

Defining Optical Plane QoS Parameters for OBS Networks

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ABSTRACT

Currently deployed optical networks are engineered to provide adequate signal quality on a per link basis. This approach works well today because of low bit rates used in data transmissions. At higher bit rates that future optical burst switched (OBS) networks envision, the increased effect of fiber non-linearities can severely limit the size of transparent domains. The effective domain of transparency of an optical network can be increased by observing that not all signals have the same Optical Quality of Service (OQoS) requirement. OQoS requirement depends on how far a data burst has to travel and other issues like availability of Forward Error Correction (FEC). By estimating the effect of impairments on signal quality, an optimal route that meets the OQoS requirement of the data signal can be determined. This can be done by using a set of signal quality related parameters in routing algorithms as well as during forwarding decisions made at each node.

We envision transparent domains in an OBS network to have some optical performance monitoring devices (like power, dispersion and crosstalk monitors) that can measure certain aspects of the overall signal quality. In addition, switches in an OBS network may be equipped with service circuits to provide some form of dynamic compensation to the signal. Services may include providing gain compensation, dispersion compensation, wavelength conversion of fiber delay loops. Since monitoring devices cannot be installed at each link, any QoS strategy has to rely on a combination of measuring some and computing the other distortions. However, computing distortions is a challenging task because distortion interacts in complex ways with signal as well as other distortions.

Two approaches to defining optical QoS (OQoS) parameters are suggested. In the first approach, effects of various linear and non-linear impairments are clubbed into Optical Signal to Noise Ratio (OSNR) and Optical Jitter (OJitter). This allows both analog and digital signals to be represented accurately as both amplitude (noise) and temporal (jitter) distortions can be accounted for independently. The source node specifies either the BER (digital signals) or the OSNR and OJitter (analog signals) directly. A **setup** message carries these OQoS parameters as it traverses the network. At each node, the OQoS budgets are updated to reflect the current signal quality. Updates are based on the link quality as well as the data being carried on the other channels. In addition to the OSNR and OJitter, additional parameters are required for dynamic compensation. For instance, to determine if power compensation is required or not, one needs to know whether the total power level has fallen below a certain threshold. In general, additional parameters are required for each type of compensation mechanism.

In the second approach, static and dynamic parameters can be used instead of the OSNR and OJitter budgets. The static parameters (for instance, wavelength and intensity dependence of refractive index) correspond to the linear and non-linear parameters of fiber. The dynamic parameters correspond to the data being carried on different channels. These could be peak and average power levels in different channels. In this approach, when a **setup** message is forwarded, only the static and dynamic parameters are adjusted. The idea behind this approach is to maintain effective static and dynamic parameters as the burst traverses the network, instead of computing the total distortion at each node. For instance, if a burst goes through two links (of lengths l and l') with a static parameter of values x and x' , then it can be considered equivalent (from a distortion perspective) to traversing a single link of length $(l + l')$ with a static parameter value x'' .

The difference in the two approaches is that while in the first approach OSNR and OJitter is computed at each step, in the second approach these values are computed only at the end points. In the second approach, forwarding only requires updating individual parameters (fiber related as well as data related). This makes forwarding computationally much simpler than the OSNR-OJitter approach, although a larger number of parameters need to be carried by **setup** messages. In both cases, these parameters can be used to implement OQoS at two levels - (i) in routing algorithms which use the overall signal quality as constraints to compute optimal paths and routing tables, and (ii) in forwarding which uses an additional set of rules to make dynamic decisions on whether a burst needs to go through a service circuit. However, for optical QoS to be successful in OBS networks more research in impairment modeling seems necessary. One specific area is the development of simple analytical models or predictive schemes that provide a good estimation of signal quality and can also be easily implemented in hardware.