25 Gb/s Ethernet Over Single Mode Fiber Call For Interest Consensus Presentation

IEEE 802.3

David Lewis, Lumentum

Kohichi Tamura, Oclaro

Peter Jones, Cisco

Dallas, TX

Nov 9th-12th, 2015

Introductions for today's presentation

Presenters and Expert Panel:

David Lewis	Lumentum
David Malicoat	HPE
Kohichi Tamura	Oclaro
Paul Kolesar	CommScope
Peter Jones	Cisco

CFI Objectives

- To gauge the interest in studying single mode fiber PMD(s) for 25 Gb/s Ethernet

- We do not need to:
  - Fully explore the problem
  - Debate strengths and weaknesses of solutions
  - Choose a solution
  - Create a PAR or 5 Criteria
  - Create a standard

- Anyone in the room may vote or speak

Overview: Motivation

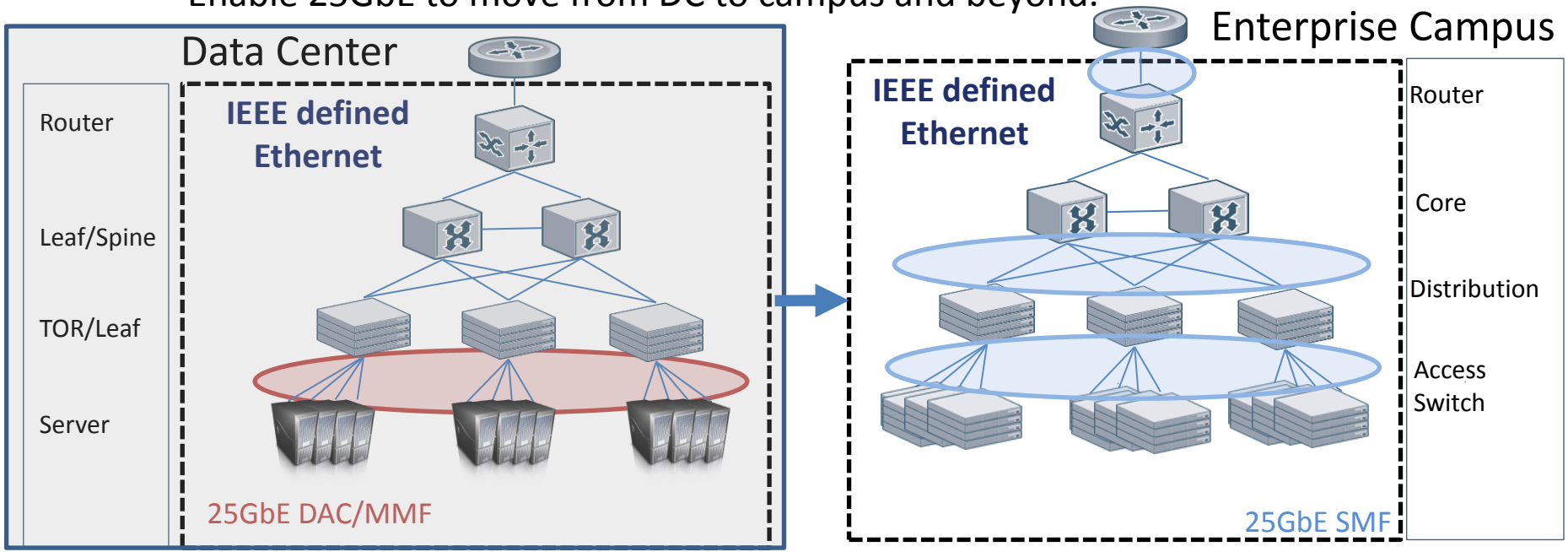
- Address 25GbE links longer than 100m.
- Develop standards for cost optimized 25GbE SMF PMD(s).
- Allow other markets (e.g., Enterprise, Metro) to adopt 25GbE.
- Initial applications?

  Enterprise campus; Metro network access
- Similar technologies

  Mobile Front-haul – 25G for Common Public Radio Interface (CPRI)

What Are We Talking About?

- Application spaces that could move to 25Gb/s lanes (1X or 4X) over SMF.
- 25GbE SMF provides optimized single lane switch/router connectivity
- Enable 25GbE to move from DC to campus and beyond.



Agenda

• Overview Discussion	David Lewis	Lumentum
• Presentations		
– 25GbE SMF Market Drivers	Peter Jones	Cisco
– 25GbE SMF Technical Feasibility	Kohichi Tamura	Oclaro
– 25GbE SMF Why Now?	David Lewis	Lumentum
• Q&A		
– Expert Panel	David Malicoat	HPE
	Paul Kolesar	CommScope
• Straw Polls		

Market Drivers

25GbE SMF PMD

Peter Jones, Cisco

Ethernet Evolution

Leading edge markets (e.g., Cloud DC, SP) drive speeds

- Initial adoption: 10G ~2004; 40G ~2012; 100G ~2013; 25G ~2016

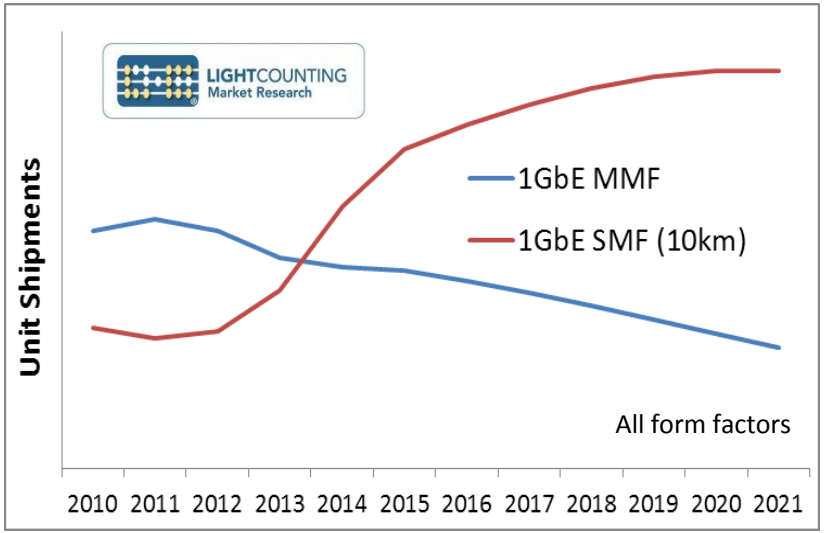
Other markets (e.g., Enterprise DC, Campus) more cost sensitive

- 1/4-lane solutions enable cost reductions and volume adoption
- Key question - “What do I need & what can I afford?”

Ethernet market is wide, varied and getting more so

- We have active projects from 100Mb/s to 400Gb/s
- Ethernet is filling in it’s “*Ecological Niches* (en.wikipedia.org/wiki/Ecological_niche) “

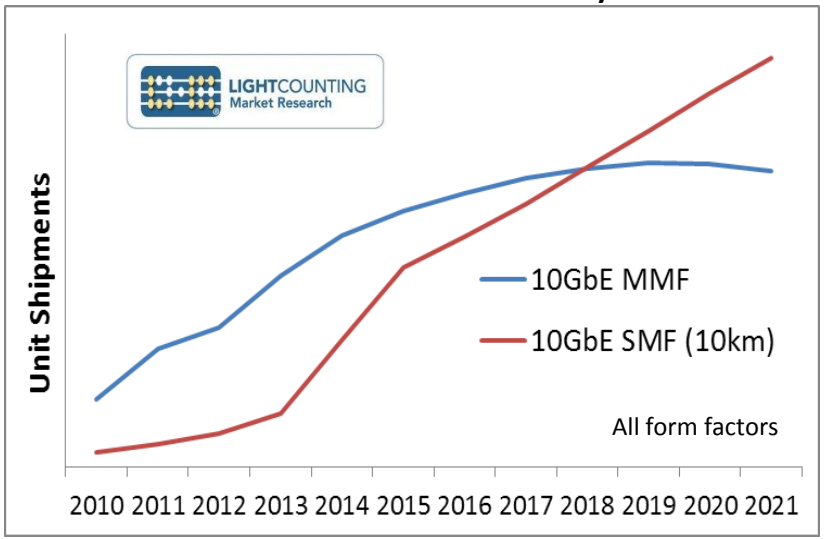
1GbE/10GbE: MMF to SMF Transition



- SMF surpasses MMF volume:
  - 1G:2013, 10G: ~2018
- Key form factors – SFP, SFP+

MMF starts earlier and ramps faster

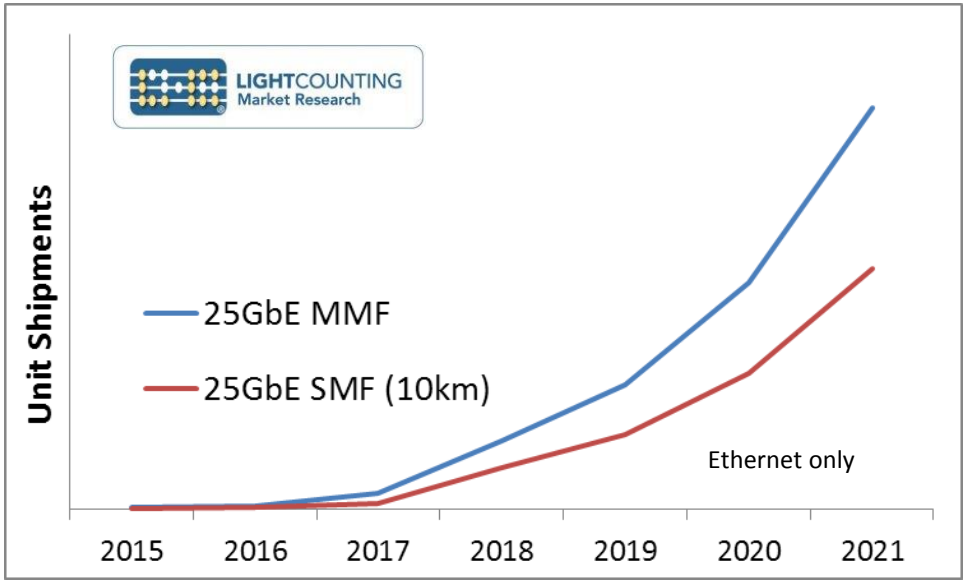
New applications, longer runs drive transition to SMF later in life cycle



LightCounting "High Speed Datacenter Optical Interconnects Report" (June'15)

25GbE: MMF to SMF Transition

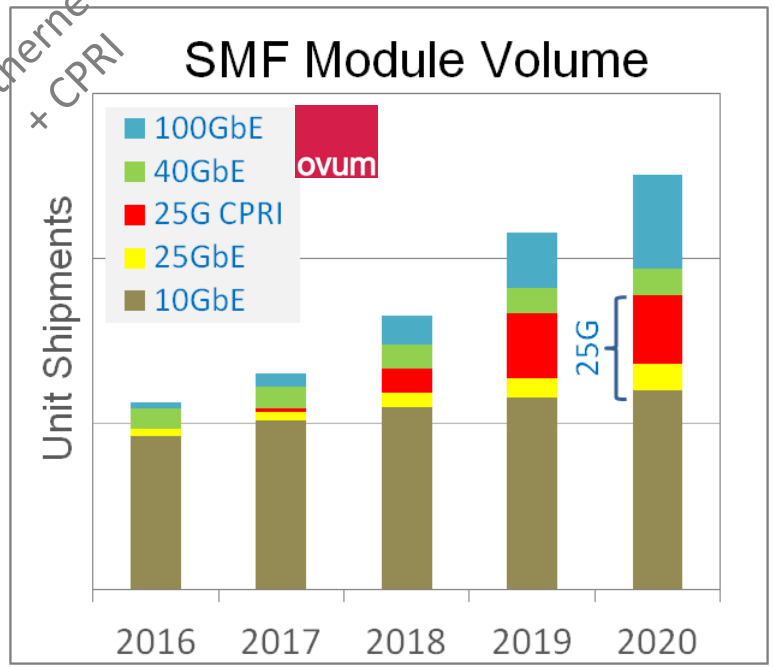
- Like 1GbE/10GbE, 25GbE MMF starts earlier and ramps faster.
- Things to think about:
  - 10GbE MMF reach is 400m
  - 25GbE MMF reach is 100m
  - *25GbE SMF transition could be faster than 10GbE*
- Key form factor – SFP28



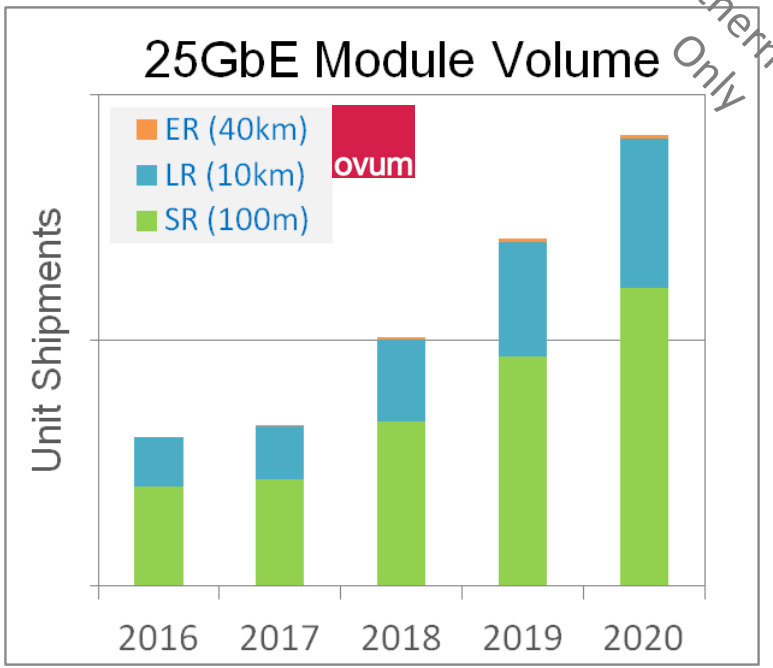
LightCounting "High Speed Datacenter Optical Interconnects Report" (June'15)

25G Module Forecast

Ethernet + CPRI



Ethernet Only



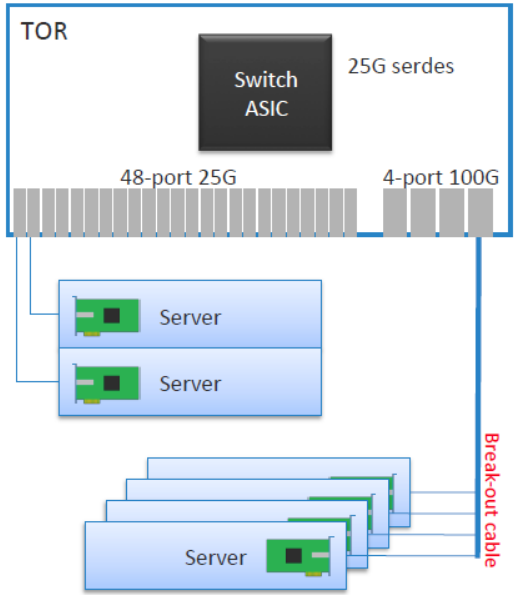
By 2020, 25G SMF volume (Ethernet+CPRI combined) is forecast to be ~25% of total SMF volume

Ovum "Total OC Forecast Spreadsheet: 2014-2020" (August 2015)

“Stop me if you’ve heard this before” - Part 1

25Gb/s Ethernet Connectivity

- Enables similar topology as 40Gb/s & 10Gb/s
  - Single 25Gb/s SFP28 port implementation or Quad 25Gb/s QSFP28 breakout implementation possible
  - Maximizes ports and bandwidth in ToR switch faceplate
  - Dense rack server
  - Within rack, less than 3m typical length



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IEEE 802.3 Call For Interest – 25Gb/s Ethernet over a single lane for server interconnect – July 2014 San Diego

25GbE CFI: www.ieee802.org/3/cfi/0714_1/CFI_01_0714.pdf

Different for Campus:

- On downlink, “Server” becomes “Access Switch”
- Reach is longer

Same for Campus:

- Moving to 25Gb/s optimizes switch design

“Stop me if you’ve heard this before” - Part 2

25Gb/s I/O Efficiency

- Switch ASIC Connectivity limited by serdes I/O
- 25Gb/s lane maximizes bandwidth/pin and switch fabric capability vs. older generation
- Single Lane port maximizes server connectivity available in single ASIC
- 25Gb/s port optimizes both port count and total bandwidth for server interconnect

For a 128 lane switch:

Port Speed (Gbps)	Lane Speed	Lanes / port	Usable ports	Total BW (Gbps)
10	10	1	128	1280
25	25	1	128	3200
40	10	4	32	1280
40	20	2	64	2560
100	25	4	32	3200

Using 25Gb/s ports maximizes connectivity and bandwidth.

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Different for Campus:

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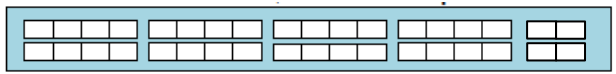
Same for Campus:

- Moving to 25Gb/s optimizes ASIC price performance

Enterprise Switching – Rate Evolution

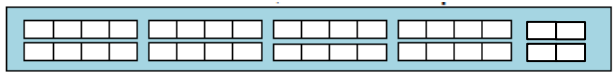
2014

Distribution



48x10GbE down, 4x40GbE up

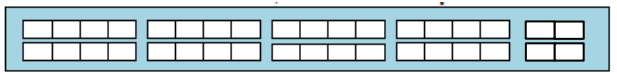
Access



48x1000BASE-T down, 4x10GbE up

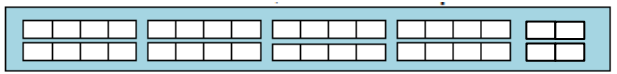
~2017/18

Distribution



48x*25GbE* down, 4x*100GbE* up

Access

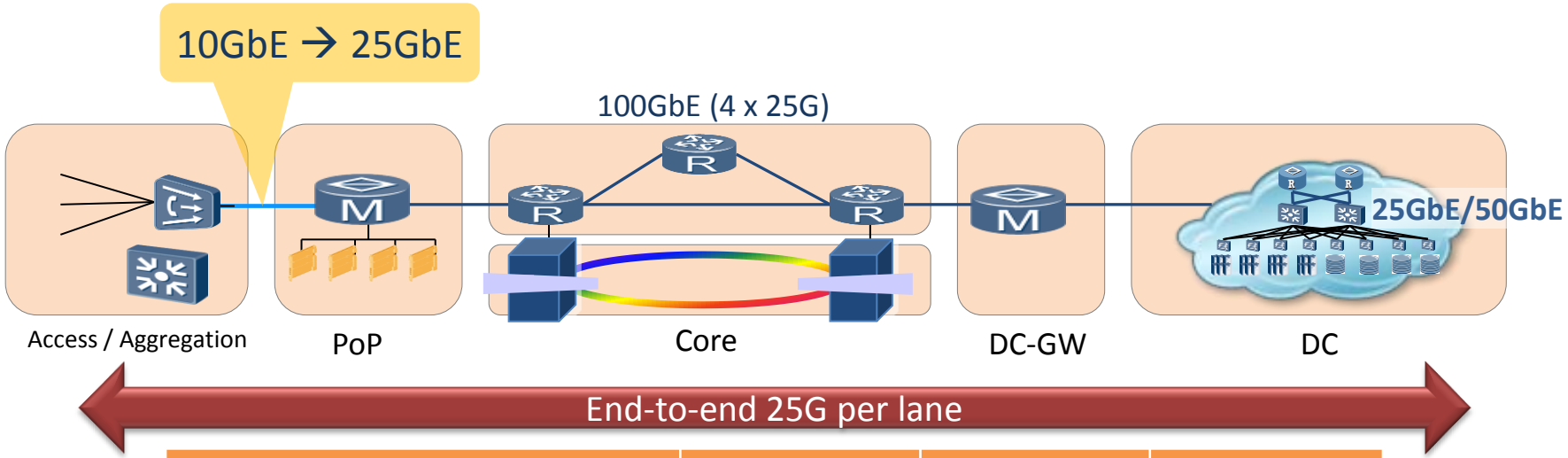


48x*2.5GBASE-T* down, 4x*25GbE* up

- 2.5X rate, same network model
- Fits nicely with 802.3bz 2.5G/5GBASE-T

Metro-Access – Rate Evolution

- Core moving to 100GbE (4 x 25G)
- Simpler system, lower cost, lower power



Current Interconnect Distance	10km	40km	80km
Fixed Broadband Network	60-70%	20%	<5%
Mobile Broadband Network	45%	45%	10%

Courtesy: Huawei

Market Drivers Summary

- 25GbE is the natural successor to 10GbE
- 25GbE ecosystem is missing a story for > 100 meters
- Enterprise, Metro and other markets need longer reach
- Leveraging 25G lane rates with 25GbE/100GbE just makes sense

Technology Feasibility

25GbE SMF PMD

Kohichi Tamura, Oclaro

Existing Standards Work (Electrical)

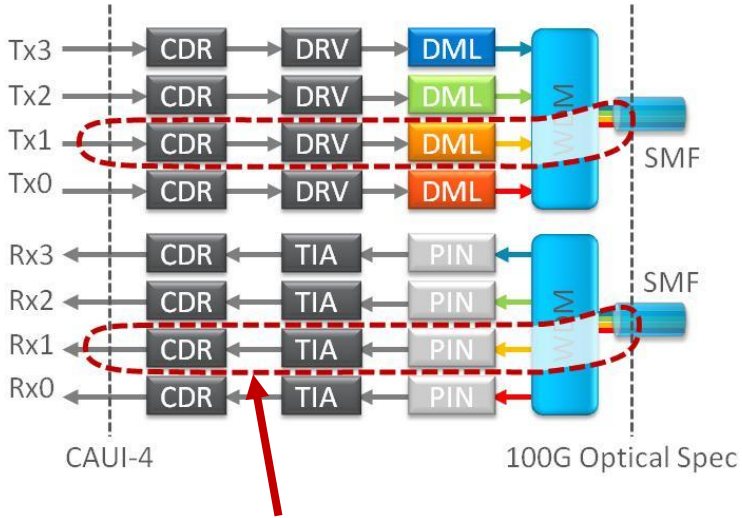
The 25GAUI chip-to-module (C2M) and 25GBASE-R RS-FEC are fully specified for 25 Gb/s operation in P802.3by.

25GAUI C2M specified in Annex 109B in P802.3by.

25GBASE-R RS-FEC specified in Clause 108 of P802.3by.

25G Leverages 100G Subcomponents

- 100GbE modules are 4 lanes of 25G (4x25G)

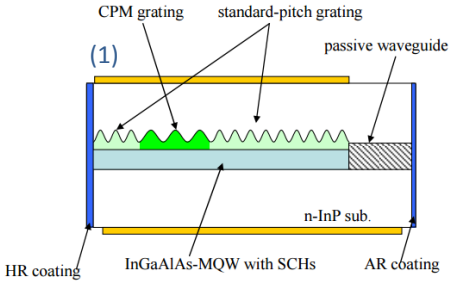


- Key subcomponents for 25G already developed:
  - Tx: Direct modulation laser (DML)
  - Tx: Electro-absorption modulated DFB laser (EML, EA-DFB)
  - Tx: MZ modulator (SiP, InP)
  - Tx: Driver amplifiers (DRV - current or voltage)
  - Rx: PIN photodiode (PIN)
  - Rx: Avalanche photodiode (APD)
  - Rx: Trans-impedance amplifier (TIA)
  - Tx/Rx: Clock-data recovery (CDR)

One 25G lane is scope of this CFI (lane selection is only to illustrate).

Many Choices Of 25G Optical Transmitter

DML



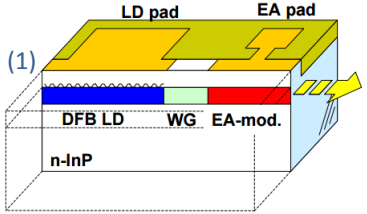
(2)

	Lane 0 (1271nm)	
	25°C	85°C
BTB	(a)	(b)
11.4km	(e)	(f)

Note: Temperature is at submount.

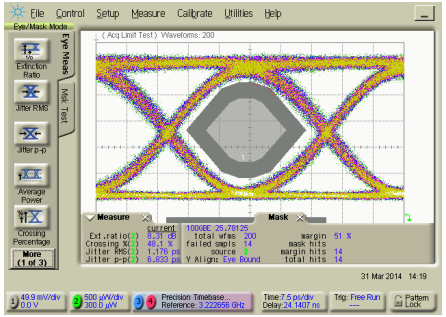
Reference:
(1) K. Nakahara et al., OFC 2013, OTh4H.3.
(2) T. Nakajima et al., OFC 2015, Th1G.6.

EML



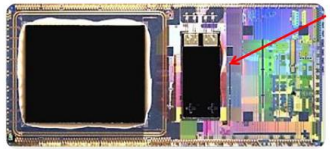
EA modulator: 100 μm
DFB laser: 400 μm

(2)

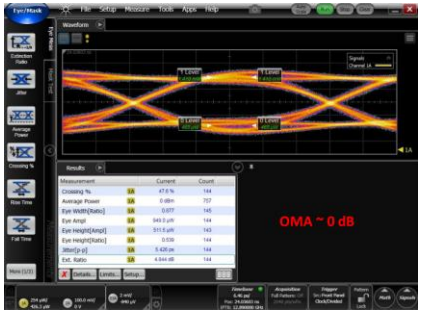


Reference:
(1) http://www.ieee802.org/3/ba/public/mar08/traverso_02_0308.pdf
(2) Oclaro internal data

SiP



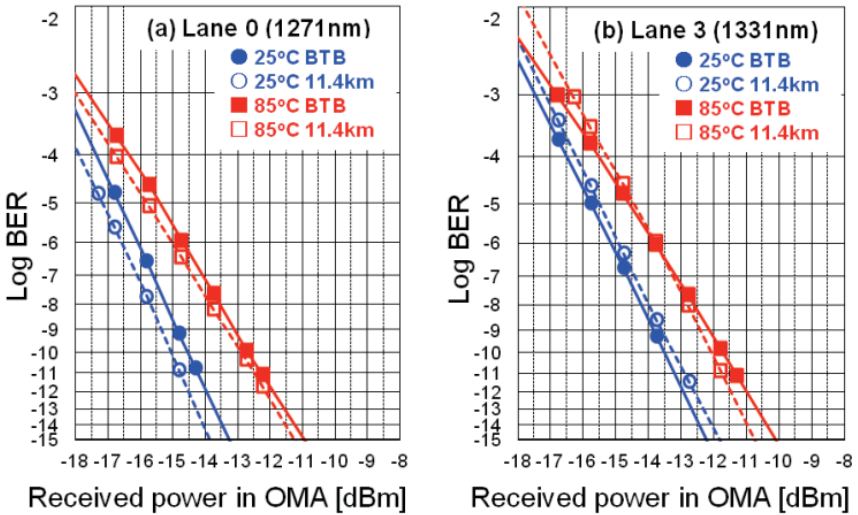
4x25 Gbps PSM4 Chipset



Reference:
http://www.ieee802.org/3/bs/public/adhoc/smf/14_10_14/welch_01_1014_smf.pdf

Long Reaches At 25G With PIN And APD Receivers

10km

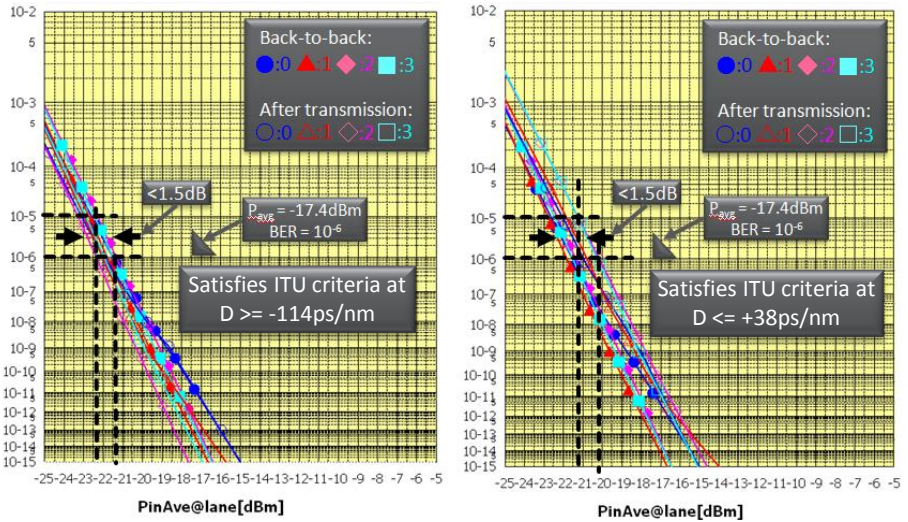


Note: Temperature is at submount.

- DML TOSA + PIN ROSA
- CWDM4 wavelength band

Ref: T. Nakajima et al., OFC 2015, Th1G.6

40km



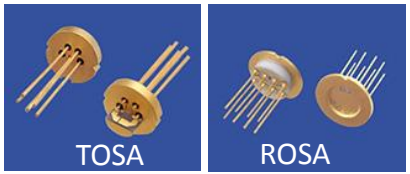
- EML TOSA + APD ROSA
- LR4 wavelength band

Ref: Submitted to ITU-T SG15 for 4L1-9D1F G.959.1, WD06-xx. (Courtesy Finisar & Oclaro).

Low Cost Optical Packaging At 25G

25G Serial (TO-CAN)

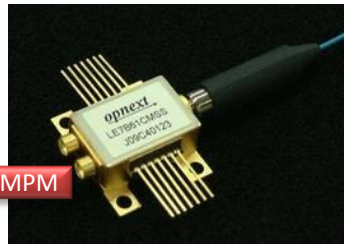
TO-CAN TOSA
- BW to 28G
(Courtesy: Oclaro)



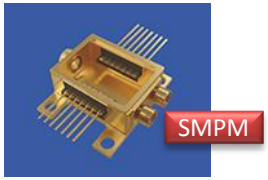
25G TO Headers
(Courtesy: Kyocera)

Low cost packaging for 25G

40G Serial (XLMD)

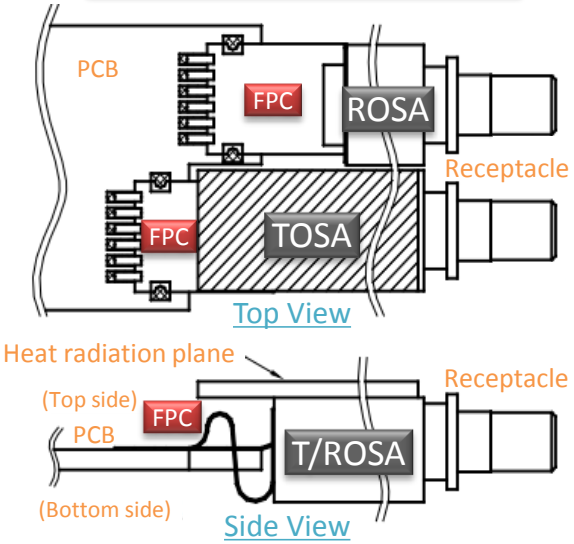


(Courtesy: Oclaro)



40G XLMD Package
(Courtesy: Kyocera)

Next Gen 40G Serial (XLMD2 - future)



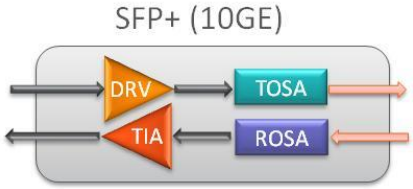
Ref: www.xlmd-msa.org

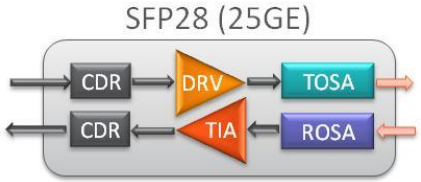
Packaging costs still high for 40G serial

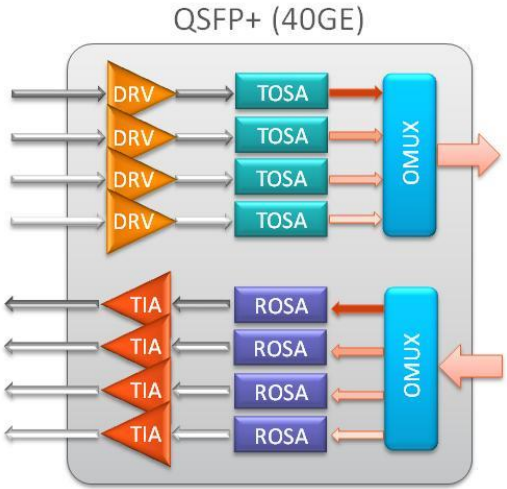
LR Module Structure Comparison

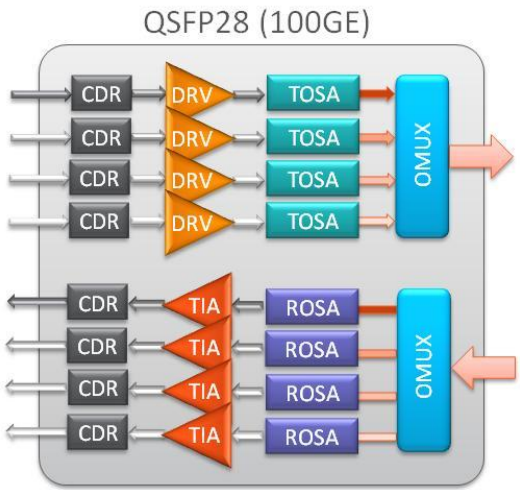
SFP

QSFP









LR Transceiver Comparison

LR Transceiver Comparison	10GbE	25GbE	40GbE	100GbE
Size	SFP+	SFP28	QSFP+	QSFP28
Modulation	NRZ	NRZ	NRZ	NRZ
Lane scheme	1 x 10G	1 x 25G	4 x 10G	4 x 25G
Optical MUX	No	No	Yes	Yes
TEC	No	No	No	Yes
CDR	No	Yes	No	Yes
Power	1W	< 1.5W	3W	< 4.5W
mW/Gbps	100	< 60	75	< 45

Note: LR = 10km reach

Summary of 25GbE SMF Technical Feasibility & Application Potential

- 25G is a proven and established technology.
- 25G is the next higher serial rate after 10G.
- 25G matches native port speed of next generation ASICs.
- Single lane serial optics gives lowest cost- and power-per-Gbps.
- Leverage SFP28 (SFF-8402) form factor.
- Many related applications already exist:
  - 500m: PSM4
  - 2km: CWDM4, CLR4
  - 10km: 32GFC, 100GBASE-LR4
  - 40km: 100GBASE-ER4, 100GBASE-ER4f
  - CPRI: Leverages 1GbE/10GbE optics. 25GbE should be the same.

Why Now?

25GbE SMF PMD

David Lewis, Lumentum

Why Now?

- 25GbE is the best choice as the next step after 10GbE for SMF transceivers
  - Single lane solutions with lower cost structure than alternative multi-lane PMDs
  - Particularly targeted at cost sensitive markets that don't yet need 40GbE to 100GbE speeds
  - Re-use technologies to reduce cost

- 25GbE SMF is needed now to complete the 25GbE ecosystem
  - Twisted pair
  - PCB backplane
  - Copper cables
  - MMF
  - SMF – No standard available yet

- High volume spaces (e.g., enterprise) is looking to adopt 25GbE – requires reaches > 100m
  - Standardization required now in order to enable market adoption

Contributors and Supporters (1/2)

75+ individuals
50+ companies

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Alan Tipper, Semtech
Ali Ghiasi, Ghiasi Quantum
Amrik Bains, Cisco
Arnold Sodder, Mercury Systems
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Scott Kipp, Brocade
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Takeshi Nishimura, Yamaichi Electronics
Thananya Baldwin, Ixia
Theo Brillhart, Fluke
Tom Palkert, Molex
Tomoo Takahara, Fujitsu Optical Components
Venu Balasubramonianm, Marvell
Vineet Salunke, Cisco
Vipul Bhatt, Inphi
Wenyu Zhao, CAICT
Yasuaki Kawatsu, Hitachi Metals
Yong Kim, Broadcom
Yoshikazu Tanaka, Mitsubishi Electric
Zhigang Gong, O-Net

Q&A

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Kohichi Tamura	Oclaro
Peter Jones	Cisco

Expert Panel

Paul Kolesar	CommScope
David Malicoat	HPE

Straw Polls

Call-for-Interest Consensus

- Should a study group be formed for “25 Gigabit/s Ethernet PMD(s) for single mode fiber”?

- Y: N: A:

- Room count:

Participation

- I would participate in a “25 Gigabit/s Ethernet PMD(s) for single mode fiber” study group in IEEE 802.3
  - Tally:

- My company would support participation in a “25 Gigabit/s Ethernet PMD(s) for single mode fiber” study group
  - Tally:

Future Work

- Ask 802.3 at Thursday's closing meeting to form study group

- If approved:
  - 802 EC votes on Friday to approve the formation of the study group
  - First study group meeting would be during the January 2016 802.3 interim meeting (in Atlanta)

End