Offset-Time-emulated OBS control architecture

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Abstract *Having variable sizes offset-times is a well-known problem in conventional OBS networks. In this paper we propose and evaluate the offset-time-emulated control architecture, which is a solution similar to the one considered in OPS networks.*

Introduction

Optical Burst Switching (OBS) [1] is a promising solution for reducing the gap between switching and transmission speeds in future networks. In conventional OBS (C-OBS), the packets from the access networks are aggregated and assembled into large units called burst at the edge nodes. Meanwhile, the control information is transmitted out-of-band and delivered with some offset-time (OT) prior to the burst in such a way that the intermediate nodes have enough time, both to process this information and to reconfigure the switching matrix.

Although the operation of OBS appears simple and effective for a single node, it becomes significantly more complex in a network environment where bursts travel over multiple nodes between source and destination.

A first well-known problem is due to the fact that, whilst the control packet travels through the network, its OT decreases successively at each hop by the processing time. Hence, bursts having higher OTs and so beginning the trip have more chances to reserve output wavelength than the bursts approaching the end with lower OTs. This causes the well-known *unfairness problem.*

A second problem is the difficulty of providing alternative routing inside the OBS network. In particular, the edge node should know the routing path prior to the control packet transmission or consider the longest path in order to calculate and setup OT accurately, which can increase the delay unnecessarily.

Finally, *burst preemption* is considered the most effective QoS mechanism. The general drawback is that in case of successful preemption either those resources are wasted or an additional signalling procedure should be carried out in order to inform downstream nodes about releasing the resources reserved for the preempted bursts.

Figures 1-2 present some exemplary results of the unfairness problem and of the preempted problem.

In Figure 1 we consider three network topologies called Simple, Nsfnet (US network) and EON (European Optical Network) with 6, 15 and 28 nodes, and 8, 23, and 43 links respectively. Each node is an edge node generating 12.8 Erlangs (0.8 normalised) and each link has 16 wavelengths at 10 Gbit/s. Bursts have exponential distributed arrival time and length (mean 125kB). 10 µs and 2 µs are used as switching and processing time respectively. JET signalling and LAUC-VF scheduling [1] are used. In these scenarios we can see that the bursts beginning the travel obtain lower burst loss probability (BLP) than burst having just one remaining hop to reach the destination.

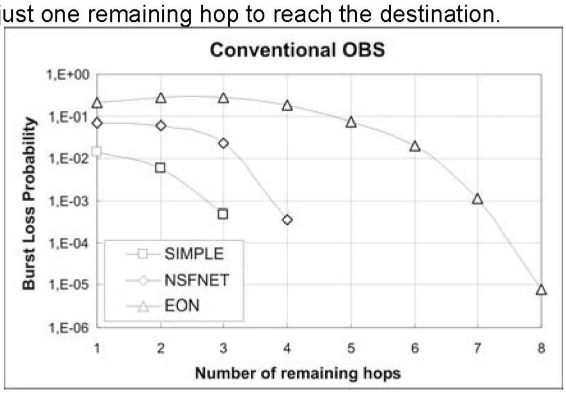

Figure 1. BLP as a function of the number of hops remaining to reach the destination comparing different network topologies

In Figure 2 we shown the percentage of additional signalling required *at each node* to release preempted burst; different mean burst lengths are considered. We can observe that the amount of additional information is significant.

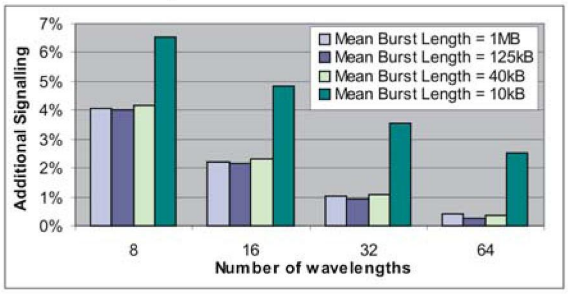

Figure 2. Percentage of additional signalling to release preempted burst at each node

OT-emulated OBS (E-OBS) control architecture

In this paper we consider an OBS control architecture that overcomes all these problems without decreasing the overall performance. It is shown in Figure 3 and comes from OPS technology [2] where an additional fibre span (FS) is inserted in the data path at the core node's input ports to emulate OT. In such architecture there is no OT setup by edge nodes; control packet and burst travel simultaneously through the network. When both reach a core node the control packet goes directly to the switch control unit, whilst the burst is delayed in the FS by period OT. This FS is responsible for compensating both control data processing and switch configuration times. Thus during this time the control packet is processed, and, in case of successful scheduling, it waits its burst in the memory of the control unit until the OT expires and then they are either sent together to the next node or dropped (in case of blocking or preemption).

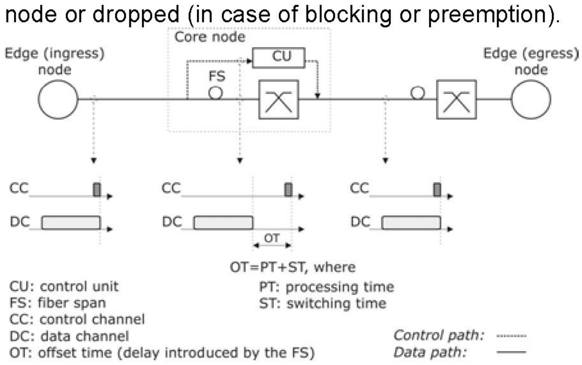

Figure 3. E-OBS control architecture

We can firstly observe in Figure 4 that E-OBS obtains the same results as C-OBS, so it does not cause performance degradation but brings several gains.

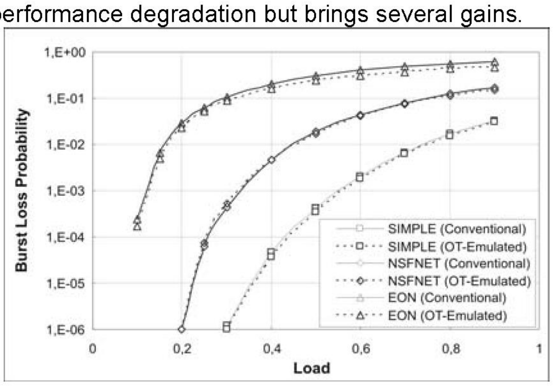

Figure 4. BLP as a function of load comparing conventional and emulated OBS

Indeed, the E-OBS architecture solves the unfairness problem since the OTs have always the same value (determined at each node by the length of the FS) and therefore a burst has the same chance of any other to access to the transmission resources. As a demonstration, Figure 5 evaluates the scenarios considered in Figure 1 but using E-OBS. We can observe that the BLP is independent of the number of hops remaining to reach the destination.

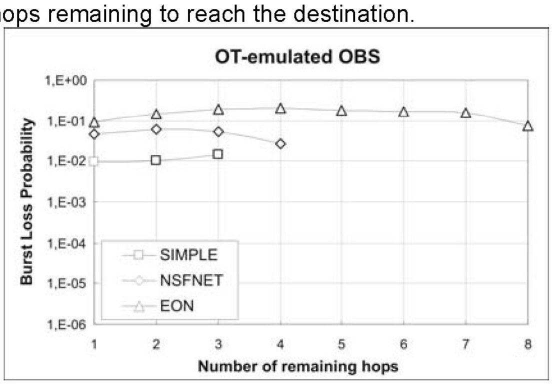

Figure 5. BLP as a function of the number of hops remaining to reach the destination

The unfairness problem is also effectively solved in [3] using the DOBS architecture. Nonetheless E-OBS has other important benefits discussed below.

The first one is that once a burst is assembled, edge node can send it immediately without waiting the OT and thus it reduces the buffering requirements.

Alternative routing can be applied since the paths can be created freely inside the network without any constraints in the number of hops due to the pre-calculated OT.

Finally, since control packet and corresponding burst are transmitted always together to the downstream node, preemptive-based QoS mechanisms can be efficiently implemented without any additional signalling information [4].

The increased end-to-end delay could be a drawback of this architecture. But we must consider that total end-to-end delay is the sum of both OTs and the propagation time. The difference between C-OBS and E-OBS is that in the former the delay necessary for switching time is introduced only once into the OT while in the latter it should be counted for each node of the path. Therefore, the delay in E-OBS is increased by the sum of switching time introduced in n-1 nodes, where n is the number of nodes on the path. Nevertheless, it can be still neglected in comparison with the propagation delay. For example, assuming a path of 8 buffer-less nodes, a total length of 2400 km, 10 μs for the switching time, and 2 μs for the processing time, the end-to-end delay is 12.024 ms versus 12.084 ms (less than 0.5 percent more).

At the same time there is a need for one FS per node input port, which compensates the OT for all data channels simultaneously. Assuming the same values considered in the previous example, E-OBS needs 16.8 km of additional fibre (2416.8 km instead of 2400 km) for inserting the FS. Nonetheless they can be usefully adopted for compensation/amplification.

Conclusions

In this paper we have highlighted the main problems of conventional OBS control architecture. The OT-emulated architecture (similar to what considered in OPS) is proposed to solve all drawbacks. Obtained results demonstrate the benefits of such solution at the expense of negligible additional fibre span and end-to-end delay.

Acknowledgements

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References

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