

Call For Interest Bidirectional 50Gb/s optical access PHYs

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Supporters

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- ▶ Hua Zhang, Hisense Broadband
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- ▶ Chan-Chih Chen, AOI
- ▶ Hai Ding, Innolight
- ▶ John Johnson, Broadcom
- ▶ David Lewis, Lumentum
- ▶ Kenneth Jackson, Sumitomo Electric Device Innovators, USA
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Outline

- ▶ Background
- ▶ Market Considerations for 50GE BiDi PMDs
- ▶ Technical Feasibility for 50GE BiDi PMDs
- ▶ Why now and Straw polls

Background activities

- ▶ IEEE 802.3 Bidirectional 10 Gb/s and 25 Gb/s Optical Access PHYs Study Group project started May 2018 meeting
 - ▶ Based on the network operator request the project was started
 - ▶ Network operators use bidirectional optics in their access networks and want to use standardized Bi-Di optics
- ▶ The study group currently considering to develop the following PHYs
 - ▶ 10 and 25 Gb/s PHY for operation over at least 10 km
 - ▶ 10 and 25 Gb/s PHY for operation over at least 20 km received more support
- ▶ With ever increasing BW in emerging 5G application, network operator can also benefit from ASIC and optics migration to 50G IO
 - ▶ There is sufficient technical feasibility to start 50 Gb/s Bi-Di project.

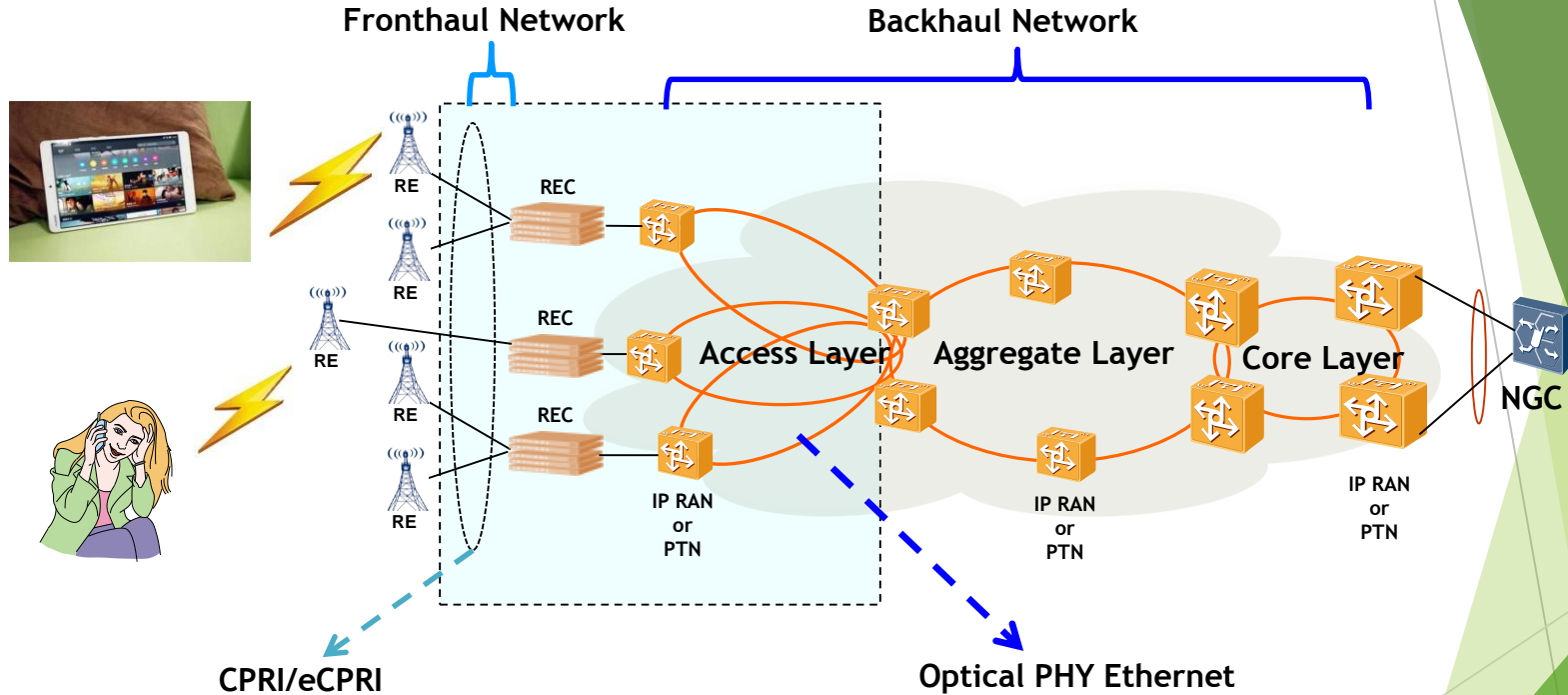
Background activities(Cont'd)

- ▶ Revisit the Call for Interest for “Bidirectional 10 Gb/s and 25 Gb/s Optical Access PHYs Study Group”

- In the past, the IEEE 802.3 Ethernet Working Group has standardized bidirectional optical PHYs running at 100Mb/s and 1Gb/s over one single mode fiber, that are intended for optical access applications. Due to the growth of bandwidth demand, there is now a need for similar systems that run at higher speeds, such as 10 Gb/s and 25 Gb/s, over distances of at least 20 km. This Call for Interest is to assess the support for the formation of a study group to explore the development of these bidirectional PHYs.

- ▶ This Bidirectional 50Gb/s optical access PHYs CFI will investigate emerging 5G mobile network applications requiring more BW, improved faceplate density, and in depth technical and economic feasibility of 50 Gb/s Bi-Di PHY.

Application of Mobile Fronthaul and Backhaul Network



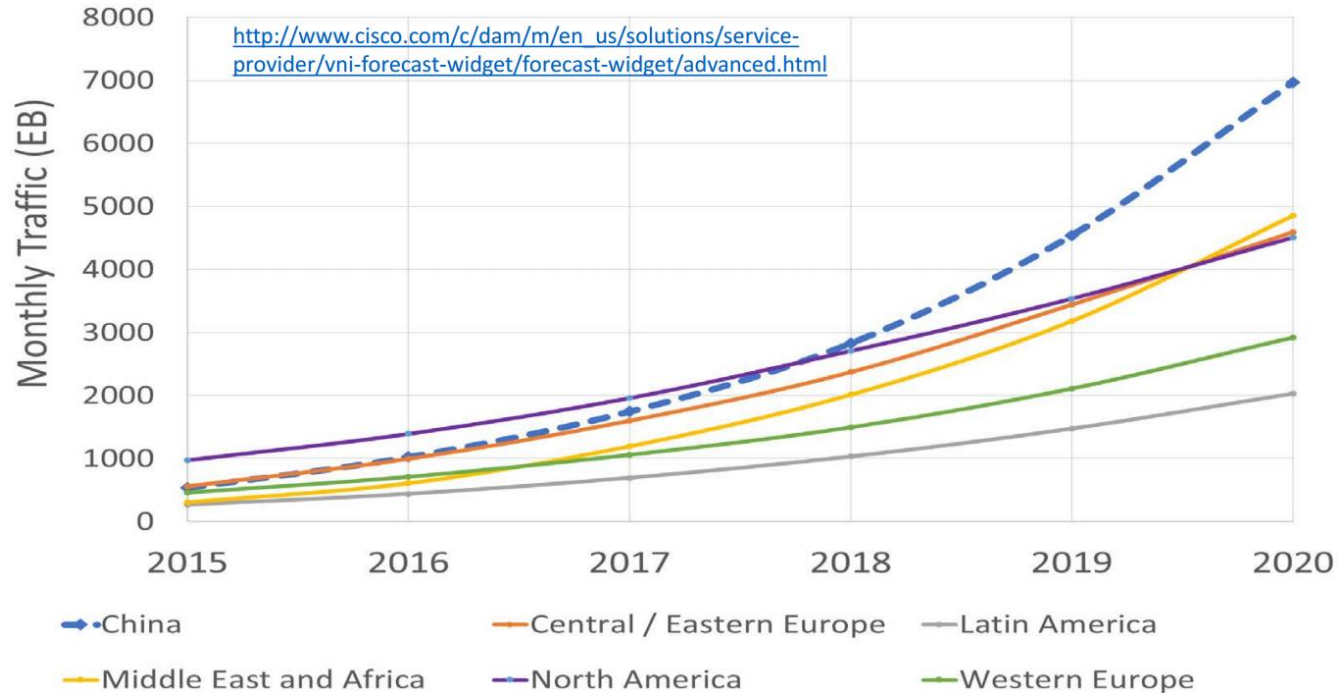
- Potential application for 50GE bidirectional Optical PHY in mobile fronthaul and backhaul for lack of fiber scenarios

FTTWireless (Fronthaul)

- ▶ CPRI and eCPRI look to be major applications of P2P PMDs
 - ▶ CPRI is very inefficient, easily justifying 10G or higher
 - ▶ eCPRI is thankfully more efficient, but 5G uses so much more, we still need 25G up to 100G links in the fronthaul
- ▶ Volume estimation
 - ▶ $3\text{B people} / (100 \text{ people} / \text{RU}) / 10 \text{ year rollout} = 3\text{M ports} / \text{year}$
- ▶ Per-port willingness to pay significantly higher than FTTH
 - ▶ Total revenue could surpass the existing market

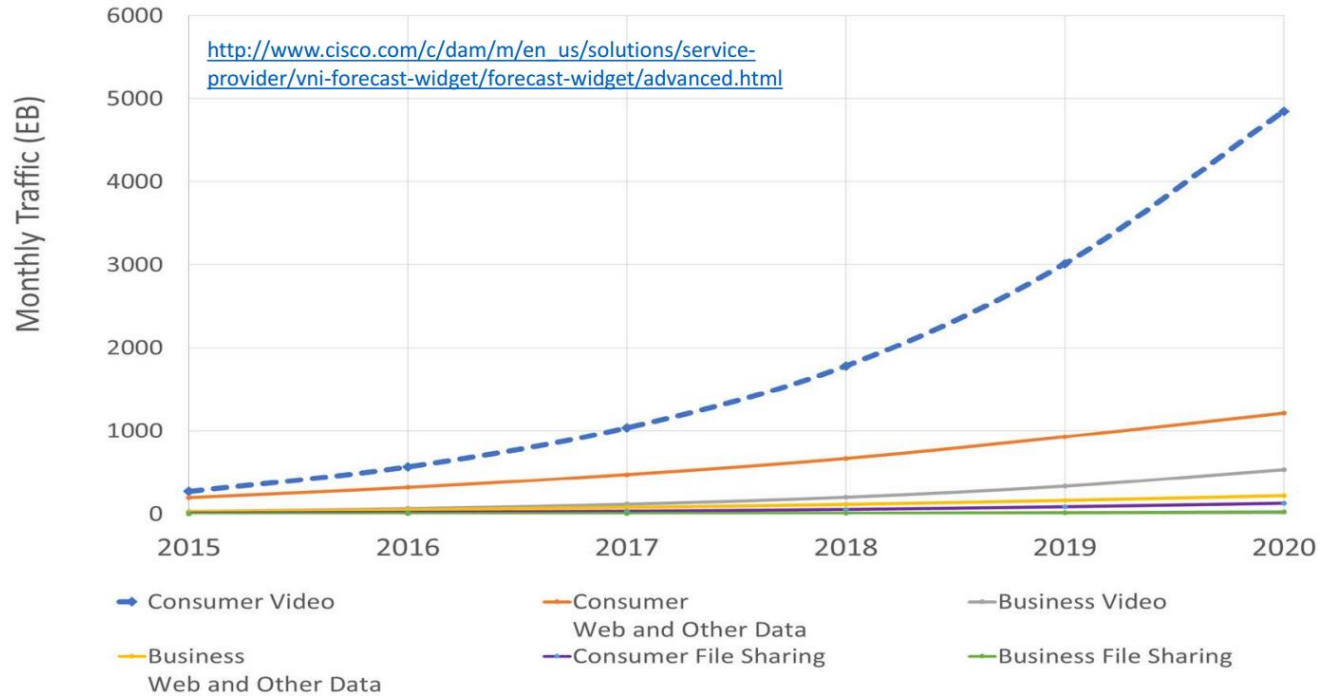
Refer to: [Call For Interest Bidirectional 10Gb/s and 25Gb/s optical access PHYs](#)

Mobile Networks Bandwidth Trends



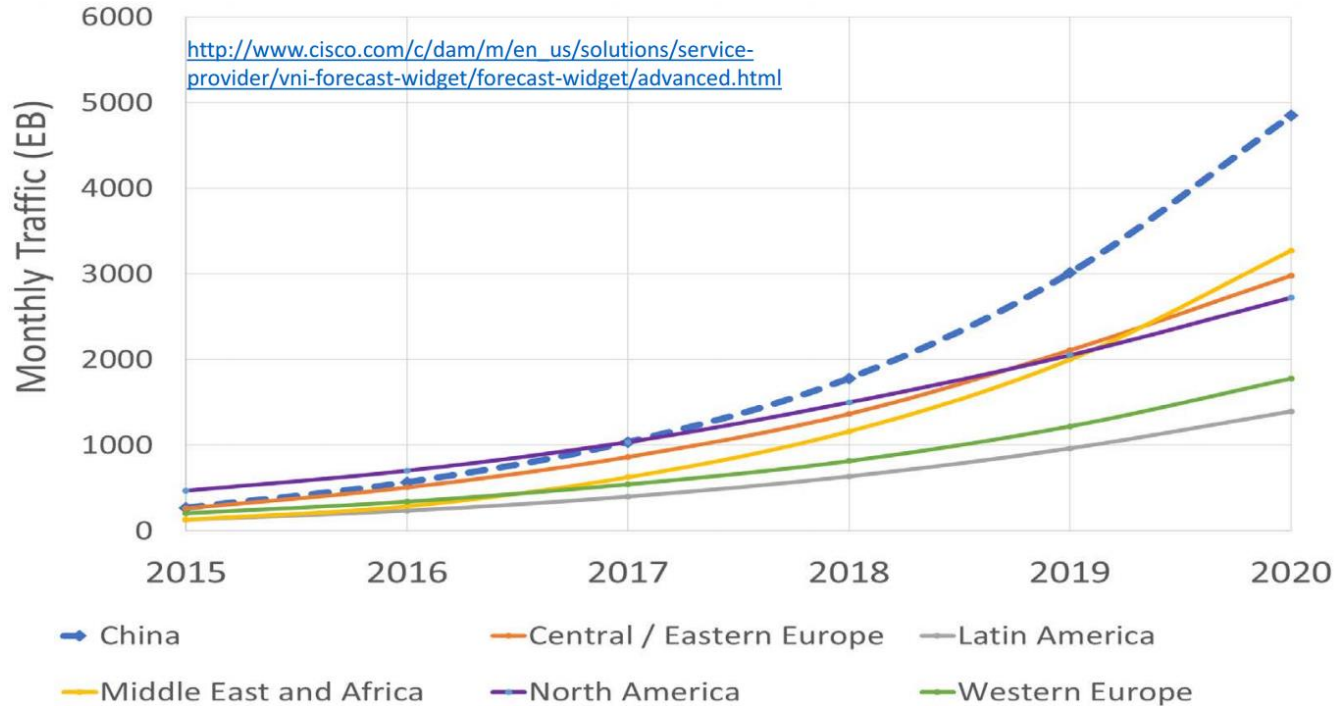
Refer to: [CFI Consensus-Beyond 10km Optical PHYs](#)

Mobile Networks - Application Bandwidth - China



Refer to: [CFI Consensus-Beyond 10km Optical PHYs](#)

Mobile Networks - Consumer Video



Refer to: [CFI Consensus-Beyond 10km Optical PHYs](#)

Higher Bandwidth Challenge of Mobile Fronthaul Network

- ▶ CPRI interface in fronthaul require higher bandwidth in optical link
- ▶ IEEE Communications Magazine(February 2016) “[An Overview of the CPRI Specification and Its Application to C-RAN-Based LTE Scenarios](#)”
 - ▶ CPRI Technical Working Group already has defined rate upto 24330.24Mbps
 - ▶ Moreover, the upcoming 5G RANs, where 100 MHz channels with massive MIMO are envisioned, may require several tens or even hundreds of gigabits per second capacity in the fronthaul .
- ▶ “[Industry leaders agree to develop new CPRI Specification for 5G](#)”
- ▶ The target of the eCPRI Specification is to offer several advantages to the base station design:
 - ▶ The new split point enables ten-fold reduction of the required bandwidth
 - ▶ Required bandwidth can scale flexibly according to the user plane traffic
 - ▶ Use of main stream transport technologies like Ethernet will be enabled

Transport network support of IMT-2020/5G

► In Table 7-1 Capacity requirements:

Fronthaul	Dependent on number of CPRI and eCPRI interfaces. See also Table 1 in 5.3.1. 10Gb/s-825Gb/s
Midhaul and Backhaul	Varies with number of interfaces. 25Gb/s-800Gb/s

► From Session 3: Mobile fronthaul, 5G mobile transport of Joint IEEE 802 and ITU-T Study Group 15 workshop “Building Tomorrow’s Networks” at Geneva, 27 January 2018

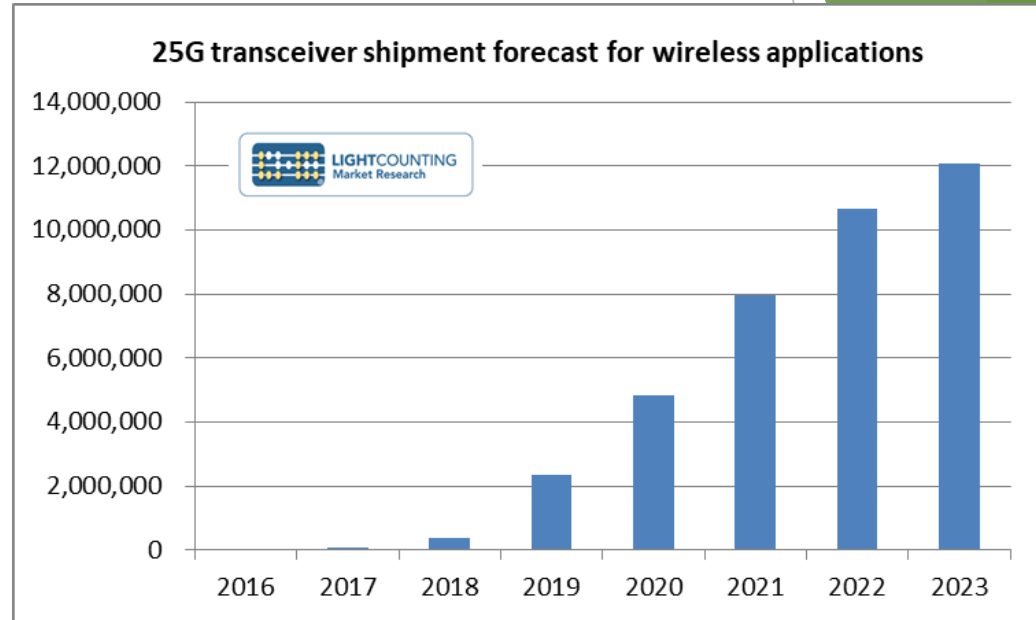
Requirement to drive requirements from the 3GPP interfaces (information flows (user, control, and synchronization), capacity, etc.)

- Interface capacity requirements – granularity e.g., 25G, 50G, 100G.

eCPRI & Wireless Fronthaul

- ▶ Assumption - Application driver is eCPRI
- ▶ Forecast includes simplex and bi-directional links
- ▶ Potential examples of today's need for 50G links -
 - ▶ Massive MIMO Deployments
 - ▶ High-density urban areas
 - ▶ 5G Fixed Wireless Pipes

Source: John Lively, LightCounting



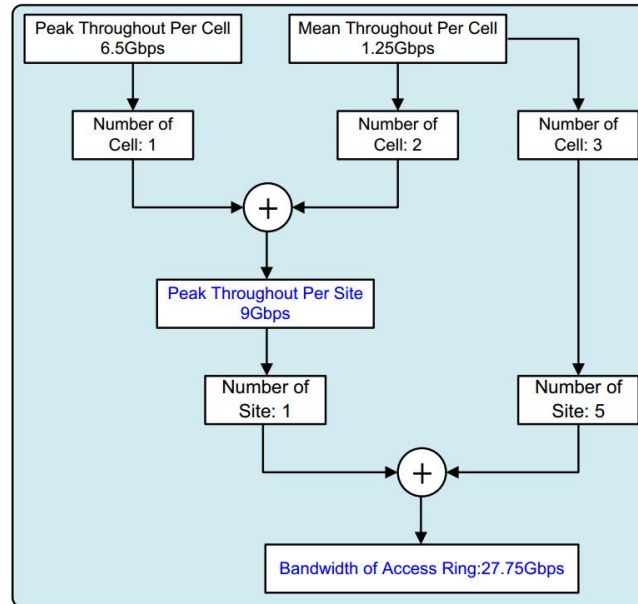
- ▶ eCPRI is thankfully more efficient, but 5G uses so much more, we still need 25G up to higher rate links in the fronthaul

Require 50GE in Access Layer of Mobile Backhaul Network

- ▶ The following information support a 50GE at access ring with same physical link when 4G upgrade to 4G+/5G 1st stage from 10GE.

Bandwidth in Access Ring of 5G Mobile Backhaul Network

- For Ring topology in Backhaul network:
 - Multiple sites will share one physical/logic link
 - Per statistics multiplexing mechanism, bandwidth forecast depend on air interface, subscribers behavior
- Typical example for access ring bandwidth:
 - 6 sites per Ring
 - 3 LTE/5G Cells per Site
 - LTE: 5X20MHz carrier
 - 5G :100MHz carrier



- In carrier network, 50GE is required in this case as service guarantee requirement

Benefit of Bidirectional 50GE Optical PHY in Mobile Application

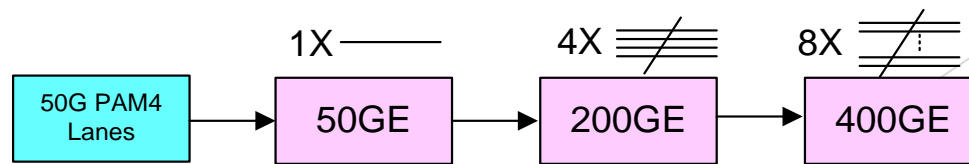
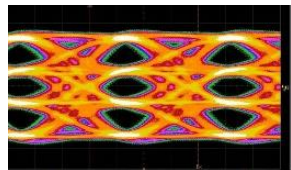
- ▶ As lack of fiber and expected bandwidth for mobile application, bidirectional optical PHY of 50GE can provide upgrade solution from most popular NX10GE, furthermore potential to reach 100GE with two 50GE bidirectional 10/40km optical link bonding.
- ▶ Key benefit of Bi-Di is to provide PTP 1588 time synchronous operation in support of mobile applications
 - ▶ Providing time synchronization is mandatory in LTE-TDD/Advanced and 5G
 - ▶ Bi-Di links do not have the two-fiber link asymmetry
 - ▶ Identical delay through Bi-Di links improves PTP 1588 time synchronization.

Requirement

- **Sync accuracy requirement in TD-SCDMA/TD-LTE**
 - Base stations need frequency sync: $\pm 0.05\text{ppm}$, and phase sync: $\pm 3\mu\text{s}$
 - Time sync between NodeB/eNB and Reference clock: $\pm 1.5\mu\text{s}$
 - Considering RNC and NodeB will introduce time offset, backhaul network (PTN for China Mobile) need more precise time synchronization: **$\pm 1\mu\text{s}$**
 - **Requirement for link delay asymmetry**
 - The transport delay of optical fiber is $5\mu\text{s}$ per 1km, so 100 meters length difference will introduce 250ns error
 - In our backhaul network, Some of physical lines had serious asymmetry, **whose error was even up to 6us**
- China Mobile has large backhaul network, compensation for asymmetry of physical line is really a mandatory requirement
- This problem is really slowing down the large scale deployment of 1588

Technical Feasibility for 50GE 2/10km Optical PHY from IEEE 802.3bs

- ▶ IEEE Std 802.3bs™-2017 has already defined 50 Gb/s PAM4 signaling for optical PMDs and C2M/C2C applications by defining the following PMDs
 - ▶ Following optical PMDs: 200GBASE-FR4, 200GBASE-LR4, 400GBASE-FR8, and 400GBASE-LR8
 - ▶ Following C2M/C2C AUIs: 200GAUI-4 and 400GAUI-8 specifications supporting 200GbE and 400GbE operation over 2 km and 10 km of single-mode fiber.
- ▶ The same PAM4 technology is being leveraged by IEEE P802.3cd project for the development of optical specifications for 50GbE operation over 2 km and 10 km of single-mode fiber.



Transmit and Receive Characteristics of 50GE 10km in D3.3 of 802.3cd

Table 139–6—50GBASE-FR and 50GBASE-LR transmit characteristics

Description	50GBASE-FR	50GBASE-LR	Unit
Signaling rate (range)	26.5625 ± 100 ppm		GBd
Modulation format	PAM4		—
Wavelengths (range)	1304.5 to 1317.5		nm
Side-mode suppression ratio (SMSR), (min)	30		dB
Average launch power (max)	3	4.2	dBm
Average launch power ^a (min)	-4.1	-4.5	dBm
Outer Optical Modulation Amplitude (OMA _{outer}) (max)	2.8	4	dBm
Outer Optical Modulation Amplitude (OMA _{outer}) (min) ^b	-2.5	-1.5	dBm
Launch power in OMA _{outer} minus TDECQ (min)	-3.9	-2.9	dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	2.8	3	dB
Average launch power of OFF transmitter (max)	-16		dBm
Extinction ratio (min)	3.5		dB
Transmitter transition time (max)	34		ps
RIN _{17,1} OMA (max)	-132	—	dB/Hz
RIN _{15,6} OMA (max)	—	-132	dB/Hz
Optical return loss tolerance (max)	17.1	15.6	dB
Transmitter reflectance ^c (max)	-26		dB

Table 139–7—50GBASE-FR and 50GBASE-LR receive characteristics

Description	50GBASE-FR	50GBASE-LR	Unit
Signaling rate (range)	26.5625 ± 100 ppm		GBd
Modulation format	PAM4		—
Wavelengths (range)	1304.5 to 1317.5		nm
Damage threshold ^d	5.2	5.2	dBm
Average receive power (max)	3	4.2	dBm
Average receive power ^b (min)	-8.1	-10.8	dBm
Receive power (OMA _{outer}) (max)	2.8	4	dBm
Receiver reflectance (max)	-26		dB
Receiver sensitivity (OMA _{outer}) ^e (max)	Equation (139–1)	Equation (139–2)	dBm
Stressed receiver sensitivity (OMA _{outer}) ^d (max)	-5.5	-6.8	dBm
Conditions of stressed receiver sensitivity test: ^e			
Stressed eye closure for PAM4 (SECQ)	2.8	3	dB

Technical Feasibility of 50GE 40km from Beyond 10km Optical PHY Study Group

- ▶ Based on “[50GbE 40km Objective 5C Study Group Discussion](#)” by David Lewis, the 50GE 40km duplex Objective has been adopted at IEEE 802.3 Jun meeting:

The proposed project will build on the array of Ethernet component and system design experience, and the broad knowledge base of Ethernet network operation.

- The experience gained in the development and deployment of 25 Gb/s and 100 Gb/s solutions targeting 40 km is applicable to the development of specifications for components at 50 Gb/s targeting 40 km.
 - Component vendors have presented data on the feasibility of the necessary components for 50 Gb/s solutions targeting 40 km.
- ▶ Test data of high power EML and APD in B10K study group show feasibility for 40km reach at 50Gbps PAM4 modulation

Possible 50G Bi-Di Wavelength Grid for Short Fiber Reach

- ▶ Leverage 200GBase-FR4 CWDM optics for Bi-Di PMD
 - ▶ Use two of the CWDM wavelengths for Bi-Di operation “1271,1291,1311,1331 nm”
- ▶ Further refer to 50GBase-LR style optics
 - ▶ 50GBase-LR works at 1304.5-1317.5nm
- ▶ Wider spaced 1270nm/1330nm offer better technical and economic feasibility in support of short fiber reach scenario, such as 10km

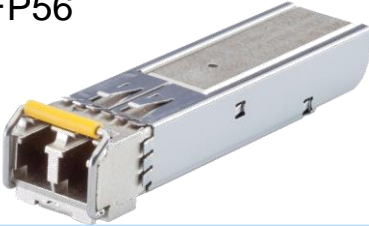
Possible 50G Bi-Di Wavelength Grid for Extend Fiber Reach

- ▶ Leverage 200GBase-LR4 LAN-WDM optics for Bi-Di PMD
 - ▶ Possibly use two of LAN-WDM wavelengths 1295.56, 1300.05, 1309.14 nm
- ▶ LAN-WDM grid 1295nm/1310nm with lower dispersion is preferred for extend fiber reach applications, such as 40km

Potential Form Factors for 50GE BiDi PMDs

- ▶ Mature state-of-the art SFP & QSFP serial module in Industry will double the faceplate density or rate

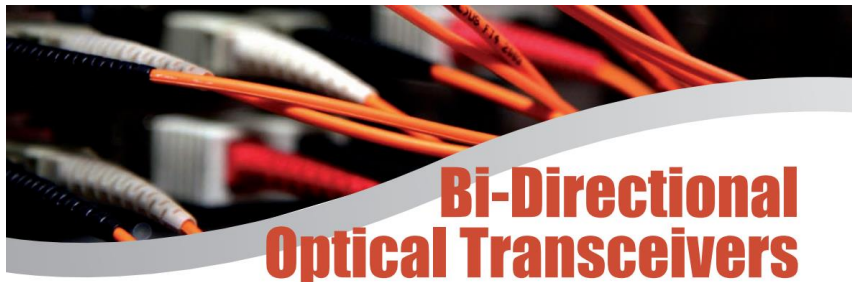
SFP56



QSFP28/56



Possible Bidi PMDs Application in Internet Exchange



LINX is offering a new fibre service to members which utilises the benefits of Bi-Directional Optical Transceivers.

What is a Bi-Directional Optical Transceiver and How does it work

When connecting to the London Internet Exchange most members will connect using a fibre pair or cross connect. One fibre is dedicated to receiving data from network equipment and the other fibre will be dedicated to transmitting data to the network. Bi-directional optical transceivers (or Bi-Di transceivers for short) allow both the transmitting and receiving of data on a single fibre.

This is achieved by splitting the light into different wavelengths using wave division multiplexors (WDM). Bi-Di transceivers must work as a matched pair having the correct receive and transmit wavelength.

Usual naming convention has one device referred to as upstream and one as downstream. For delivery of the LINX Bi-Di product LINX will always be the downstream device. The member will have to purchase the corresponding downstream device. The wavelengths of its Bi-Di transceivers are as shown in the table on the right.

Benefits of Bi-Directional Optics

- Reduced interconnect costs
- Double the capacity of each cross connect
- Optical Distribution Frame (ODF) port reduction
- Conduit space saving
- Ports charged at the same rate as traditional optics

Port Size	Member Side "Upstream"		LINX Side "Downstream"	
	Transmit (nm)	Receive (nm)	Transmit (nm)	Receive (nm)
1GE	1310	1490	1490	1310
10GE	1270	1330	1330	1270

Refer to: <https://www.linx.net/wp-content/uploads/2017/08/bi-directional-optics-datasheet.pdf>

Conclusions

- ▶ Bi-directional 50Gb/s optical access PHYs leveraging 802.3bs/802.3cd technology can address near-term need of 5G Mobile networks bandwidth
 - ▶ Technically feasible
 - ▶ Leveraging existing IEEE 802.3bs/cd PHYs and investment
 - ▶ Reasonable market opportunity
- ▶ Why do this work in 802.3 now?
 - ▶ This is the rightful home of this technology
 - ▶ 50G Bi-Di will address near-term 5G BW demand
 - ▶ 50GE Bi-Di optical PHY can share same standard resource with current on going project.

Straw Poll #1

► Should a study group be formed to consider bidirectional 50Gb/s PHYs?

► All in the room: Yes No Abs

► 802.3 Voters: Yes No Abs

Straw Poll #2

- ▶ I would participate in the bidirectional study group, if formed?
 - ▶ Yes
 - ▶ No
 - ▶ Don't know

Straw Poll #3

- ▶ I would support expanding the scope of the existing Bidirectional 10 Gb/s and 25 Gb/s Optical Access PHYs Study Group to include this 50Gb/s PHY
 - ▶ Yes
 - ▶ No
 - ▶ Don't know

Future Work

- ▶ Look for indication from current Bi-directional 10 Gb/s and 25 Gb/s Optical Access PHYs Study Group that if this CFI is successful, that there is interest in expanding the scope to include this work
- ▶ Ask 802.3 Working Group on Thursday to form a Bi-directional 50 Gb/s Optical Access PHYs Study Group
- ▶ Let 802.3 Working Group determine if 50 Gb/s Bi-Di PHY should be combined with existing study group or form a separate study group
 - ▶ Assuming approved, on Friday by 802 EC.

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Thank you

Questions? Comments?