Operational Expenditures savings in IP/MPLS over DWDM networks by Multi-layer restoration.

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Abstract: Multi-layer restoration enhances recovery in multiple failure scenarios and can relax the urgency of the reparation of damaged network equipment. This work analyses the operational expenditures (OpEx) savings obtained with multi-layer restoration.

1. Introduction

The cost associated to network operation, and in particular to repair damaged or malfunctioning network equipment, accounts for a great amount of the operational expenses (OpEx) of a Network Operator. A good management of the reparation of the failures can achieve significant savings for operators. In the case of IP/MPLS over optical networks, authors in [1] report that multilayer restoration can achieve OpEx savings by reducing the urgency in reparations and thus can help in a better planning of the repair actions. However, the authors in [1] does not quantify such savings in measurable terms.

The rationale of multi-layer restoration is to extend the restoration mechanism to a network where multiple technologies are involved in the restoration process (e.g. IP/MPLS over optical). Typical survivability schemes (protection and restoration) found in state-of-the art network equipment are defined for single-layer scenarios and create resource inefficiencies and imposes urgency in the reparation of the damaged network equipment.

The potential savings by multilayer restoration imply a reduction in operational expenditures (OpEx), the amount of money that network operators spend on an ongoing, day-to-day basis in order to run their business. According to [2], the OpEx for an operator can be divided in to seven general categories In particular, the OpEx category where this paper can play a role is the network operation, with the reparation of failures in the network.

The goal of this work is to achieve a reduction of operational expenditures related to the maintenance and reparation of the network by obtaining the minimum number of repair teams needed to maintain the service. Each repair team has an associated monthly cost and can give an estimate of the labor cost of repair the communication network. This paper proposes a model which assumes that upon each failure detected in the network, the failure should be repaired within a given time.

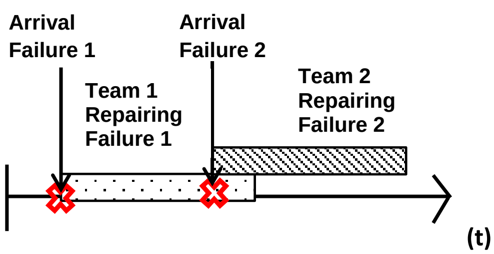
The remaining of this paper is organized as follows. Section 2 introduces the model proposed to calculate the number of required repair teams in a communication network. Next, section 3 presents the case study for multilayer restoration in IP/MPLS over DWDM network. Finally, section 4 presents the conclusions of the paper.

2. Reparation WorkForce Model

In order to be able to quantify the Operational Expenses related to network failures reparation we propose a Reparation WorkForce (RW) model that obtains the number of repair teams needed, that is the work force devoted to reparation. The proposed RW model is based on a centralized location of the repair teams. Each repair team is specialized in failures of a given network layer and can only repair one network element at a time. In sake of simplicity the model assumes a fixed repair time (RT) per network element, measured since the repair team is assigned to a failure and is independent on the failure location, that is, travel times to the failure location are not considered. It is important to highlight that the RT is measured from the moment that the repair team starts working on the failure (not the moment of the failure). Optionally, location and travel time can be considered. In this case, the RT can be calculated as a travelling time (depending on the location) plus actual repair time. The travelling time is the time that the repair team needs for going from their base location to the failure location. The actual repair time is the time that the repair team needs to work on the failure.

In order to guarantee a given Service Level Agreement or a given Network Availability, we introduce the notion of Maximum Time to Repair (MTR). This is the actual time by which the failure must be solved, measured since the time when the failure is notified. Based on this MTR value, a repair team could delay the start of the repair process provided that the MTR is satisfied. As is shown later, this optional delay can help to minimize the number of repair teams, as the same team could work on several nearby faults or close in time failures or operations.

With the intention of understanding better the relationship between RT, MTR and number of repair teams, Figure 1 and Figure 2 below illustrate an example in which two failures happen in the network, and the second failure occurs before the repair team working in the failure can finish their task.



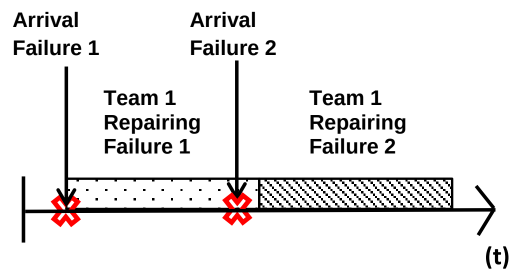


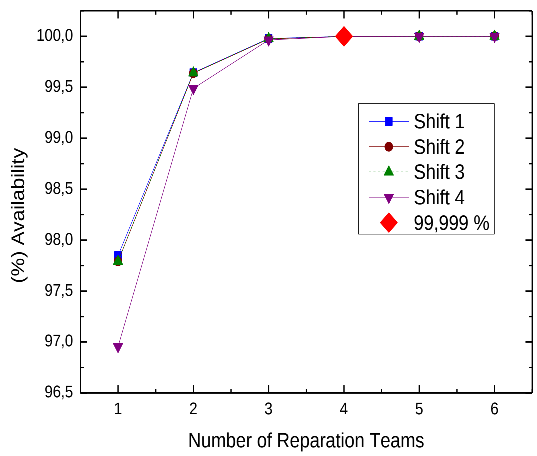
Figure 1. Urgent reparation

Figure 2. Delay allowed

Figure 1 shows one example in which the reparations are very urgent and no delays are allowed (the maximum repair time equals the repair time). Thus, when the second failure arrives, a second repair team would be needed, as with only one the actual repair time would exceed the MTR. However, in the case of Figure 2, the reparation is not so urgent, that is maximum repair time is bigger than the repair time. In this case it is observed that the beginning of the reparation of the second failure is delayed until the team repairing the first failure finishes. Therefore just one repair team would be necessary to repair the two failures, saving thus one repair team.
The examples in Figure 1 and Figure 2 assume that repair teams are always available (at any time). However, each repair team has certain availability. The two most common models in the market are 8x5 (8 hours per day, 5 days per week) and 24x7 (24 hours a day, 7 days per week). In the 8x5 it is assumed that the repair teams are only available from Monday to Friday, eight hours a day. In the 24/7 it is assumed 3 shifts on weekdays (Monday to Friday) and a Weekend shift. Based on this model, given a certain mean time between failures, a repair time, a maximum repair time, and the number of equipment subject to failure, the number of repair teams is obtained to guarantee the compliance of the repair time 100% of the time. Then, iteratively, the process is repeated but eliminating one repair team each time. For each number of team, the availability in terms of percentage of reparation of failures when the guarantee is assured

3. Case Study: Multi-layer Restoration

Let us assume a multi-layer network in which failures can happen in the one of the network layers. We take the results of [1] which obtains the maximum mean time to repair to guarantee a certain service availability with different survivability schemes, specially protection and multi-layer restoration. This paper follows the same network scenario, an IP/MPLS over Optical backbone topology, with a mean time between failures of 5 years. The repair work time has been fixed to 6 hours. Two maximum repair times are considered, 12 hours, that guarantees 99,999% service availability with single layer protection and 5 days, which guarantees the same service availability for multi-layer restoration. This case study has been performed for the two different Repair Team availabilities previously mentioned, 8/5 and 24/7.
The results obtained are, for each number of repair teams needed, the percentage of successful repair cases when the maximum time to repair is achieved. Simulations are performed for periods of time of 10 years generating random time between fail.
Figure 3 shows the number of reparation team versus availability for the four different shifts of the 24/7 availability model when the mean time to repair is 12 hours versus 6 hours needed to fix the failure. In this case the failure reparation can be delayed until 6 hours.



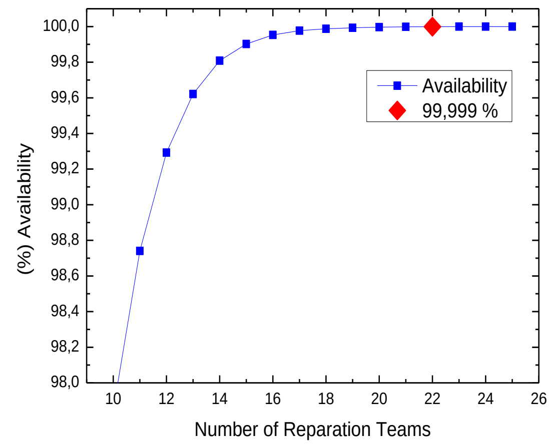


Figure 3. Single layer protection 24x7 model

Figure 4. Multilayer restoration 8x5 model

In this model (24x7), if a failure is not completely fixed for the repair teams of a shift, the teams which are working in the next shift must be continue with this reparation.

The results show that around 16 reparation teams (4 teams of each shift) are needed to achieve the maximum repair time guarantee in 99,999% of the failures in case of single layer protection.

When Multilayer restoration is used the maximum repair time is relaxed to 5 days which allows to delay much more the reparation that in the case of single layer protection. According with the same procedure, in this case, it is obtained that just one reparation team is necessary for each shift to accomplish with 99,999% (not shown in the graphs) which sums 4 reparation teams.

On the other hand, the same study has been performance for the model 8x5 based on multilayer restoration (MTR=5days). The number of reparation teams has been calculated again in order to accomplish with certain availability. In Figure 4 it can be observe that in this case, at least 22 reparation teams are necessary to reach 99,999% availability.

Looking at the above results, definitively we can assume that is much better a model which covers every hour of the day divided in different shifts than a model which just covers 8 hour a day with just one shift.

Operators and service providers typically consider two main models for the repair costs, a flat fee model with a fixed monthly cost during the year, which includes the salary of the repair teams, and event base model, used when the repair teams are shared between operators.

4. Conclusions

This work shows how it is possible to save operational expenditures by alleviating the urgency in the reparations by enhancing the survivability mechanisms. In the case of IP over optical networks, multi-layer restoration can reduce to a forth the work force needed to maintain the network. On the other hand, this paper also shows the influence on the operational expenditures by using different repair model which assume different time availabilities.

5. Acknowledgements

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6. References

[1] F. Muñoz, V. Lopez, O. González de Dios, J.P. Fernández-Palacios. Multi-layer Restoration in Hierarchical IP/MPLS over WSON Networks

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