



Coherent Technology Advances in the market, DCI Interop, and shorter reaches for AI

Karl Gass, OIF PLL Optical Vice-Chair

OIF - Where the optical networking industry's interoperability work gets done

Who:

- 160+ member companies
 - Network operators
 - System vendors
 - Component vendors
 - Test & measurement vendors
 - Academia & research

What:

- Identify needs, gaps
- Develop interoperable optical, electrical, and control solutions
- Publish Implementation Agreements and White Papers
- Interoperability Demos

Why:

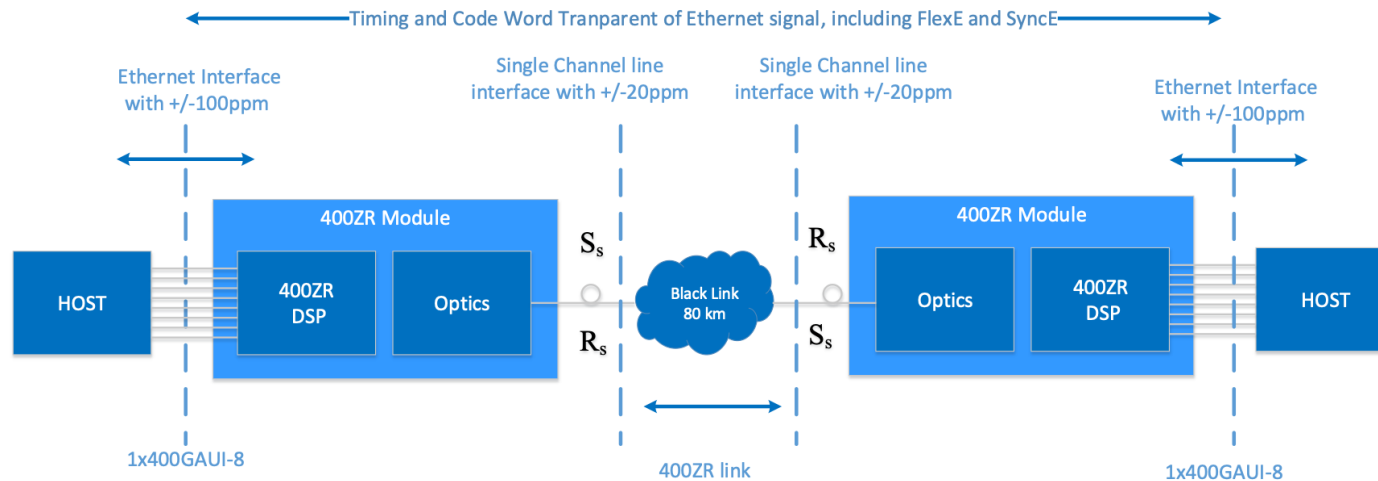
- Accelerate adoption of advanced technology to connect a global, open networked world

Challenge: Support innovation while preserving interoperability, optimizing performance and cost

An international consortium that since 1998, has brought together industry groups from the data and telecom worlds

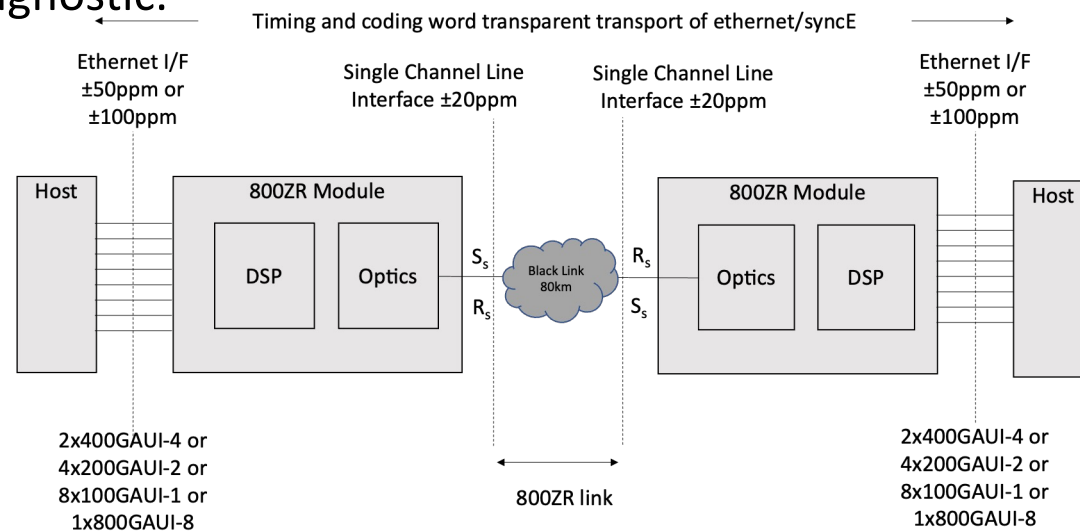
What is 400ZR?

- 400ZR is an interoperable, cost-effective, 400Gb/s interface based on single-carrier coherent DP-16QAM modulation, low power DSP supporting absolute (Non-Differential) phase encoding/decoding, and a Concatenated FEC (C-FEC) with a post-FEC error floor $<1.0E-15$. Up to 120km amplified, point-to-point, DWDM, noise-limited links. . Form-factor agnostic.



What is 800ZR?

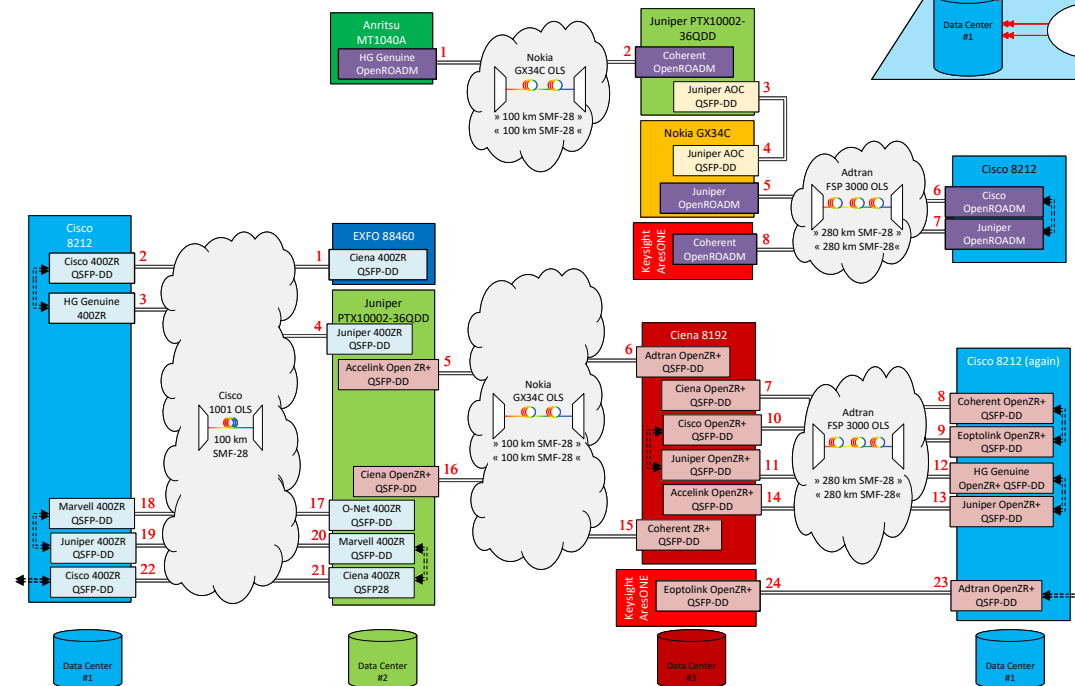
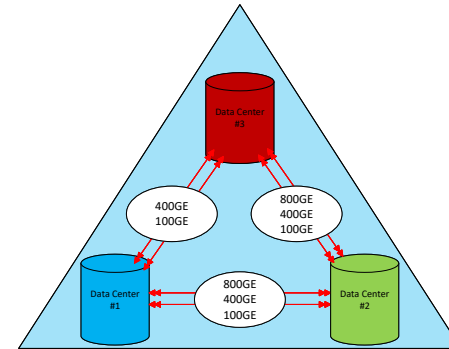
- 800ZR is an interoperable, cost-effective, 800Gb/s interface based on single-carrier coherent DP-16QAM modulation, low power DSP supporting non-differential phase encoding/decoding, and OFEC with a post-FEC error floor $<1.0E-15$. Up to 120km amplified, point-to-point, DWDM, noise-limited links. Form-factor agnostic.



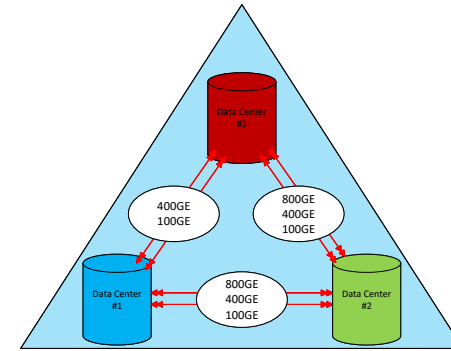
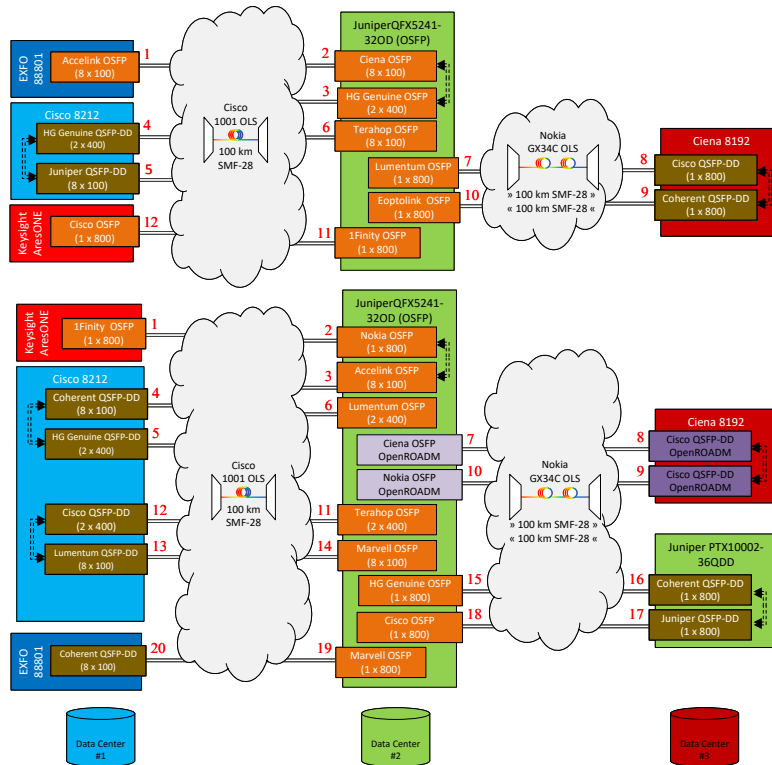
What is ZR+?

- X00ZR+ is a generic term for “more capable than X00ZR” and is not standardized across the ecosystem.
- OpenZR+ MSA is the product of an MSA designed to address extended reaches, including flexible Ethernet rates and modulation types. High Tx output power (0 dBm) added in v3.0 (9/2023).
- OpenROADM refers to the product of the OpenROADM MSA and supports both Ethernet and OTN traffic. Since it is similar, we’ve included it in our demo.
- At 800G, the OpenROADM MSA has specified interoperable Probabilistic Constellation Shaping (PCS) to enable even longer reaches.

OIF ECOC 2025 Interoperability Demonstration 400G



OIF ECOC 2025 Interoperability Demonstration 800G



OFC 2025 Measurement Plugfest - 400ZR rOSNR

Anritsu OSA 193.7 THz		Tx									
		Vendor A	Vendor B	Vendor C	Vendor D	Vendor E	Vendor F	Vendor G	Vendor H	Vendor I	Vendor J
Rx	A	22.44	24.18	22.53	22.63	23.52	23.25	23.35	22.67	24.14	23.53
	B	23.31	22.74	22.69	22.80	23.46	23.31	23.38	22.72	23.71	24.45
	C	23.16	23.92	22.92	23.15	23.70	23.87	23.54	22.88	24.37	25.21
	D	23.28	23.54	23.00	23.19	23.80	24.08	23.71	23.16	23.71	25.44
	E	22.80	22.77	22.59	23.80	23.38	23.45	23.71	22.69	23.98	24.63
	F	23.31	23.16	22.98	23.33	23.90	23.77	23.86	23.01	24.47	25.67
	G	23.63	23.32	22.96	23.34	24.06	23.96	23.94	23.23	24.27	25.21
	H	24.43	23.98	23.69	23.89	25.74	25.14	24.59	24.11	25.77	26.20
	I	24.35	24.18	23.95	24.21	24.99	24.93	24.46	23.90	24.25	26.38
	J	24.64	23.87	23.55	24.15	25.00	25.11	24.53	23.48	25.24	24.63

rOSNR liaised to IEEE 802.3.dj and ITU-T for ETCC development.

Compared these results for six vendors that participated in the 2023 OFC measurement plugfest. Average difference is .02 dB.

Vendor # is unique to this measurement and does not correlate to 800ZR or any other OIF plugfest.

OFC 2025 Measurement Plugfest - 400ZR TQM

400ZR TUT from Vendor	A	B	C	D	E	F	G	H	I	J
EVM_{MAX} [%] using EVM script according to 400ZR IA	11.3	11.6	10.3	10.3	No	No	10.7	10.2	11.6	No
EVM_{MAX} [%] using EVM script with OSNR = Inf	10.6	10.9	9.6	9.6	No	No	10.0	9.5	10.9	No
EVM_{MAX} [%] using EVM script with more equalizer taps and RRC filter	8.7	9.2	8.0	7.4	No	No	8.5	7.8	No	No
EVM_{MAX} [%] using OMA SW	8.7	9.3	8.0	7.4	8.7	7.9	8.4	7.8	9.4	8.0
Avg rOSNR [dB] (from Ref. 13)	24.2	23.9	23.5	23.9	24.7	24.7	24.3	23.5	25.4	25.3

Raw Tx waveform recordings liaisoned to IEEE 802.3.dj and ITU-T for ETCC development.

“No” indicates demodulation failed. Vendor # is unique to this measurement and does not correlate to 800ZR or any other OIF plugfest.

OFC 2025 Measurement Plugfest - 800ZR rOSNR

EXFO OSA 193.775 THz		Tx							
		Vendor K	Vendor L	Vendor M	Vendor N	Vendor O	Vendor P	Vendor Q	Vendor R
Rx	K	25.08	26.13	25.47	26.54	25.51	25.45	27.18	27.51
	L	26.01	25.51	28.79	30.40	27.85		26.14	26.40
	M	25.51	26.25	25.92	26.77	25.63	25.75	27.29	27.70
	N	25.95	26.59	26.48	26.05	26.07	26.21	25.83	26.61
	O	25.70	26.09	26.09	25.84	26.25	26.15	27.45	27.99
	P	26.03		26.56	27.18	26.20	26.74	27.91	28.21
	Q	25.40	25.69	26.05	25.52	25.51	25.62	27.21	25.99
	R	25.76	26.76	26.05	25.75	26.04	26.15	27.89	27.72

rOSNR liaised to IEEE 802.3.dj and ITU-T for ETCC development.

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OFC 2025 Measurement Plugfest - 800ZR TQM

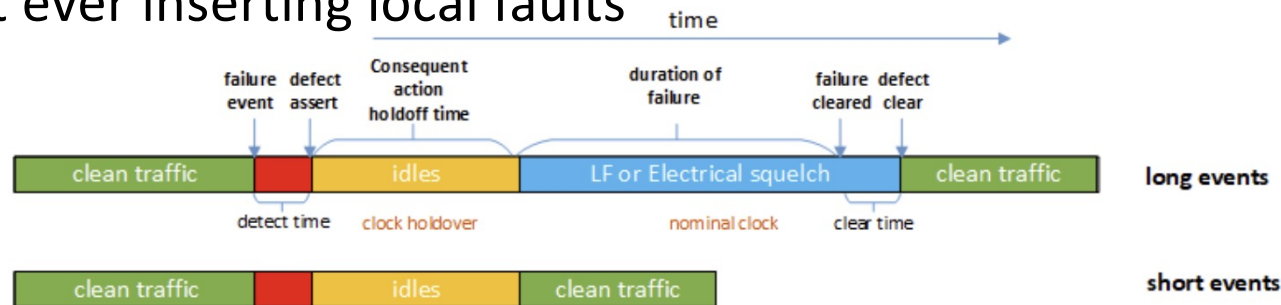
800ZR TUT from Vendor	K	L	M	N	O	P	Q	R
EVM_{MAX} [%] using EVM script	No	8.7	No	No	No	N/A	No	No
EVM_{MAX} [%] using OMA SW	No	8.6	No	No	No	N/A	No	12.2
EVM_{MAX} [%] using OMA SW with additional Tx phase EQ	11.2	8.5	10.1	9.9	11.8	N/A	9.8	10.6
Avg rOSNR [dB] (from Ref. 14)	25.7	26.1	26.4	26.8	26.1	26.0	27.1	27.3

Raw Tx waveform recordings liaisoned to IEEE 802.3.dj and ITU-T for ETCC development.

“No” indicates demodulation failed. Vendor # is unique to this measurement and does not correlate to 800ZR or any other OIF plugfest.

Consequent Action Hold-off

- If an optical protection switch (OPS) is deployed, operators desire no PCS/link alarm during OPS switchover.
- 800ZR and C-CMIS 1.4 enable the module to use this configurable parameter to delay the insertion of Local Faults.
- “If the failure and the corresponding defect is cleared prior to the expiry of the hold-off timer, the traffic and clock resume as normal without ever inserting local faults”



Plugfest Goal: How well does this work for interop?

- Customer request to was to measure the recovery time and monitor link status with Hold-off at 0 ms and 50 ms for 100G, 400G, and 800G
- 100ZR modules do not support Hold-off. Few 400ZR and 800ZR modules supported C-CMIS 1.4... Manual configuration, was different for each module and too time consuming.
- Hold-off works as advertised on 800ZR modules configured @ 50 ms.
- The significant data collection is the “recovery time” between module pairs. We focused on 100G and 800G.
- OPS “switching” time was a factor. One switch was ~0.5 ms while the other was 3 or 6 ms (asymmetric).

Test results indicate multi-vendor (multi-DSPs) short recovery time

Plugfest: Interop Recovery Time after Switching!

800ZR			RX									
			Vendor A	Vendor B	Vendor C	Vendor D	Vendor E	Vendor F	Vendor G	Vendor H	Vendor I	Vendor J
TX	Vendor A	Avg	8.6			9.3		9.2		9.9		
		LD						007				
	Vendor B	Avg		9.2				9.3		9.9		
		LD						007				
	Vendor C	Avg			9.2			9.3		10.0		
		LD						007				
	Vendor D	Avg				9.3		9.3	9.8	9.9	10.4	
		LD						007				
	Vendor E	Avg					9.3			9.9		
		LD										
	Vendor F	Avg	8.5	9.2	9.3	9.3		9.4	9.8	9.9		
		LD						007				
	Vendor G	Avg		9.2	9.3	9.2			9.7	10.0		12.6
		LD										
	Vendor H	Avg	8.5		9.5	9.3	9.4		9.7	9.9		
		LD										
	Vendor I	Avg	9.4	9.2	9.3	9.3	9.3	9.6	9.8	9.9	10.4	
		LD						009				
	Vendor J	Avg										12.8
		LD										

1 x 800GE application

Average of 10 optical protection switch events

Link recovery time in milliseconds. Switching time was 0.6 ms.

Red is link down. Green is Hold-off prevented link down. Some modules set default Hold-off to 50 ms.

Vendor F included two modules, serial #007 set Hold-off default to 50 ms. Serial #009 was set to default of 0 ms.

100GBASE-ZR		RX				
		Vendor K	Vendor L	Vendor M	Vendor N	Vendor O
TX	Vendor K	12.6	15.6	15.1	12.3	15.0
	Vendor L	12.3	15.1	16.3	15.3	14.9
	Vendor M	12.1	15.5	15.1	15.2	15.2
	Vendor N	12.3	16.1	15.6	16.1	15.7
	Vendor O	11.9	16.3	16.6	16.3	16.3

100GE application

Average of 10 optical protection switch events

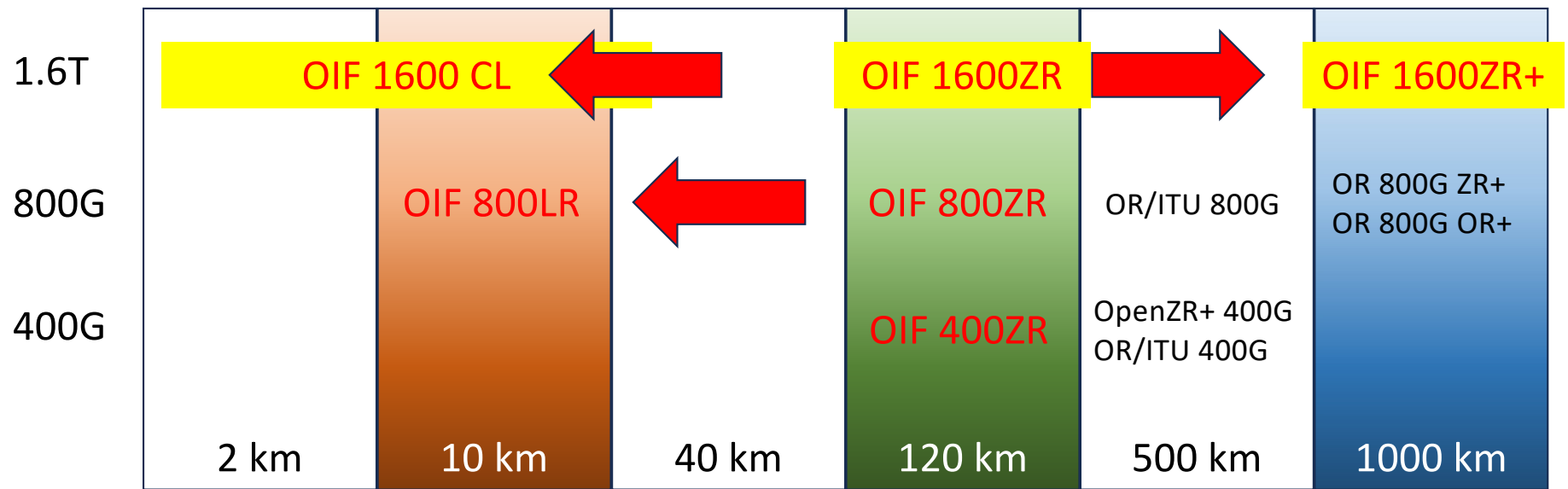
Link recovery time in milliseconds. Switching time averaged 4.5 ms.

No hold-off, so link down every time*.

* Actually not true but that would make it non-anonymous

Thanks to Anritsu, EXFO, Accelink, and Adtran for the measurements and Keysight for hosting!

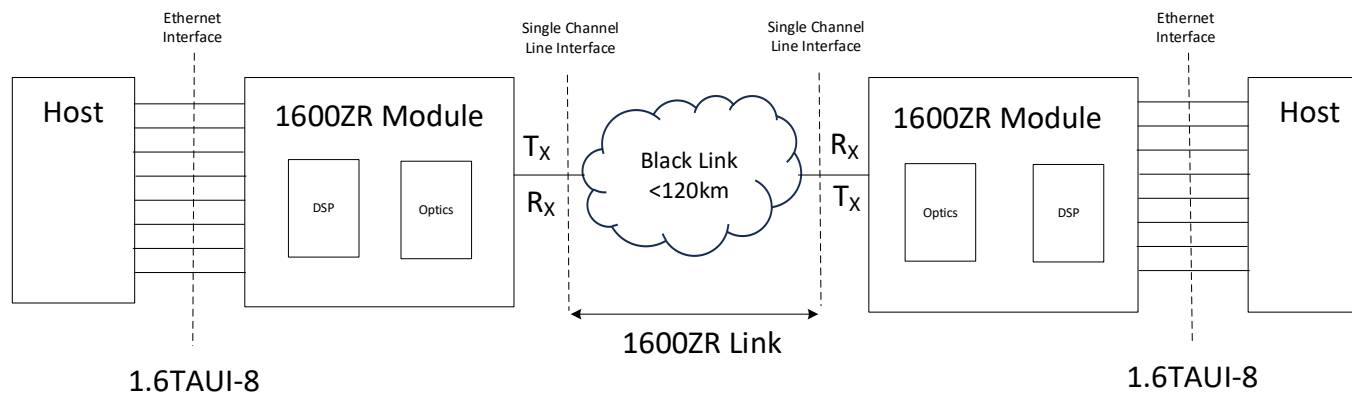
OIF Scope has Expanded



Our goal is to complement other Standards Bodies and Forums

What is 1600ZR?

- 1600ZR is an interoperable, cost-effective, 1600Gb/s interface based on single lambda, single-carrier, coherent DP-16QAM modulation, low power DSP supporting non-differential phase encoding/decoding, and OFEC with a post-FEC error floor $<1.0E-15$. Up to 120km amplified, point-to-point, DWDM, noise-limited links. Form-factor agnostic. Leverage IEEE 802.3 and ITU-T as much as possible.

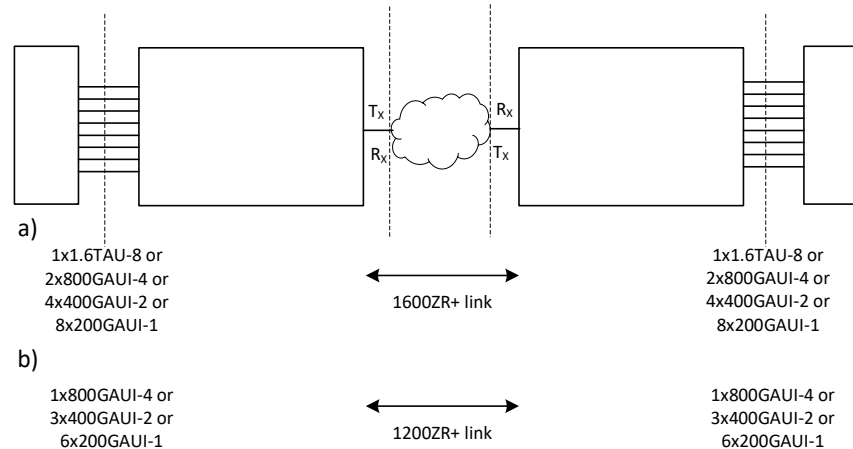


Project Status: 1600ZR

- 3Q-2023: Project start
- Q224: FEC options narrowed down
- Q324: Key decisions taken:
FEC, Baud Rate, client mapping
- Q424: key decisions taken, reflected into editor's draft
DSP frame, pilots, training symbols, ZR and ZR+ documentation strategy
- Q125: Agreement on # of OFEC engines, Alignment on Optical Parameters,
conversation on interoperability started
- Q225: Converging on digital section, discussion optical parameters
- Objective Q325: Conclude discussions on digital section, additional
discussion on optical parameters, conduct straw ballot

What is 1600ZR+?

- 1600ZR+ is an interoperable, cost-effective, 1600Gb/s interface based on fixed hierarchical tree probabilistic constellation shaping, OFEC with a post-FEC error floor $<1.0E-15$, dual-polarization 16QAM (DP-16QAM) modulation, two digital subcarriers in a low power DSP. C + L bands. Up to 1000km for 1600ZR+ and 2000 km for 1200ZR+. Form-factor agnostic. Leverage 1600ZR, IEEE 802.3, and ITU-T as much as possible.



Project Status: 1600ZR+

- Decisions made at 2025 Q3 meeting
 - Adopted laser phase noise mask
 - EEPN penalty will be included in CD penalty
 - Removed regen functionality
 - Naming of sub-carriers
 - Accepted HiLUT contents proposal

What is 1600CL?

- Project called 1600CL (Coherent-Lite) to address multiple possible applications and not just “LR”
- 1600CL is an interoperable, cost-effective, 1600Gb/s interface designed for a single lambda, unamplified link supporting a single 1.6TE, two 800GE clients or four 400GE clients. Initial optical specifications apply to O-band LR 10km 6-8dB and O-band FR 2km 4dB applications. Form-factor agnostic. Leverage 800LR, IEEE 802.3, and ITU-T as much as possible.

