400GBASE-ER8, 200GBASE-ER4, 50GBASE-ER1 Specifications Proposal

Interim Teleconference
P802.3cn 50 Gb/s, 200 Gb/s, and 400 Gb/s over greater than 10 km of SMF Task Force
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Network Operator 400G >10km Requirements

- Weiqiang Cheng, China Mobile:
  Cost is really sensitive for 400GE ER. However, If possible, we hope 400GE ER can keep 40km capability so that we can share the same infrastructure with 100GE ER.
- Junjie Li, China Telecom:
  Beyond 10km, the use of grey optical interfaces is a very small corner case for China Telecom. Typically we prefer DWDM systems when the distance is longer than 10km.
- Ralf-Peter Braun, DT:
  It is more important to achieve significantly lower cost than hitting the 40km reach

The comments on this page do not represent any type of support for this presentation. They are only statements on requirements.

Network Operator 400G >10km Requirements

- Glenn Wellbrock, Verizon:
  Verizon rarely uses gray interfaces outside the office except for "access" which is usually 20km or less due to its distribution networks. I seriously doubt this would change for 400G.
- Sam Sambasivan, ATT:
  25km is preferable, at the lowest possible cost.
- Masahito Tomizawa, NTT:
  Lower cost 30km IF (Interface) is preferred for NTT, if there is a large cost difference between 30km IF and 40km IF. If the cost difference is small, then 40km IF is better for NTT because there are many 10G and 100G 40km IFs already installed in NTT's network. 400G 40km IF is the simplest replacement from 10G/100G 40km IF.

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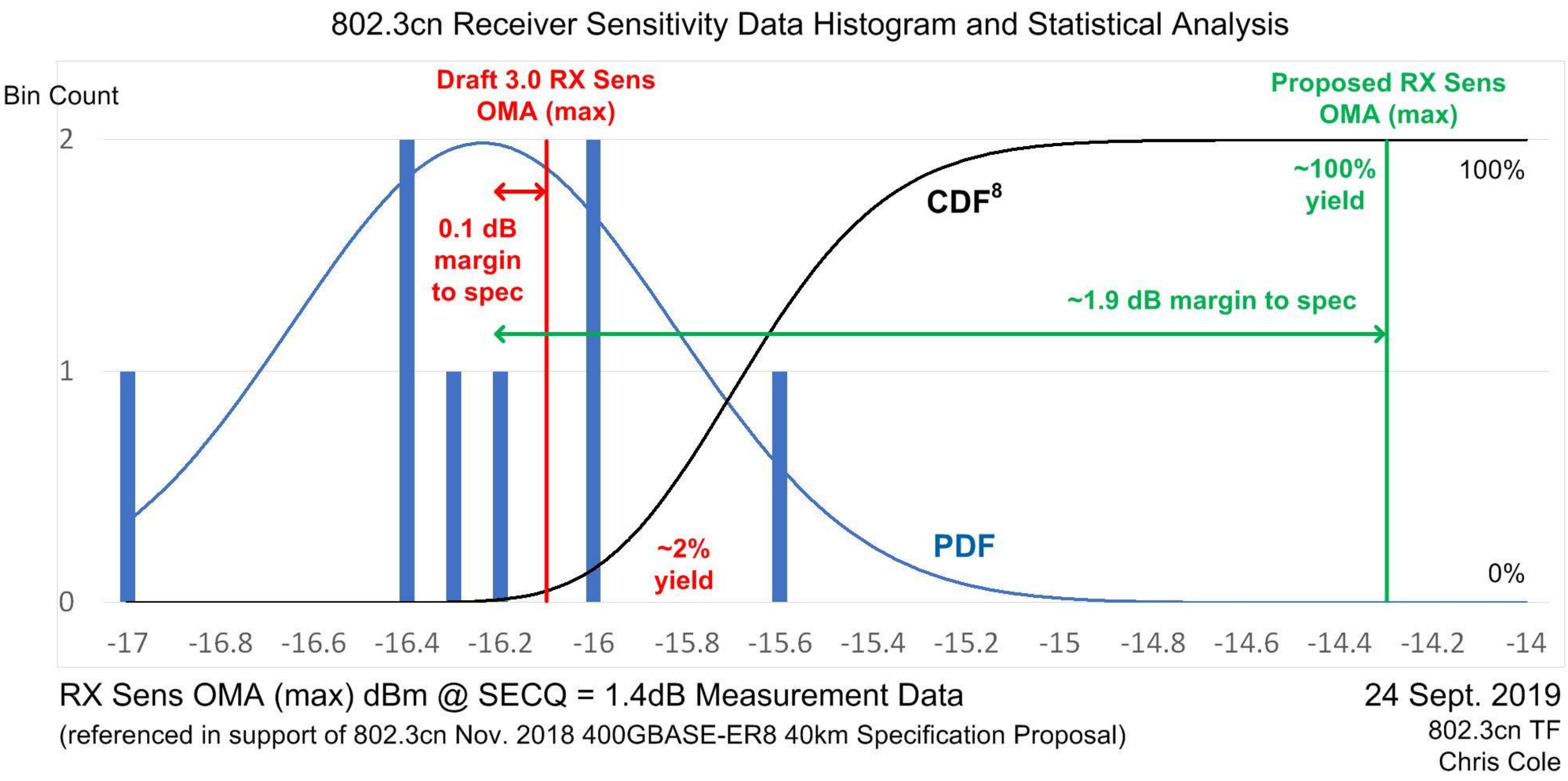
Introduction

- Graph 1 shows all contributed ER8 data and its analysis
- Tables 1, 2, and 3, for ER8, ER4, ER1, respectively, compare Optical Margins between all TF contributed data
- Since Jan. 2018, all the data sets show the same thing:
  - ER1 and ER4 will benefit from decreasing TX OMA (min) and RX Sens (max)
  - ER8 does not have sufficient TX and RX Optical Margin to be manufacturable.
- TF contributors recognized that to meet the 40km ER8 reach requirement with sufficient manufacturing margin, requires new technologies:
  - Shuto Yamamoto identified stronger FEC
  - Xinyuan Wang identified enhanced EML, enhanced APD, and enhanced FEC

Introduction, cont.

- When applied to ER8, these will fundamentally alter the specification, in unknown combination of TX OMA (min), RX Sens (max), penalties, and other changes.
- It is very unlikely that the new technologies will optimally match the 40km ER8 spec. baseline in Draft 3.0.
- The TF choice is simple
  - adopt 30km reach ER8 spec. which is feasible today
  - defer adopting any spec. until new technologies are proven to support 40km reach, and then write a new spec accordingly
- Adopting a 40km spec. not manufacturable with today's technology does not serve anyone's interests.

Graph 1. 400GBASE-ER8 Data & Analysis



Graph 1 plots and annotates data from Tables 5 and 7

Table 1. 400GBASE PMD Optical Margin comparisons

Reference	400G PMD	Transmitter Optical Margin (or Yield)	Receiver Optical Margin (or Yield)	Total Optical Margin (or Yield)	Units
cole_3bs_01a_0515	LR8	2	**1.9 ***	3.9	dB
yamamoto_b10k_01a_0118 **(1 RX, 1 TX data sets)**	ER8	**-0.2**	**0.9**	**0.7 ***	dB
yu_b10k_01c_0318 **(2 RX, 1 TX data sets)**	ER8	**0.9**	**0.2**	1.1	dB
wang_b10k_01a_0518 **(1 RX, 1 TX data sets)**	ER8	**1.6**	**-0.1**	**1.5 ***	dB
jackson_b10k_01_0918 **(2 RX, 2 TX data sets)**	ER8	**0.9**	**0.2**	1.1	dB
huang_b10k_01a_0918 **(2 RX data sets)**	ER8		**-0.1**		dB
cole_3cn_01_190924 draft D3.0 analysis	ER8	**0.9**	**0.1**	1.0	dB
		42	***2***	*1*	%
cole_3cn_01_190924 draft D3.0 proposal	LR8	**2.0**	**1.9**	3.9	dB
		98	***100***	*98*	%

*** Margin shown in the presentation**

Table 2. 200GBASE PMD Optical Margin comparisons

Reference	200G PMD	Transmitter Optical Margin (or Yield)	Receiver Optical Margin (or Yield)	Total Optical Margin (or Yield)	Units
cole_3bs_03_0516	LR4	3.1	**2.2 ***	5.3	dB
yu_b10k_01c_0318	ER4	**1.1**	**2.2**	**3.3 ***	dB
cole_3cn_01_190924 draft D3.0 analysis	ER4	**0.8**	**2.1**	2.9	dB
		65	***100***	*64.6*	%
cole_3cn_01_190924 draft D3.0 proposal	ER4	**1.5**	**1.4**	2.9	dB
		96	***100***	*96*	%

*** Margin shown in the presentation**

Table 3. 50GBASE PMD Optical Margin comparisons

Reference	50G PMD	Transmitter Optical Margin (or Yield)	Receiver Optical Margin (or Yield)	Total Optical Margin (or Yield)	Units
cole_3cd_01_0516	LR1	6.2	**3.1 ***	9.3	dB
xu_3cn_01b_1118	ER1	**2.9**	**4.2**	7.1	dB
cole_3cn_01_190924 draft D3.0 analysis	ER1	**2.8**	**4.1**	6.9	dB
		100	***100***	*99.8*	%
cole_3cn_01_190924 draft D3.0 proposal	ER1	**3.9**	**3.0**	6.9	dB
		100	***100***	*100*	%

*** Margin shown in the presentation**

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802.3cn Data Sets Analysis

- Table 4 summarizes the statistics for the TF contributed data sets, which are all listed in Table 1 (p.6)
- Table 4 includes histograms of measurement occurrences and below shows histograms of a normal distribution for the total number of samples to evaluate the fit
- Tables 5, 6, and 7 show Draft D3.0 select Optical Specifications with
  - Margin and Yield analysis of the select Optical Specifications (T5)
  - public comment changes and same analysis (T6)
  - updated proposed changes and same analysis (T7)

Table 4. 802.3cn Data Statistics

Description	median	average	sigma	min	max	units
TX OMA Pre-Mux	8.2	8.2	0.7	7.2	9.0	dBm
RX Sens OMA Post-DeMux	-19.2	-19.2	0.4	-20.0	-18.6	dBm
Sigma bin	-3 → -2	-2 → -1	-1 → 0	0 → 1	1 → 2	2 → 3
TX OMA bin count	0	1	1	2	1	0
TX Normal ref. count	0.1	0.7	1.7	1.7	0.7	0.1
RX OMA bin count	0	1	3	3	1	0
RX Normal ref. count	0.2	1.1	2.7	2.7	1.1	0.2

Table 5. P802.3cn draft D3.0 Select Optical Specifications Margin and Yield analysis

Transmitter Description	50G ER1	200G ER4	400G ER8	unit
Reach	40	40	40	km
Penalties	2	2	2	dB
Mux loss (max)	0	2	3	dB
TX OMA (max)	7.4	7.4	6.4	dBm
TX OMA (min)	3.4	3.4	2.4	dBm
TX OMA (min) margin	**2.8**	**0.8**	**0.8**	dB
TX OMA Yield	**100**	**65**	**42**	%
Receiver Description	50G ER1	200G ER4	400G ER8	unit
RX Sens OMA (max) SECQ = 1.4	-15.1	-15.1	-16.1	dBm
DeMux loss (max)	0	2	3	dB
RX OMA (max) margin	**4.1**	**2.1**	**0.1**	dB
RX Sens OMA Yield	**100**	**100**	**2**	%
TX OMA * RX Yield	100	65	1	%

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Table 6. P802.3cn draft D3.0 Select Optical Specifications with public comment changes and analysis

Transmitter Description	50G ER1	200G ER4	400G ER8	unit
Reach	40	40	30	km
Penalties	2	2	2	dB
Mux loss (max)	0	2	3	dB
TX OMA (max)	7.4	5.2	4.2	dBm
TX OMA (min)	3.4	1.2	0.2	dBm
TX OMA (min) margin	**2.8**	**3.0**	**3.0**	dB
TX OMA Yield	**100**	**99**	**98**	%
Receiver Description	50G ER1	200G ER4	400G ER8	unit
RX Sens OMA (max) SECQ = 1.4	-15.1	-17.3	-15.3	dBm
DeMux loss (max)	0	2	3	dB
RX OMA (max) margin	**4.1**	**-0.1**	**0.9**	dB
RX Sens OMA Yield	**100**	**4**	**91**	%
TX OMA * RX Yield	100	3	90	%

Table 7. P802.3cn draft D3.0 Select Optical Specifications with updated proposed changes and analysis

Transmitter Description	50G ER1	200G ER4	400G ER8	unit
Reach	40	40	30	km
Penalties	2	2	2	dB
Mux loss (max)	0	2	3	dB
TX OMA (max)	6.3	6.7	5.2	dBm
TX OMA (min)	2.3	2.7	1.2	dBm
TX OMA (min) margin	**3.9**	**1.5**	**2.0**	dB
TX OMA Yield	**100**	**96**	**98**	%
Receiver Description	50G ER1	200G ER4	400G ER8	unit
RX Sens OMA (max) SECQ = 1.4	-16.2	-15.8	-14.3	dBm
DeMux loss (max)	0	2	3	dB
RX OMA (max) margin	**3.0**	**1.4**	**1.9**	dB
RX Sens OMA Yield	**100**	**100**	**100**	%
TX OMA * RX Yield	100	96	98	%

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ER8, ER4, ER1 Specifications Proposal

Thank You

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Appendix

Discussion of Chromatic Dispersion Penalty scaling

Chromatic Dispersion Penalty Figure of Merit

- The following is an explanation of Chromatic Dispersion Penalty (CDP) scaling with reach and Baud rate, and interplay with transmitter chirp characteristics.
- CDP is proportional to CD coefficient, link length, and Baud rate squared:

  $CDP \propto CD * L * B^2$

- While calculating the exact penalty is complex, $CD * L * B^2$ term can be used for direct, relative comparisons, by defining it as a CDP Figure of Merit (CDP FM).
- 10km and 25GBaud are used for normalization

  CDP FM = CD * (L/10) * (B/25)

- Table 1 below lists key transmitters specs. and CDP FM for various codes, with red highlighting concerns.

TABLE 1	~Baud Rate	Reach	TX OMA	TX OMA – TDECQ	TDECQ	~CD	CDP FM	~CD	CDP FM
Codes	each lane	(max)	each lane (min)	each lane (min)	(max)	(min)	for CD (min)	(max)	for CD (max)
	Gbaud	km	dBm	dBm	dB	ps/nm-km		ps/nm-km	
4WDM-40 (100G ER4f) (TDP not TDECQ)	25	40	0.5	-0.5	3	-3	12	1	4
50GBASE-LR1	25	10	-1.5	-2.9	3.2	-2	2	1.5	2
50GBASE-ER1	25	40	3.4	2	3.2	-2	8	1.5	6
100GBASE-LR1	50	10	0.7	-0.6	3.4	-2	8	1.5	6
200GBASE-LR4	25	10	-0.4	-1.7	3.4	-3	3	1	1
200GBASE-ER4	25	40	**3.4**	2	3.2	-3	12	1	4
400GBASE-LR8	25	10	0.2	-1.1	3.1	-5	5	1	1
400GBASE-ER8	*25*	*30*	*0.2*	*-1.2*	*3.4*	*-5*	*15*	*1*	*3*
400GBASE-ER8	25	40	**2.4**	1	3.4	-5	**20**	1	4
400GBASE-LR4	50	6	0.2	-1.1	3.5	-6	14	3	7
400GBASE-LR4	*50*	*10*	*0.2*	*-1.1*	*3.5*	*-6*	***24***	*3*	***12***

Appendix

Thank You