100GbE and Beyond

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Regarding the Views Expressed

- Industry Involvement
  - Chair, Former IEEE p802.3ba 40Gb/s and 100Gb/s Ethernet Task Force
  - Chair, IEEE 802.3 100 Gb/s Backplane and Copper Cable Study Group
  - Chair, IEEE 802.3 Ethernet Bandwidth Assessment Ad hoc
  - Chairman, Ethernet Alliance Board of Directors

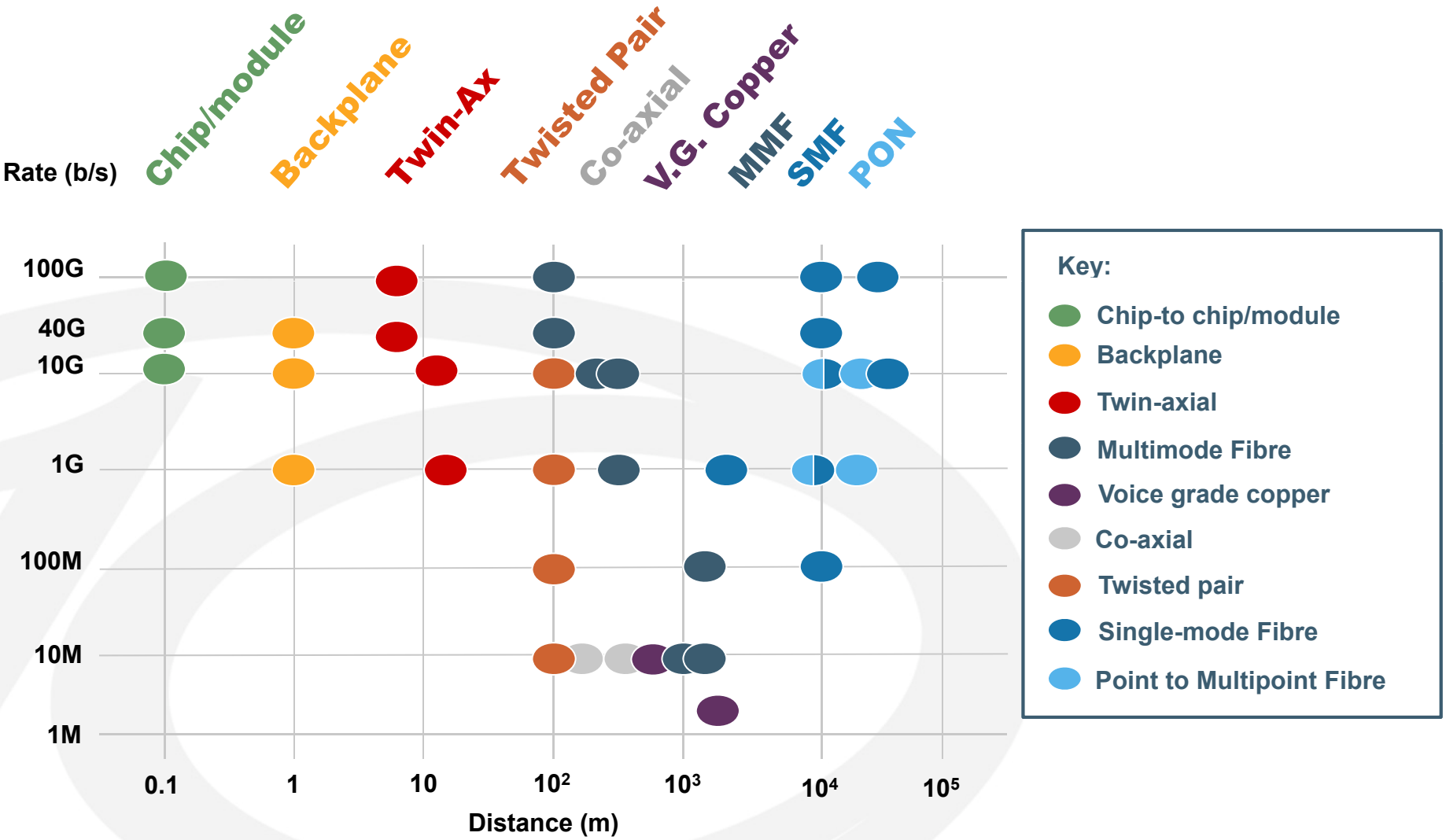
- Per IEEE-SA Standards Board Operations Manual, January 2005:

  "At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE."

- The views I am expressing on IEEE standards and related products should NOT be considered the formal position, explanation, o interpretation of the Ethernet Alliance.

ethernet alliance member

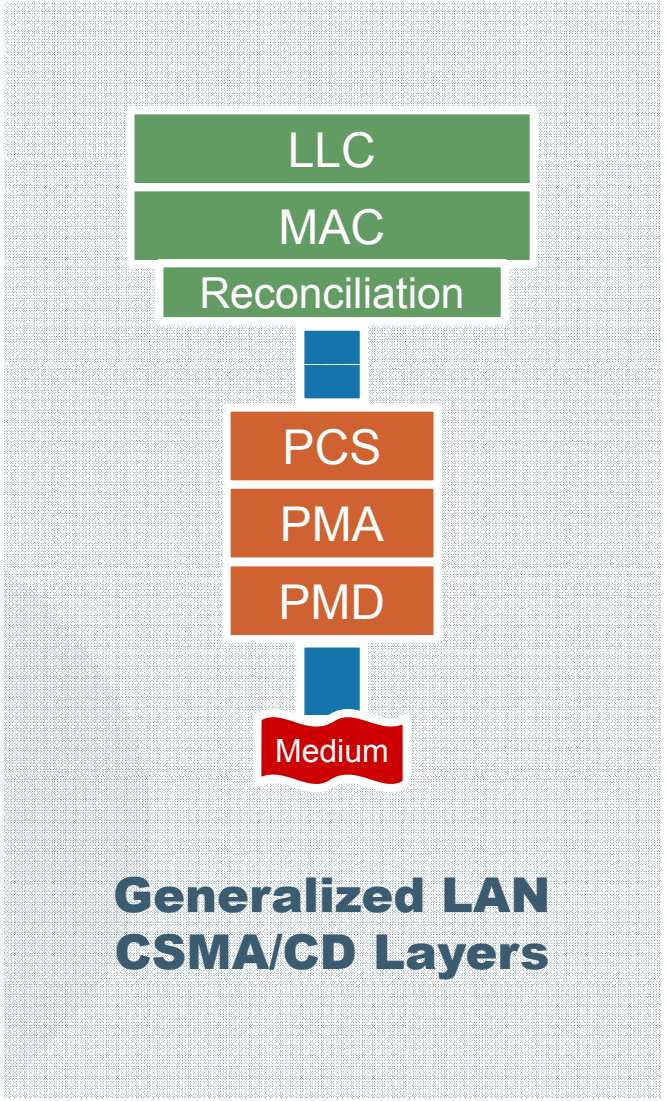
The Ethernet 802.3 Umbrella



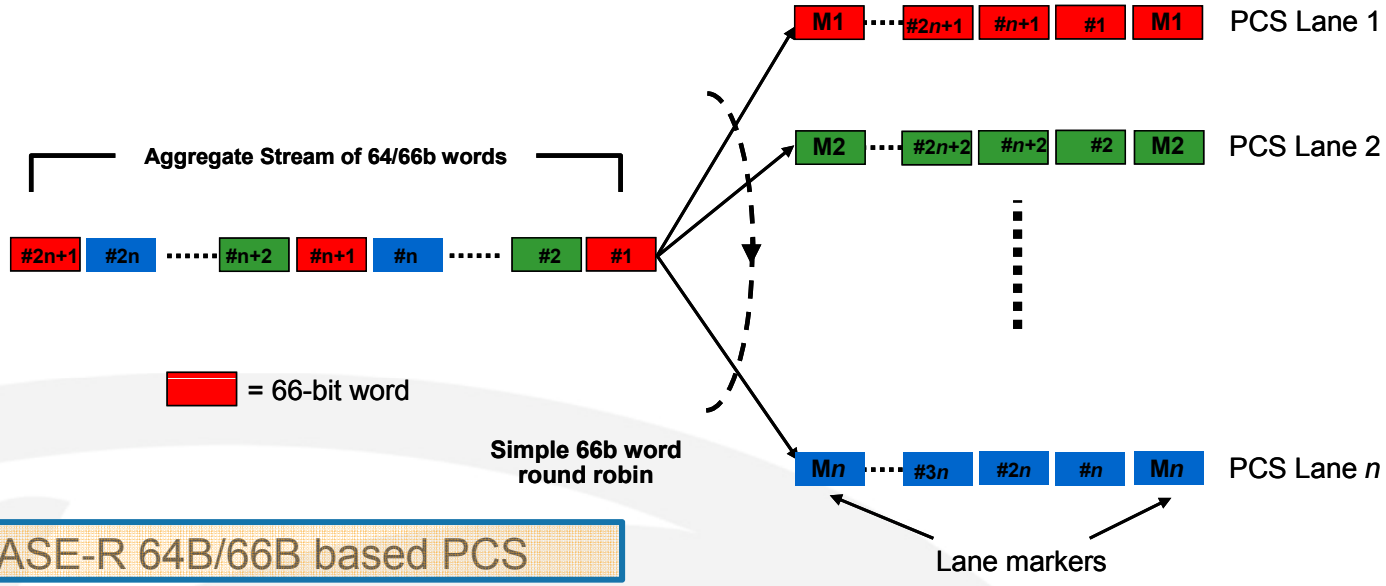
Based on slide used by permission from David Law.

Overview of Architecture

- Consistent with previous Ethernet rates, extension to 40Gb/s & 100Gb/s data rates
  - Frame format; Services; Management attributes
- Media Access Control (MAC)
  - No changes to the MAC operation
- Physical Coding Sublayer (PCS)
- Physical Medium Attachment Sublayer (PMA)
- Physical Medium Dependent Sublayer (PMD)
- Interface Definitions
- Provide appropriate support for OTN



Physical Coding Sublayer (PCS)

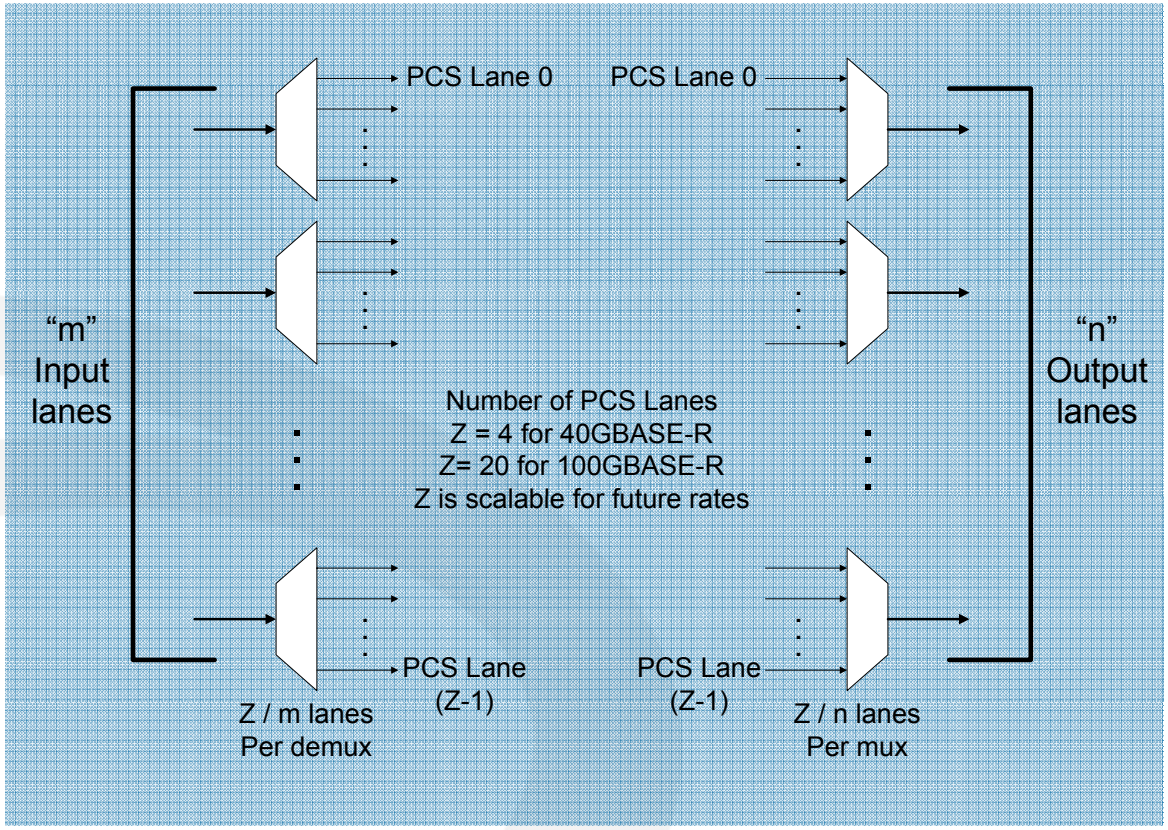


- 10GBASE-R 64B/66B based PCS
  - Run at 40Gbps or 100Gbps serial rate
  - Includes 66 bit block encoding and scrambling
- Multi-Lane Distribution
  - Data is distributed across “n” PCS lanes 66 bit blocks at a time
  - 40GbE uses 4 PCS Lanes, 100GbE uses 20 PCS Lanes
  - Round robin distribution
  - Periodic alignment blocks added to each PCS lane for Rx PCS deskew
- Alignment and static skew compensation is done in the Rx PCS only

Source: D’Ambrosia, Law, Nowell, “40 Gigabit Ethernet and 100 Gigabit Ethernet Technology Overview,” Ethernet Alliance White Paper, http://www.ethernetalliance.org/images/40G_100G_Tech_overview(2).pdf. , November 2008.

PMA Demux / Mux Functionality

- Enables changing of lane number and rate per lane for multiple physical layer specifications
- For example 100GbE:
  - 10 x10 Gb/s
  - 4 x 25 Gb/s
  - 1 x 100 Gb/s



SHOWS PMA DEMUX / MUX FUNCTIONALITY IN ONE DIRECTION ONLY

IEEE 40Gb/s and 100Gb/s: Physical Layer Specifications

Port Type	Description	40GbE	100GbE
40GBASE-KR4	At least 1m backplane	√	
40GBASE-CR4 100GBASE-CR10	At least 7m cu (twin-ax) cable	√	√
40GBASE-SR4 100GBASE-SR10	At least 100m OM3 MMF (150m OM4 MMF)	√	√
40GBASE-FR*	At least 2km SMF	√	
40GBASE-LR4 100GBASE-LR4	At least 10km SMF	√	√
100GBASE-ER4	At least 40km SMF		√

* Ratification March 31, 2011

Looking Ahead - Growing the 40GbE / 100GbE Family

	Description	40GbE	100GbE
Backplane	4 x 25 Gb/s		CFI - Nov New SG - Jan
Twin-axial	10 x 10 Gb/s > 4 x 25 Gb/s		
Chip-to-Chip / Module	10 x 10 Gb/s > 4 x 25 Gb/s		CFI July **2011**
Multi-mode Fibre	Reduced width or lambda ? Longer reach?	✓	
Single-mode Fibre	Single Lambda? Shorter reach? Longer reach?	✓	
Twisted Pair	Focus on Data Center Applications (< 100m?)	✓	✓
Energy Efficiency	Apply to electrical and optical aspects?	✓	✓

Front panel I/O driving backplane capacities

Source: 100GbE Electrical Backplane/Cu Cable CFI

Line card illustrations

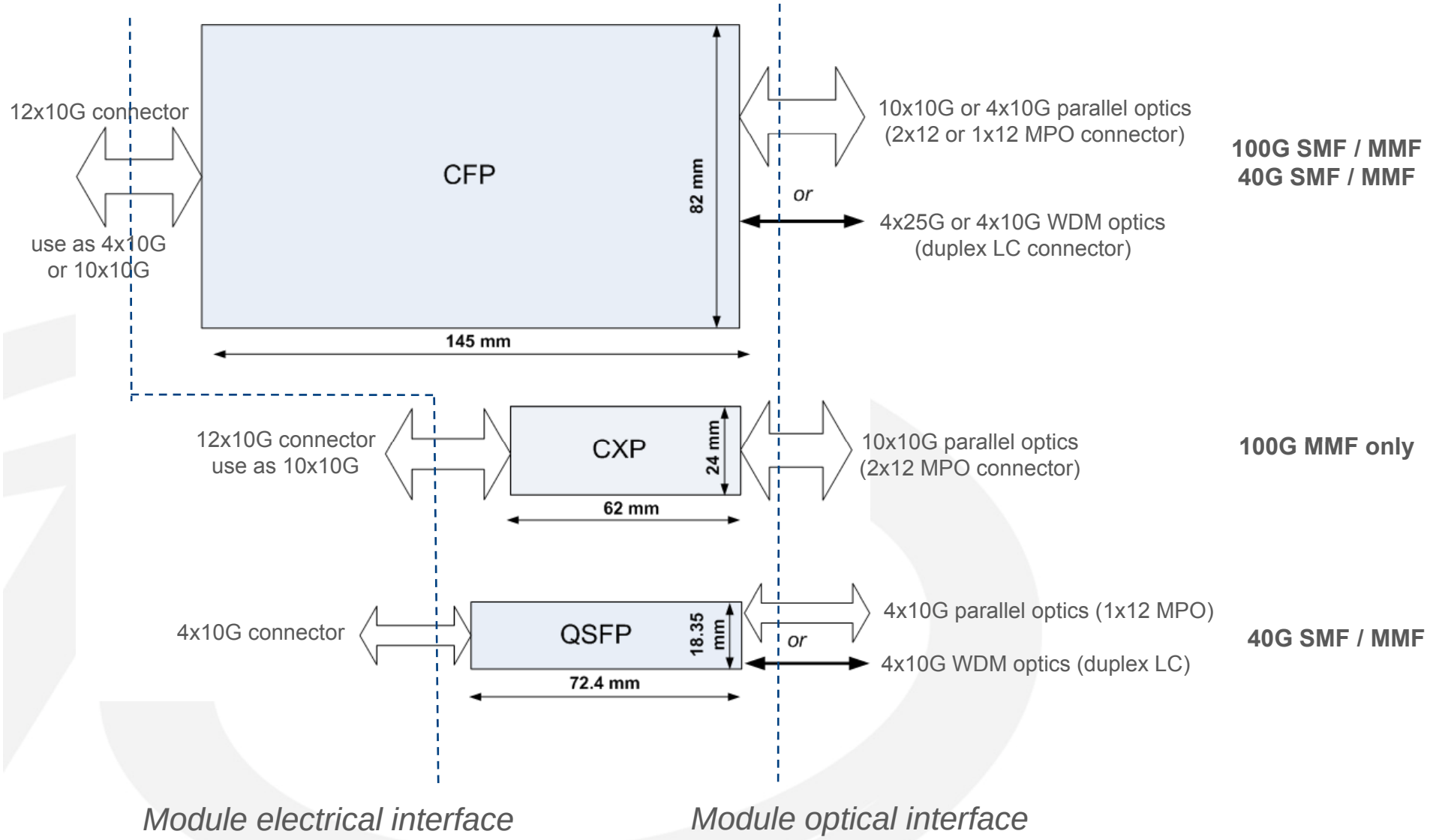
a. 48 ports SFP+ @ 10GbE = 480Gb/s
b. 44 ports QSFP @ 40GbE = 1.76 Tb/s
c. 4 ports CFP @ 100GbE= 400 Gb/s
d. 32 ports CXP@ 100GbE= 3.2 Tb/s

Potential backplane bandwidth capacities

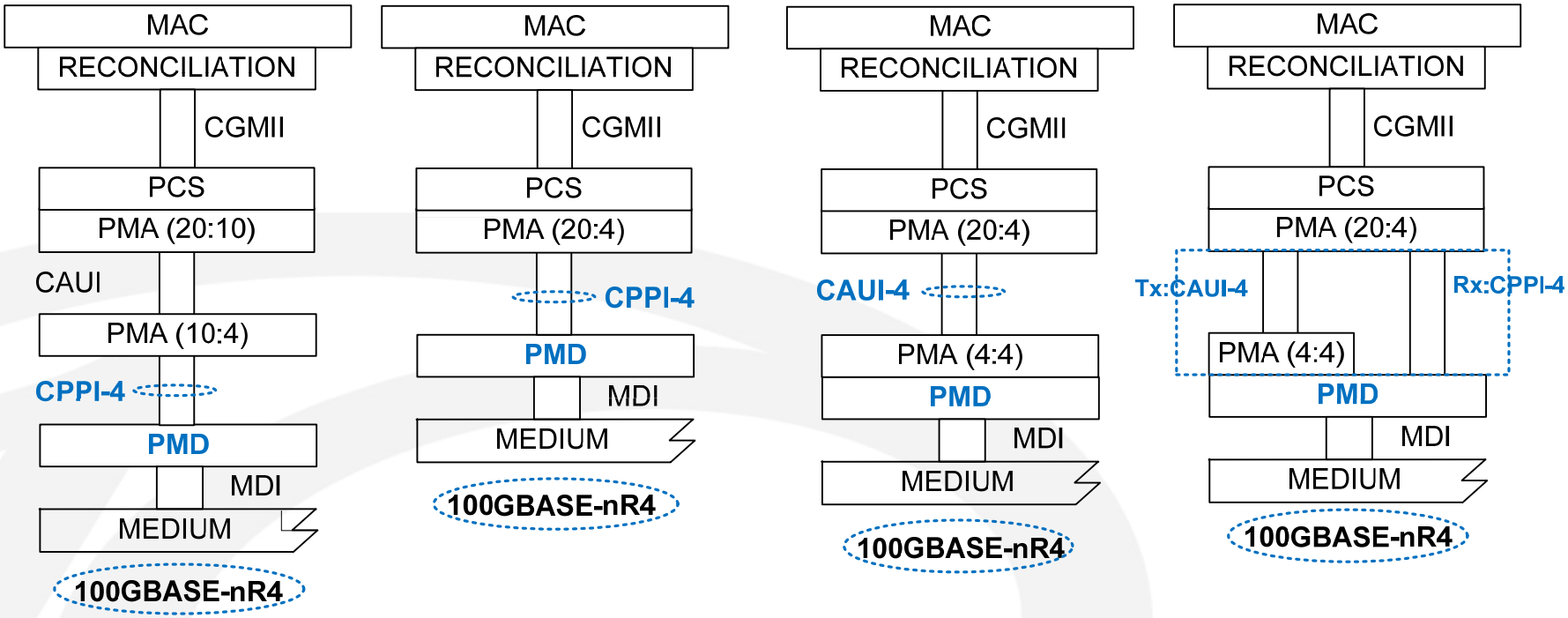
- 8 Line Cards: 3.2 Tb/s to 25.6 Tb/s
- 14 Line Cards: 5.6 Tb/s to 44.8 Tb/s

New Study Group Formed Jan 2011 to look at 100Gb/s backplane and copper cables.

40/100G Ethernet pluggable modules

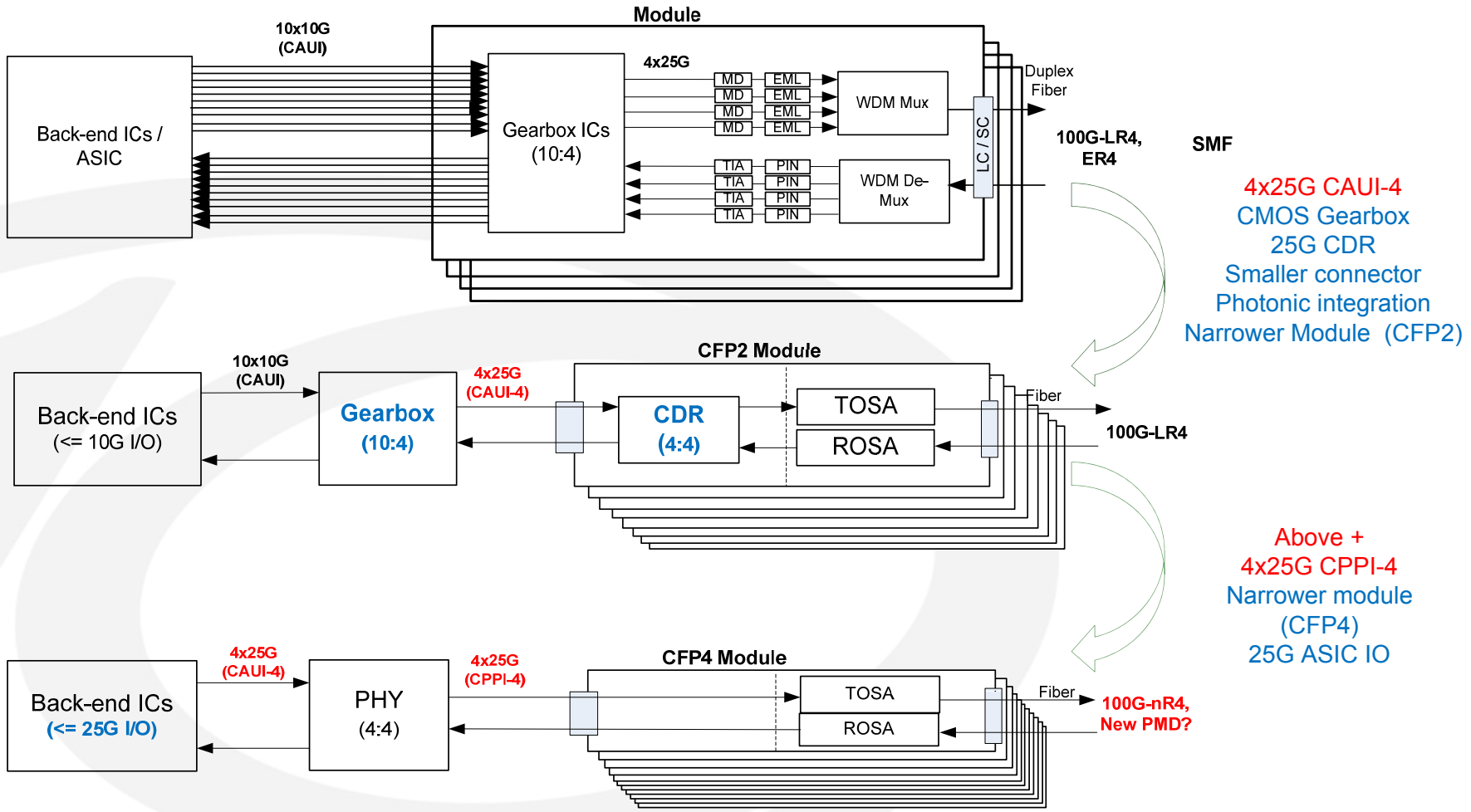


Next Gen Optics - Leveraging the 4x25G Architecture

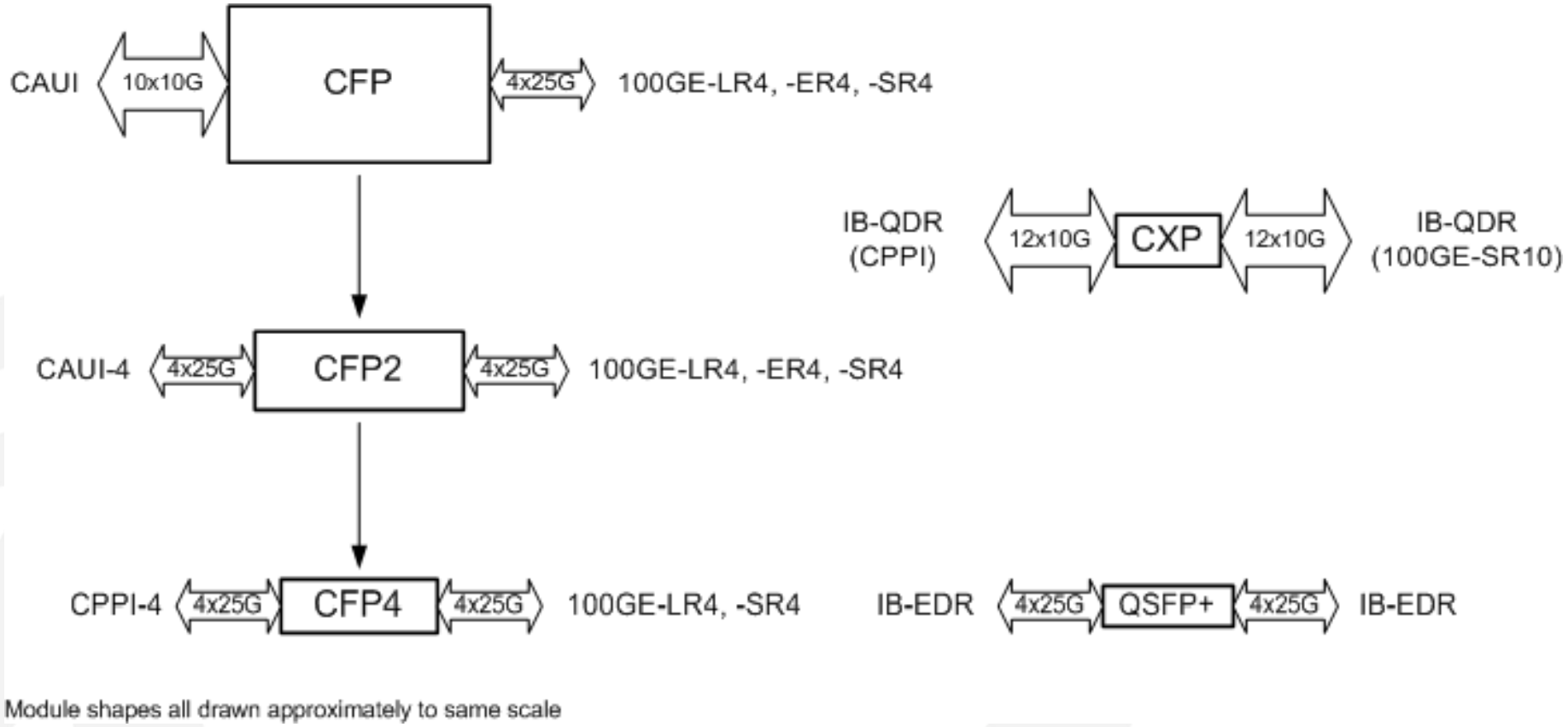


Host architecture using 4x25G signaling

- 4x25G module interface + 25G ASIC interface can enable low-power high-density modules *and* host systems to scale to higher port counts

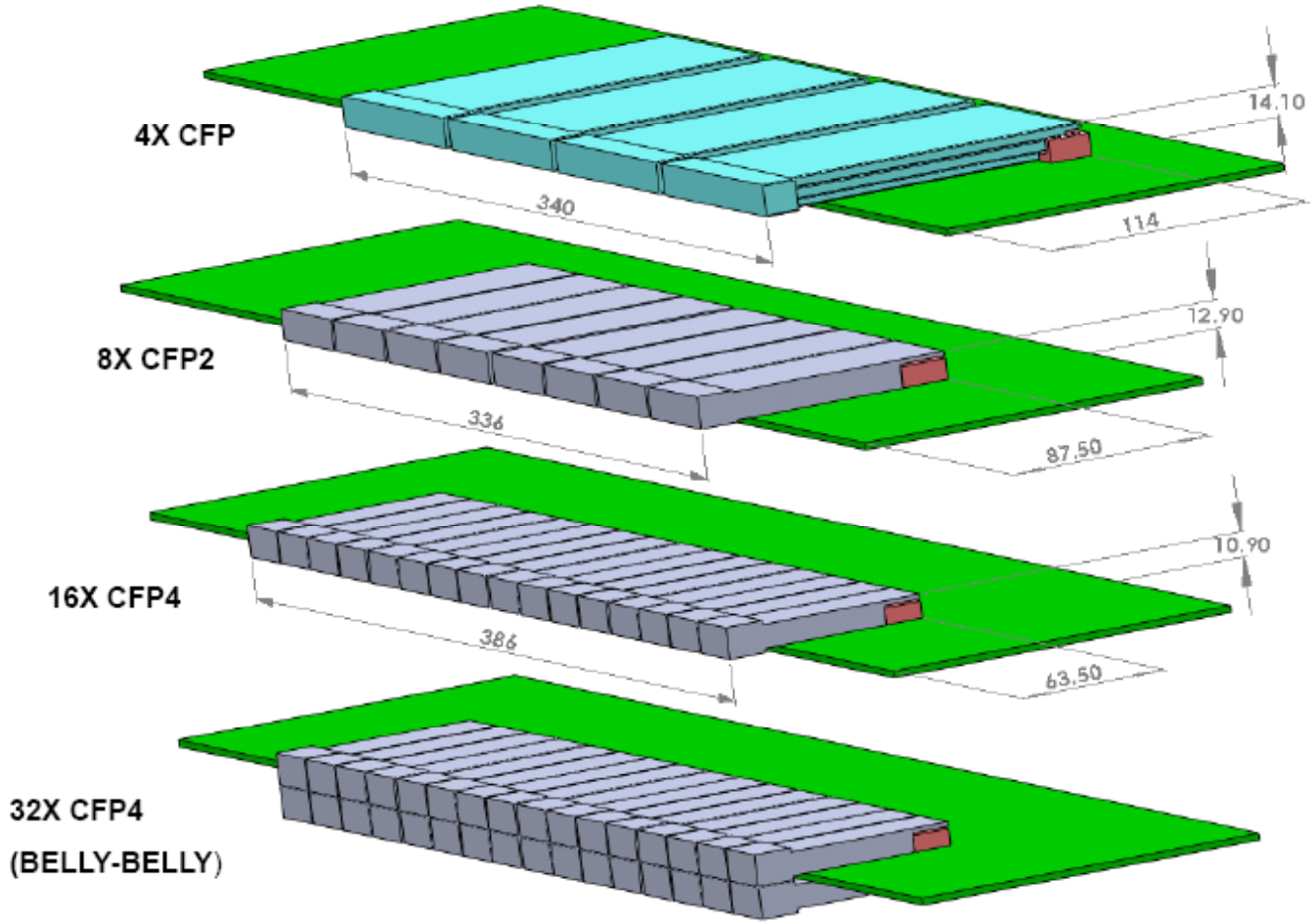


CFP MSA Roadmap



Source: “CFP MSA 100G Roadmap and Applications

CFP MSA Roadmap



Slot Capacity

400 Gb/s

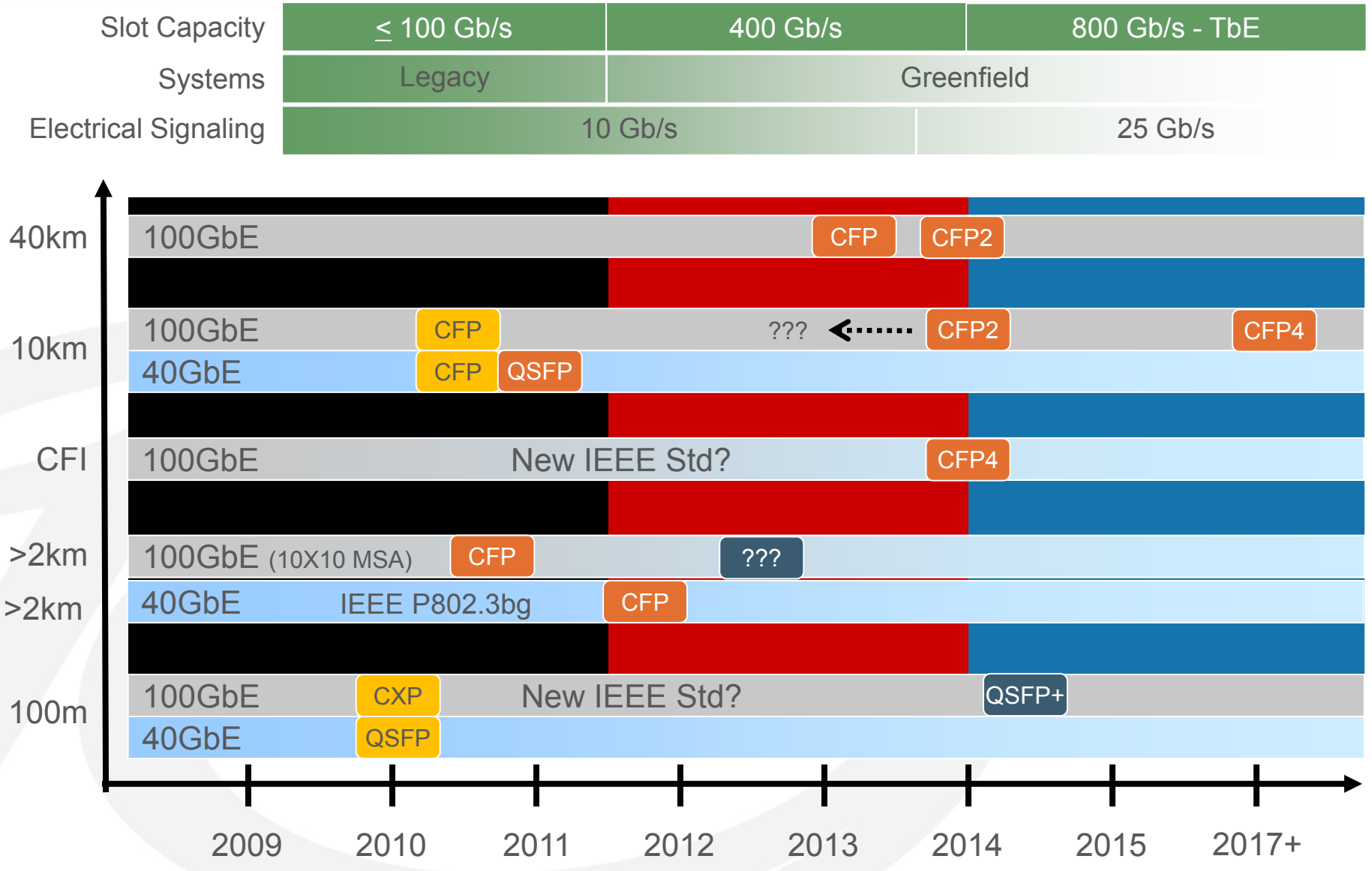
800 Gb/s

1600 Gb/s

3200 Gb/s

Source: CFP MSA

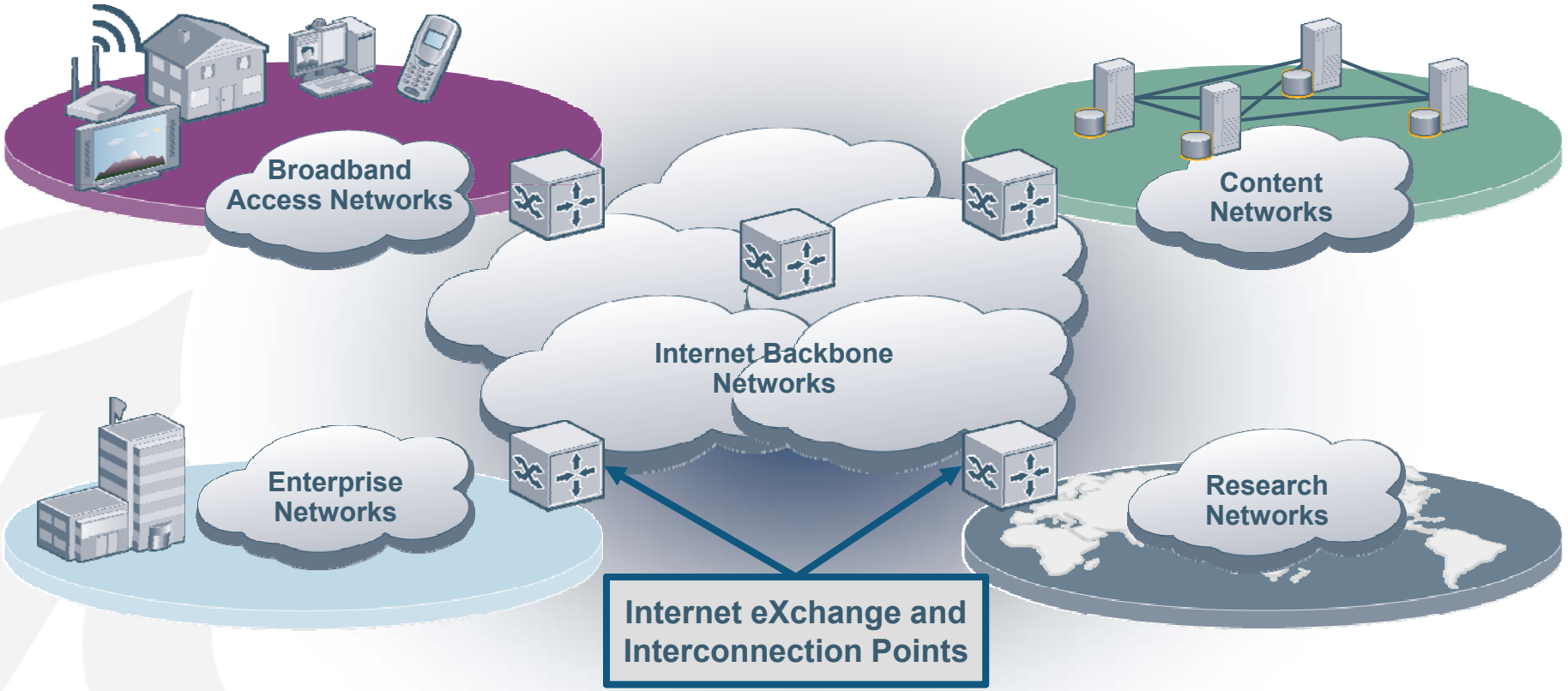
40GbE / 100GbE Industry Technology Roadmap



The Ethernet Ecosystem

BROADBAND ACCESS

CONTENT PROVIDERS

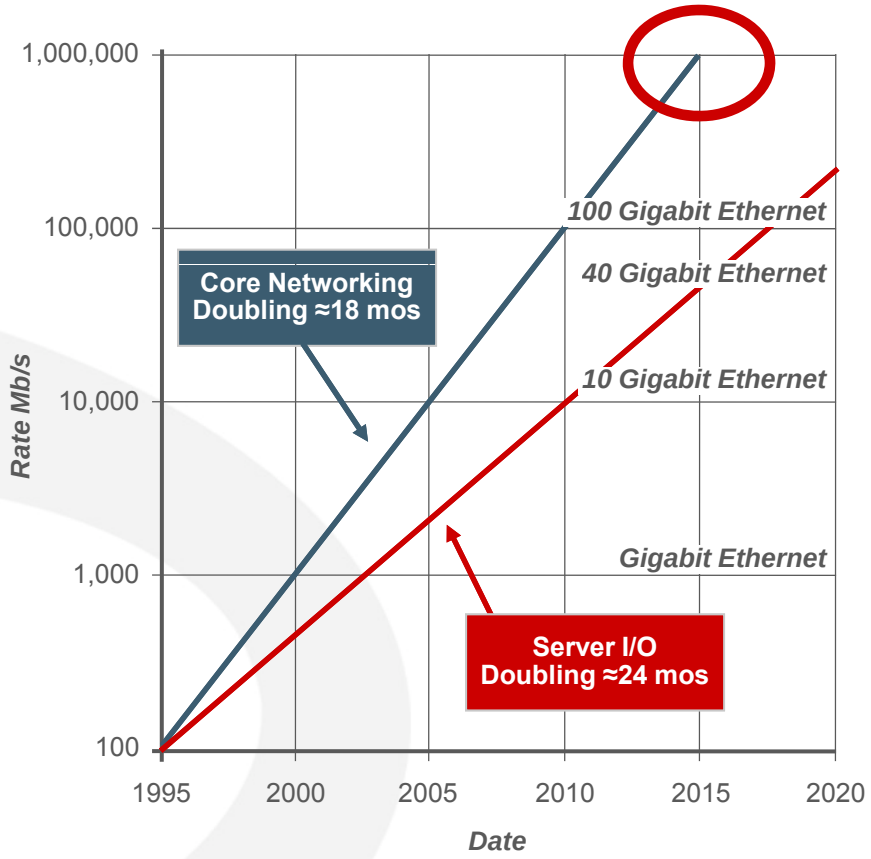


DATA CENTERS AND ENTERPRISE

RESEARCH, EDUCATION & GOVERNMENT FACILITIES

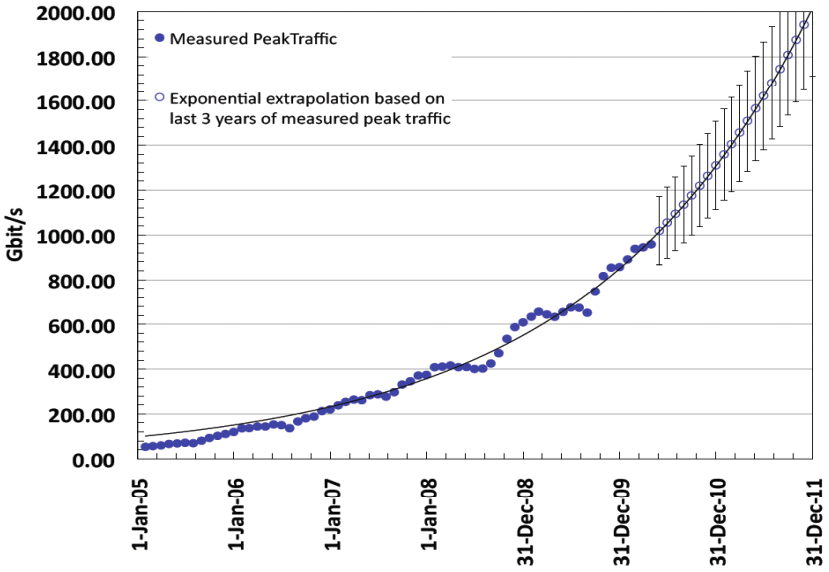
Looking Beyond 100GbE

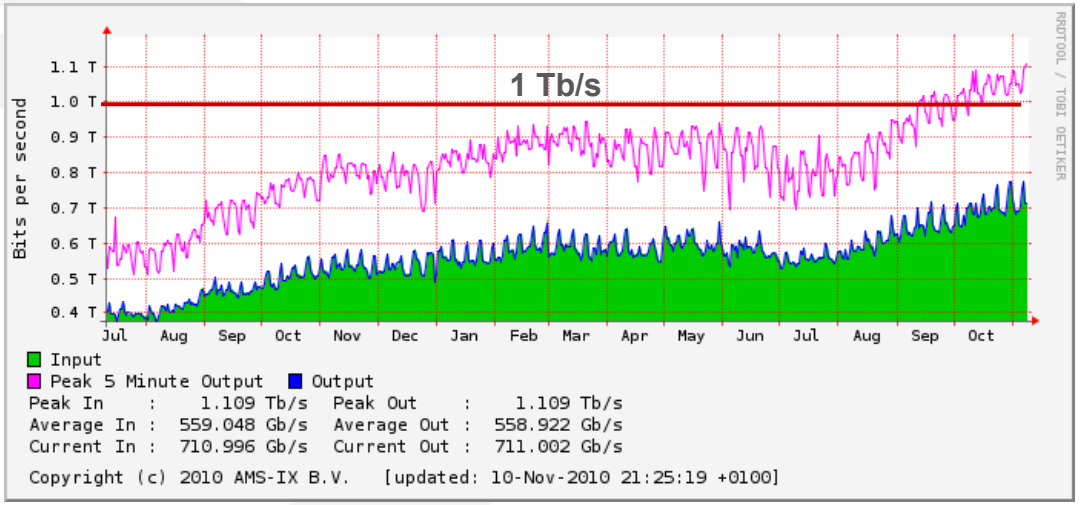
- Industry being challenged on two fronts
  - Low cost, high density 100GbE
  - Next Rate of Ethernet
- Technical Feasibility
  - Electrical Signaling
  - Optical Signaling
- Market Need
  - Data Centers
  - Internet Exchanges
  - Carriers
- The economics of the application will dictate the solution



Growing bandwidth demand

- Many studies showing 40-50% annual growth in global Internet traffic
  - Atlas Internet Observatory Report, at NANOG: http://www.nanog.org/meetings/nanog47/abstracts.php?pt=MTQ3NSZuYW5vZzQ3&nm=nanog47
  - MINT studies http://www.dtc.umn.edu/mints/
  - Bandwidth measurements from AMS-IX (Amsterdam Internet Exchange)
    - Left: peak traffic from 2005-2010
    - Right: peak and average traffic in Y2010 (Jan to Oct)

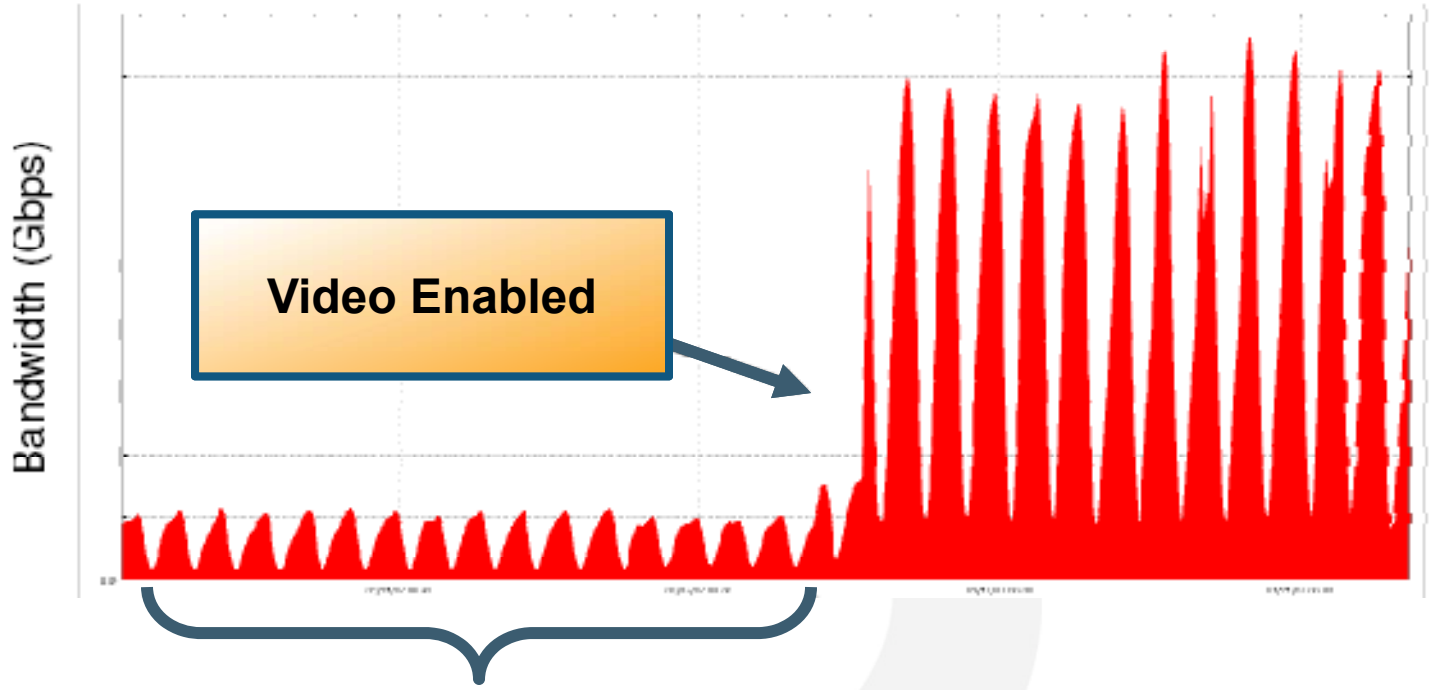




Data Provided by Henk Steenman, Amsterdam Internet Exchange (AMS-IX)

OFC / NFOEC 2008: Facebook Living in the Video World

TOOTHBRUSH GRAPH



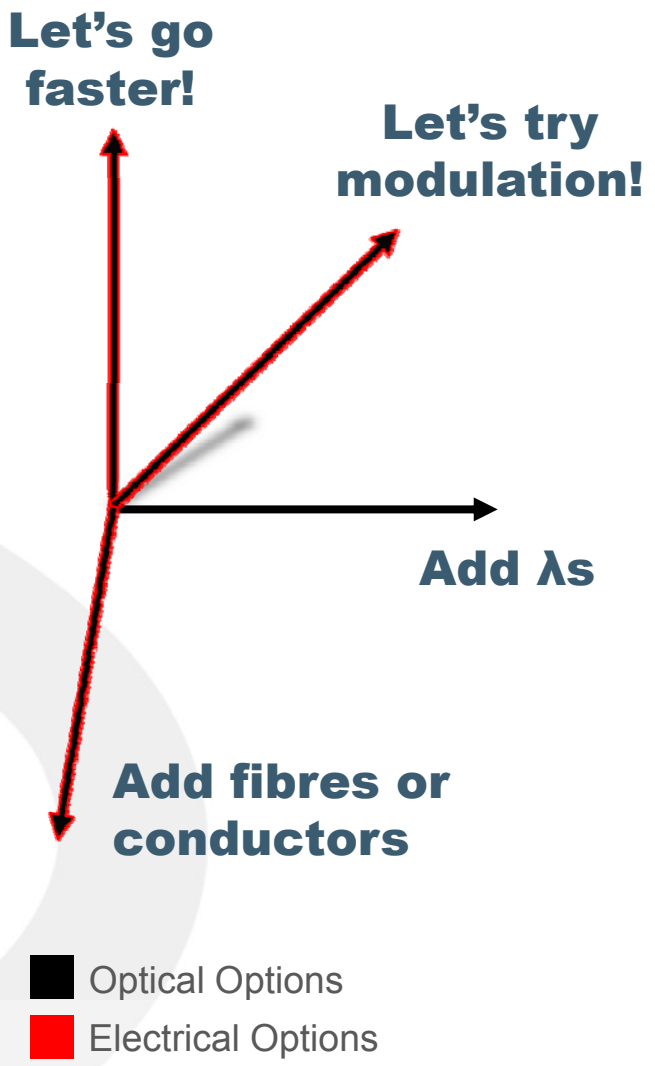
This was a huge amount of traffic (multiple web services, millions of users)

Source: Donn Lee Presentation OFC 2008

Considering the Options

- Time Division Multiplexing
  - Let's go faster
- Modulation
  - Let's add more symbols per second
- Wavelength Division Multiplexing
  - Let's add wavelengths
- Space Division Multiplexing
  - Let's add fibres or conductors

Bit rate, Gb/s	Gb/s per Lane	Number of lanes
100	10	10
	25	4
400	25	16
	40	10
	50	8
1000	25	40
	50	20



Historical Perspective

Reaching Consensus

Myth: The IEEE makes the decisions
Reality: The IEEE is a forum for the industry to make the decisions

For a new higher speed - consider that a standards development effort might include these (and others):

- End users
- Equipment Vendors
- Chip Vendors
- Optics Vendors
- Cable Suppliers
- Connector Vendors
- Test Equipment Vendors
- PCB Materials Vendors
- PCB Mfg. and Assembly Vendors
- Consultants

- In the IEEE technical decisions require ≥ 75% consensus
- Is there consensus in the industry?

IEEE 802.3 "Ethernet Bandwidth Assessment" Ad Hoc

- Charter and Scope
  - Evaluate Ethernet wireline 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
- Reflector - http://www.ieee802.org/3/ad_hoc/bwa/reflector.html

- Meetings will be face-to-face and teleconferences.

- The Ad Hoc needs data. If interested in contributing contact Chair, John D'Ambrosia, Force10 Networks (jdambrosia@ieee.org)

Summary

- Everything is going Ethernet and Ethernet is going everywhere!
- New Key Initiatives
  - IEEE 802.3 100Gb/s Backplane & Cu Cable Study Group
  - IEEE 802.3 Ethernet Bandwidth Assessment Ad hoc
  - CFI Preparation – Next Generation 100GbE Optics
- 25 Gb/s Electrical Signaling Development Key to 100GbE and beyond
- CFP MSA – Next Generation Module Form Factors

THANK YOU