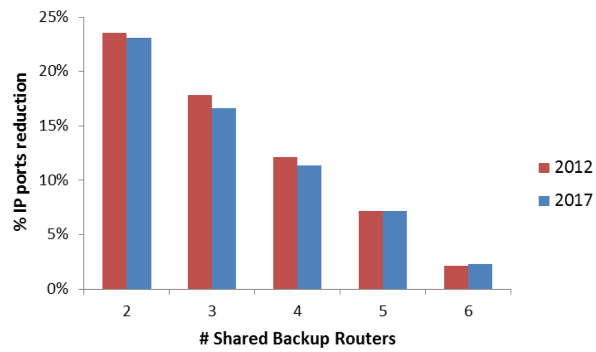


Fig. 4. MLSBR Simulation results of network dimensioning

In light of the results, it is seen that the savings by introducing two SBRs it is obtained almost 24% of savings in the number of IP ports needed to deploy. The percentage decreases conforms the number of SBR grows, but the savings are conserved in 2017. If there were 7 SBRs, there would be the same number of IP routers than in the dual-plane protection case.

5. Requirements and conclusions

Previous sections present the two aforementioned approaches to deal with node failures in a multi-layer scenario. MLSBR can reduce up to 24% the number of IP ports in the network and it can increase the MTTR. This means that network operators can reduce their CAPEX and OPEX using this approach. However, there are some requirements that have to be fulfilled to deploy this solution in the network. Following table summarizes the advantages, disadvantages of both approaches and defines requirements to take into account to deploy the solution.

	Advantages	**Drawbacks**	**Requirements**
Original planning	• Simple operation • Traffic restoration in less than 50ms with FRR.	• Resource duplication. • Small MTTR	• By-pass selection is required to reduce the cost of this approach. • FRR to minimize restoration time.
MLSBR	• Minimize routers investment in chassis and ports. • Extend MTTR and reduce OPEX	• MLSBR takes around 1 minute. It is limited by optical restoration time.	• Optical mesh • GMPLS enabled in the optical mesh. • UNI enabled. • Back-up routes pre-loaded in routers. • Configuration pre-loaded in transit back-up routers. • FRR to minimize restoration time.

Table 2: Operational requirements and advantages/drawbacks summary.

6. Acknowledgements

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7. References

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