Considerations on 800Gb/s coherent solution for 10km

• Haojie Wang, *China Mobile*
• Weiqiang Cheng, *China Mobile*
• Ruibo Han, *China Mobile*
• Zhenhua Feng, *ZTE*
• Weiming Wang, *ZTE*
Supporters

- Xiang He -- Huawei
- Aihua Liu -- ZTE
- Sen Zhang -- Huawei
- Tingting Zhang -- Huawei
- Ning Cheng -- Innolight
- Yanjun Zhu -- Hisense
- Bo Zhang -- Accelink
- Haijun Wang -- China Unicom

- Xue Wang -- H3C
- Ben Chen -- HTGD
- Zhen Han -- Fiberhome
- Tom Williams -- Cisco
- Mike Sluyski -- Cisco
- Guangpeng Ma -- NeoPhotonics
Purpose

• There is a technical uncertainty about 800Gb/s 10km application, which involves direct detection and coherent signaling technology.

• In March session, rodes_3df_01a_220329, yu_3df_01a_220329 and williams_3df_01a_220329 all inject the valuable contributions to the objective. However, the road ahead is still full of unknowns!

• This presentation can provide some technical and industry inclined considerations from network operators’ perspective on 800Gb/s 10km. We hope it will be helpful.
In *wang_b400g_01b_210301*, we proposed that 400Gb/s and B400Gb/s ports can address the OAM issues induced by the LAG links which are widely deployed at China Mobile’s backbone network.

There are about 30% LAG links with the equivalent rate of 800Gb/s or more. The quantity will still grow in the next two years.

At present, the LR(10km) optical modules are extensively used in metro and backbone routers.

When LAG ports are replaced with 400Gb/s or 800Gb/s single ports, the requirement for 10km reach will remain.
Overview of the former proposals

• In March session, rodes_3df_01a_220329 and yu_3df_01a_220329 both have illustrated the technical feasibility of 800G LR4 with PAM4 IMDD.

• Four-wave mixing (FWM) and chromatic dispersion (CD) are proved to be able to suppressed effectively by an optimized wavelength scheme, and transceiver components can be supported well.

• Meanwhile, williams_3df_01a_220329 has presented the comparison of complexity between coherent and IMDD. Some advantages of coherent are highlighted, such as fewer lasers, dispensing with optical mux/demux.

• In lam_b400g_01a_210720, the gap of energy per bit between coherent and IMDD at 800Gb/s is obviously reduced than that of 400Gb/s.

• It is reasonable that the coherent solution could migrate to 800Gb/s 10km application, with the development in CMOS processing and cost reduction of opto-electronic components.
Coherent Technical Considerations

- Three coherent solutions are considered on technical feasibility in `zhang_b400g_01a_210720` and `zhang_b400g_01_0812`

**Option A:** single-carrier $1 \times 800G$

**Option B:** dual-carrier $2 \times 400G$

**Option C:** self homodyne detection (SHD) $2 \times 400G$

**Single carrier** of 800Gb/s requires typically fewer wavelength, inherited architectures without new designs, but more harsh demands on opto-electrical components.

- **Dual-carrier** option reuses the 400ZR components, but the challenge is size and power consumption in QSFP-DD/OSFP.

- **SHD** allows using low-cost, un-cooled DFB lasers, simplified DSP algorithm, and potentially low-cost modulators, however requiring polarization control. Industry still needs to pay more attention to interest and investigation.
Coherent Technical Considerations

By the simulation of 800G single-carrier system with the following parameters, the impacts of AD/DA’s bandwidth and laser’s linewidth on BER versus OSNR are obtained. Considering AD/DA with 50GHz bandwidth, the OSNRs at 8.5e-3 and 4.5e-3 are both required over 28dB correspondingly. By contrast, the required OSNRs could be less than about 27dB when the bandwidth of AD/DA is around 55~60GHz.

<table>
<thead>
<tr>
<th>Modulation</th>
<th>DP-16QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baud Rate</td>
<td>120GBd</td>
</tr>
<tr>
<td>ENOB</td>
<td>5</td>
</tr>
<tr>
<td>AD/DA</td>
<td>50G/55G/60G</td>
</tr>
<tr>
<td>Laser linewidth</td>
<td>300k/1M/2M</td>
</tr>
<tr>
<td>PMD</td>
<td>5ps</td>
</tr>
<tr>
<td>CD</td>
<td>200ps/nm</td>
</tr>
<tr>
<td>SOP</td>
<td>50krad/s</td>
</tr>
</tbody>
</table>

- OSNR@8.5E-3: 28.1dB (50GHz) 26.1dB(55GHz) 25.3dB(60GHz)
- OSNR@4.5E-3: 29.6dB (50GHz) 27.2dB(55GHz) 26.4dB(60GHz)
Coherent Technical Considerations

• Comparing the simulation results at the BER threshold of $4.5 \times 10^{-3}$, the OSNR penalty of about 0.2 dB is imposed when the laser linewidth is relieved from 300 kHz to 1 MHz.
• Fixed- wavelength Lasers with lower cost and power consumption, such as DFB lasers, are more applicable at 10 km coherent design.

- **Fixed-wavelength Laser:**
  - **Lower cost:** simplified wavelength tuning unit, smaller chip size, manufacturing and testing cost, more vendors
  - **Lower power consumption:** without active control units, power efficient with higher coupling efficiency

![Graph showing BER vs. OSNR for different laser linewidths](image)

- **OSNR@8.5E-3:** 25.3 dB (300 kHz) 25.6 dB (1 MHz) 26.0 dB (2 MHz)
- **OSNR@4.5E-3:** 26.4 dB (300 kHz) 26.6 dB (1 MHz) 27.0 dB (2 MHz)
Industry inclination from operators’ perspective

• Don’t let our vision be blocked by floating clouds. Maybe when getting out of the technical debates, a more clear viewpoint can be captured.

• **From the horizontal reach**, if coherent solution is chosen for 800Gb/s 10km, a common industrial chain can be built for 10/40/80km to achieve a scale effect in order to lower cost.

• **From the vertical rate**, 800Gb/s at 2km offers optical PMDs of 200Gb/s per lane over 4 pairs of fibers, and 1.6Tb/s at 2km pursues the same PMD over 8 pairs of fibers. Likewise, 1.6Tb/s at 10km can most likely reuse optical PMD of 800Gb/s 10km, on condition that both choose coherent solution.
Summary

IMDD and coherent both have all-right technical feasibility. On the other hand, **coherent** may be a more attractive solution to industry and operators currently.

Proposed Solution

- **Module package:** QSFP-DD/OSFP/OSFP-XD. QSFP-DD preferred
- **Laser:** low cost DFB, not iTLA, linewidth relaxed to ~MHz level.
- **Optical/electrical device:** 3dB bandwidth of 55~60GHz
- **FEC:** pre-FEC BER threshold $\geq 4E-3$, latency $<300$ns.
- **Basic architecture:** 800G single carrier, conventional coherent optics with matured supply chain
- **SHD:** also has the potential of reducing the cost of the modulators/coherent receivers, and power consumption of DSP ASICs.

**Finally, we hope that coherent readiness is seen for 800Gb/s 10km with the joint efforts of all colleagues!**
• Thank you!

• Q&A