50G/λ & 100G/λ SMF PMD Alternatives Study

400 Gb/s Ethernet Task Force

802.3 Plenary Session

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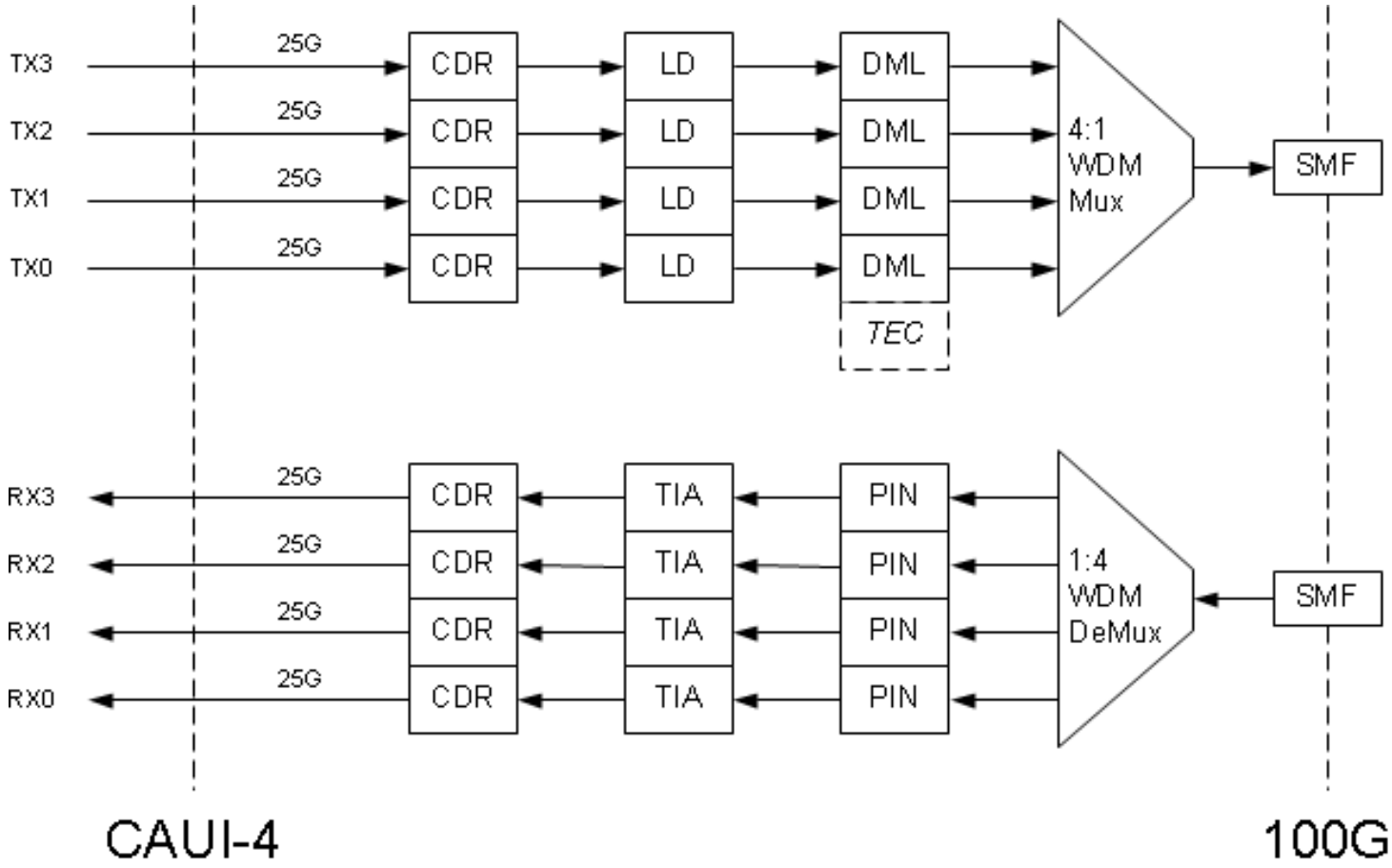
IEEE

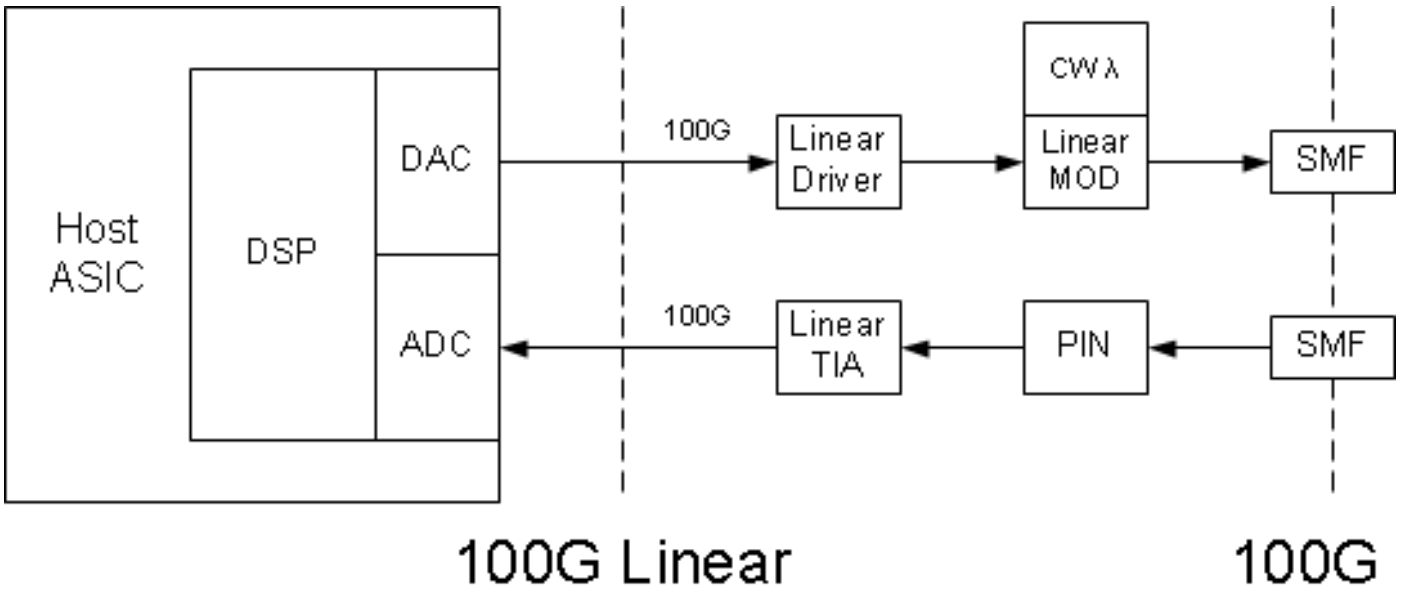
Finisar®

Today's 100G: 4x 25G λs NRZ



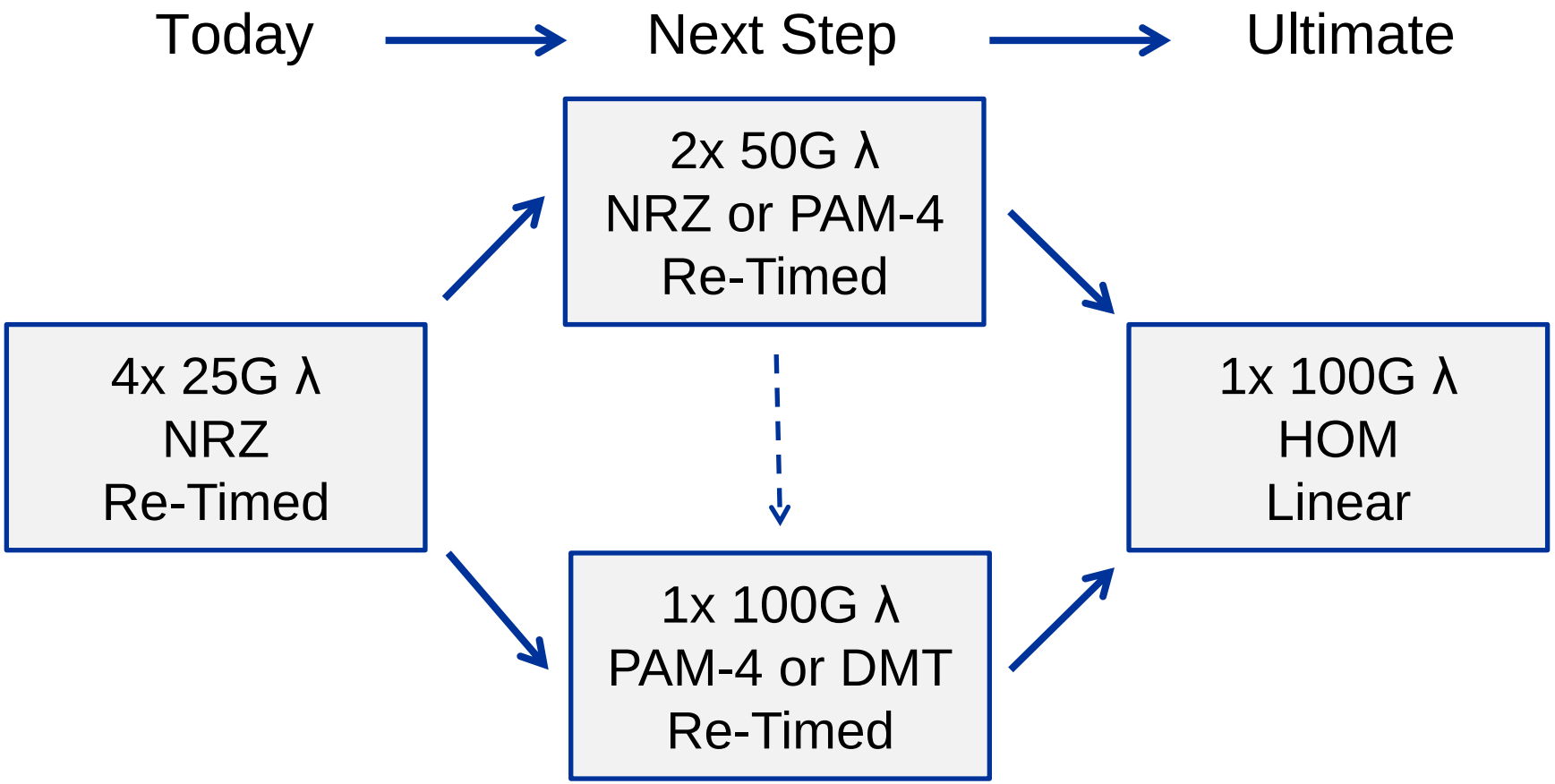
- Alternative to 4x DMLs is 4x Modulators & CW Lasers

Ultimate Cost/Power 100G: 1x 100G λ HOM



- SFP single 100G
- QSFP and CFP4 quad 100G
- Linear interface means PAM has no TX implementation advantage over other HOM formats like DMT or QAM
- ASIC 100G I/O technology available >2020

Next Step Alternatives to Ultimate 100G



How to pick the right next step?

"Let's learn from history, be honest with ourselves …"

([Gary Nicholl, Mark Nowell, 802.3bs, Norfolk, p.16, 5/13/14])

802.3 SMF PMD λ Rate Debates

Ethernet Rate	10G	40G	100G	400G
Task Force	802.3ae	802.3ba	802.3ba	802.3bs
SG/TF years	1999-2002	2006-2010	2006-2010	2013-
Existing optics	OC192	OC768	OC768	LR4
Existing λ rate	10G/λ	40G/λ	40G/λ	25G/λ
Existing I/O rate	2.5G (3G)	10G	10G	25G
Predicted next I/O (SerDes) rate	10G	25G	25G	50G
λ rate debate	**4x3G/λ v. 1x10G/λ**	**4x10G/λ v. 1x40G/λ**	**10x10G/λ v. 4x25G/λ**	**2x50G/λ v. 1x100G/λ**
Market Winner	1x10G/λ	4x10G/λ	4x25G/λ	???

802.3 SMF PMD λ Rate Debates Observations

- 802.3 λ rate debates were always between rates in existing client optics
- 802.3bs SMF PMD λ rate debate breaks this precedent by considering rate (100G/λ) not in existing client optics

- 802.3ae 10G and 802.3ba 100G PMD λ rate debates:
  - adopt existing vs. predicted next I/O (SerDes) rate
- 802.3bs MMF PMD λ rate debate is similar (25G vs. 50G)

- 802.3ba 40G PMD λ rate debate:
  - adopt existing vs. >8 years out I/O (SerDes) rate
  - single laser TX is cheapest
  - CMOS is free
- 802.3bs SMF PMD λ rate debate is similar

100G SMF PMD Power

- Gen 1 LR4 CFP discrete EML: 20W
- Gen 2 LR4 CFP2 DML or MZ: 6W
- Gen 3 LR4 CFP4 DML: 4W
- Gen 4 LR4 QSFP28 DML: 3.5W
- Gen 4 CWDM4 QSFP28 DML: 3W
- Next Gen CWDM2 (2x50G/λ) MZ or DML Target: 2W
  - Enables dual 100G QSFP and CFP4
- Today's 100G/λ Re-Timed proposals, even w/ advanced CMOS, at best match power of current LR4 or CWDM4
  - Need other proposals to be compelling (ex. linear I/O)
- Ultimate 100G/λ Compelling Target: 1W
  - Enables SFP 100G and CFP4 and QSFP quad 100G

50G/λ is the Right Next Step

- Same reason that crooks rob banks:
  - It's where the money is
  - Equivalently it's where the volume is
- Manageable optics technology risk
- Leverages next high-volume mainstream 40/50G I/O rate
- Optimally connects to 50G I/O
- Multiple other applications
  - 400G parallel MMF
  - 2x density increase duplex SMF and MMF 100G
  - 4x density increase duplex SMF and MMF 40/50G

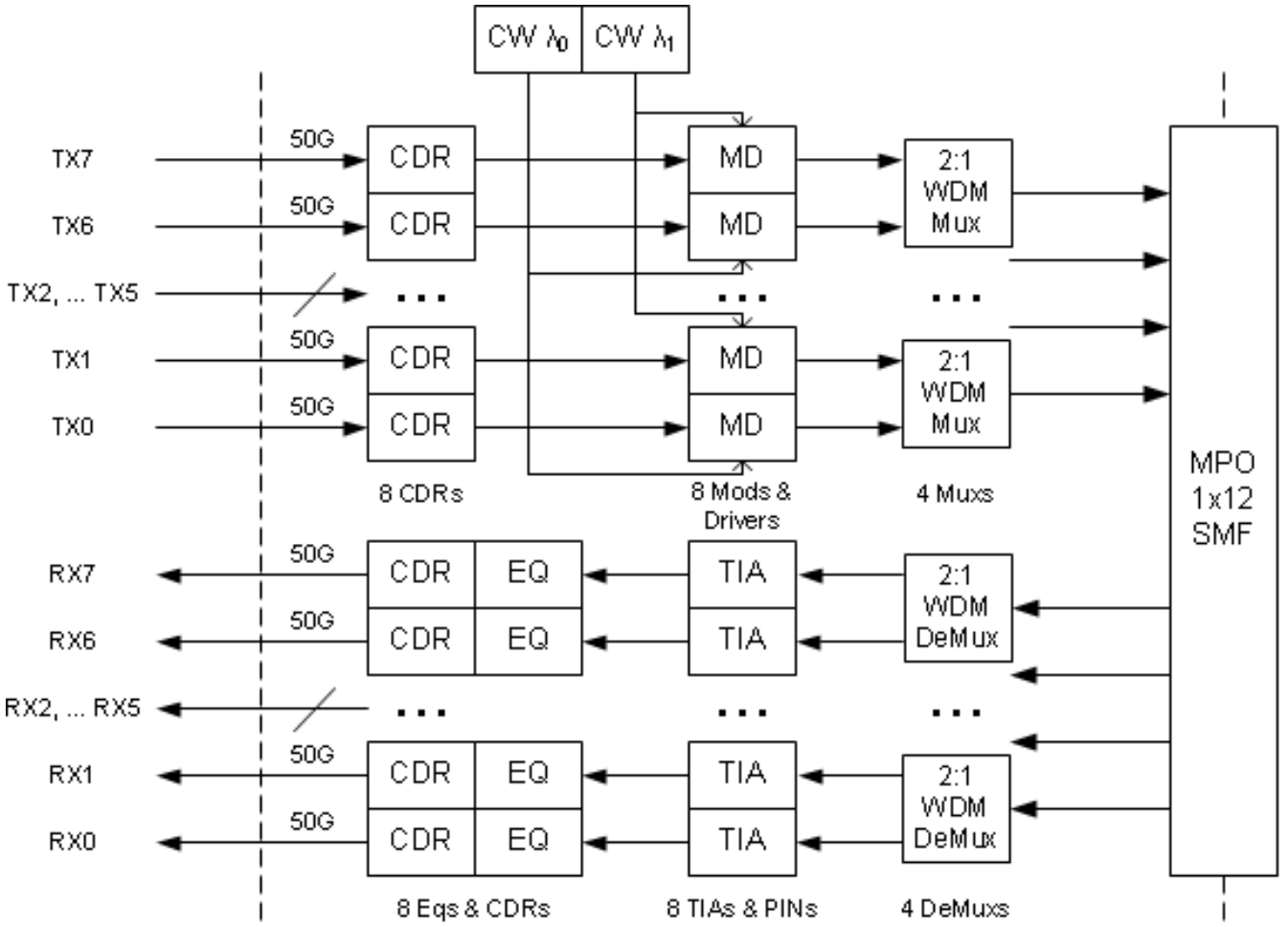
100G/λ is The Ultimate Solution

- Adoption in 802.3bs is premature
  - Bleeding-edge optics negate architecture advantage
  - No power advantage over today's approach (4x25G/λ)
  - Skips next high-volume mainstream I/O rate (50G)
  - Niche application and rate for many years (>2020)
- Specified in a future 802.3 project when:
  - There is experience with the optics
  - Compelling power is achievable (ex. 1W/100G)
  - 100G I/O architecture and volume have visibility
  - Multiple volume applications exist to drive down cost
- Requires long term technology development starting now for >2020 deployment

Appendix: 50G/λ Applications

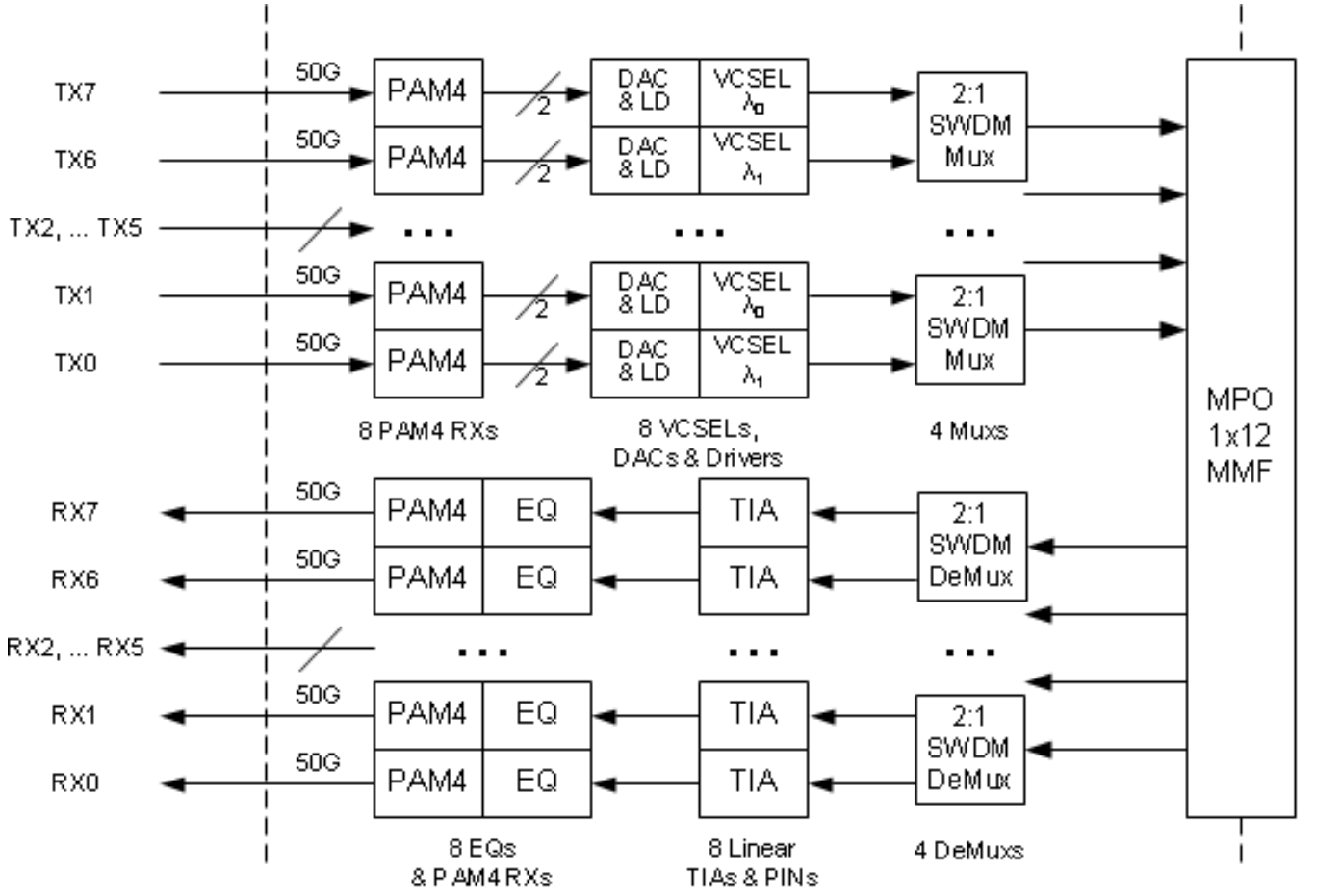
- 400G (4x2x50G λs)
  - duplex SMF
  - PSM4 and SR4 (parallel MMF)
  - CFP2 or other quad 100G (400G) module
- 100G (2x50G λs)
  - duplex SMF and MMF
  - QSFP and CFP4 dual 100G (200G) module
  - 2x port density increase
- 40G (40/50G λ) Ethernet & 64xFC
  - duplex SMF and MMF
  - QSFP and CFP4 quad 40/50G (160/200G) module
  - 4x port density increase
  - SFP 40/50G module

400G 2x50G λs SMF PMD Ex.: NRZ MZ



CDAUI-8 4x100GbE-FR2 & 400GbE-PSM4

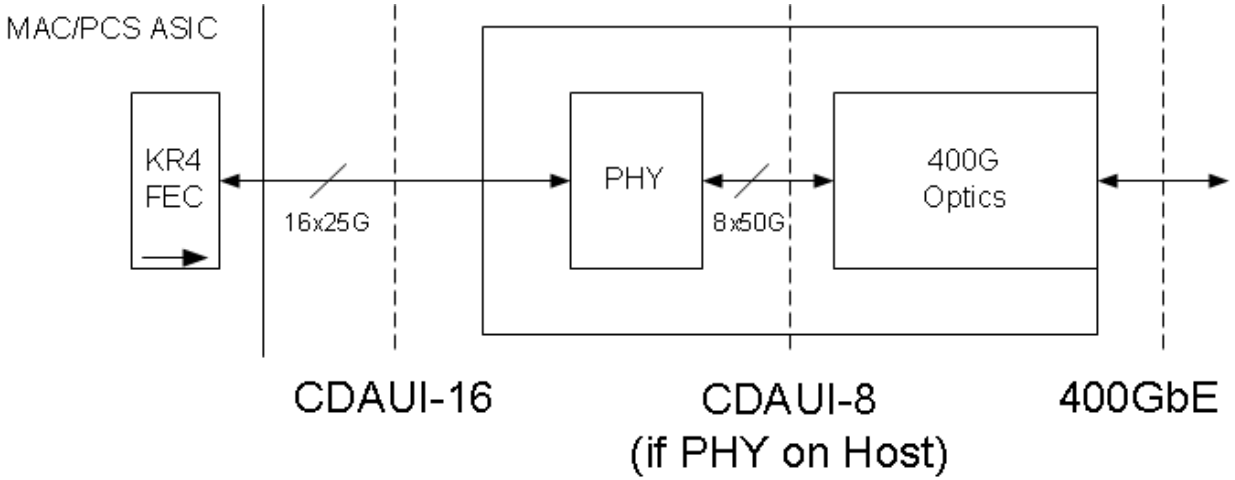
400G 2x50G λs MMF PMD Ex.: PAM4 VCSEL



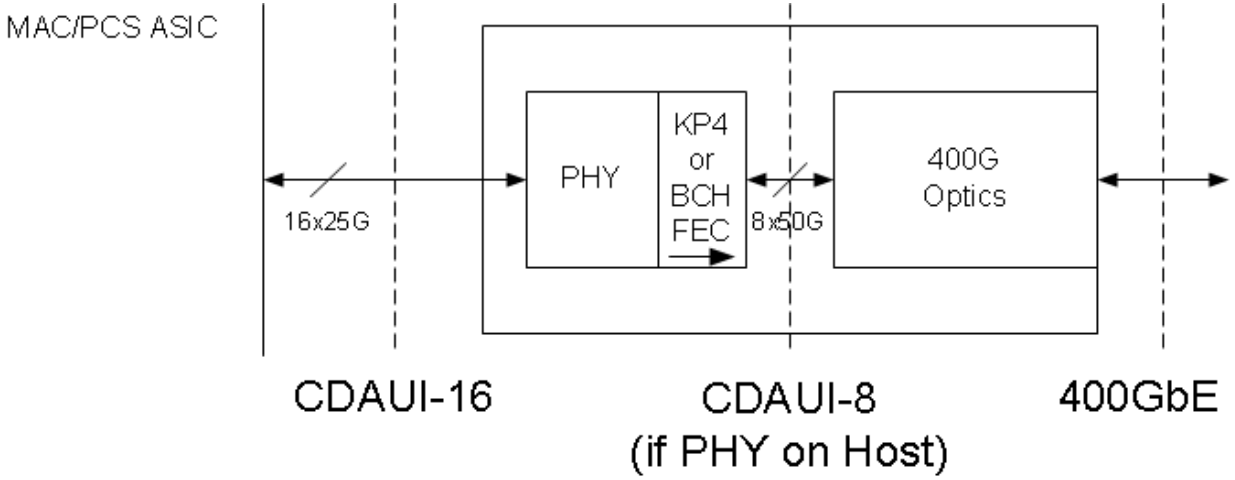
CDAUI-8 4x100GbE-SR2 & 400GbE-SR4.2

400G CDAUI-16 I/O ASIC Host Architecture

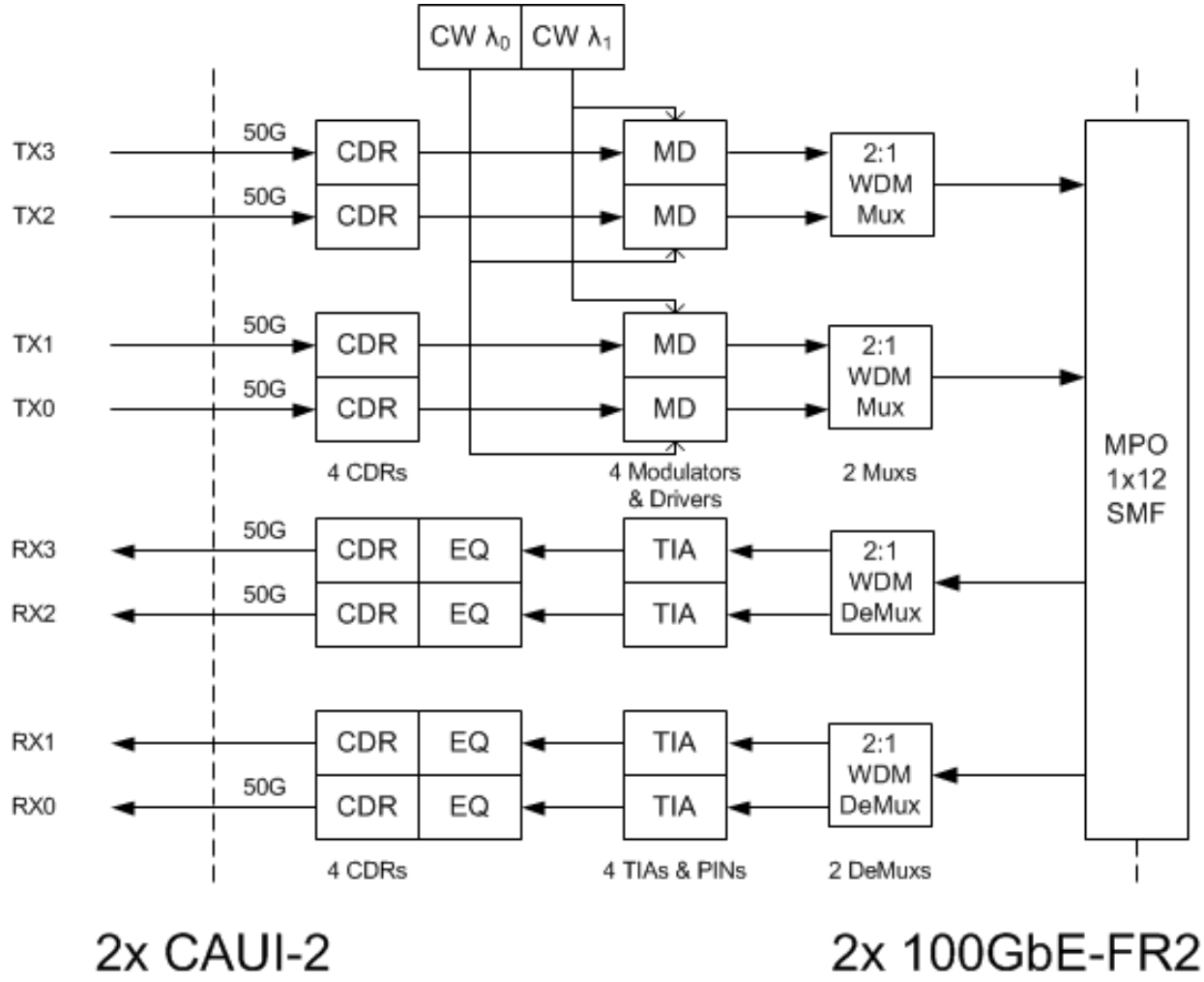
400G .bs PMD FEC: KR4



400G .bs PMD FEC: other than KR4

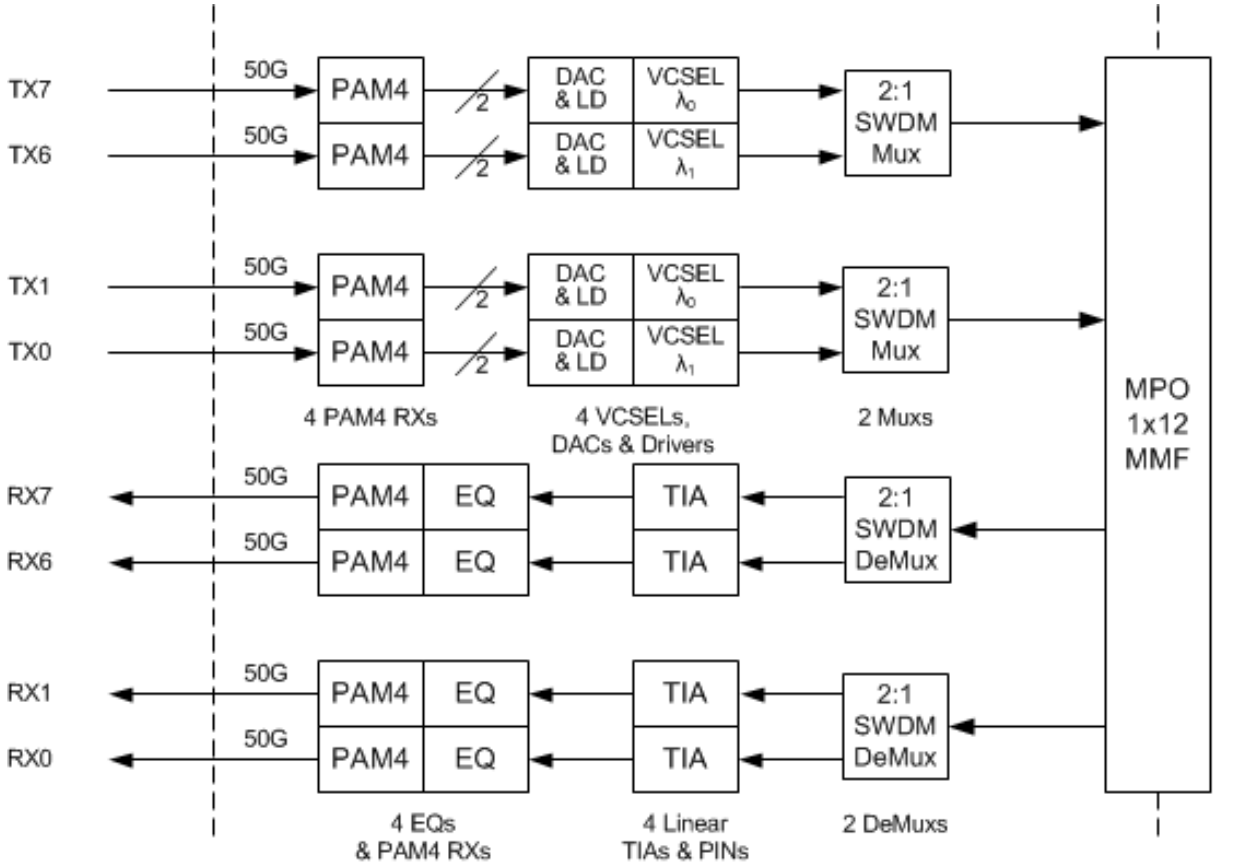


100G 2x50G λs SMF PMD Ex.: NRZ MZ



- QSFP & CFP4 dual 100G (160/200G) module

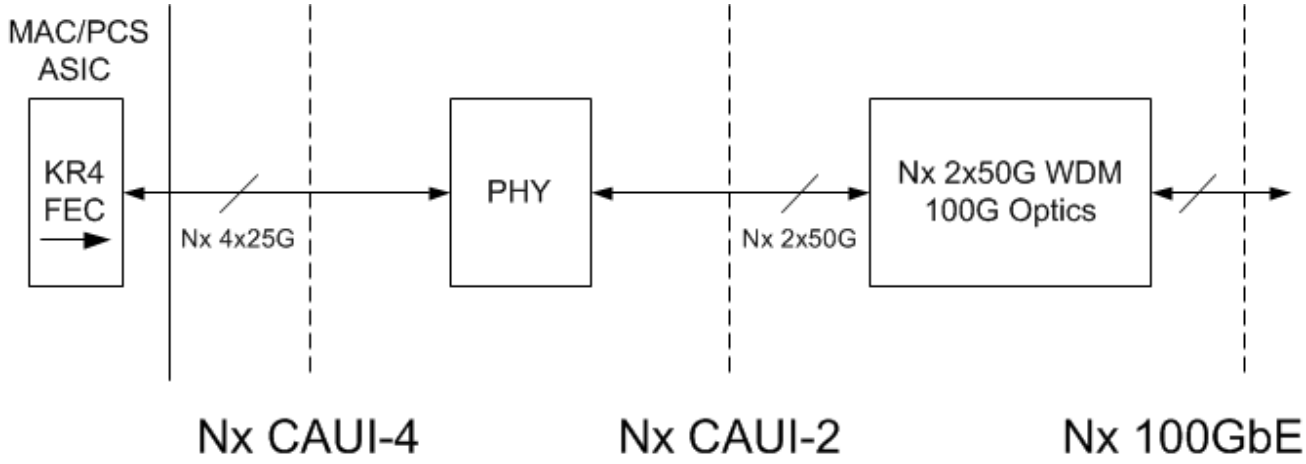
100G 2x50G λs MMF PMD Ex.: PAM-4 VCSEL



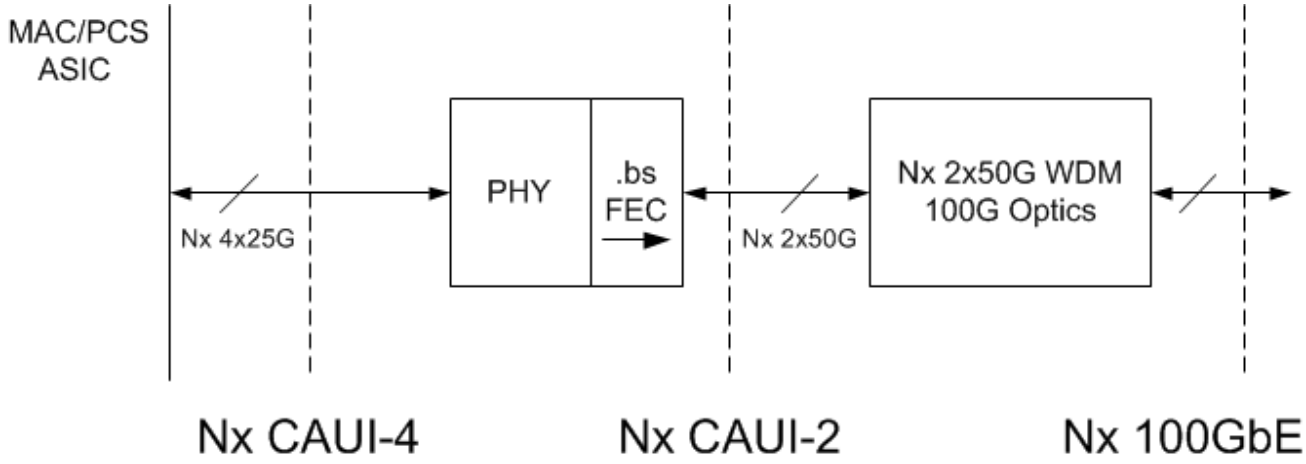
- QSFP & CFP4 dual 100G (160/200G) module

100G CAUI-4 I/O ASIC Host Architecture

400G .bs PMD FEC: KR4

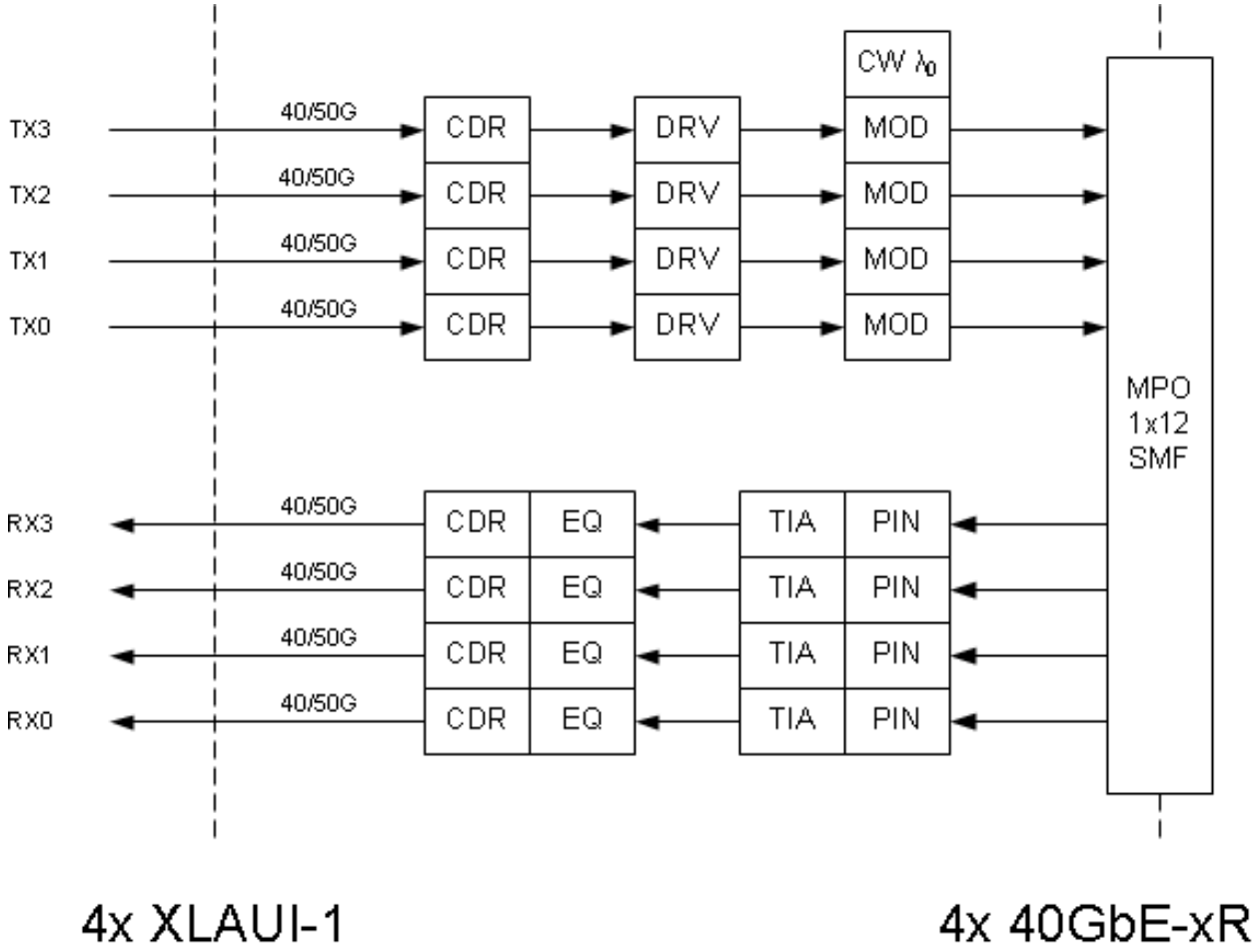


400G .bs PMD FEC: other than KR4



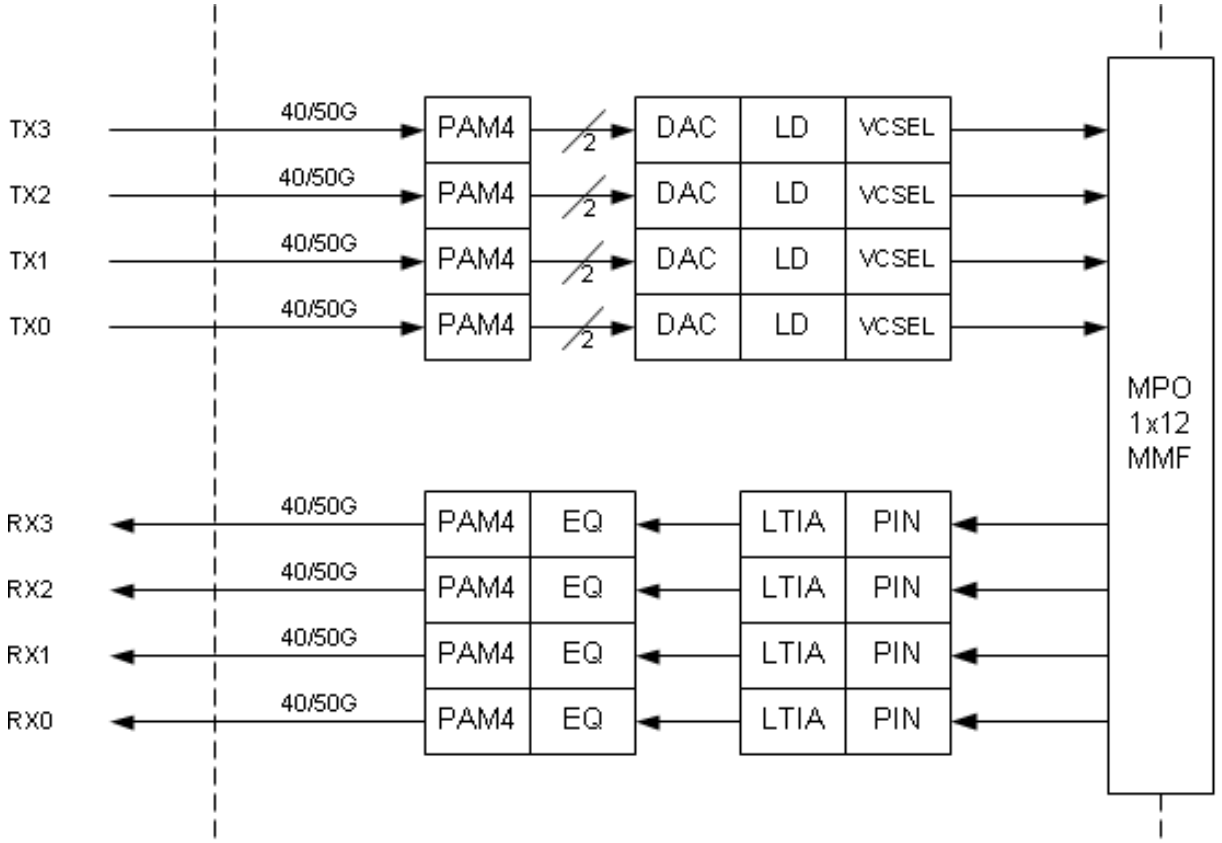
- CAUI-4 I/O module (ex. QSFP) requires internal PHY

40/50G Serial SMF PMD Ex: NRZ MZ



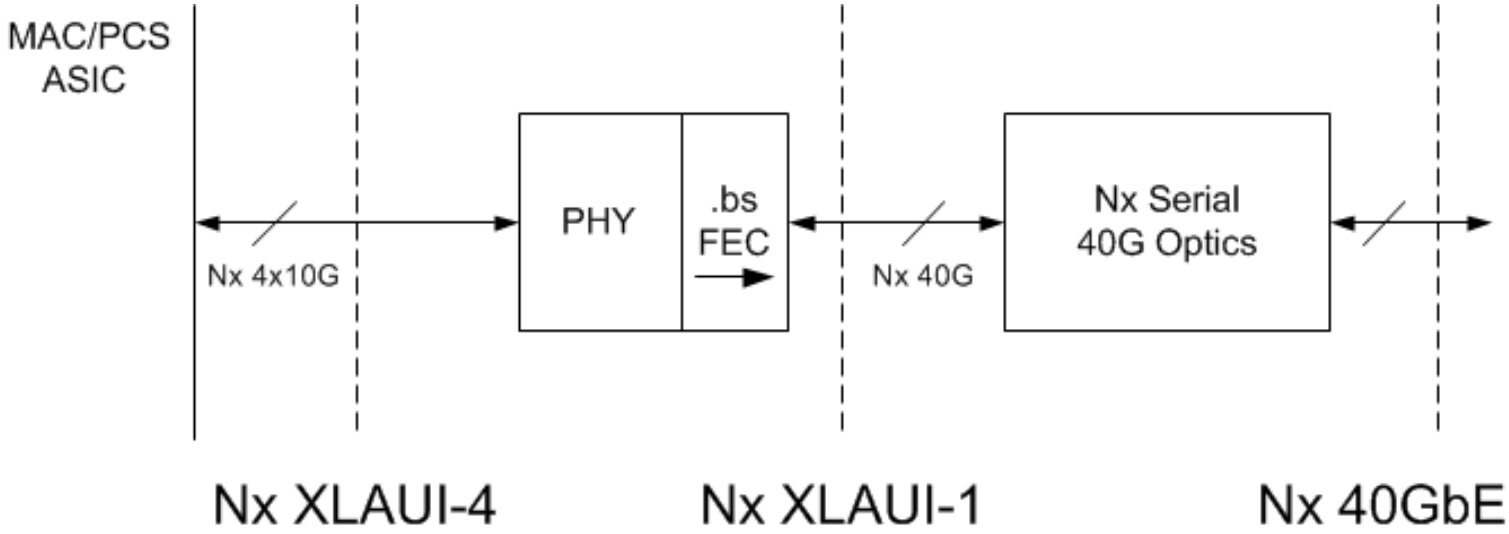
- QSFP quad 40/50G (160/200G) module
- SFP 40/50G (single channel) module

40/50G Serial MMF PMD Ex.: PAM-4 VCSEL



- QSFP quad 40/50G (160/200G) module
- SFP 40/50G (single channel) module

40G XLAUI-4 I/O ASIC Host Architecture



- 400G .bs PMD FEC may be KR4, KP4, BCH, or other
- XLAUI-4 I/O module (ex. QSFP) requires internal PHY

50G/λ vs.100G/λ SMF PMD Alternatives Study

Thank you