

Towards 50 Gb/s per lane MMF baseline proposals

IEEE 50G & NGOATH Study Group

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- Adopted MMF objectives
- Baseline proposals for retimed single-lane 50Gb/s and four-lane 200Gb/s PAM4 PMDs
 - Physical layer specifications which support link distances of at least 100 m on MMF
 - FEC supported (RS-544) or similar to enable 100 m reach
 - Single-lane, and four-lane short wavelength based PMDs for 50GBASE-SR and 200GBASE-SR4
 - Leveraging an evolution of 25G NRZ optics, CDAUI-8 50 Gb/s electrical interfaces, and some of the PAM4 metrics developed in 802.3bs
- Architecture, parameters and specifications for optical interfaces follow.

Adopted MMF Objectives

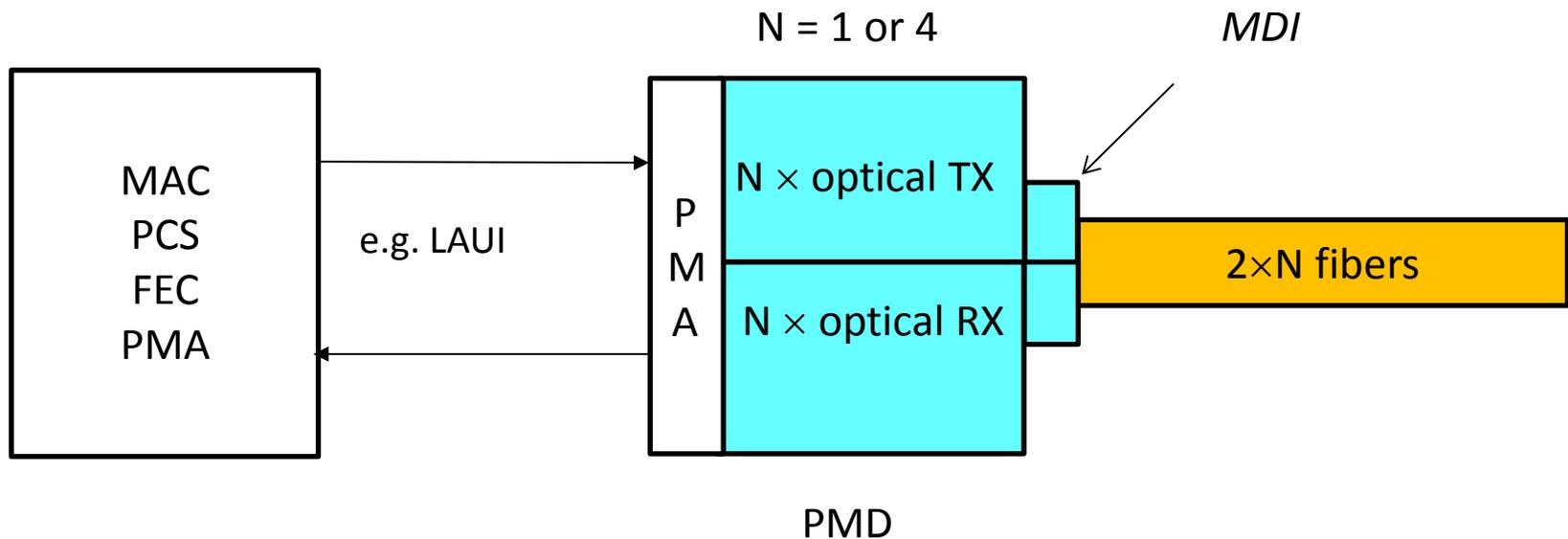
- **Define a single-lane 50 Gb/s PHY for operation over MMF with lengths up to at least 100 m.**
- Define a two-lane 100 Gb/s PHY for operation over MMF with lengths up to at least 100 m.
- **Define 200 Gb/s PHYs for operation over MMF with lengths up to at least 100 m.**

Motivation

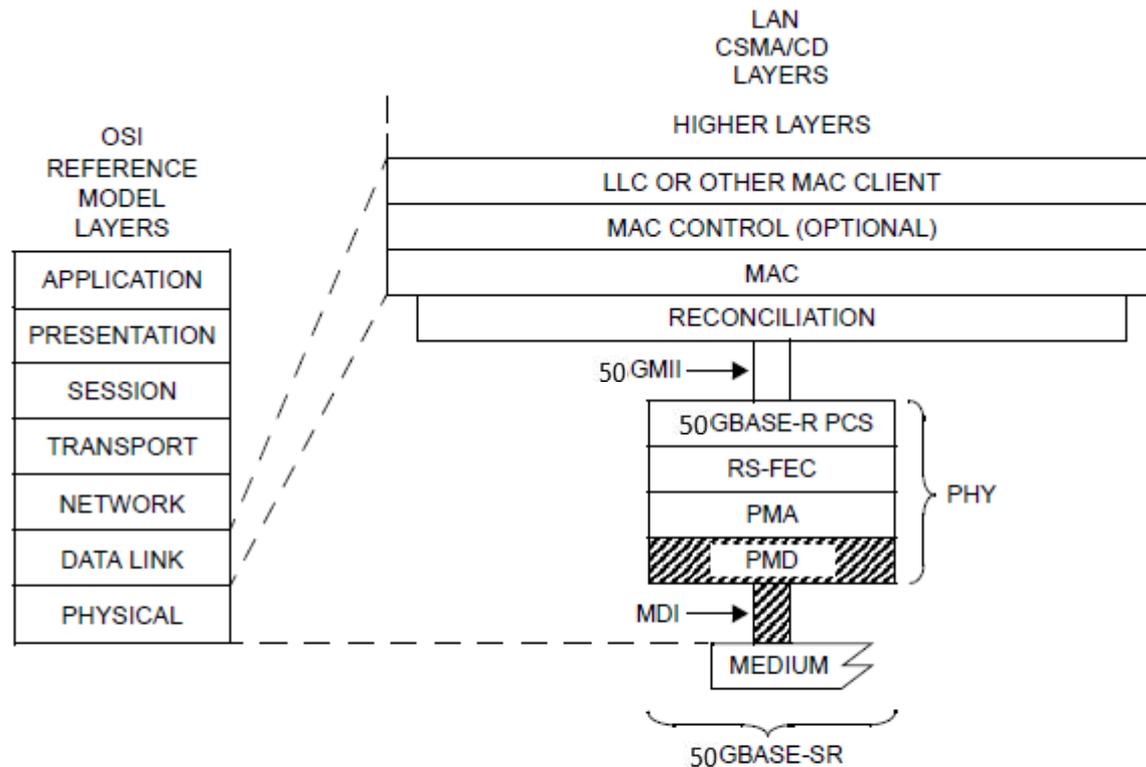
- Single-lane and four-lane links using PAM4 modulation at 26.5625 GBd/lane
- Utilize low cost, high performance MMF compatible optics and electronics
 - Leverage 28 Gb/s NRZ optics technology used in 25G, 100G, 400G Ethernet, and 32G Fibre Channel
 - FEC-supported retimed interface enables a lowest power, lowest cost, 100 m solution today
 - Uses existing viable semiconductor technologies and uncooled VCSELs
- Single optical lane directly maps to a single electrical lane of LAUI or CCAUI, without requiring multiplexing, translation, or de-skewing inside the module.
- This proposal is supported by multiple vendors and users, and is economically feasible and competitive compared to other alternatives.

Proposal

- Single optical lane per direction for 50GBASE-SR
- Four optical lanes per direction for 200GBASE-SR4
- Each lane @ 26.5625 GBd PAM4 over 100 m OM4 fiber.
 - Exact signaling rate is determined by project's choice of FEC.
- 850 nm sources and receivers
 - Assumes target BER (prior to error correction) around 2.4×10^{-4}



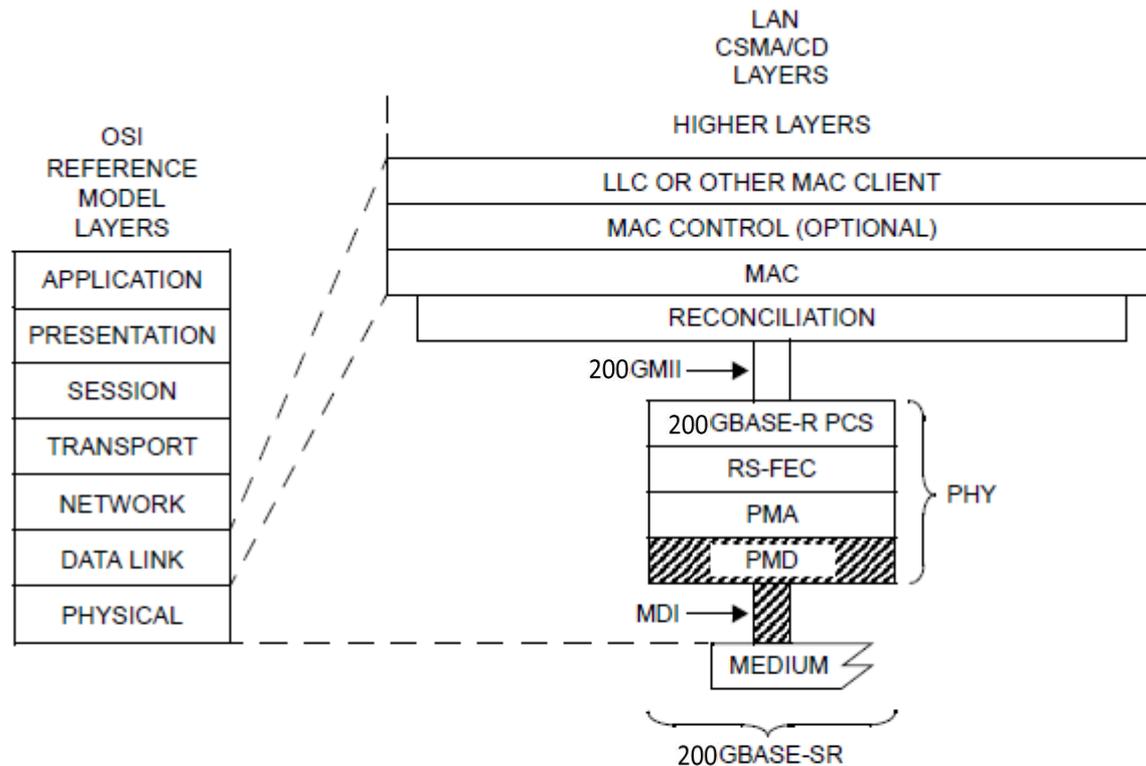
50GBASE-SR: Position in 802.3 architecture



50GMII: 50Gb/s MEDIA INDEPENDENT INTERFACE
 LLC = LOGICAL LINK CONTROL
 MAC = MEDIA ACCESS CONTROL
 MDI = MEDIUM DEPENDENT INTERFACE
 PCS = PHYSICAL CODING SUBLAYER

PHY = PHYSICAL LAYER DEVICE
 PMA = PHYSICAL MEDIUM ATTACHMENT
 PMD = PHYSICAL MEDIUM DEPENDENT
 RS-FEC = REED-SOLOMON FORWARD ERROR
 CORRECTION
 SR = PMD FOR MULTIMODE FIBER

200GBASE-SR4: Position in 802.3 architecture



200GMII: 200Gb/s MEDIA INDEPENDENT INTERFACE
 LLC = LOGICAL LINK CONTROL
 MAC = MEDIA ACCESS CONTROL
 MDI = MEDIUM DEPENDENT INTERFACE
 PCS = PHYSICAL CODING SUBLAYER

PHY = PHYSICAL LAYER DEVICE
 PMA = PHYSICAL MEDIUM ATTACHMENT
 PMD = PHYSICAL MEDIUM DEPENDENT
 RS-FEC = REED-SOLOMON FORWARD ERROR
 CORRECTION
 SR = PMD FOR MULTIMODE FIBER

Transmitter characteristics (each lane) at TP2

Description	Value	Unit
Signaling rate, each lane, (range)	26.5625 ± 100ppm	GBd
Modulation format	PAM4	
Center wavelength (range)	840 - 860	nm
RMS spectral width	0.6	nm
Average launch power, each lane (max)	+4	dBm
Average launch power, each lane (min)	-6	dBm
Optical Modulation Amplitude (OMA _{outer}), each lane (max) ^a	+3	dBm
Optical Modulation Amplitude (OMA _{outer}), each lane (min) ^{ab}	-4 <i>TBC</i>	dBm
Launch power in OMA _{outer} minus TDECQ (min) ^a	-5 <i>TBC</i>	dBm
Transmitter and dispersion eye closure (TDECQ), each lane (max) ^a	4 <i>TBC</i>	dB
Average launch power of OFF transmitter, each lane (max)	-30	dBm
Extinction ratio (min) ^a	3	dB
Encircled Flux	≥ 86% at 19 μm ≤ 30% at 4.5 μm	

^a OMA_{outer}, and TDECQ are as defined in 802.3bs; the 5 tap T/2 reference is *TBC* for MMF links

^b Even if TDECQ is <1dB, OMA_{outer} must be at least this value

Receiver characteristics (each lane) at TP3

Description	Value	Unit
Signaling rate, each lane, (range)	26.5625 ± 100ppm	GBd
Modulation format	PAM4	
Center wavelength (range)	840 - 860	nm
Damage threshold (min)	+5	dBm
Average receive power, each lane (max)	+4	dBm
Average receive power, each lane (min)	-7.9	dBm
Receive power, each lane (OMA _{outer}) (max)	+3	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity (OMA _{outer}), each lane (max) ^a	-3 <i>TBC</i>	dBm at 2.4 x 10 ⁻⁴
Receiver sensitivity (OMA _{outer}), each lane (max) ^{ab}	-7 <i>TBC</i>	dBm at 2.4 x 10 ⁻⁴
Conditions of stressed receiver sensitivity test		
Stressed eye closure (SECQ), lane under test ^a	4 <i>TBC</i>	dB
OMA of each aggressor lane	+3	dBm

^a OMA_{outer}, and SECQ are as defined in 802.3bs, the 5 tap T/2 reference is *TBC* for MMF links

^b Receiver sensitivity is informative

Illustrative link power budget (each lane)

Parameter	OM3	OM4	Unit
Effective modal bandwidth at 850 nm	2000	4400	MHz.km
Power budget (for max TDECQ)	6.0 <i>TBC</i>		dB
Operating distance	70	100	m
Channel insertion loss	1.8	1.9	dB
Allocation for penalties (for max TDECQ)	4.1 <i>TBC</i>		dB
Additional insertion loss allowed	0.1	0	dB

Concluding remarks

- Baseline proposals for single-lane 50G and four-lane 200G PMDs, based on 50 Gb/s PAM4 per lane offers:
 - an evolution of current 25 G VCSEL and receiver optics, to manage RIN and increase link budget.
 - substantial re-use of transmitter and receiver electronics technologies, developed for 50Gb/s PAM4 over SMF
 - substantial re-use of the Tx and Rx quality metrics for SMF, under development in P802.3bs
 - substantial amount of work from several groups showing technical feasibility
- 100 m on OM4 is achievable with RS-544 support or similar
- Potentially compatible with SFP28 form factors
 - four lane variant compatible with QSFP28 form factors

Q & A

Thanks !