Draft:
Call For Interest Consensus Presentation Bidirectional 50Gb/s Optical Access PHYs

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Supporters

- ?

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 has started from May 2018 meeting
  - The origin of this work comes from network operators, who use bidirectional optics in their access networks, and want to standardize higher speeds
  - The following document, May 2018 Agreed Bidi Objectives, is agreed during 1st Study Group Meeting

IEEE P802.3cp objectives

- Support full-duplex operation only
- Support bidirectional transmission over a single strand of single mode fiber
- Preserve the Ethernet frame format utilizing the Ethernet MAC
- Support optional Energy-Efficient Ethernet operation
- Support a MAC data rate of 10 Gb/s, 25 Gb/s, and 50 Gb/s
- Support a BER of better than or equal to 10^{-12} at the MAC/PLS service interface (or the frame loss ratio equivalent)
- Support silent start* operation to prevent bidirectional PHYs interfering with P2MP networks

- Define single lane 10 Gb/s PHYs for operation over at least 10 km and at least 20 km
- Define single lane 25 Gb/s PHYs for operation over at least 10 km and at least 20 km
- Define single lane 50 Gb/s PHYs for operation over at least 10 km

* Silent start means that the upstream-facing PHY does not transmit unless a valid downstream signal is received. This prevents the bidirectional PHY from jamming transmission on the P2MP network in cases of unintentional connection

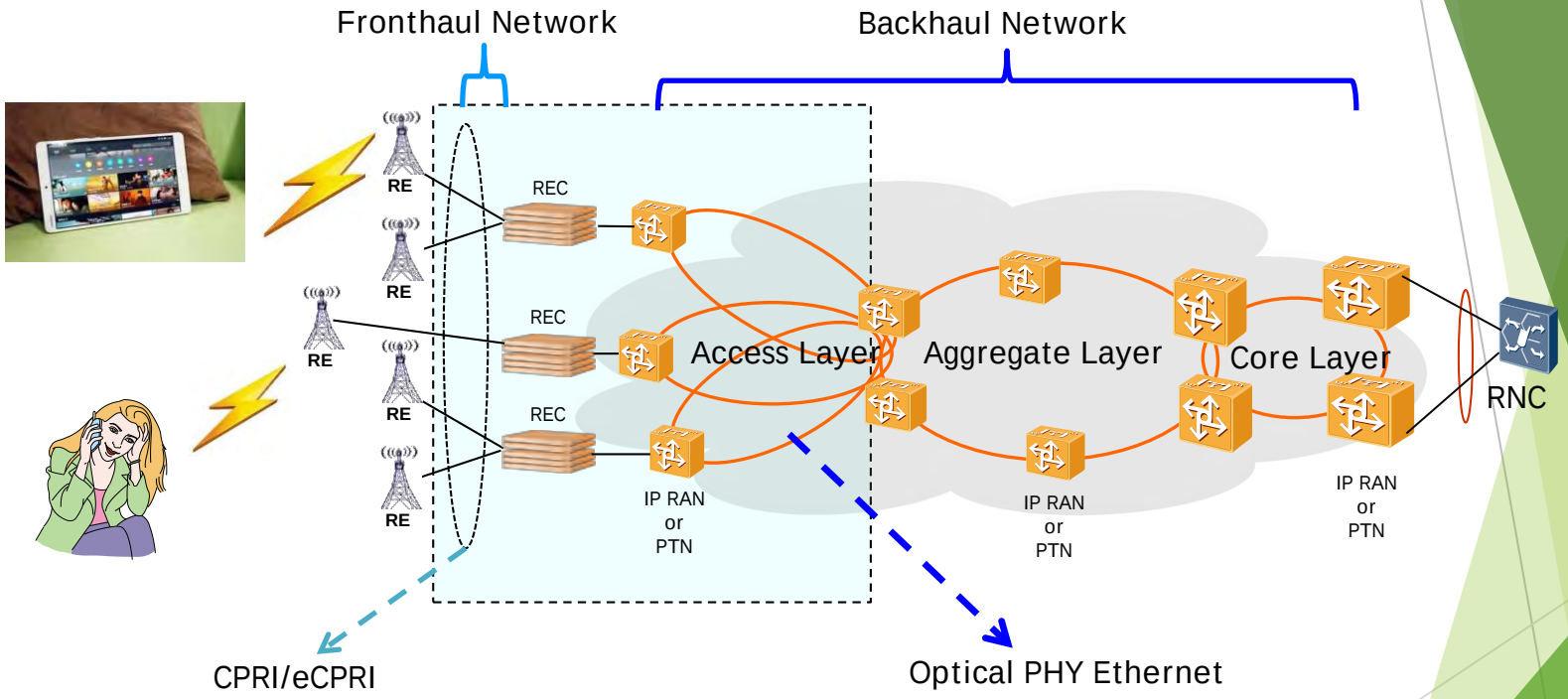
Background activities(Cont'd)

- 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 further investigate the applications, market drive and technical feasibility for beyond the previous 10/25Gb/s BiDi CFI.

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)

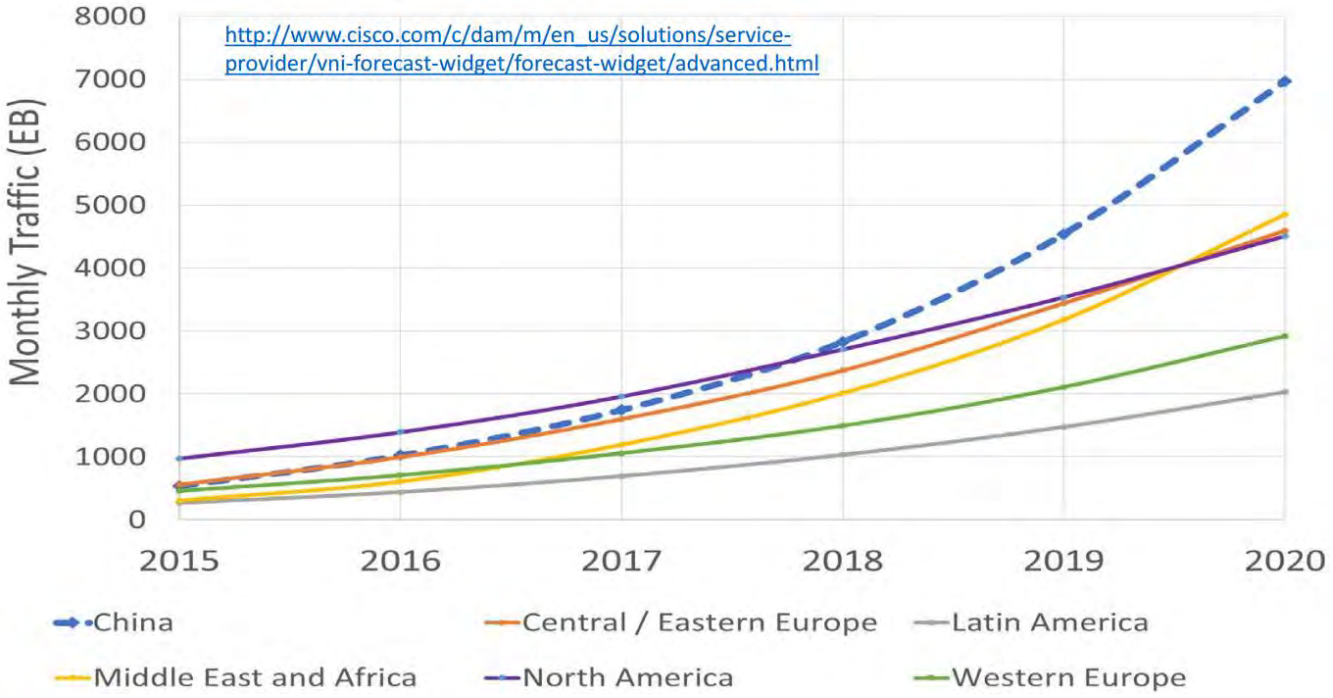
- CPRI and eCPRI look to be major applications of P2P PMDs
  - CPRI is very inefficient, easily justifying 10G or higher
  - eCPRI is thankfully more efficient, but 5G uses so much more, we still need 25G up to 100G links in the fronthaul
- Volume estimation
  - 3B people / (100 people / RU) / 10 year rollout = 3M ports / 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

Higher Bandwidth Challenge of Mobile Fronthaul Network

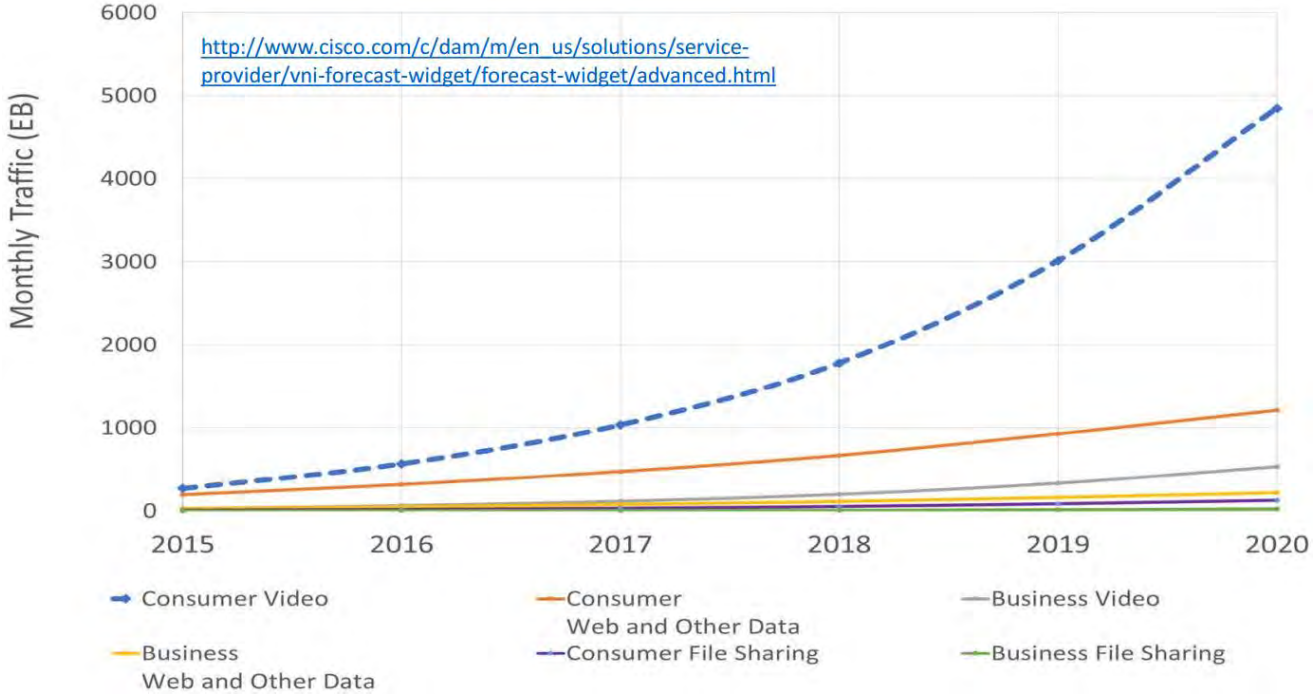
- CPRI interface in fronthaul require higher bandwidth in optical link
- IEEE Communications Magazine(February 2016) "An Overview of the CPRI Specification and Its Application to C-RAN-Based LTE Scenarios"
  - CPRI CPRI Technical Working Group already define upto 24330.24Mbps
  - Moreover, the upcoming 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

Mobile Networks Bandwidth Trends



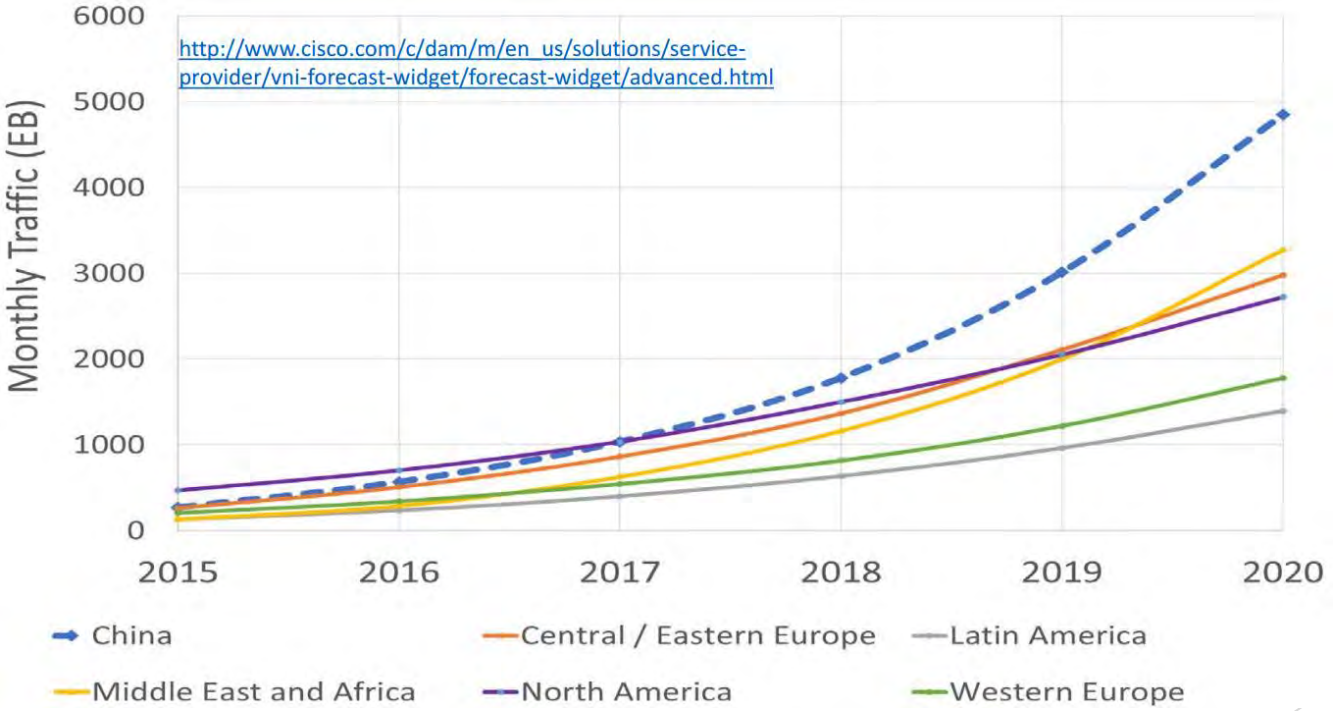
Refer to: CFI Consensus-Beyond 10km Optical PHYs

Mobile Networks - Application Bandwidth - China



Refer to: CFI Consensus-Beyond 10km Optical PHYs

Mobile Networks - Consumer Video



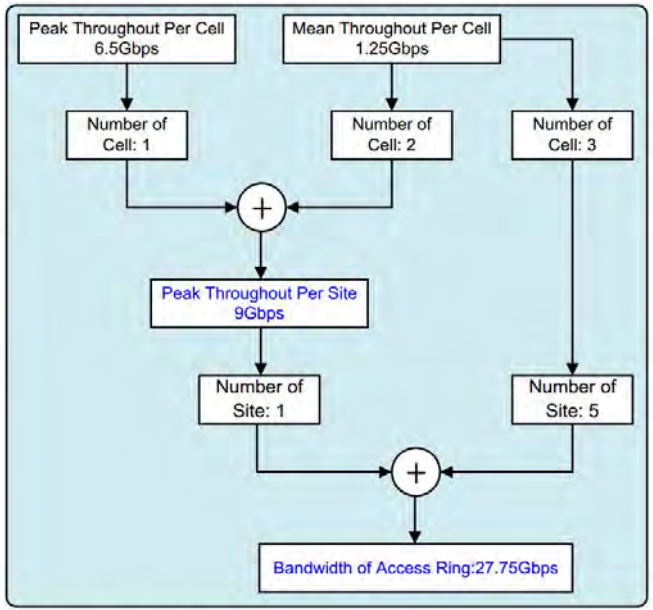
Refer to: CFI Consensus-Beyond 10km Optical PHYs

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

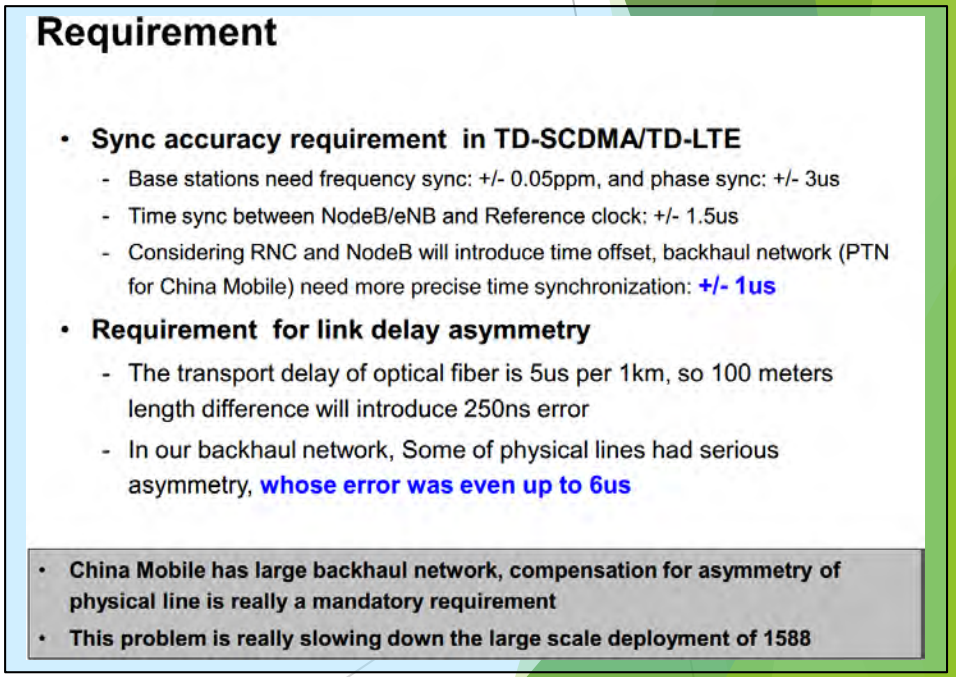
- For Ring topology in Backhaul network:
  - Multiple sites will share one physical/logic link
  - Per statistics multiplexing mechanism, bandwidth forecast depend on air interface, subscribers behavior
- Typical example for access ring bandwidth:
  - 6 sites per Ring
  - 3 LTE/5G Cells per Site
  -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

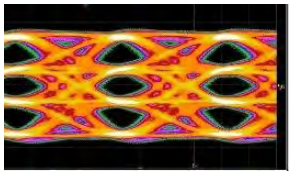
- As lack of fiber and expected bandwidth for mobile application, bidirectional optical PHY of 50GE can provide upgrade solution from most popular NX10GE, furthermore potential to reach 100GE with two 50GE bidirectional 10/40km optical link bonding.
- Another key benefit of BIDI in mobile application: To benefit IEEE 1588 time synchronous deployment, as provide identical latency rather than by duplex optical PHY with different fiber length at TX and RX side.
  - Time synchronous is mandatory in LTE-TDD/Advanced and 5G.
  - No link asymmetry challenge with BiDi Optical PHY

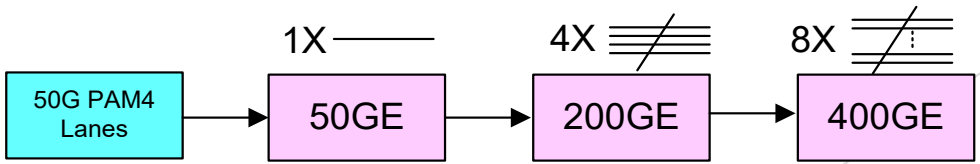


http://www.ieee802.org/1/files/public/docs2014/asbt-huang-measurement-of-link-delay-asymmetry-0714-

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

- The development of 50 Gb/s optical signaling, based on PAM4 modulation, was used in the development of IEEE Std 802.3bs™-2017 to develop optical specifications supporting 200GbE and 400GbE operation over 2 km and 10 km of single-mode fiber.
- The technology is also 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[a]	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})[c] (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 Approach for Wavelength of 50GE Bidirectional Optical PHY

- Start with 200GBase-FR4 style optics
  - 200GBase-FR4 use 1271,1291,1311,1331nm
- Further refer to 50GBase-LR style optics
  - 50GBase-LR works at 1304.5-1317.5nm
- From technical and economic feasibility, it could use 1270nm/1330nm for short fiber reach scenario

Possible Approach for Wavelength of 50GE Bidirectional Optical PHY(Cont'd)

- Start with 200GBase-LR4 style optics
  - 200GBase-LR4 use 1295, 1300, 1305, 1310nm
- it could use 1295nm/1310nm for extend fiber reach scenario

Conclusions

- Bidirectional 50Gb/s optical access PHYs, especially in 5G Mobile networks, appears to be a viable use case for Ethernet technology
  - Certainly technically feasible, leveraging existing PHYs
  - Market opportunity is of reasonable size
- Why do this work in 802.3?
  - This is the rightful home of this technology
  - 50GE BiDi 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 Bidirectional 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 Bidirectional 50 Gb/s Optical Access PHYs Study Group
- Let 802.3 Working Group determine how this will go forward if successful
- If approved, on Friday
  - 802 EC

Thank you

Questions? Comments?