Considerations on 800Gb/s coherent solution for 10km

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- Yanjun Zhu -- Hisense
- Bo Zhang -- Accelink
- Haijun Wang -- China Unicom
- Xue Wang -- H3C
- Ben Chen -- HTGD
- Zhen Han -- Fiberhome
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Purpose

Adopted Physical Layer Objectives

Ethernet Rate	Assumed Signaling Rate	AUI	BP	Cu Cable	MMF 50m	MMF 100m	SMF 500m	SMF 2km	SMF 10km	SMF 40km
200 Gb/s	200 Gb/s	Over 1 lane		Over 1 pair			Over 1 Pair	Over 1 Pair		
400 Gb/s	200 Gb/s	Over 2 lanes		Over 2 pairs			Over 2 Pair			
800 Gb/s	100 Gb/s	Over 8 lanes	Over 8 lanes	Over 8 pairs	Over 8 pairs	Over 8 pairs	Over 8 pairs	Over 8 pairs		
	200 Gb/s	Over 4 lanes		Over 4 pairs			Over 4 pairs	1) Over 4 pairs 2) Over 4 λ's		
	TBD								Over single SMF in each direction	Over single SMF in each direction
1.6 Tb/s	100 Gb/s	Over 16 lanes								
	200 Gb/s	Over 8 lanes		Over 8 pairs			Over 8 pairs	Over 8 pairs		

Technology Reuse

Leverage existing or work-in-progress 100 Gb/s per lane (e.g. 3cu, 3ck, 3db) to higher lane counts

Develop 200 Gb/s per lane electrical signaling for 1/2/4/8 lane variants of AUIs and electrical PMDs

Develop 200 Gb/s per optical fiber for 1/2/4/8 fiber based optical PMDs and 4 lambda WDM optical PMD

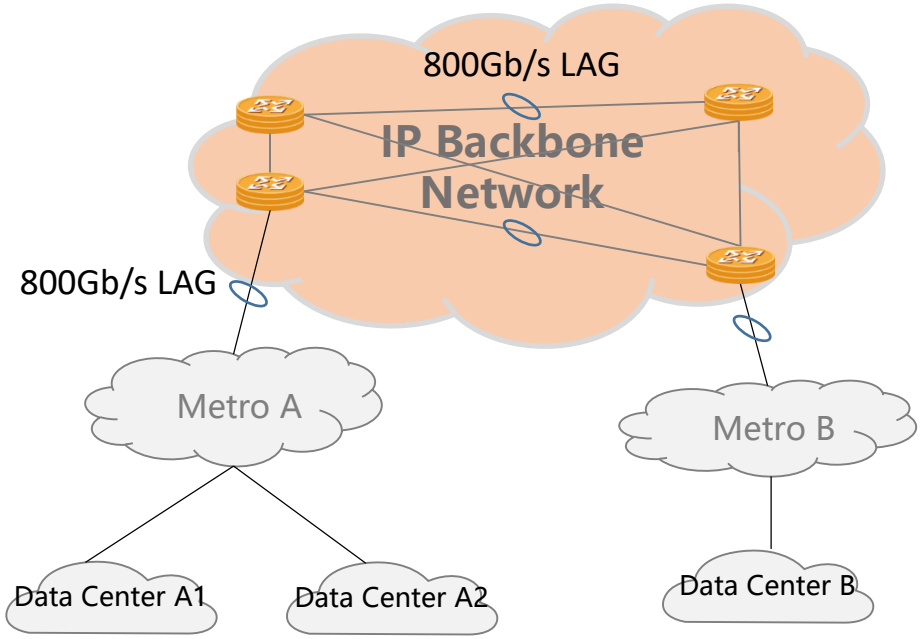
Potential for either direct detect and / or coherent signaling technology

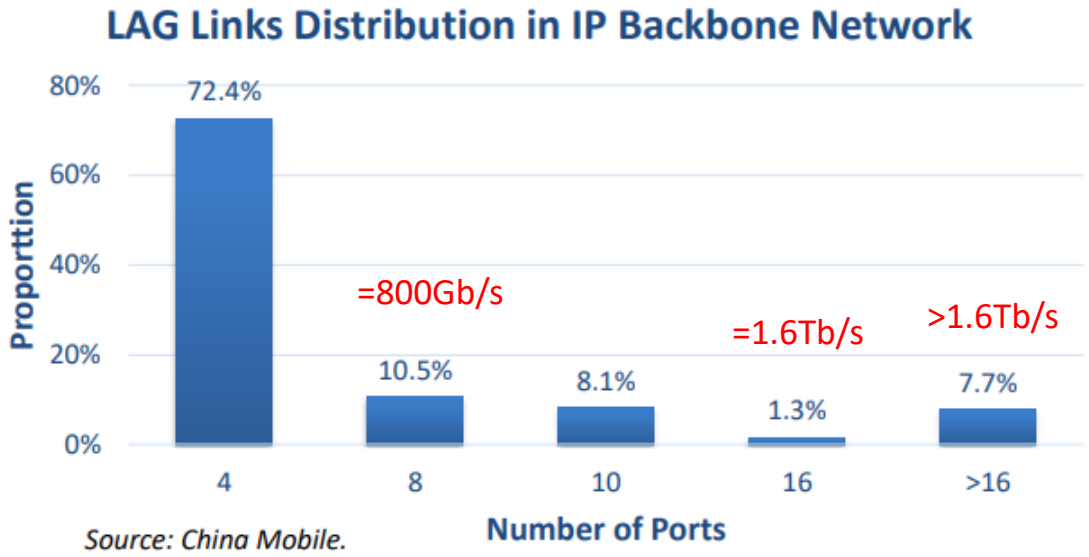
Arguments may exist !!!

Source: dambrosia_3df_01_220111

- 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.

Scenario Requirement for 800Gb/s 10km

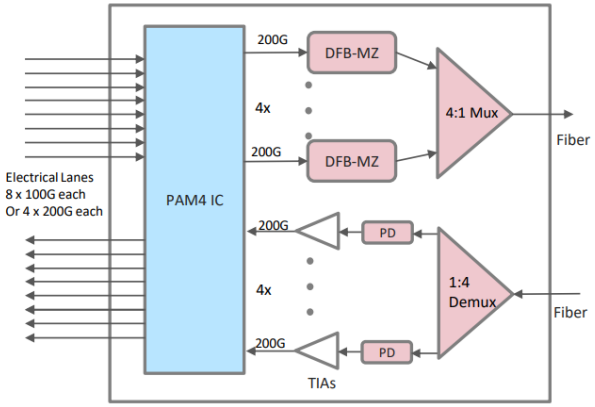




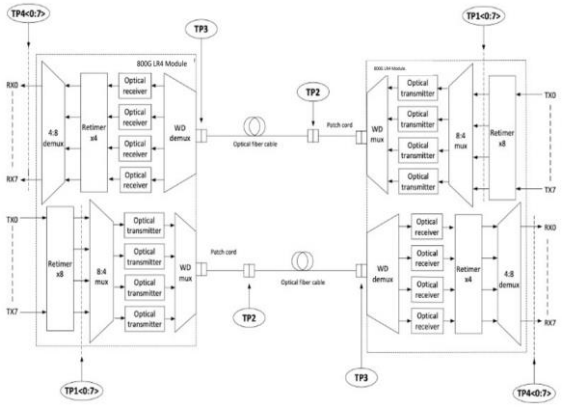
- In **wang_b400g_01b_210301**, we proposed that 400Gb/s and B400Gb/s ports can address the OAM issues induced by the LAG links which are widely deployed at China Mobile's backbone network.
- There are about 30% LAG links with the equivalent rate of 800Gb/s or more. The quantity will still grow in the 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

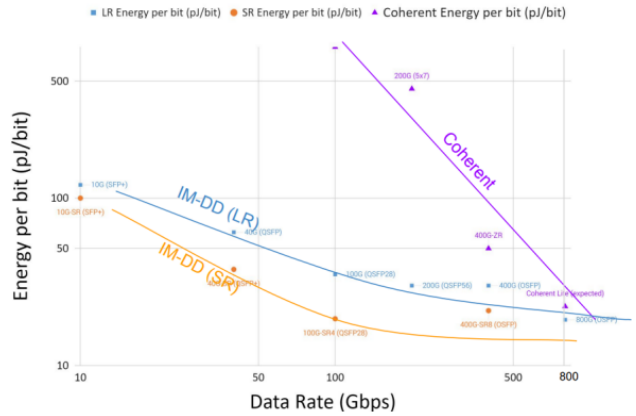
- In March session, **rodes_3df_01a_220329** and **yu_3df_01a_220329** both have illustrated the technical feasibility of 800G LR4 with PAM4 IMDD.
- Four-wave mixing (FWM) and chromatic dispersion (CD) are proved to be able to suppressed effectively by an optimized wavelength scheme, and transceiver components can be supported well.



source: rodes_3df_01a_220329



source: yu_3df_01a_220329

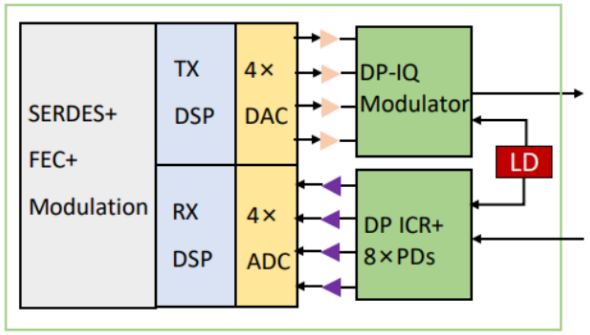


source: lam_b400g_01a_210720

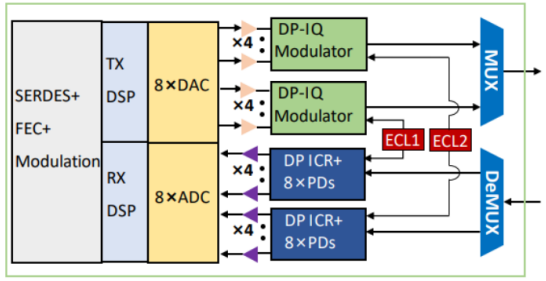
- Meanwhile, **williams_3df_01a_220329** has presented the comparison of complexity between coherent and IMDD. Some advantages of coherent are highlighted, such as fewer lasers, dispensing with optical mux/demux.
- In **lam_b400g_01a_210720**, the gap of energy per bit between coherent and IMDD at 800Gb/s 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

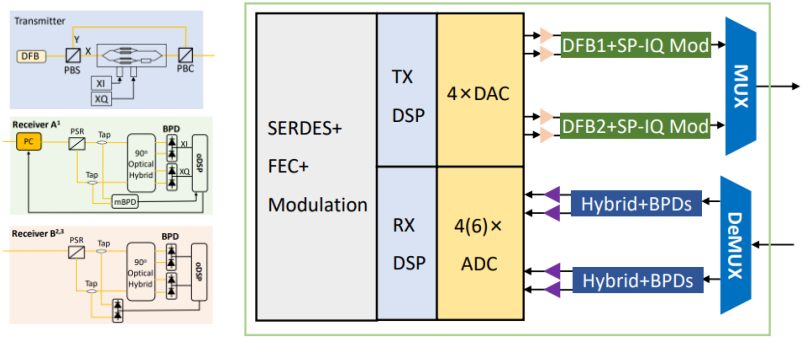
- Three coherent solutions are considered on technical feasibility in **zhang_b400g_01a_210720** and **zhang_b400g_01_0812**



Option A: single-carrier 1×800G



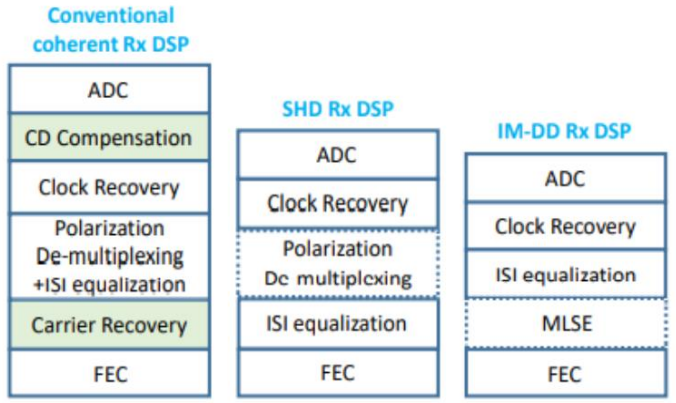
Option B: dual-carrier 2×400G



Option C: self homodyne detection (SHD) 2×400G

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

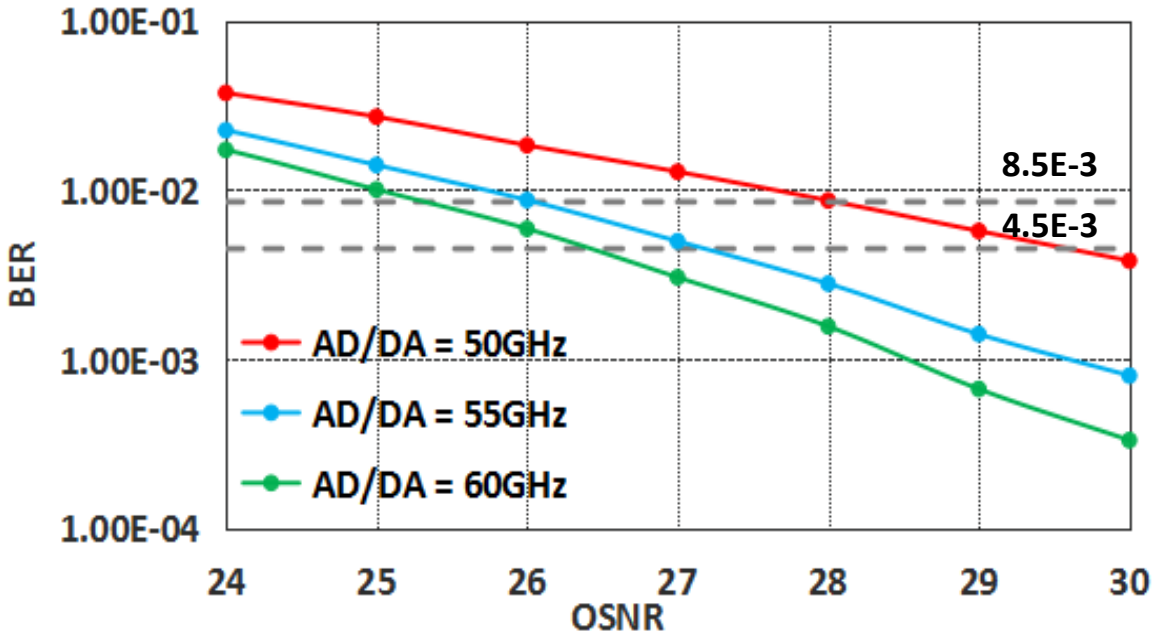
- **Dual-carrier** option reuses the 400ZR components, but the challenge is size and power consumption in QSFP-DD/OSFP.
- **SHD** allows using low-cost, un-cooled DFB lasers, simplified DSP algorithm, and potentially low-cost modulators, however requiring polarization control. Industry still needs to 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.

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

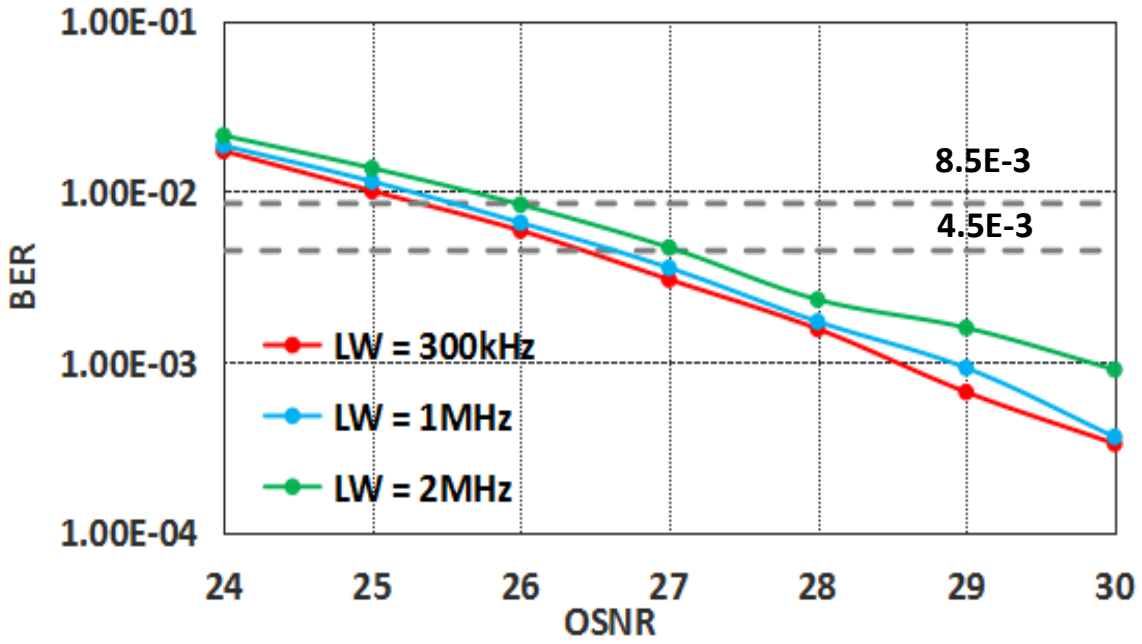


- OSNR@8.5E-3: 28.1dB (50GHz) 26.1dB(55GHz) 25.3dB(60GHz)
- OSNR@4.5E-3: 29.6dB (50GHz) 27.2dB(55GHz) 26.4dB(60GHz)

Coherent Technical Considerations

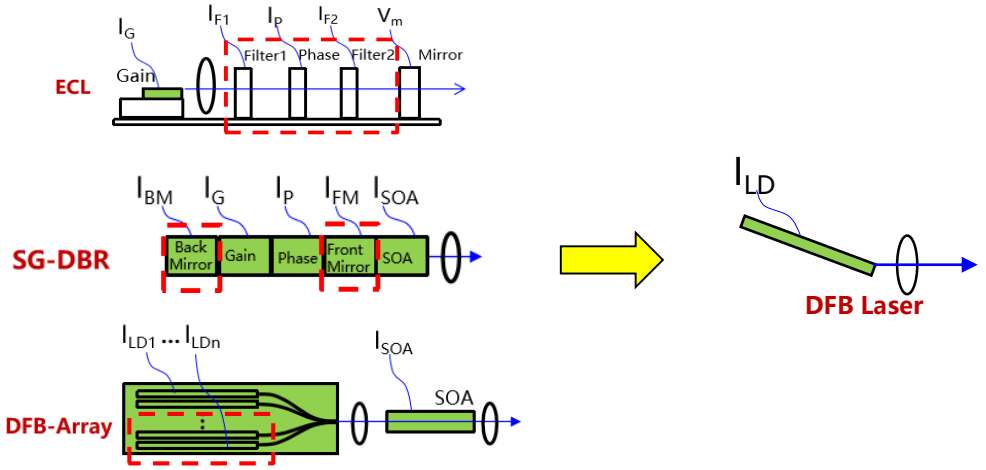
•Comparing the simulation results at the BER threshold of 4.5e-3, the OSNR penalty of about 0.2dB is imposed when the laser linewidth is relieved from 300kHz to 1MHz.

•Fixed- wavelength Lasers with lower cost and power consumption, such as DFB lasers, are more applicable at 10km coherent design.



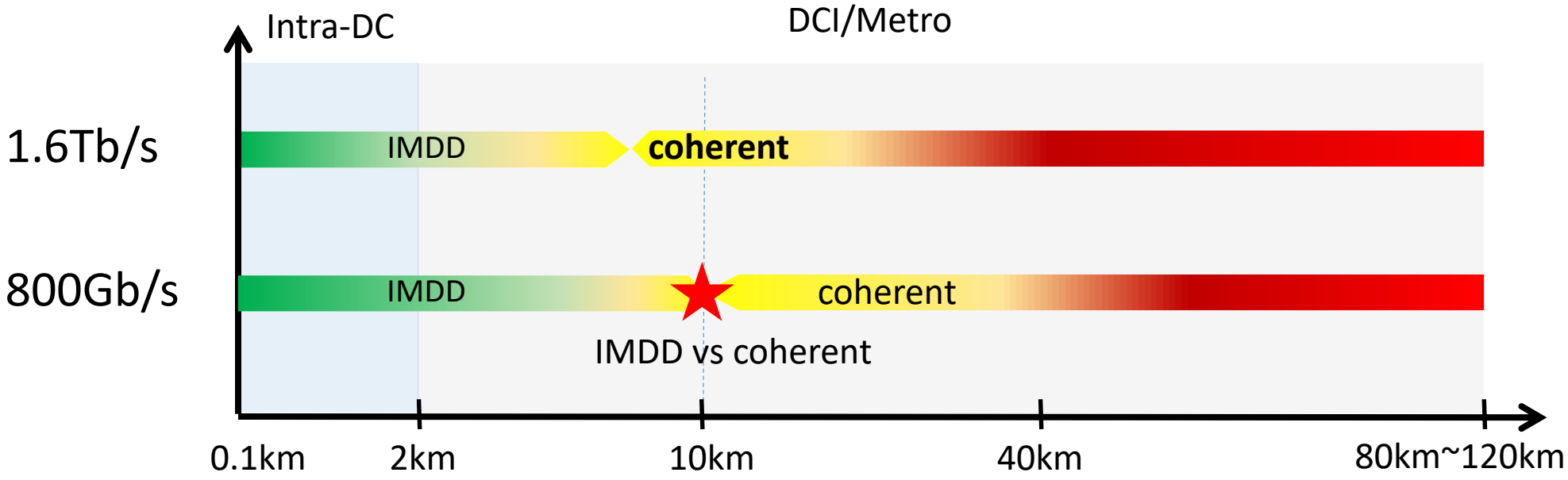
- OSNR@8.5E-3: 25.3dB (300KHz) 25.6dB(1MHz) 26.0dB(2MHz)
- OSNR@4.5E-3: 26.4dB (300KHz) 26.6dB(1MHz) 27.0dB(2MHz)

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



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 ≥ 4E-3, latency <300ns.
- 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