Exploring the Effects of Physical Layer Parameters in WDM based Fixed and Flexible-Grid Networks

Abstract: Coherent technology with electronic compensation of fiber chromatic-dispersion has made it possible to use multilevel modulation formats that increase optical systems Spectral Efficiency (SE). Besides that, it has also drastically changed the key features of signal propagation and of non-linearity generation in the fiber. Hence, simplified models are no longer valid. This proposal accentuates the importance of investigating the impact of fiber nonlinearities in the design of optical networks.

GN-Model: (Gaussian-Noise Model)

- Performance prediction tool for non-linear propagation in dispersion Uncompensated Coherent Systems
- Signal Disturbance generated by non-linearity manifests itself as Additive Gaussian noise (AGN)

![Figure 1: OSNR vs. Channel power for linear and non-linear model](image)

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>$\alpha_{db}$ (dB/km)</th>
<th>$D$ (ps/nm/km)</th>
<th>$A_{eff}$ (µm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZDSF</td>
<td>0.2 dB/km</td>
<td>4 ps/nm/km</td>
<td>55 µm$^2$</td>
</tr>
<tr>
<td>SSMF</td>
<td>0.2 dB/km</td>
<td>16.7 ps/nm/km</td>
<td>80 µm$^2$</td>
</tr>
<tr>
<td>PSCF</td>
<td>0.17 dB/km</td>
<td>21.0 ps/nm/km</td>
<td>135 µm$^2$</td>
</tr>
</tbody>
</table>

Our use case scenario

- Three architecture scenarios:
  - 1) Fixed-grid with pure formats (FPF),
  - 2) Fixed-grid with TDHMF (FHF) and
  - 3) Flexible grid with pure formats
- 20-nodes random network topology with uniform traffic matrices

![Figure 2: Point-to-point link layout](image)

Results

![Figure 3: Flex-grid: Different fiber types](image)

![Figure 4: Fix-TDHMF: Varying span length](image)

![Figure 5: Spectral efficiency variation with changing fiber types](image)

![Figure 6: Number of blocked requests vs. Traffic (Gbps/node), varying fiber type for different network scenario](image)

![Figure 7: Number of blocked requests vs. Traffic (Gbps/node), varying the span length for different network scenario](image)

![Figure 8: Number of blocked requests vs. traffic (Gbps/node), using a simplified physical layer model (Linear) vs. a detailed model with non-linear interference (NLI).](image)

Summary

- Inaccuracy of using linear model can reach up to 25%, this shows the importance of including non-linearity in calculating OSNR based on GN-model.
- Non-linearity decreases as fibers’ effective area increases and consequently OSNR increases. Hence, fibers are ordered as follows in terms of performance: PSCF, SMF and NZDSF.
- TDHMF shows to be a good solution to increase current DWDM fixed-grid network capacity.

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