4X25G Optical Modules and Future Optics

EA Panel Moderator

Daniel Dove - Applied Micro

ethernet alliance

The views expressed today on this presentation are the personal views of the participants and should not be considered the views or positions of Ethernet Alliance

Panel Speakers & Topics

- Dan Dove, Applied Micro
  - IEEE 802.3™ Optical Standards Update
- Brad Booth, Dell
  - Short Reach Optics for Data Center Racks
- Jeffery Maki, Juniper
  - 100G link infrastructure requirements to support future 400G PMDs
- Matt Traverso, Cisco
  - Next Generation Optics - Advanced Modulation

IEEE 802.3 Standards

ethernet alliance

IEEE 802.3bm

- Next Generation 40 Gb/s and 100 Gb/s Optical Ethernet
  - Defining 40GBASE-ER4 (40km) solution
  - Defining 100GBASE-SR4 solution
  - Defining 100GBASE-nR4 solution
  - Defining a 4x25G Electrical Interface CAUI-4

Industry Connections (at the end of presentation)

- Bandwidth Assessment Ad hoc
  - Identified industry trends and bandwidth growth
- Consensus Building for Higher Speed of Ethernet
  - Forum for building consensus towards an 802.3 Call For Interest

40GBASE-ER4

ethernet alliance

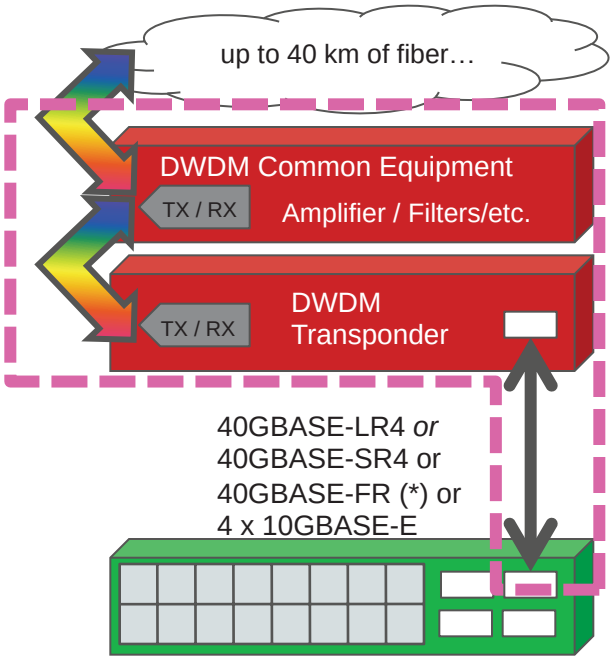
Plan to modify Clause 87 to enable 40 km reach

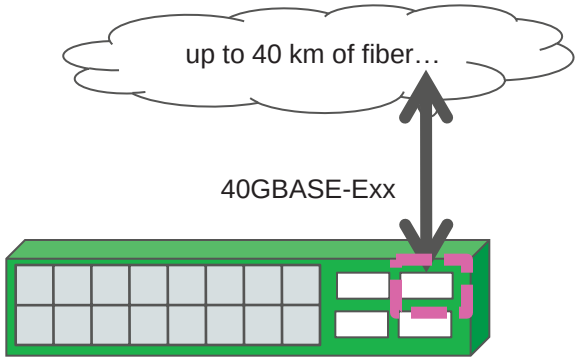
- Allow low cost 40G adoption in metropolitan applications
- CWDM grid leveraged from 40GBASE-LR4
- Anticipate early baseline proposal to allow industry adoption with low risk of change
- Anticipate stable parameters early in 2013

40GBASE-ER4

ethernet alliance

A 40km 40GBASE standard can simplify networks





Existing Solution – bulky & costly

- Requires sophisticated user base
- Requires additional equipment
- Optimized for '00s to '000s of km

Proposed Solution – simple…

- New PMD only
- Lack of point to point definition in telecom allows for additional Ethernet application

* Added 40GBASE-FR

Ref: cfi_0312_2.pdf

CAUI-4

ethernet alliance

100G (C) Attachment Unit Interface

- Four lanes @ 25G data rate
- Reduces width/cost/power of I/O to module
- Potentially will leverage OIF CEI-VSR-28G
- Common electrical channel with 802.3bj
  - Single host budget for copper cables, optics

Fundamental to reducing cost/power and increasing density of 100G optics

- Eliminates need for 10:4 mux/demux (aka: Gearbox) in optical modules

100GBASE-SR4

ethernet alliance

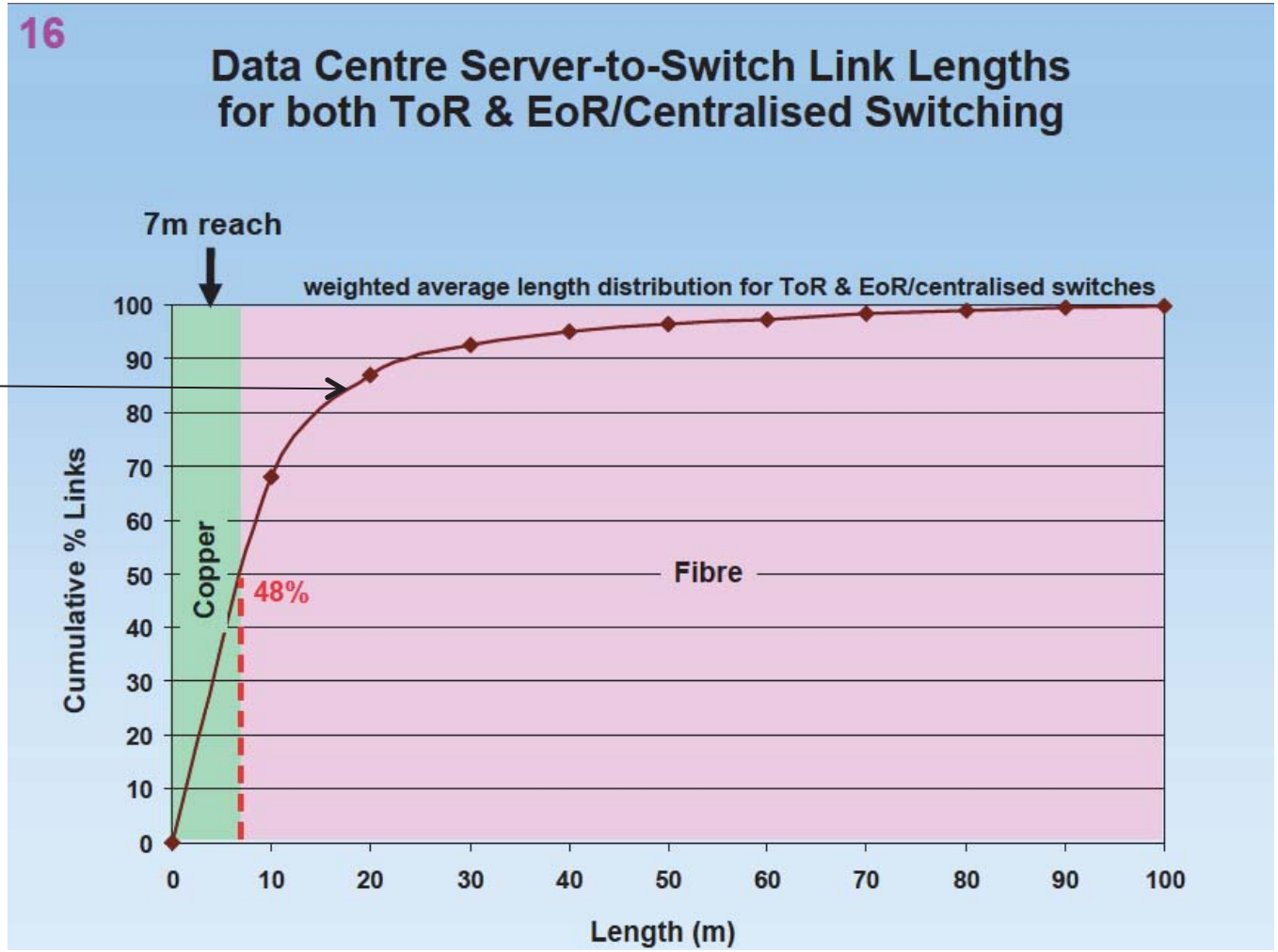
4x25G optical interface for MMF

- Compatible with new 25G I/O
- Reduce cost, power of transceivers, solution
- Reduce # of fibers per link
- Focus on Data Center application
  - May be a single PMD capable of >100m
  - May be two PMDs, one shorter reach (>20m) cost-focused and one >100m
  - Task Force will decide based on cost/performance difference between longer/shorter reach alternatives

100GBASE-SR4

ethernet alliance

85% or more server/switch ports are < 20m



Ref: flatman_01_0311_NG100GOPTX.pdf

100GBASE-SR4

ethernet alliance

Areas for consideration

- Equalization; To compensate for BW limitations of VCSELs, PDs, TIAs, traces
- Forward Error Correction (FEC); To increase reach while maintaining BER
- Mode Partition Noise – Effects of higher speed links on existing channel models
- Re-timed vs Un-retimed interfaces

100GBASE-nR4

ethernet alliance

4x25G optical interface for SMF

- Reduce cost, power of transceivers, solution
- Focus on Data Center application
  - May be a new PMD capable of ≥ 500m
  - May be LR4 with 4x25G electrical interface
  - Decision to add a new PMD will be based on cost
- Alternatives under consideration
  - Multi-pair (4x25G) SMF (eliminate TEC, optical mux/demux)
  - Complex Modulation (reduce optics, move $ to DSP)
  - CWDM grid spacing (eliminate TEC)

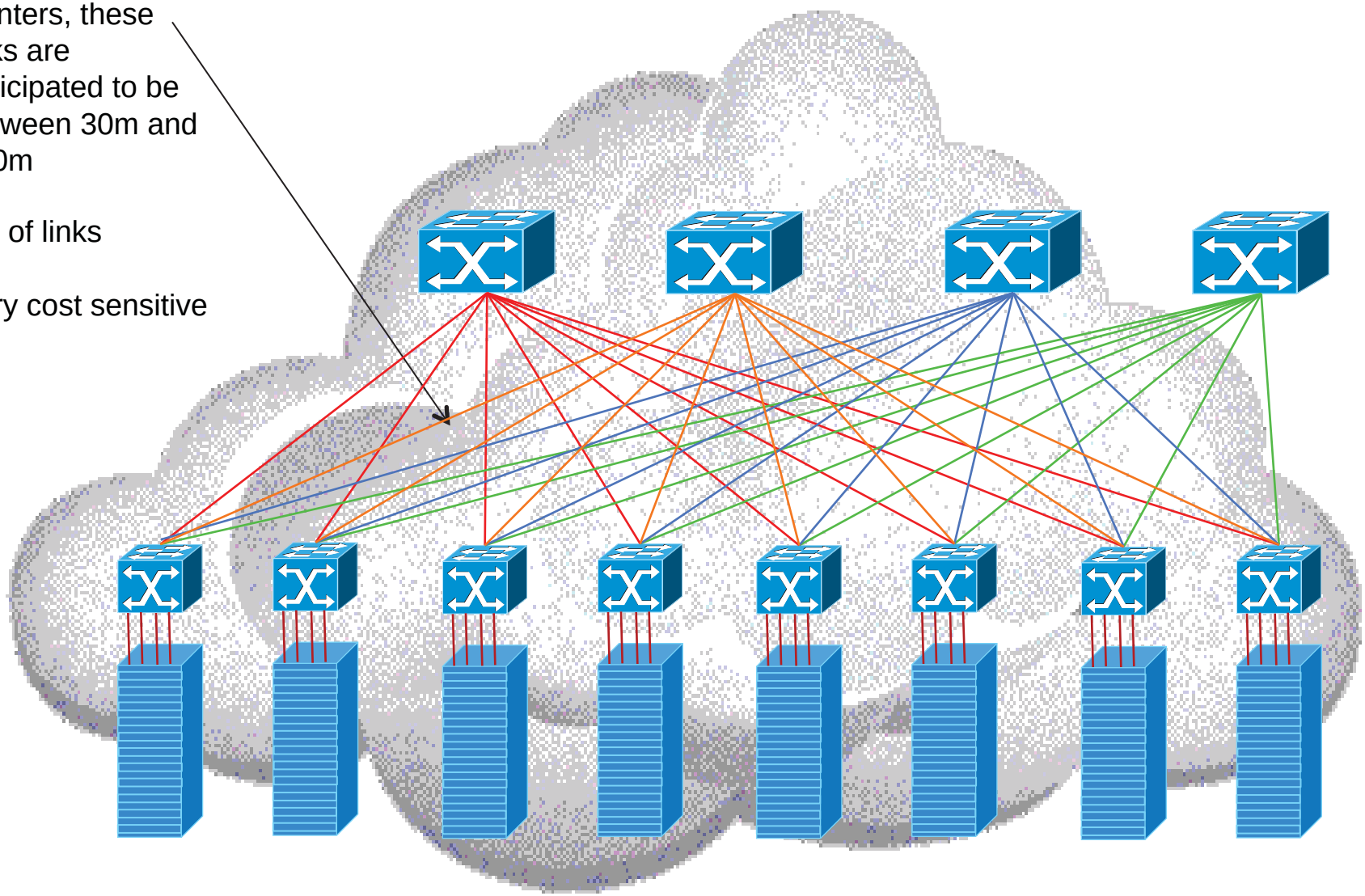
100GBASE-nR4

ethernet alliance

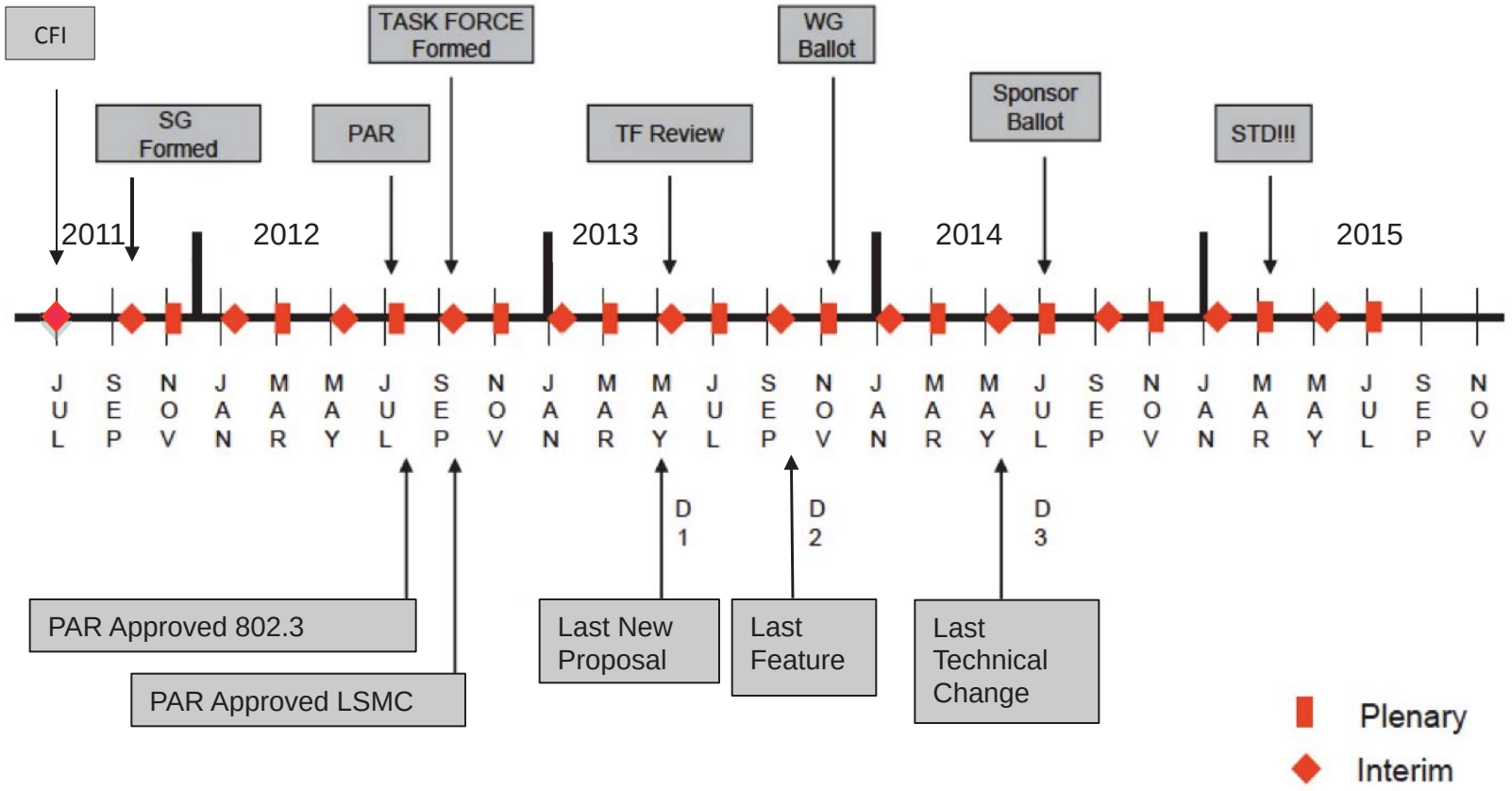
For Massive Data Centers, these links are anticipated to be between 30m and 500m

Lot of links

Very cost sensitive



P802.3bm Schedule (tentative)



ethernet alliance

Questions Will Be Taken at the end of all presentations

ethernet alliance

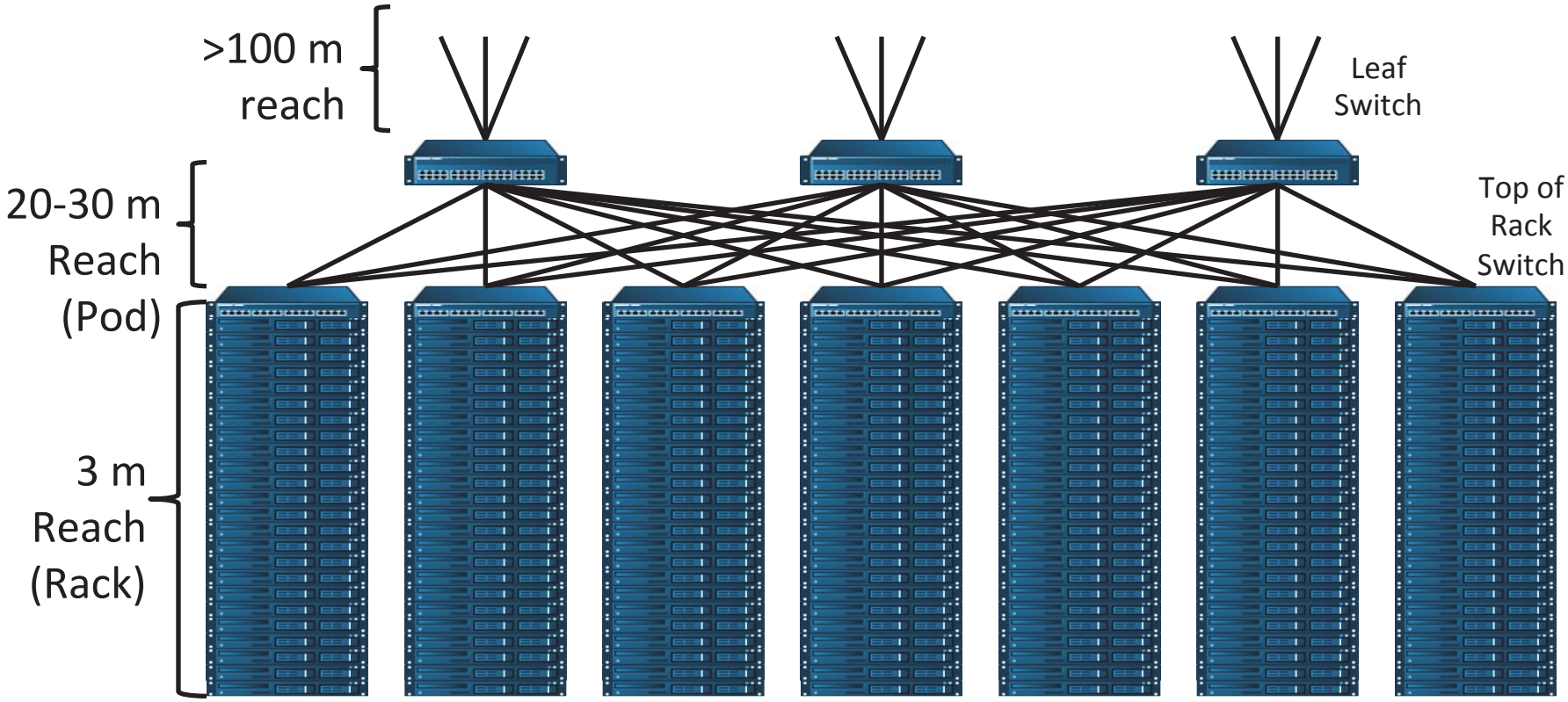
Short Reach Optics for Data Center Racks

Brad Booth

Dir., Network Architecture

Dell

Data Center Topology



Pod Examples

Open Compute Rack Example

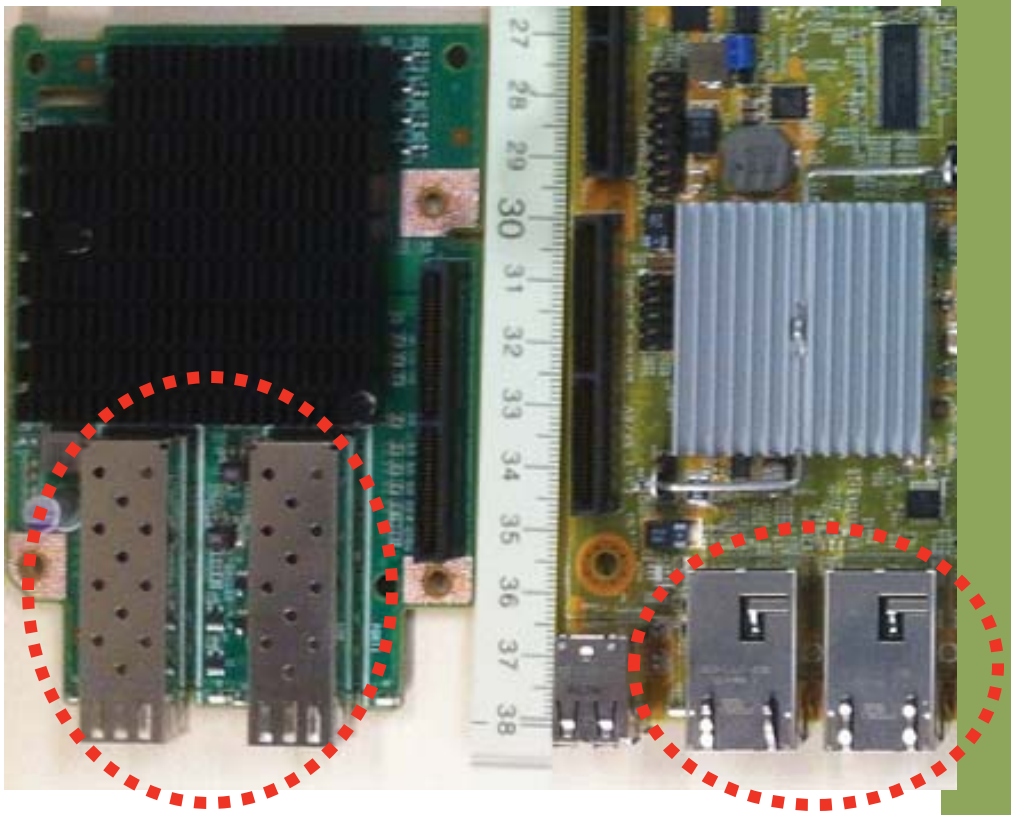
Server Motherboard

Optics require greater area

- SFP+ depth is 2x RJ45 MagJack

Server motherboard is space limited

- CPU and RAM get priority



* Measurements are in metric.

Optical Form Factors

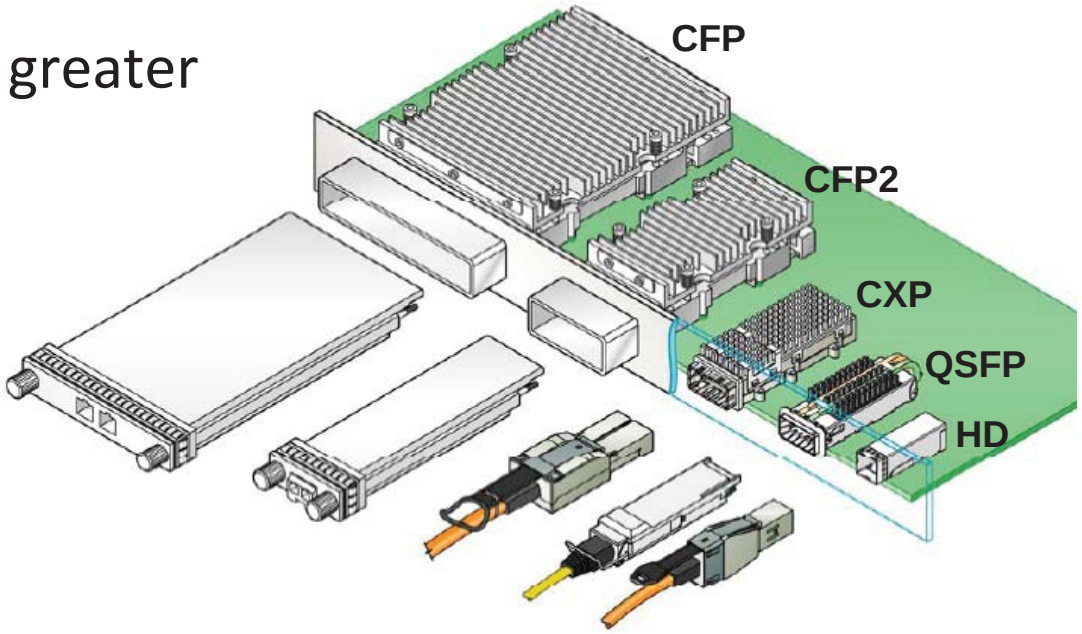
Not designed for server motherboards

Board area

- HD significantly better than other options

Faceplate protrusion

- CXP and HD far greater



* Diagram from http://tinyurl.com/8l8emdj

Server Connectivity Trends

ethernet alliance

Copper not keeping pace

- Increasing cable diameter to support higher data rates
- Shorter reach capabilities

Optics could be the future

- Not a simple win
- Form factors impediment to deployment on server motherboards

Optics into Data Center Racks

ethernet alliance

Standards based commodity

- Volume drives down price
- Interoperability fosters competition

Form factor

- MSA's typically used
- Size often dictated by broad module support
- Compact form factors needed to penetrate volume server market

ethernet alliance

Questions Will Be Taken
at the end of all presentations

ethernet alliance

100G Link Infrastructure Requirements to Support Future 400G PMDs

Jeffery Maki
Distinguished Engineer
Juniper Networks

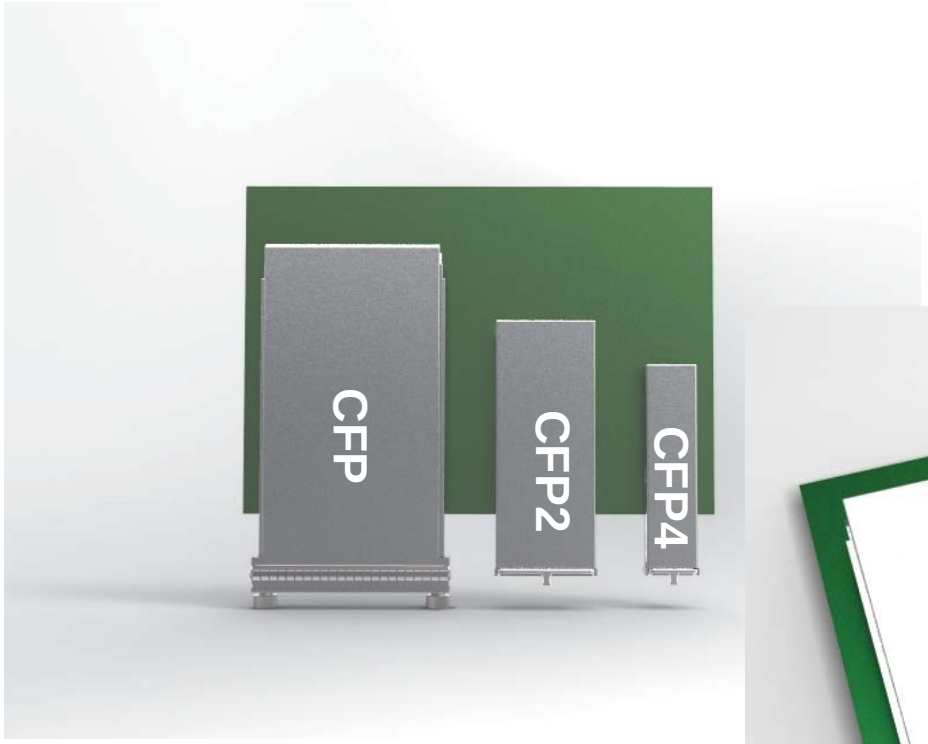
100GE

100G Ethernet Standard and Upcoming Standardization

ethernet alliance

PMD Support	10G Media Lanes	25G Media Lanes
Backplane	-none-	*100GBASE-KR4/KP4 (802.3bj-Draft Clause 93/94)*
Copper Cable Assembly	100GBASE-CR10 (802.3 Clause 85)	*100GBASE-CR4 (802.3bj-Draft Clause 92)*
MMF	100GBASE-SR10 (802.3 Clause 86)	*Two Objectives (NG 40G/100G SG)*
SMF (At least 500 meters)	-none-	*Objective (NG 40G/100G SG)*
SMF (At least 2 km)	-none-	-none-
SMF (At least 10 km)	-none-	100GBASE-LR4 (802.3 Clause 88)
SMF (At least 40 km)	-none-	100GBASE-ER4 (802.3 Clause 88)
SMF (At least 80 km)	-none-	-none-

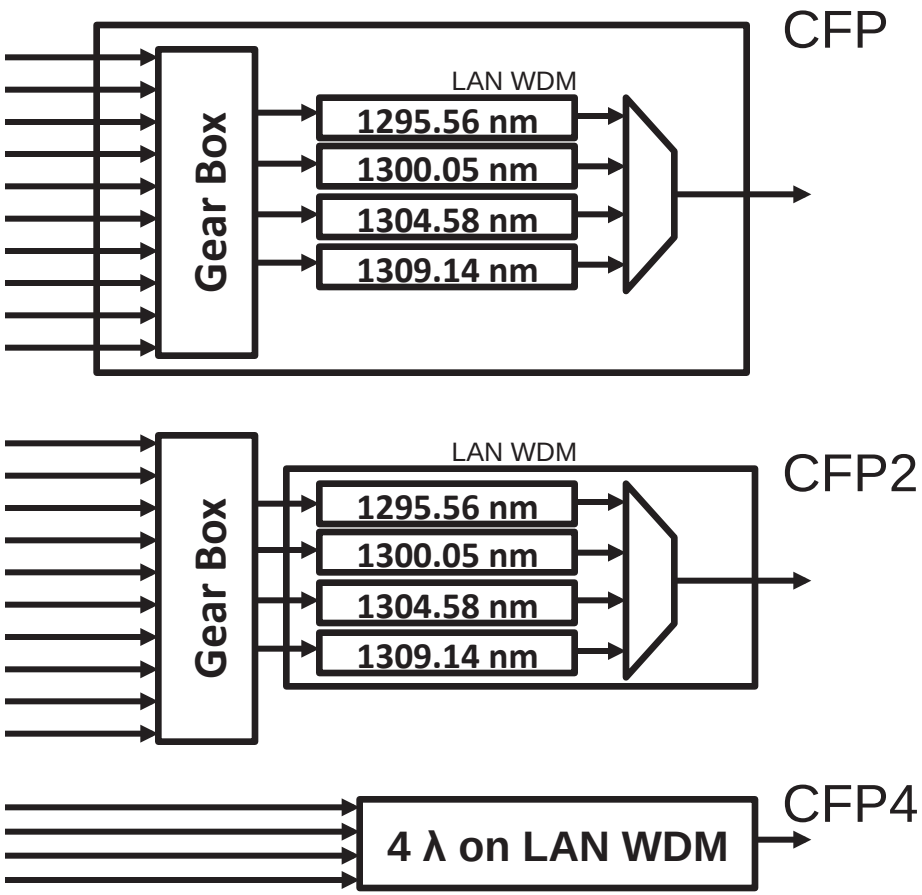
CFP(LC), CFP2(LC) and CFP4(LC) for SMF Applications



CFP MSA Form Factors:
http://www.cfp-msa.org/

Example: CFP, CFP2, and CFP4 for 100GBASE-LR4/ER4 SMF PMD

Transmit side only depicted.



100GBASE-nR4

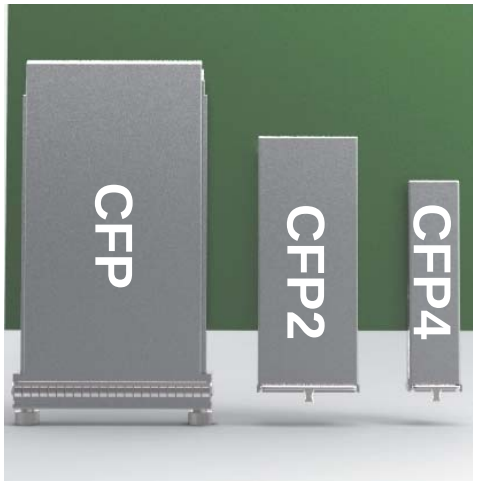
- A new **500-m** reach **SMF** PMD for 100GE is actively being considered in the 802.3 NG 40G/100G Optical Ethernet Study Group
- Character "n" is a place holder
- 100GBASE-LR4 is the current option

400GE

Projection of Form Factor Evolution to 400G

ethernet alliance

100G



defensible

speculation

400G

16x25G electrical lanes

8x50G electrical lanes

4x100G electrical lanes

Roman Numerals
XL = 40
C = 100
CD = 400

400G Optical Ethernet

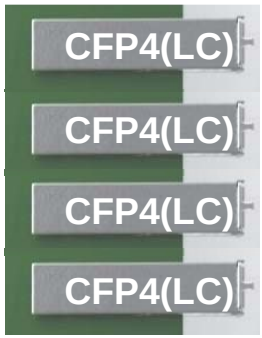
ethernet alliance

- First-generation PMDs have to be implementable that meet and eventually do better than these requirements
  - Size (Width): ≤ 82 mm (CFP width, ~4 x CFP4)
  - Cost: ≤ 4 x CFP4
  - Power: ≤ 24 W (4 x 6 W power profile of CFP4)
- Improved bandwidth density PMDs will need higher rate optical and/or electrical lane technologies such as 50 to 56 Gbps

Possible SMF Road Map: 100G, 400G, 1.6T

ethernet alliance

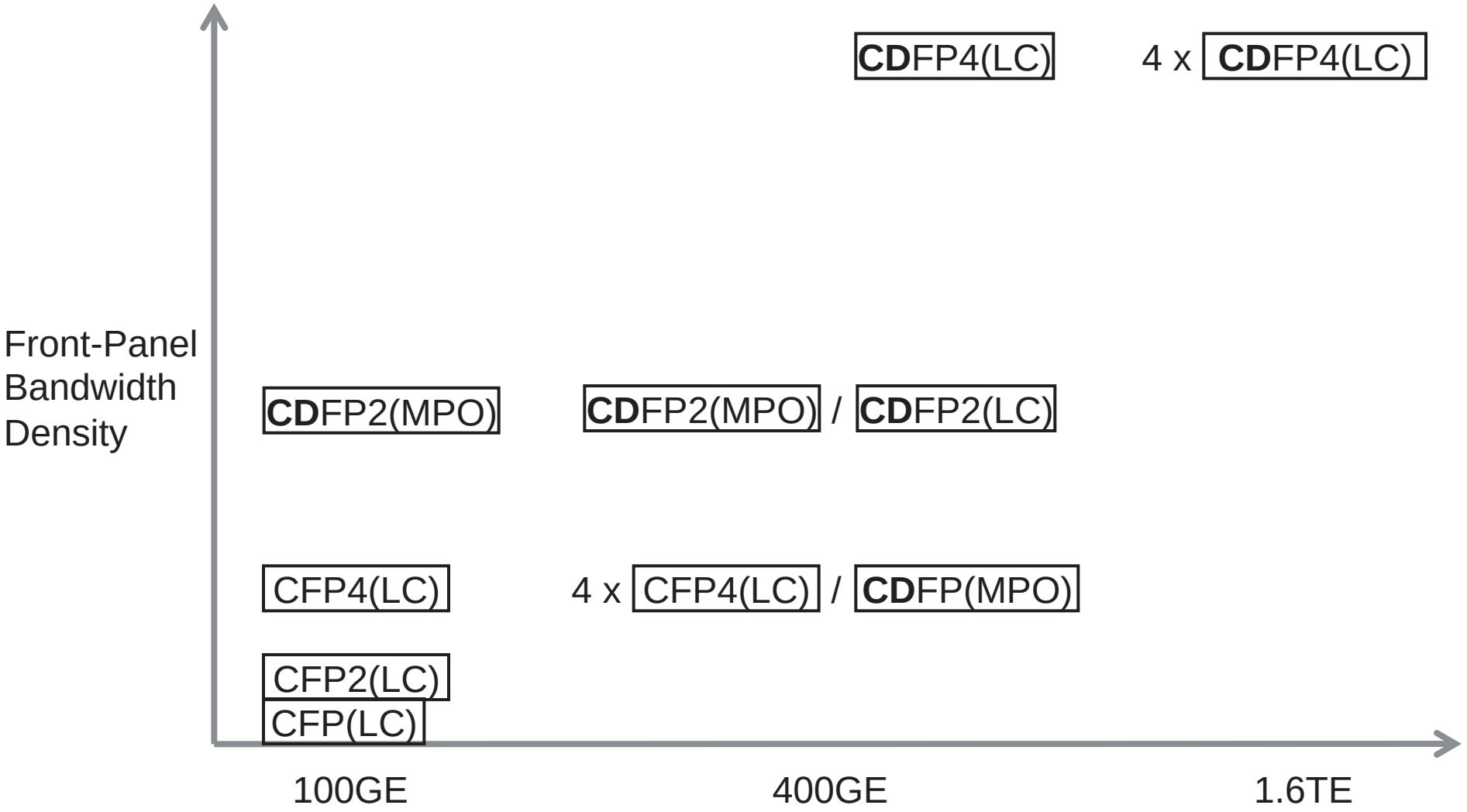
Early Adopter 400G	Mature 400G	Early Adopter 1.6T
4 x 100GBASE-nR4 or 400GBASE-PSM4	400GBASE-???	4 x 400GBASE-??? or 1600GBASE-PSM4



(High-Density 100GE)

Parallel Single Mode, 4 Lanes (PSM4)
4, Tx and 4, Rx
1x12 MPO Connector

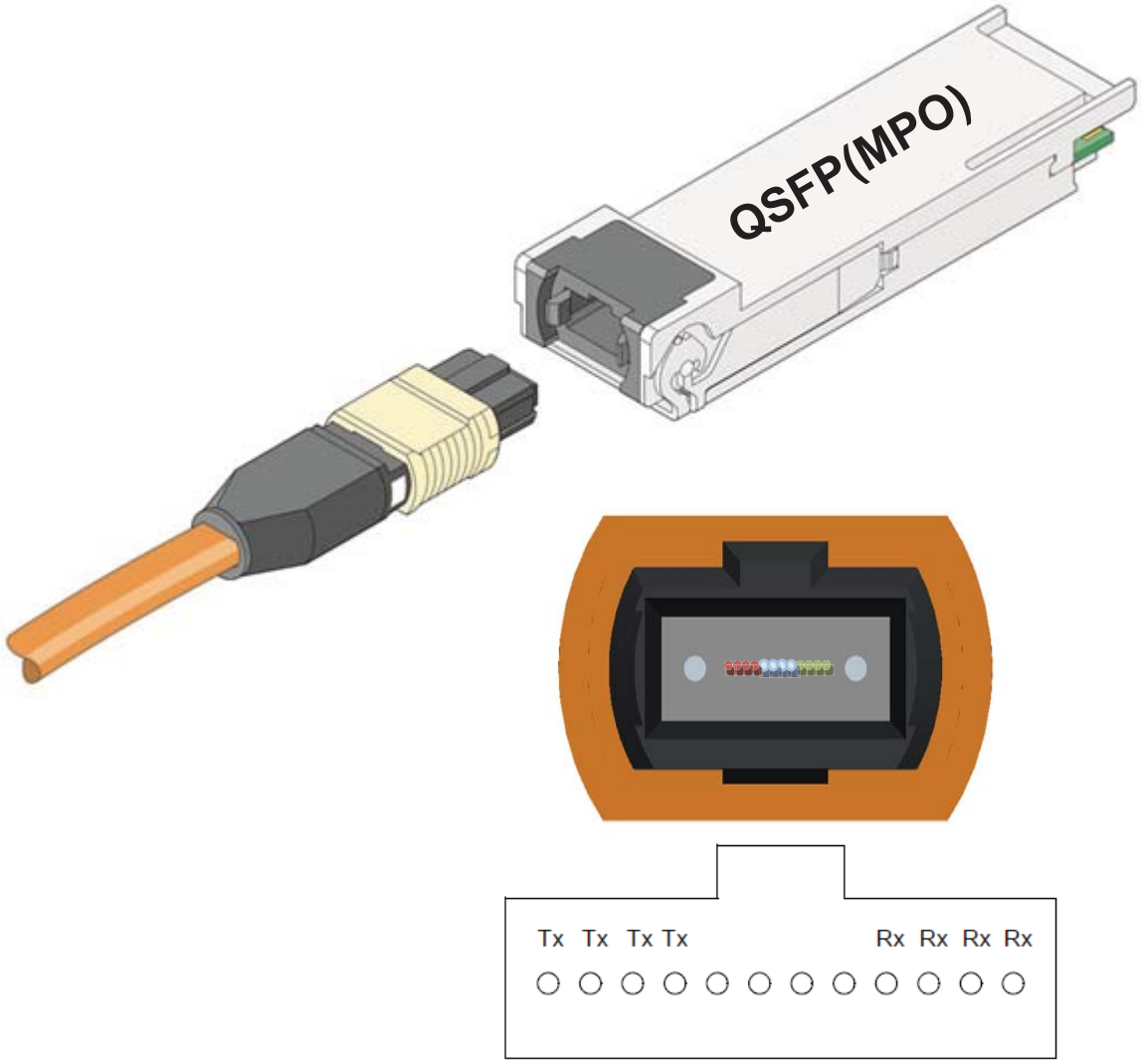
Density Road Map



ethernet alliance

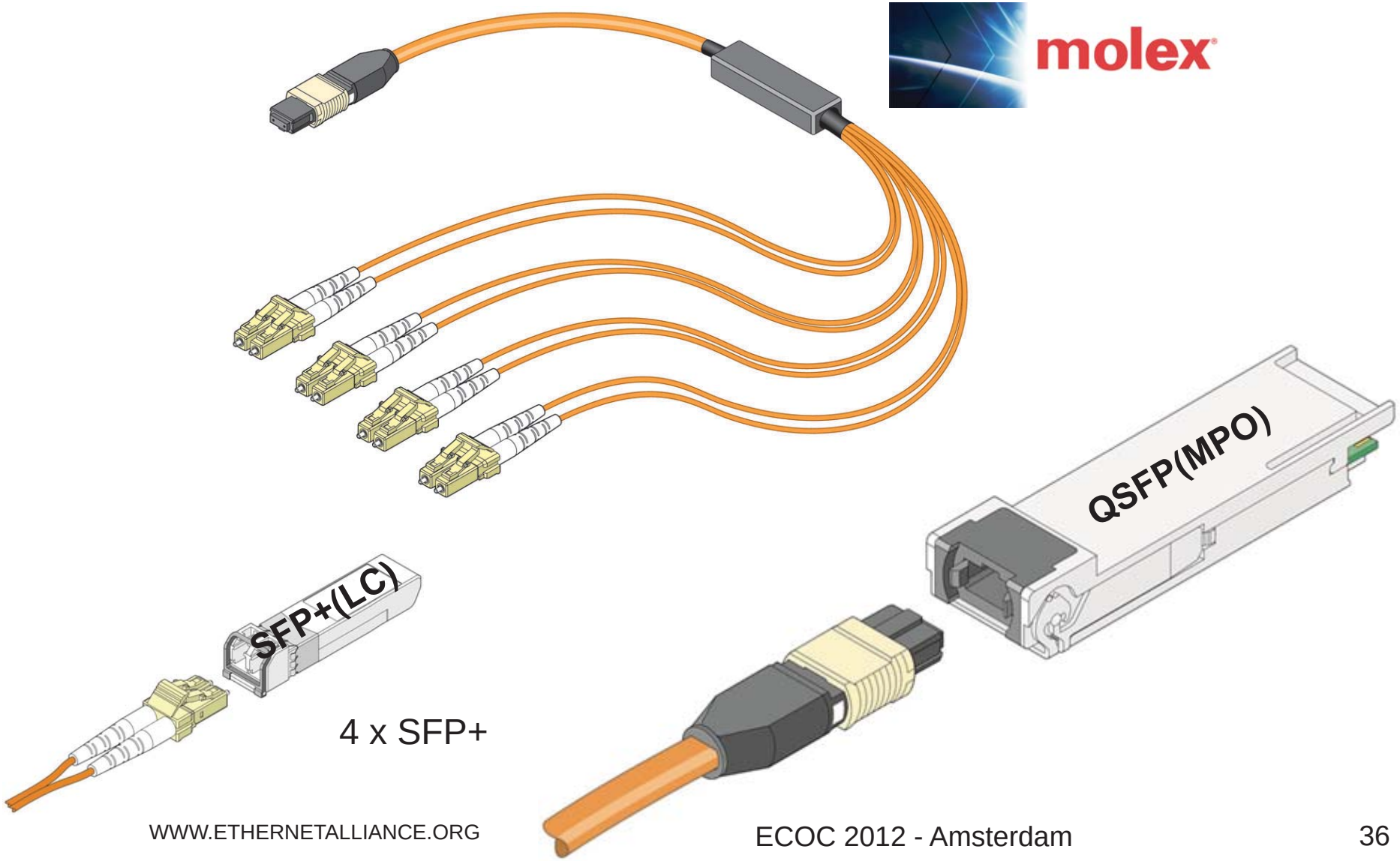
Parallel fiber Infrastructure

Paradigm Example: QSFP(MPO) for Parallel Fiber Applications



40GBASE-SR4

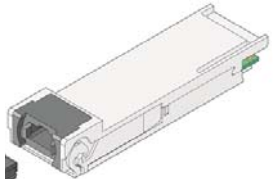
High-Density 10GE Based on QSFP(MPO): 4 x 10GBASE-SR



Example:
Structured Cabling for 10G/40G

ethernet alliance

QSFP(1x12 MPO)

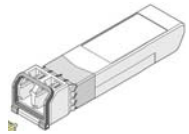


1 x 12 Fiber
Patch Cable

40G

2 x 12 Fiber
Trunk Cable

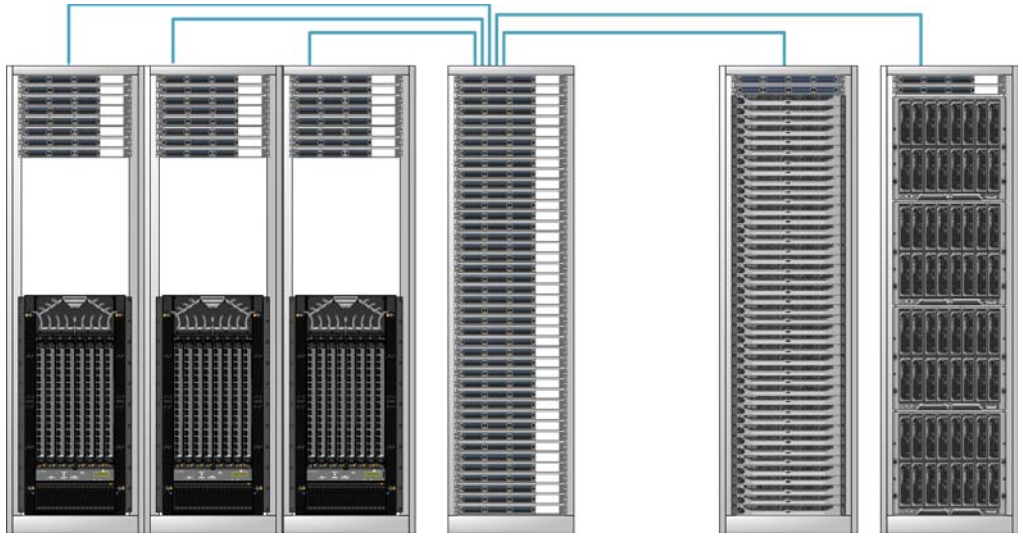
SFP+(LC Duplex)



10G

LC-Duplex
Patch Cable

TE connectivity



Use SMF
for 100G/
400G

Summary

- CFP MSA form factors for bandwidth evolution
- Early adopter 400GE using 100GE module and SMF cabling infrastructure
- Possible common module for 400GE and high-density (i.e., 4-port) 100GE

ethernet alliance

Questions Will Be Taken
at the end of all presentations

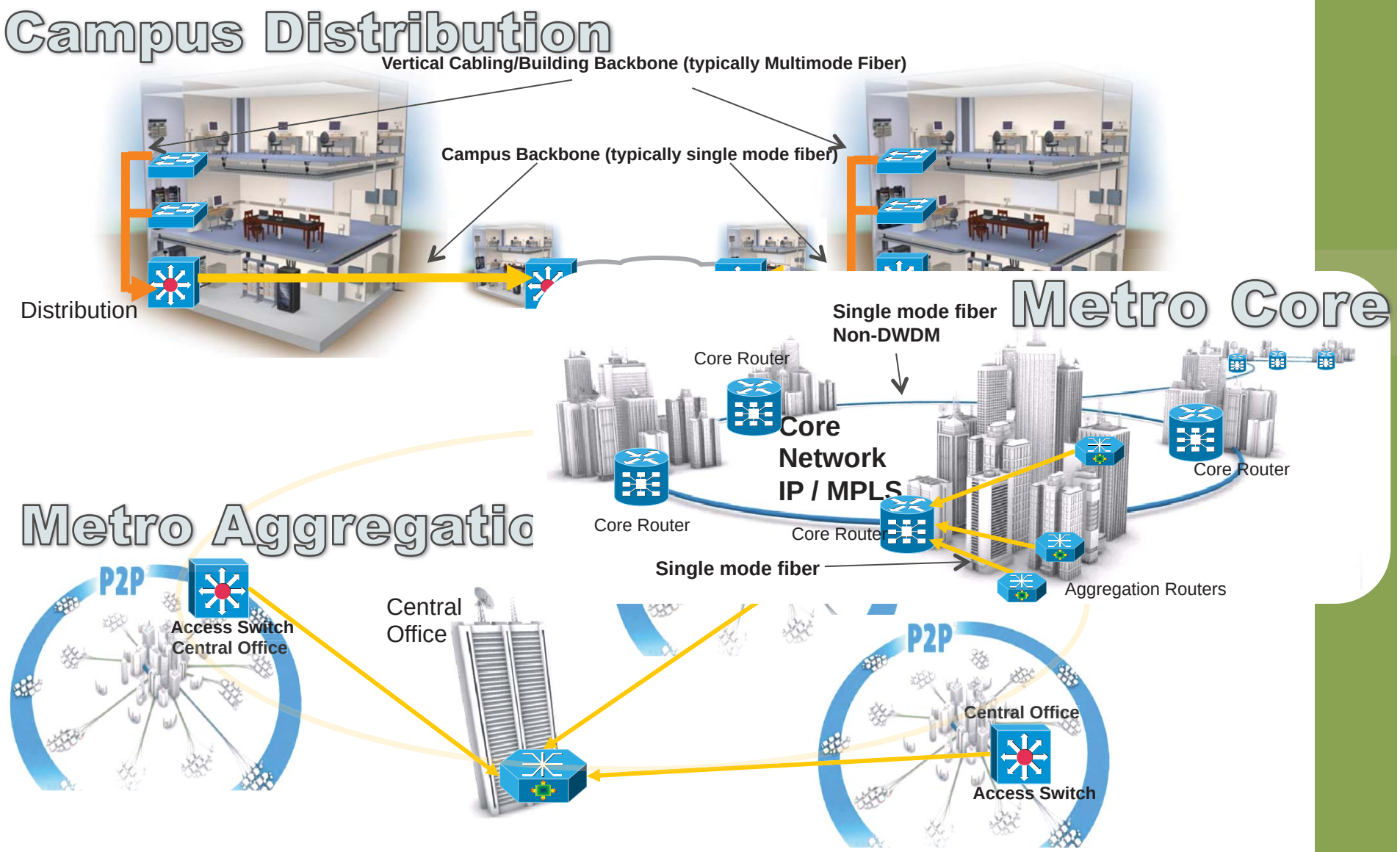
Next Generation Optics

Advanced Modulation

Matt Traverso

Beyond the Building

ethernet alliance



Too Far Beyond the Building
for this talk…

ethernet alliance

DWDM Application different than Client Optics

- Some Parameters are important for both
- Spectral/Transmission are critical for DWDM
- Density, Link Budget & Latency are critical for Client

	Client Optics	DWDM
Cost	3	3
Power	3	2
Size	3	2
Spectral Efficiency	0	3
Optical Filter Tolerance	0	3
Dispersion Tolerance	1	3
Latency	3	1
Port Density	3	1
Optical Loss Budget	3	1

Arbitrary Weighting of some interface parameters with 3 being "important" and 0 being "not important"

Advanced Modulation – what it is… (1)

ethernet alliance

Encoding widely used for Long Haul & Metro over the past few years

- 40G: Duobinary, DQPSK, QPSK, BPSK
- 100G: QPSK and more…
- Client Advanced Modulation has different drivers than Long Haul & Metro

At 100GE/802.3bm, IEEE is studying advanced modulation

Widely anticipated that beyond 100G – *Encoding is coming to client optics*

Client optics defined by their density

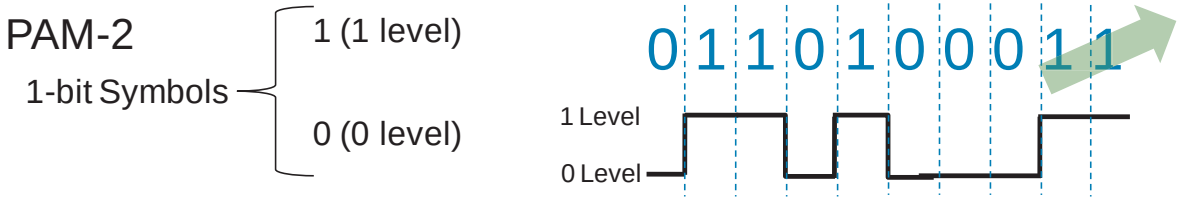
Cisco Nexus 3064

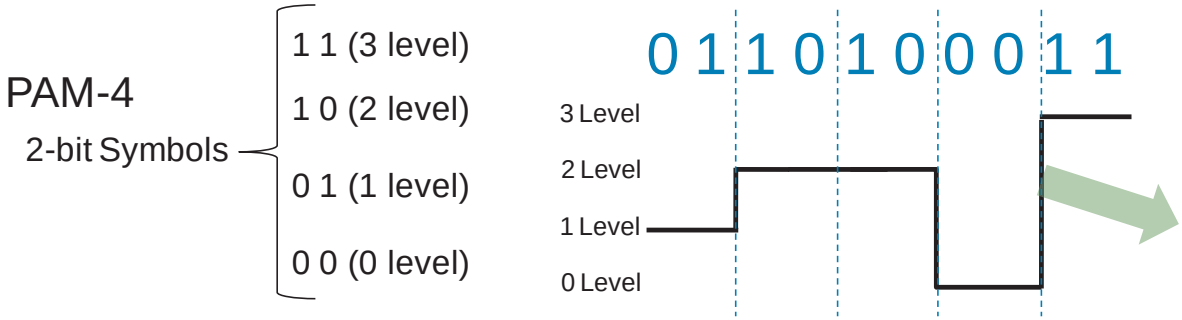
Advanced Modulation – what it is… (2)

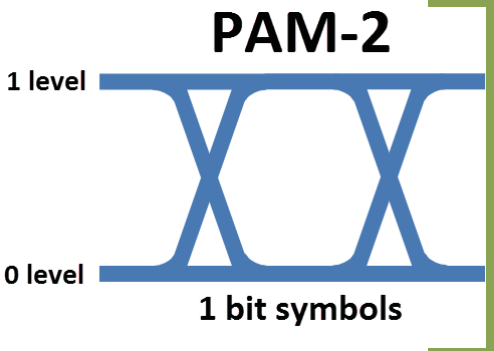
ethernet alliance

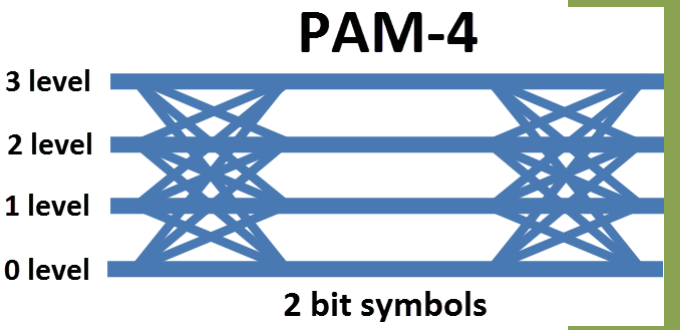
4 ways to increase optical data-rate:

- Increase the transmission frequency, or
- Increase the number of fibers, or
- Increase number of optical wavelengths, or
- Increase number of bits per symbol









Advanced Mod – Background and Drivers

Underlying assumption is that optical component count, associated packaging, and number of fibers are the dominant cost driver.

- *"Reduction of number of components is key to achieve the lowest cost solution for data center application" (Source: anderson_01_1111*)*

The goal of advanced modulation is to move complexity into the electronics in a attempt to simplify the optics,

It is anticipated that this reduction in optical component count and associated packaging complexity (ideally to a single laser and receiver) drives down the cost

*See: http://www.ieee802.org/3/100GNGOPTX/public/nov11/anderson_01_1111_NG100GOPTX.pdf

SAMPLE PROPOSAL @ JULY IEEE (1)

CUI_01_0712_OPTX.PDF *

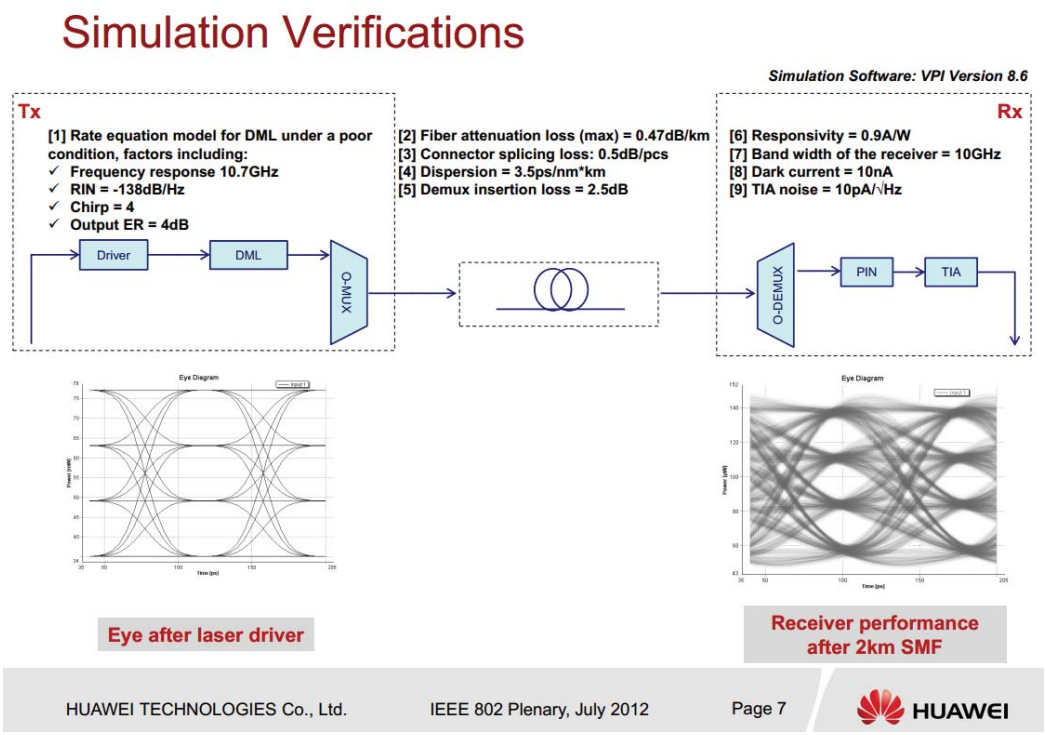
ethernet alliance

Proposal leverages WDM and Advanced Modulation to enable high bit rate transmission @ low cost

2 bits per Symbol

4 Wavelengths

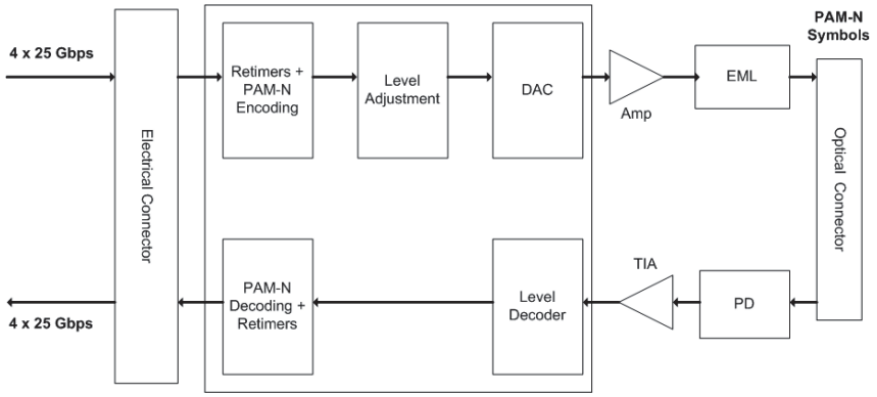
Use lower cost DMLs

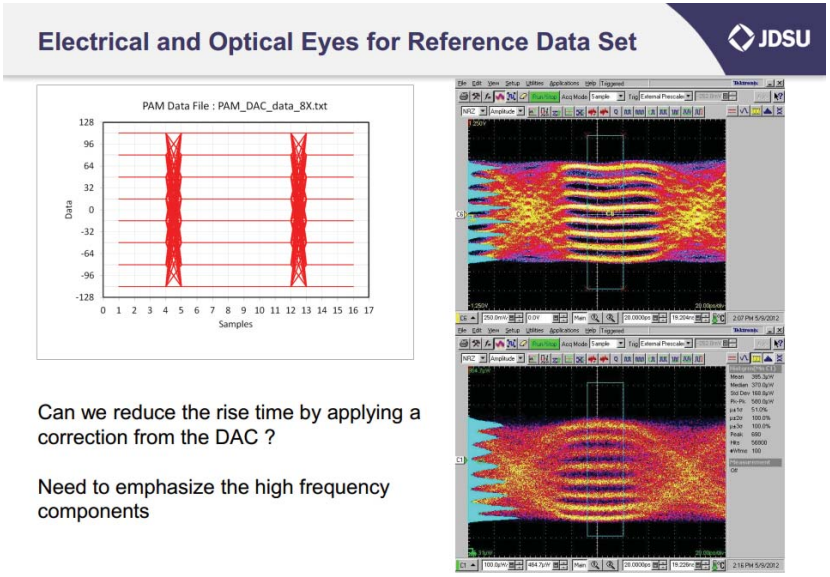


*See: http://www.ieee802.org/3/100GNGOPTX/public/jul12/cui_01_0712_optx.pdf

SAMPLE PROPOSAL @ JULY IEEE (2)

LEWIS_01A_0712_OPTX.PDF *





lewis_01a_0712_optx.pdf

These results highlight a PAM-8 implementation

3 bits per Symbol

DAC (Digital to Analog Convertor)

Using EML as light source & modulator

Spectral shaping investigated

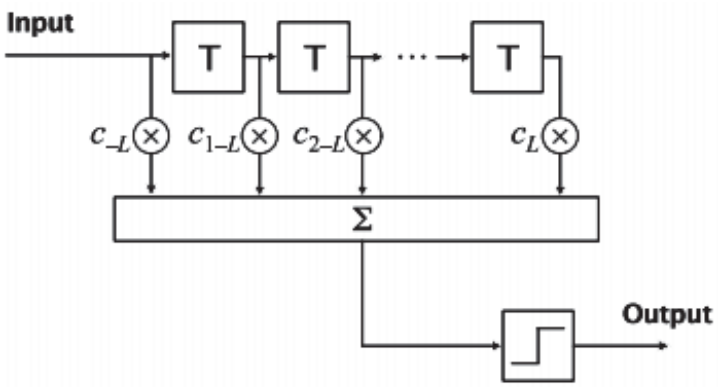
*See: http://www.ieee802.org/3/100GNGOPTX/public/jul12/lewis_01a_0712_optx.pdf

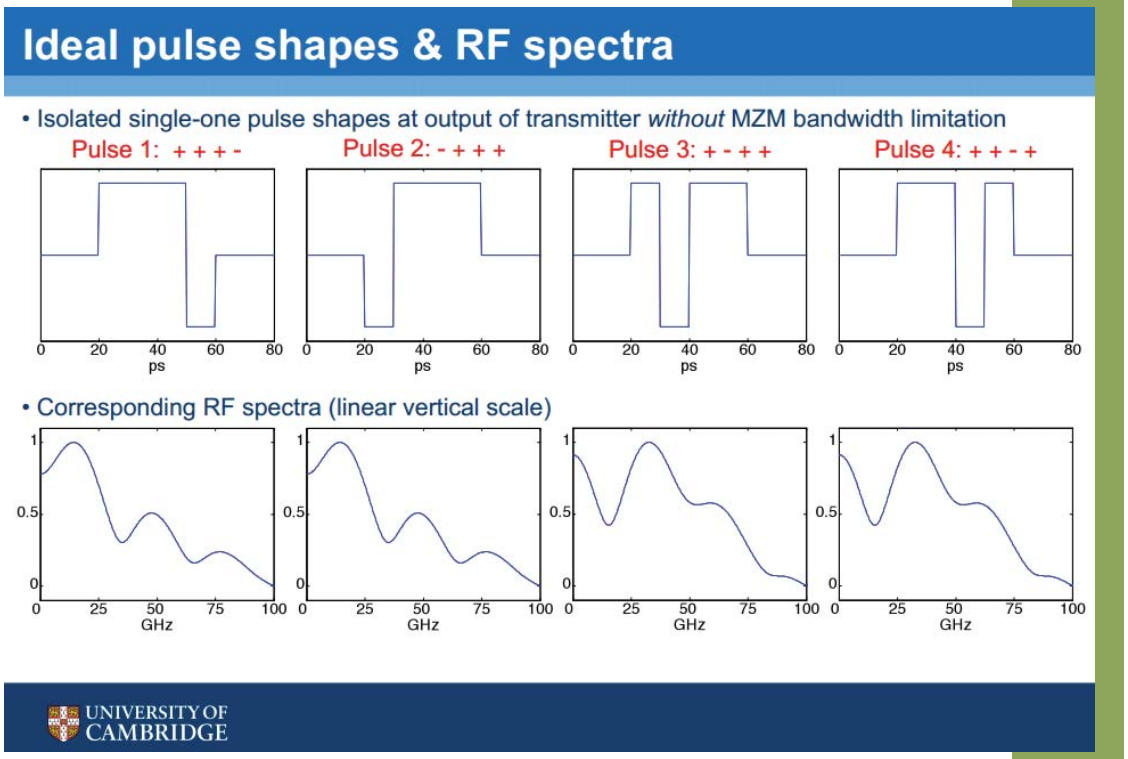
SAMPLE PROPOSAL @ JULY IEEE (3A)

INGHAM_01A_0712_OPTX.PDF *

ethernet alliance

Multipulse Modulation is proposed leveraging transversal filters to create orthogonal signals





*See: http://www.ieee802.org/3/100GNGOPTX/public/jul12/ingham_01a_0712_optx.pdf

SAMPLE PROPOSAL @ JULY IEEE (3B)

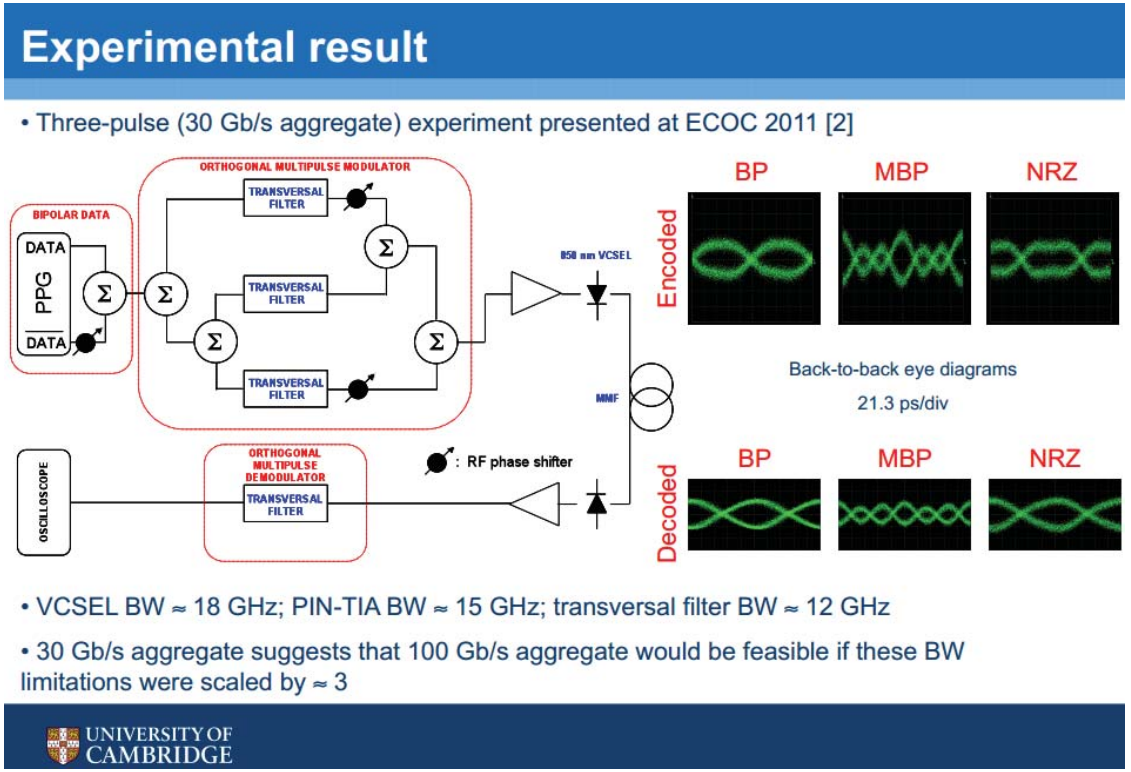
INGHAM_01A_0712_OPTX.PDF *

ethernet alliance

Multipulse Modulation is proposed leveraging transversal filters to create orthogonal signals

Directly modulated lasers

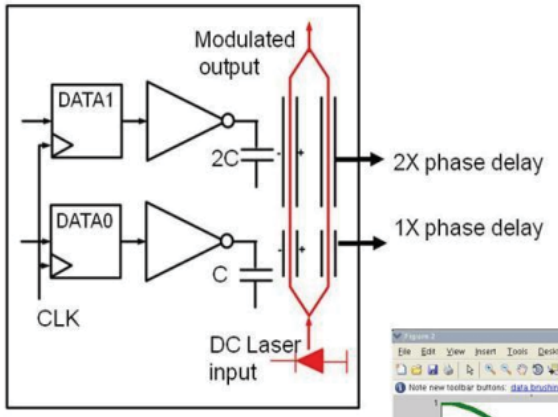
Published at ECOC'11

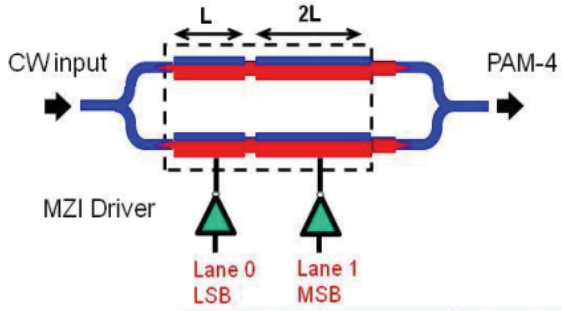


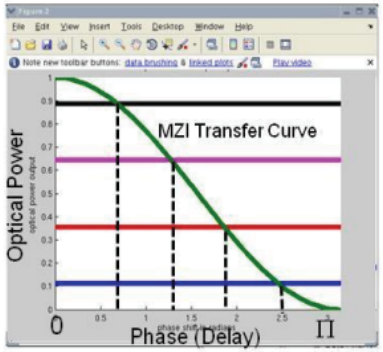
J. D. Ingham, R. V. Penty, I. H. White, D. G. Cunningham, P. Westbergh, J. Gustavsson, Å. Haglund, A. Larsson, "Orthogonal multipulse modulation for next-generation datacommunication links," 37th European Conference on Optical Communication, paper Tu.3.C.2. Geneva, Switzerland, September 2011

Sample Proposal @ July IEEE (4a)

nicholl_01_0712_optx.pdf *





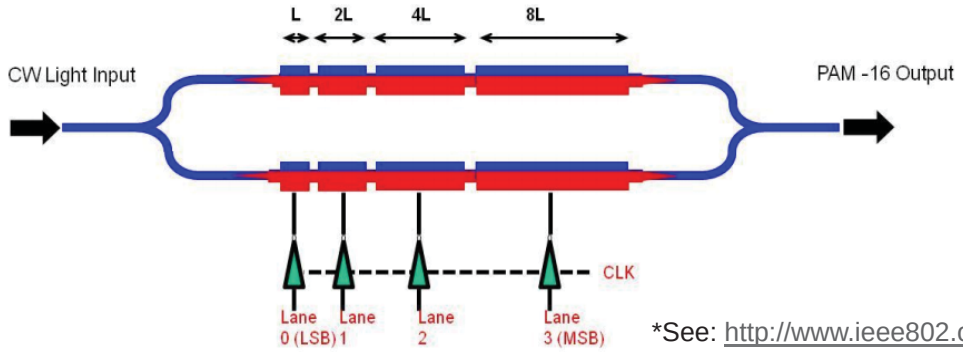


Lane 1 – Electrical MSB 0.66 ϕ	Lane 0 – Electrical LSB 0.33 ϕ	Optical Out
0	0	0
0	1	1
1	0	2
1	1	3

Silicon Photonics enables an Optical DAC

- DAC (Digital to Analog Convertor)
- Low cost CW laser light source
- DAC defined via lithography

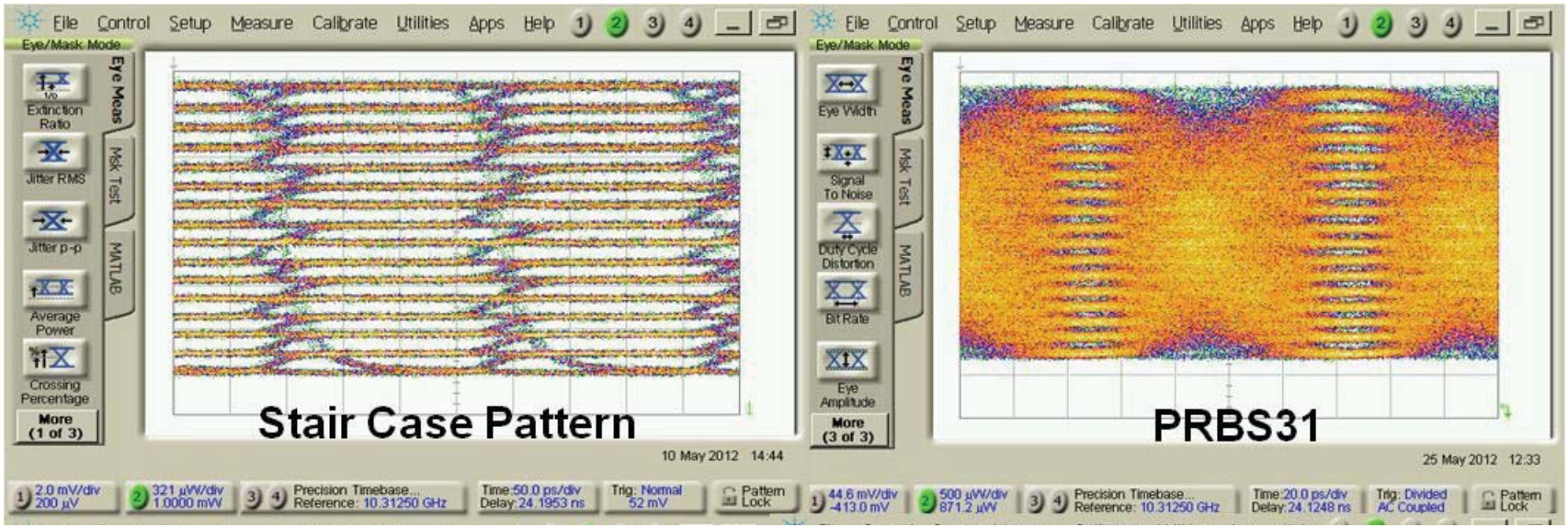
Segmented MZI + Simple Digital Driver > DAC function for PAM



*See: http://www.ieee802.org/3/100GNGOPTX/public/jul12/nicholl_01_0712_optx.pdf

Sample Proposal @ July IEEE (4b)

nicholl_01_0712_optx.pdf *



- Demonstrated PAM16 modulation using a segmented MZI, driven by an inverter based digital driver – ***Optical DAC!***
- Power consumption for MZI Driver and MZI is 10mW (250 fJ/bit)
- Power consumption for whole transmit datapath including CDR, MZI, CW Laser (complete transmit solution) is 450mW
- PRBS-31 Eye Noisy – Currently under investigation
  - Excessive optical noise at the scope – 112uW each level with 17G optical filter
  - Rise time / fall time larger than design intent due to modeling error - 48-54ps instead of target 30-33ps – need to size inverter correctly

*See: http://www.ieee802.org/3/100GNGOPTX/public/jul12/nicholl_01_0712_optx.pdf

Summary:
Advanced Modulation is the (Right) Way Forward !

IEEE Objective is to develop a new SMF PMD that provides a 'step function reduction' in cost over 100GBASE-LR4

Going forward to rates >100G, Advanced Modulation provides a path to lower cost via reduced optical component count and associated packaging

Advanced modulation is a promising approach to reduce optical complexity/cost while not sacrificing data rate increases

ethernet alliance

Questions Will Be Taken at the end of all presentations

Industry Connections

Daniel Dove - Applied Micro

Industry Connections (BWA)

ethernet alliance

Consensus Building process within IEEE

Charter and Scope

- Evaluate Ethernet wire-line bandwidth needs of the industry
- Reference material for a future activity
- The role of this ad hoc is to gather information, not make recommendations or create a CFI

Webpage - http://www.ieee802.org/3/ad_hoc/bwa/index.html

Chair, John D'Ambrosia, Dell (jdambrosia@ieee.org)

Findings of the IEEE 802.3 BWA

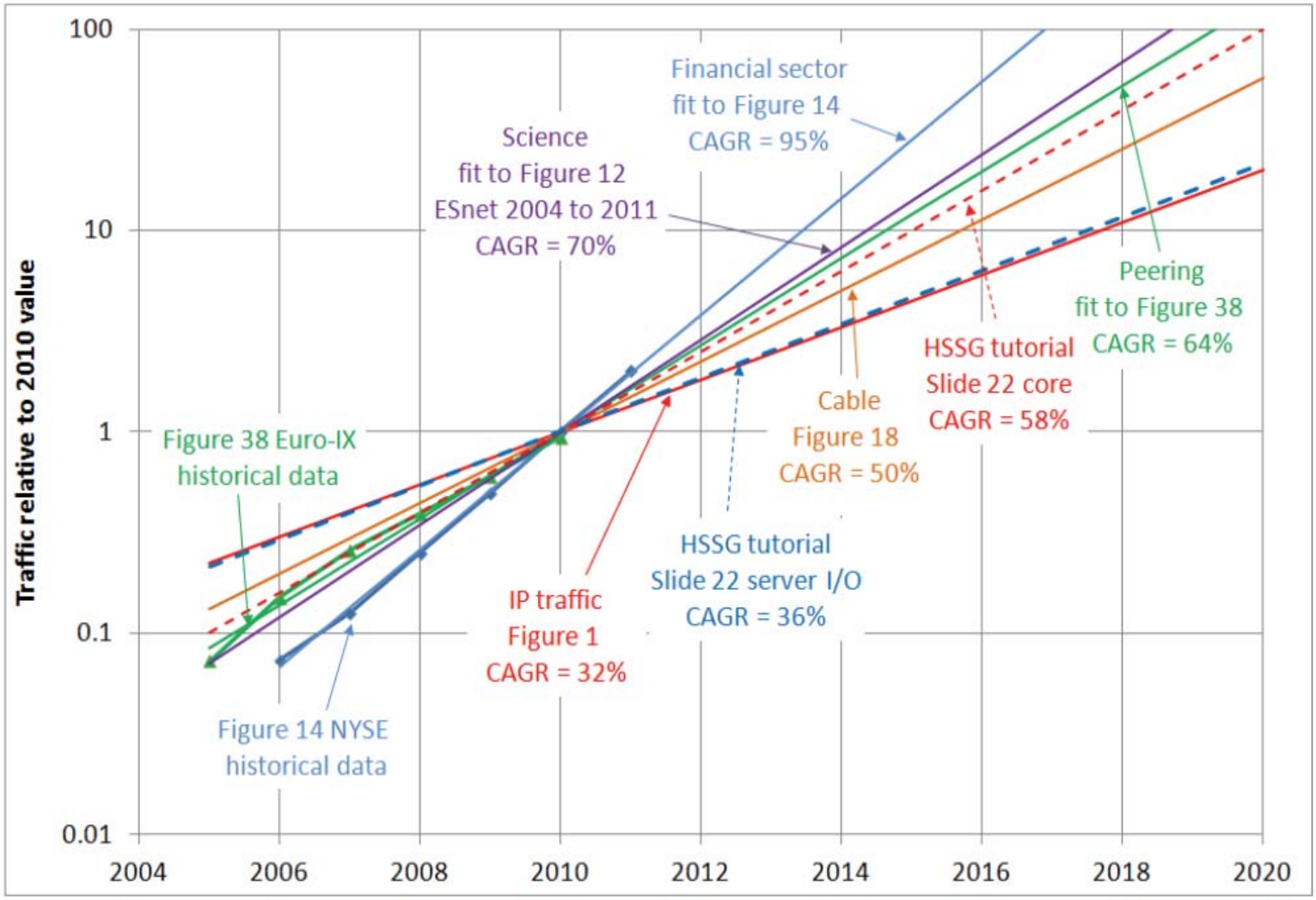


Figure 40—Relative traffic increase normalized to 2010

* http://www.ieee802.org/3/ad_hoc/bwa/BWA_Report.pdf

Industry Connections – Higher Speed Ethernet

ethernet alliance

Chair – John D'Ambrosia, Dell

To join reflector - http://www.ieee802.org/3/ad_hoc/bwa/reflector.html

HSE ICAID: http://www.ieee802.org/3/ad_hoc/hse/ec-12-0033-01-00ec.pdf

Background and Purpose

- The completion of the IEEE 802.3 Industry Connections Ethernet Bandwidth Assessment Ad hoc has demonstrated that the bandwidth requirements of multiple application spaces are continuing an exponential climb with the forecasted growth in 2020 to reach a level 100x the bandwidth required in 2010. The purpose of the IEEE 802.3 Industry Connection's Higher Speed Ethernet Consensus activity will be to build consensus related to initiating a new effort targeting the next speed of Ethernet for wireline applications, which will be used for the evaluation and possible development of a Call-For-Interest for the next IEEE 802.3 Higher Speed Study Group.
- Related Standards – IEEE Std 802.3-2008 and IEEE Std 802.3ba-2010
- Related Sponsor – IEEE 802

Charter and Scope

- The scope of this IC activity will focus on building consensus related to the next speed of Ethernet for wire-line applications, which will be used for the evaluation and possible development of a Call-For-Interest for the next IEEE 802.3 Higher Speed Study Group. The requested duration for this Industry Connections activity is 12 months.

Proposed Deliverables

- The proposed deliverables will be the historical records, i.e. meeting notes & presentations, of the meetings held by this Industry Connections activity.

ethernet alliance

Q & A