Translucent OPS for Avoiding Internet Capacity Crunch

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Abstract: In this work, a hybrid optical network, using OPS and OCS switching, was analyzed and compared with a conventional optical network, only using OCS. A realistic proportion was used relative to world Internet data traffic, switching with OPS 80% of generating traffic, and OCS for the remaining 20% of traffic. The results allow us to state that the network blocking probability drops dramatically by means of using hybrid switching, and can be a strategy for avoiding the Capacity Crunch.

Keywords — Hybrid Switching Paradigm, Capacity Crunch, Translucent OPS

1. Introduction

Due to the growth of Internet access and the improvement of media transmission technologies, in 2019 nearly 80% of global data traffic will be due to the video transmission [1]. The perception of this demand growth was added to the already worrying proximity of the Internet Capacity Crunch [2] that drives the scientific community to search for new solutions [3].

In this work was analyzed, through simulation, a hybrid switching optical network using Optical Circuit Switching (OCS) and Optical Packet Switching (OPS), generating the traffic with the proportion of 20% of OCS and 80% of OPS. In addition, the network was analyzed under the same conditions, but only with traditional OCS switching for control purposes. Moreover, other combinations of OCS against OPS were tested for comparison purposes. The BP of these scenarios were compared, evaluating the impact that the use of hybridization has on the network as a whole.

The choice of the hybridization scenario is directly linked to the fact that the proportion of 80% estimated for video traffic, largely refers to the stored video, coming from services like YouTube and others, which would not necessarily have to travel on networks of low latency, switched to OCS, since these have higher network cost, and that could perfectly travel via translucent OPS along with the other data types, keeping 20% operating with OCS for priority traffic, such as videoconferencing and others. Redirect this large amount of video to the OPS switching can be an auxiliary solution on the issue of the Internet Capacity Crunch.

2. Hybrid Switching

Currently, backbone optical networks establishes communication between nodes through OCS switching, in which data travels in the optical domain from origin to destination, with the advantages of having negligible latency and enormous throughput, but with the disadvantage of occupying the resources exclusively during the transfer, as a conventional telephone call. In this type of switching, a unique lightpath between source and destination remains while the bidirectional transfer of data is required.

In the translucent OPS switching, since currently there is no commercially available solutions to store the optical package inside routers, a conversion from optical to electrical packet is made, and then this package is routed into the electrical domain, and so it is reconverted into optical package before being reinserted into fiber traveling to the next router, and so on. The advantage of OPS switching over OCS is not to exclusively occupy the network resources. The OPS cost is that successive cross-domain conversions causes a considerable delay in signal propagation.

The following is an example of a hybrid network using OCS for low latency traffic and OPS for the rest of the traffic in general, including stored video stream. In the example, the nodes allow the conversion of the optical domain to the electrical and vice versa, but there is only one optical node. Although the example displays simplified snippets with OCS and others with OPS, is possible to reserve certain wavelengths for OCS and others for OPS within the same fiber. The example is shown in Figure 1.

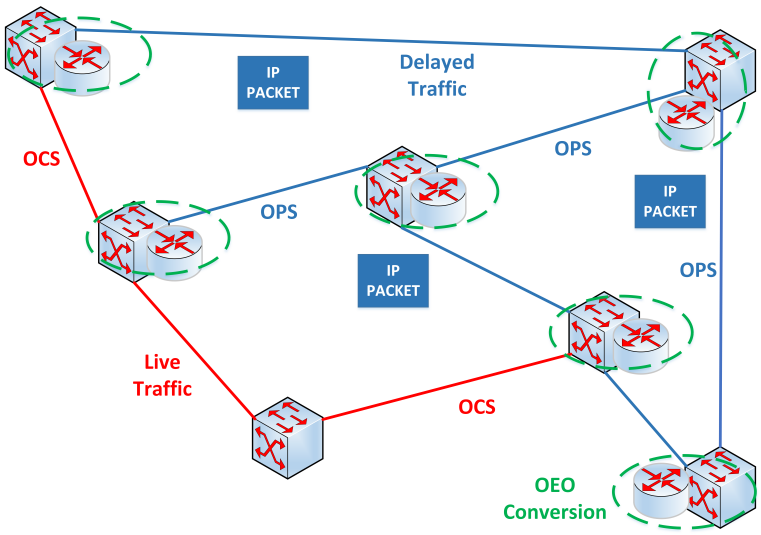

Fig. 1. Optical Network with Hybrid Switching of OCS and OPS

The 80% ratio used in the scenario is based on a report published by Cisco [1], and considers global traffic generated by individuals, consisting of specifically video traffic and total traffic, which includes video, email, navigation, sharing, downloads and others. The numbers of this traffic estimate are shown in Table 1, where you can get that video traffic is just over 79% of the overall traffic.

Table 1. Traffic Forecast for 2019.

Type	Exabytes / month
Consumer Internet traffic	124,252
Consumer Internet video	98,182

[1]Source: CISCO.

3. Material and Methods

In order to perform the experiment, the ONSIM simulator [4] was used, developed in Java language, which allows network modeling in detail, determining parameters such as the switching paradigms. In this simulation, traffic was randomly generated using the Mersenne Twister algorithm, being 20% generated as OCS connection requisitions, and 80% in the form of OPS packages. The simulator has 95% statistical reliability and free license.

The NSFNet topology was used, with 14 nodes and 21 bidirectional links defined by their distances, as in [5], and approximately 2.1 average hops. The independent greatness was the load, which varied in 10 steps of 100 E each, totaling 1000 E, in a network with an estimated capacity of 733.6 E. For each load point 1 million arrival events were generated. Setup times for OCS and OPS were 5μs, and occupancy times were 3600s for OCS and 1μs for OCS. For this simulation, a single type of service was considered, with a spectral demand of 100 GHz, regardless of the type of switching. The total spectrum used was 4000 GHz, approximately C-band width. The entire spectrum was shared between OCS and OPS and the OOK modulation was used.

4. Results

The obtained results are shown in Figure 2. The lines represent the Blocking Probability (BP) at the network, which the smaller the better. Comparing the OCS switched network, the blue Line, against hybrid switching, the red line, the perceived result at full load is about 36% of OCS and 9% by hybrid switching. If load balance of 0.7 is considered, the drop will be more than 80%.

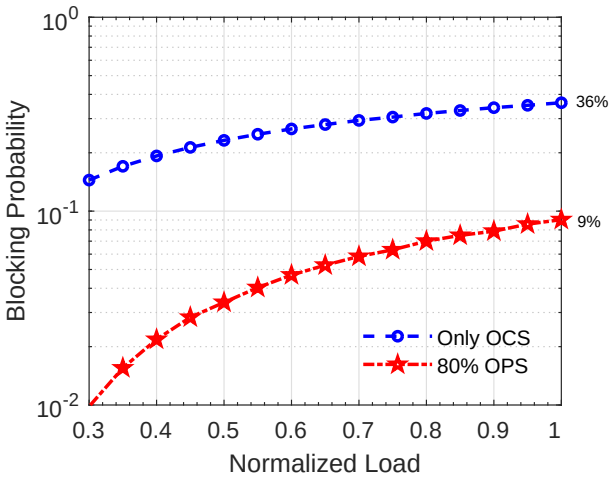

Fig. 2. General Loss with Only OCS against Hybrid Switching of 80% OPS

Additionally, scenarios were simulated with other combinations of OCS against OPS ratios, for comparison purposes, as shown in Figure 3. As shown, the higher the OPS rate, the lower the BP.

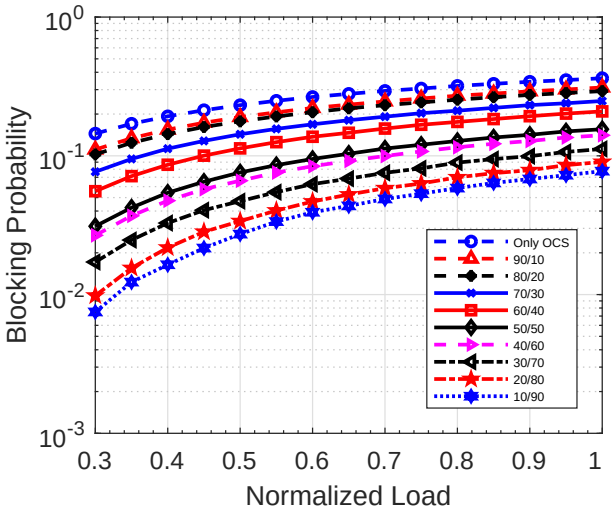

Fig. 3. General Loss with OCS against Hybrid Switching

5. Conclusions

In this work a simulation of backbone optical networks was performed comparing an OCS and OPS hybrid switching scenario, against an OCS only scenario, with several combinations of ratio between them, in terms of General Blocking Probability. The results allow us to conclude that the use of 80% of the traffic with OPS significantly reduces the Blocking Probability, from 36% to 9% of full load (-75%), or from 29% to 6% at 0.7 of full load (-80%), compared to OCS only scenario.

This result alone is sufficient reason to stimulate further studies on switching hybridization by using translucent OPS, in a reality where transparent OPS networks are not yet commercially available.

As future studies, a more thorough study is suggested, in which other topologies and several network parameters can be investigated, with the aim of endorsing this result.

6. References

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