# Improved remote node configuration for passive ring-tree architectures

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**Abstract**

*In this paper, a set of optically fed passive remote node configurations for a Ring-Tree extended reach PON which allow increased efficiency and resilience are presented.*

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## Introduction

Next generation Passive Optical Network (NG-PON) aims to provide higher user density and bandwidth, extended reach, scalability, flexibility, robustness and resiliency. Scalable Advanced Ring Based Passive Dense Access Network Architecture (SARDANA) is an effort to demonstrate how to exploit the NG-PON in a cost-effective and reliable way, allowing integration with the actual G-PONs. This network is based on a wavelength division multiplexing (WDM) ring with several time division multiplexing (TDM) trees connected together by Remote Nodes (RNs), which are able to provide amplification. The RNs are remotely pumped to compensate the encompassed losses resultant from propagation from the Central Office (CO) down the tress and reaching more than 1000 users spread over 100km, with symmetric 100Mbit/s of bit rate per user [1-2]. An appropriate RN architecture is critical to balance the power inside the ring, the total pump power supplied by the CO, which is one major limitation due to eventual power rupture in the fibres causing definitive damage to the installed fibres.

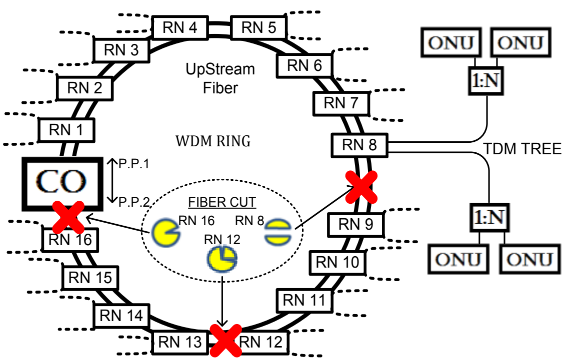


*Figure 1. SARDANA architecture with realised simulation set-up.*

In this paper, we analyze different structures and architectures for the RN optimizing its parameters taking into consideration full network structure. The limitations and advantages of these configurations are also presented.

## Simulation set-up and results

In figure 1, the simulated system is presented. The network is assumed to be designed for its higher capacity, 16 RNs, reaching by each one 32 users spread over 2km. The CO operates at traffic balance mode, emitting each signal by the shorter path to the correspondent RN and pump power for both sides of the ring. Figure 2 shows four different RN configurations. In order to compare the impact of each configuration on the network, the pump power supplied by the CO and the number of dead RNs(1) are calculated for networks with ring length's of 20, 30 and 60km for fiber cuts at RN 8, 12 and 16. Latched optical switches or attenuators can be operated with optical power [3].

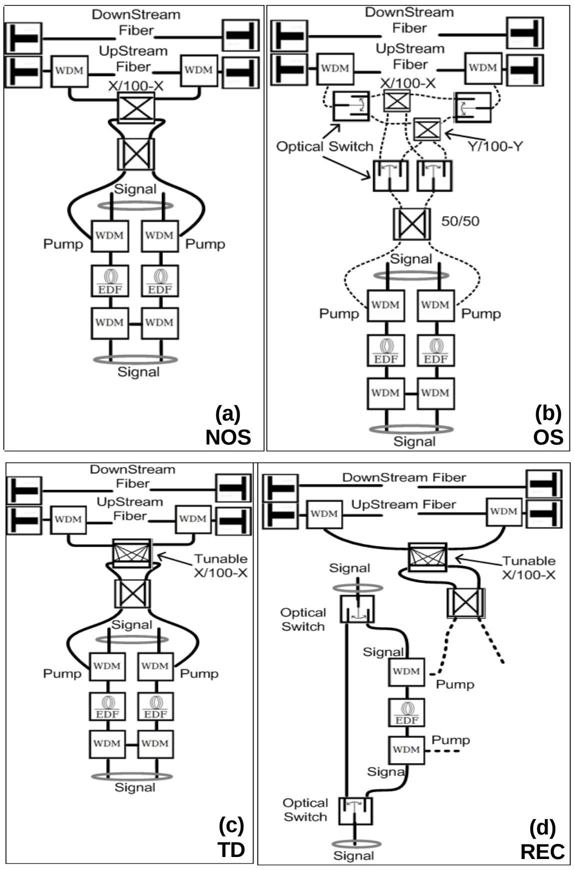


*Figure 2: RN architectures simulated.*

(1) A RN is considered dead when each of the EDFs doesn't receive enough pump power to provide gain (7dBm).

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Figure 2 (a) shows the RN architecture proposed in [1], where power splitter ratio is chosen taking in consideration the pump power available on the network, its length, number of RNs, scalability and resiliency in the case of fiber cut. The simplest solution is to have all power splitter ratios equal (10/90) to provide resilient and scalable network. However, it requires excessive pump power generated by the CO, 35dBm on each direction for 20km network. A better solution is to have for 16 RNs the ratios 10, 13, 17, 20, 25, 30, 40 and 50, reducing the pump power produced by the CO to 31dBm on each direction, but in case of fiber cut at RN 16, 43dBm is necessary at the CO letting 6 RNs with no pump power (dead).

An alternative for the previous configuration is to select between the best fiber cut at RN 8 and RN 16 power splitters ratios by means of optical switching, as seen in figure 2(b). For fiber cut occurred at RN 8, 35dBm is necessary in each direction, more 4dB than previous configuration and for fiber cut at RN 16, 44dBm is necessary leaving in any case 6 RNs dead. This excess pump power is necessary due to the extra Insertion Losses (IL) imposed by the optical switches. Thus, the RN configuration with simple addition of optical switches is not a much better solution.

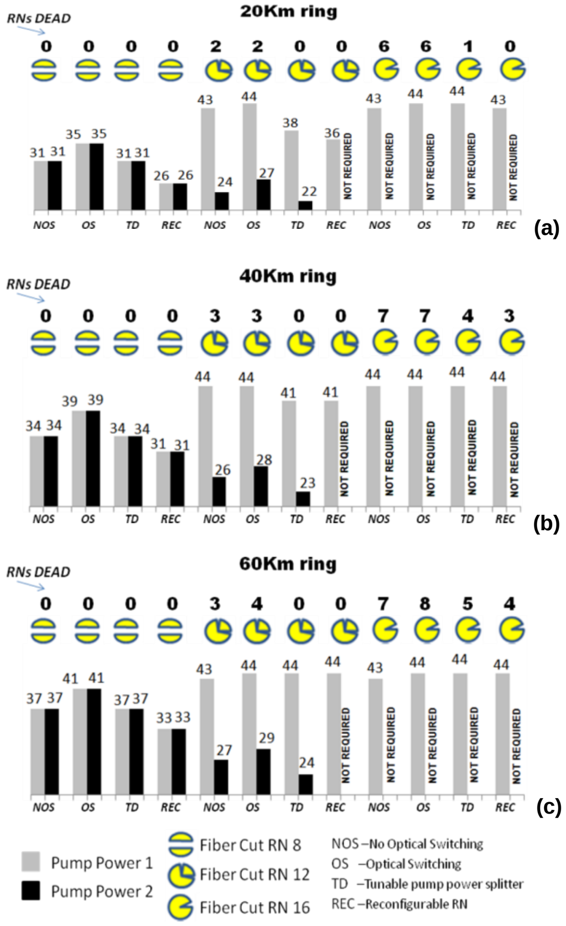


*Figure 3. Pump power supplied by the CO on both directions and the number of RN with not enough pump power for amplification (dead RN) for the four different configurations of RN. (a) 20km, (b) 40km and (c) 60Km networks.*

A reduction of the IL of the RN and a better adaptability to the pump power available on the network can be achieved with a tunable pump power splitter. This provides better resiliency and scalability, as seen in figure 2(c). Although the possibility to select between fiber cut at RN 8 and RN 16 power splitter ratios, the RN is also able to select an intermediate situation (fiber cut at RN 12 simulated), increasing the efficiency. For fiber cut at RN 8, this configuration requests the same pumping power than the first configuration, 31dBm in each direction, but for fiber cut at RN 16, a total production of 43dBm is necessary, reducing the dead RN from 6 to just 1.

For signal power supplied to the EDF higher than -10dBm (10 meters of HE980 pumped at 11dBm), the gain is reduced and the pump consumption is increased, reducing the efficiency of the network. In order to solve this limitation, new generation reconfigurable RN is proposed, shown in figure 2(d). The main advantage is to provide the RN close to the CO with the possibility to adjust the tunable pump power splitter to maximum pass, and the optical switch selecting no amplification mode saving the pump power. For fiber cut at RN 8, the CO supplies the network with 26dBm in each direction and in case of fiber cut at RN 16, 43dBm provides the pump power to all the RNs.

In figure 3, a comparison between the four RN's configurations for 20, 40 and 60km ring lengths is presented. It shows, for fiber cuts at RN 8, 12 and 16, the pump power supplied by the CO on both directions of the ring and the number of RN with not enough pump power to provide amplification. For fiber cut at RN 8 and 12 using the RN REC configuration, the network is capable to provide all RNs with enough pump power from the CO, as seen in figure 3.

## Conclusions

The introduction of tuneable pump power splitters and optical switching, introduce significant improvements on the total pump power produced by the CO, diminishing 5, 3 and 4dB for 20, 40 and 60km, respectively, at normal operation mode (fiber cut at RN 8). At extreme resilience mode (fiber cut at RN 16), for the same pump power supplied by the CO, the number of RNs with no pump power available (dead RN) decreases 6, 4 and 3 unities for 20, 40 and 60km, respectively.

Implementation of the reconfigurable RN increases the network scalability, resiliency and robustness, leading to more efficient NG-PON.

## References

1. J. A. Lázaro, OFC/NFOEC 2008, February 08, San Diego, paper OTHL2.
2. J. A. Lázaro et al, OSA JON vol. 6, pp. 801-807, 2007.
3. H. Ramanitra, OFC2006, March 5-10, 2006, Anaheim, California, USA, paper OFE2.