









100 Gbe and Beyond

Agenda

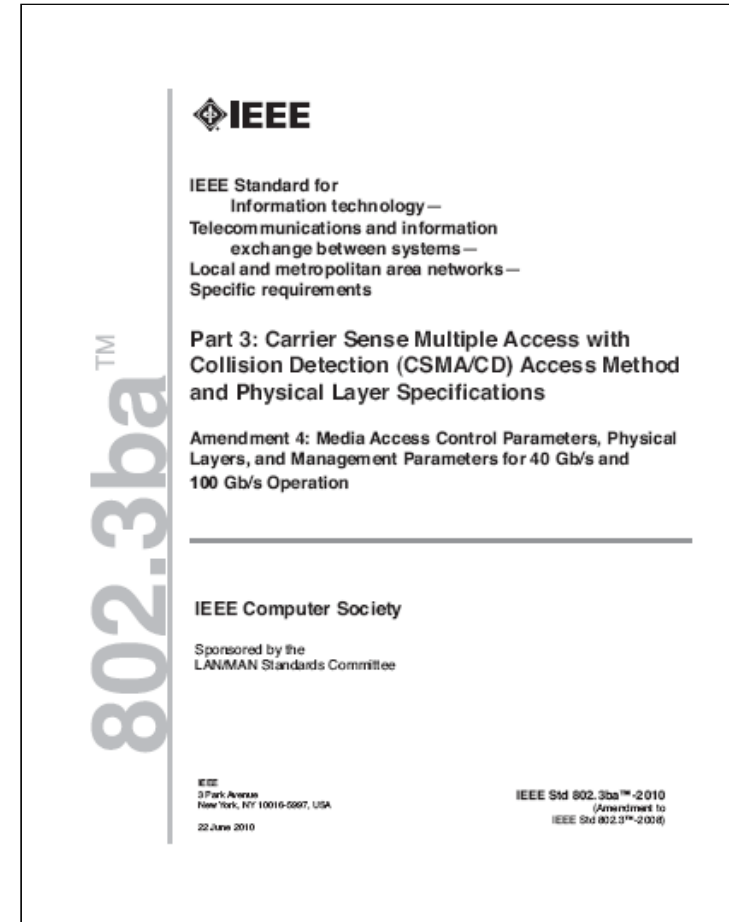
- **Overview**
- 28 Gbps Common Electrical Interfaces (CEI)
- 100GBASE-XXX and the 10x10 MSA
- New 100 Gbps Media Modules
- 100 GbE Developments
- Beyond 100 GbE...

Standards Organizations and You, Revisited

Name	Primary Role (in Context of this Presentation)	Primary Players
Customers	Buy Your Services	
<i>You</i>	<i>Run Networks</i>	
Hardware Vendors	Make Equipment	
 MEF METRO ETHERNET FORUM	Ethernet Service Definitions, Standards and Certification	Hardware Vendors, Network Operators
 I E T F	Higher Layer Protocol Standards	Hardware Vendors, Network Operators
 IEEE	Ethernet Standards (802.1, 802.3)	
 incits	Fibre Channel Standards (T11)	Component and Hardware Vendors
 ITU International Telecommunication Union	Telecom Standards (SG15)	
 10X10 MSA	Optical Module Standards	Component and Hardware Vendors, Network Operators
 CFP SFF Committee	Media Module Standards	Component and Hardware Vendors
 OIF OPTICAL INTERNETWORKING FORUM	Component Interface Standards	Component and Hardware Vendors

Current State of the Industry

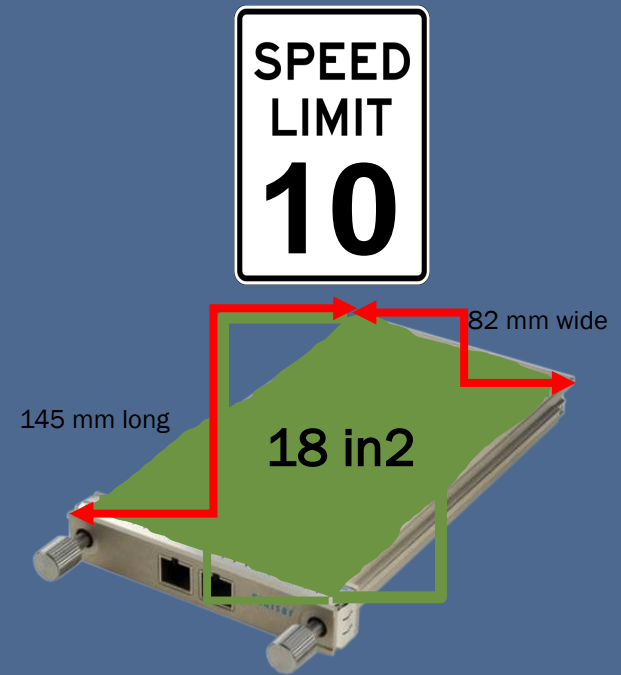
- IEEE 802.3ba standard approved June 17, 2010
 - 457 pages will be added to IEEE 802.3-2012
- Shipping 1st generation media, test equipment, router interfaces, and optical transport gear in 2010/2011
- Mature, interoperable technology with broad vendor support
- 2nd generation technology projects for both 40 and 100 GbE have started



- Expected on the market in 2014

Current State of the Industry

- Fundamental 1st generation technology constraints limits higher 100 GbE density and lower cost
- Electrical signaling inside the box
 - 100 Gbps Attachment Unit Interface (CAUI) uses 10 x 10 Gbps
- Optical signaling outside the box
 - 10x10 MSA: 10 x 10 Gbps
 - 100GBASE-LR4 and 100GBASE-ER4: 4 x 25 Gbps
- CFP module size and power consumption



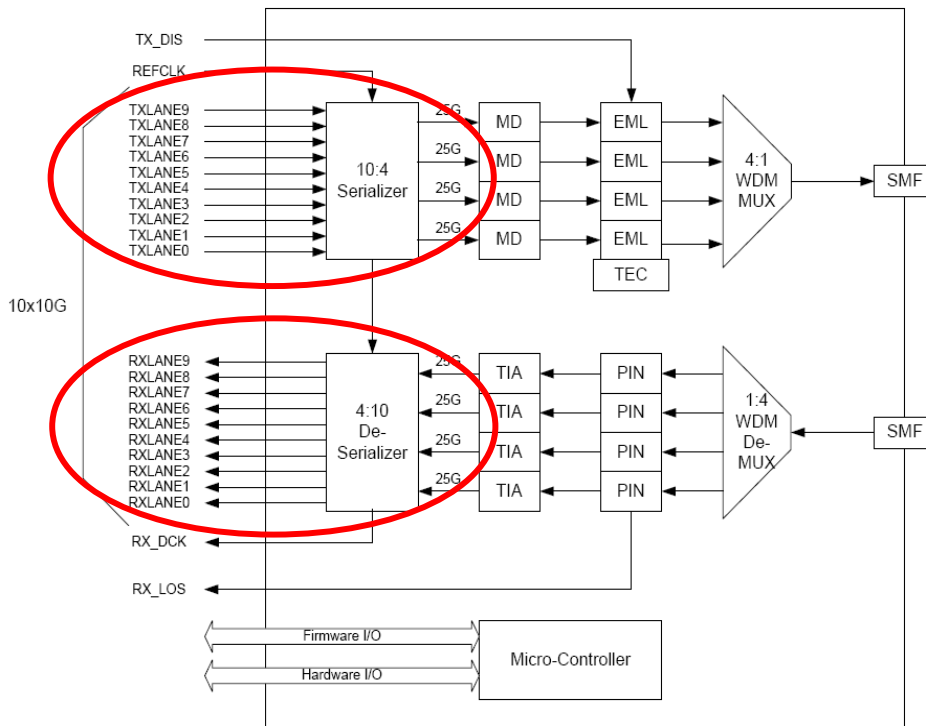
100 GbE

1st Generation vs 2nd Generation 100 GbE

- 2nd Generation 100 GbE Needs Faster Electrical Signaling

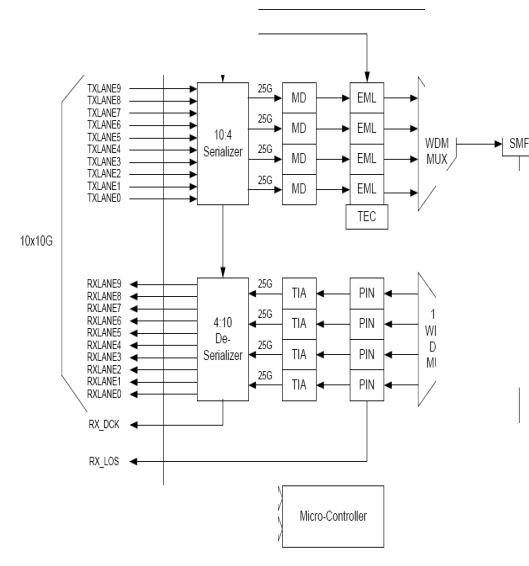
1st Generation

1st Generation 10 x 10 Gbps



10 Gbps Electrical Signaling and 10:4 Gearbox Adds Complexity, Cost, Space, Power...

2nd Generation 4 x 25 Gbps



25 Gbps Electrical and Optical Signaling

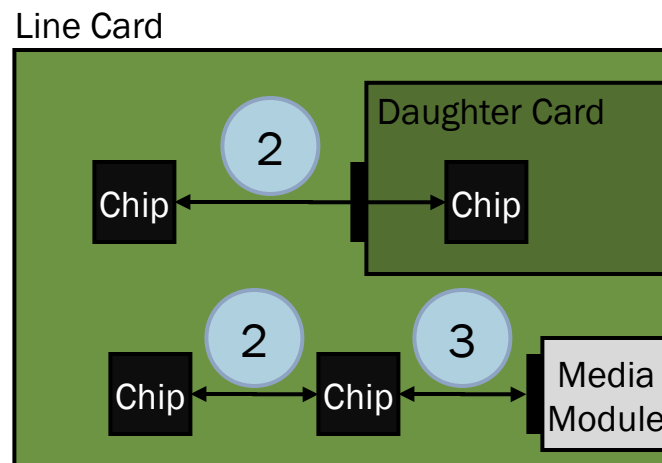
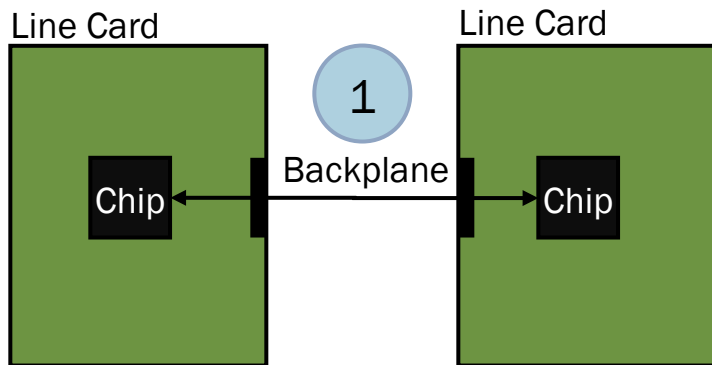


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25 Gbps and 28 Gbps Common Electrical Interfaces (CEI)

1. Backplane: CEI-25G-LR – 30”
2. Chip to chip: CEI-28G-SR – 12”
3. Chip to module: CEI-28G-VSR – 4”
(used by 2nd generation 100 GbE media modules)



28 Gbps Common Electrical Interfaces (CEI)

- Enabling 2nd Generation 100 GbE
- OIF is doing fundamental work on 28 Gbps electrical signaling which will make newer interfaces and pluggable media modules possible
- Lower power, Very Short Reach (VSR) 4” interfaces are being defined for several new applications
 - 1 lane for 32 Gbps Fibre Channel at 28.05 Gbps
 - 4 lanes for 100 GbE at 25.78125 Gbps
 - 16 lanes for 400 GbE at 25.78125 Gbps?
- Recently completed this year



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- Current IEEE standards have a gap
 - 100GBASE-SR10 supports up to 150 m on OM4 MMF
 - 100GBASE-LR4 supports up to 10 km on SMF
 - Missing a shorter SMF reach
- 100GBASE-LR4 100 GbE optics are complex and expensive
- 10x10 MSA bridges the gap
 - Support for 2 km, 10 km and 40 km on SMF
 - Considerably more economical
 - Eliminates expensive components
 - Consumes lesser power
- Network operator members!

Members



www.10x10msa.org

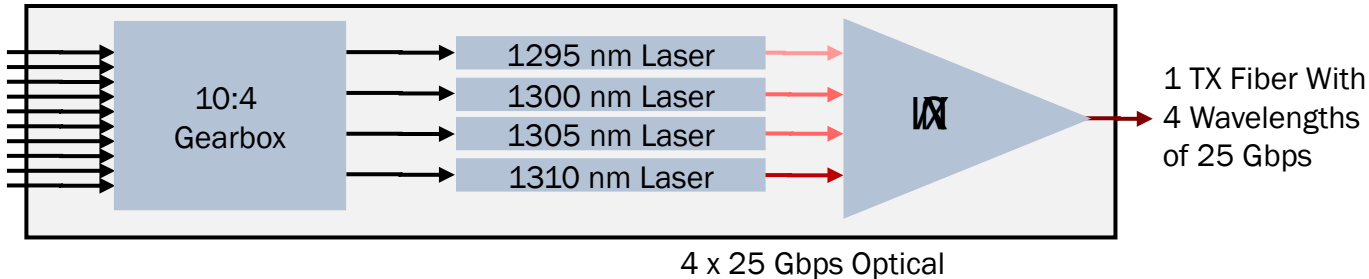


100 GbE Module Technologies Compared

Transmit Side of Module

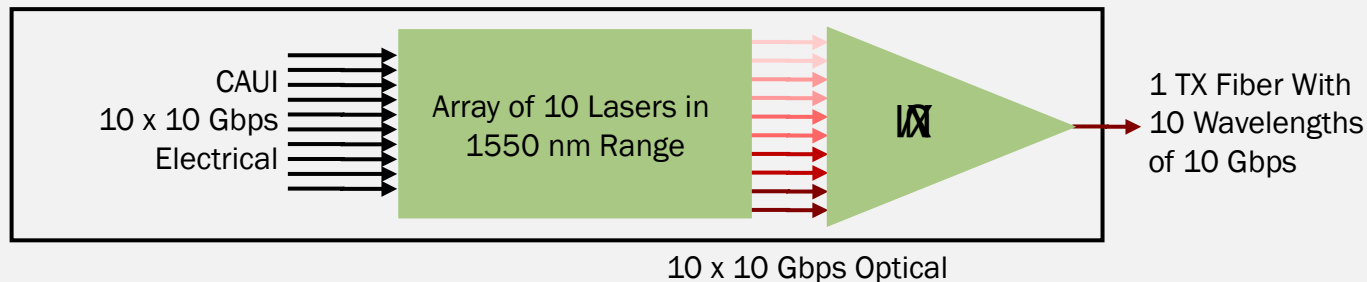
100GBASE-LR4 10 km CFP

CAUI 10 x 10 Gbps Electrical



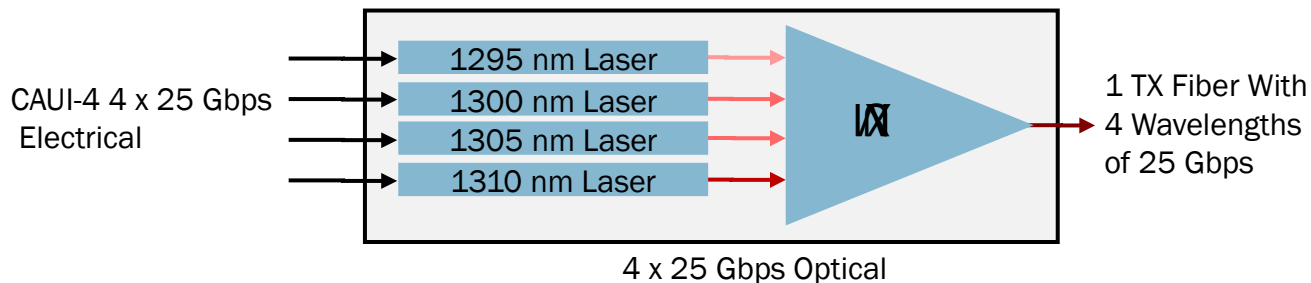
- Most expensive, complex and uses the most power
- Gearbox converts 10 x 10 Gbps electrical signaling into 4 x 25 Gbps signaling

10x10 MSA 2 km, 10 km, 40 km CFP



- Less cost, complexity and power consumption
- Uses 10 x 10 Gbps electrical and optical signaling
- Doesn't need the gearbox

100GBASE-LR4 10 km CFP2



- Lower cost, complexity and power consumption
- Uses 25 Gbps electrical and optical signaling
- Doesn't need the gearbox







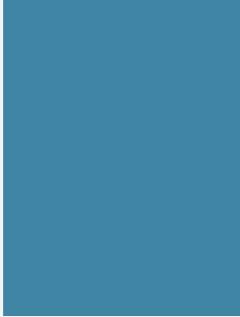







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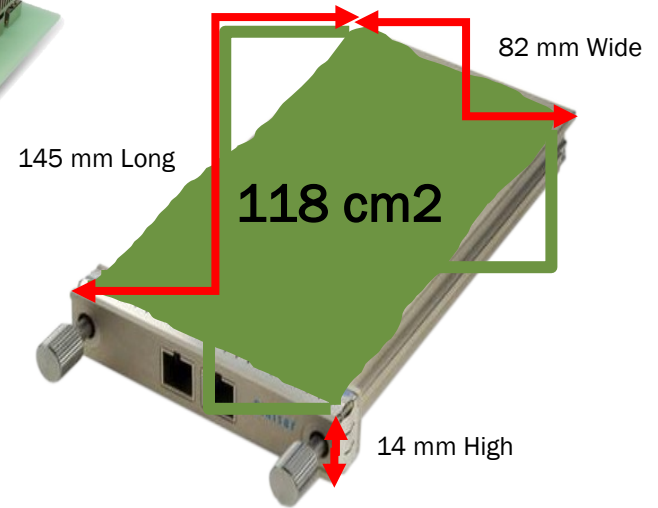
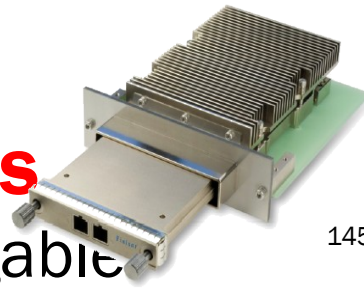
10 Gbps Module Review – 3 Generations of 10 GbE Over 7 Years

- Each Module Increased Density, While Reducing Cost

	1st Generation	2nd Generation			3rd Generation	
Module Name (Images not to Scale)	 300PIN MSA	 XENPAK	 XPAK	 X2	 XFP	 SFP+
Approximate Module Dimensions (Length x Width to Scale)						
Front Panel Density	1	4	8	8	16	48
Electrical Interface	XSBI	XAUI	XAUI	XAUI	XFI	SFI
Electrical Signaling	16 x 644 Mbps	4 x 3.125 Gbps	4 x 3.125 Gbps	4 x 3.125 Gbps	1 x 10.3125 Gbps	1 x 10.3125 Gbps
Release Year	2002	2003	2004	2004	2006	2009




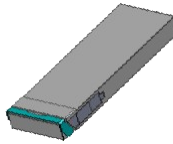
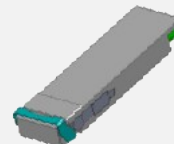





100 GbE CFP Modules

- C (100) Form-factor Pluggable
- New module optimized for 100 GbE long reach applications
- Used for 40GBASE-SR4, 40GBASE-LR4, 100GBASE-SR10, 100GBASE-LR4, 100GBASE-ER4, and 10x10 MSA
- Complex electrical and optical components need a large module
- Large module form factor and power consumption limits front panel density (larger than an iPhone)



100 Gbps Module Evolution

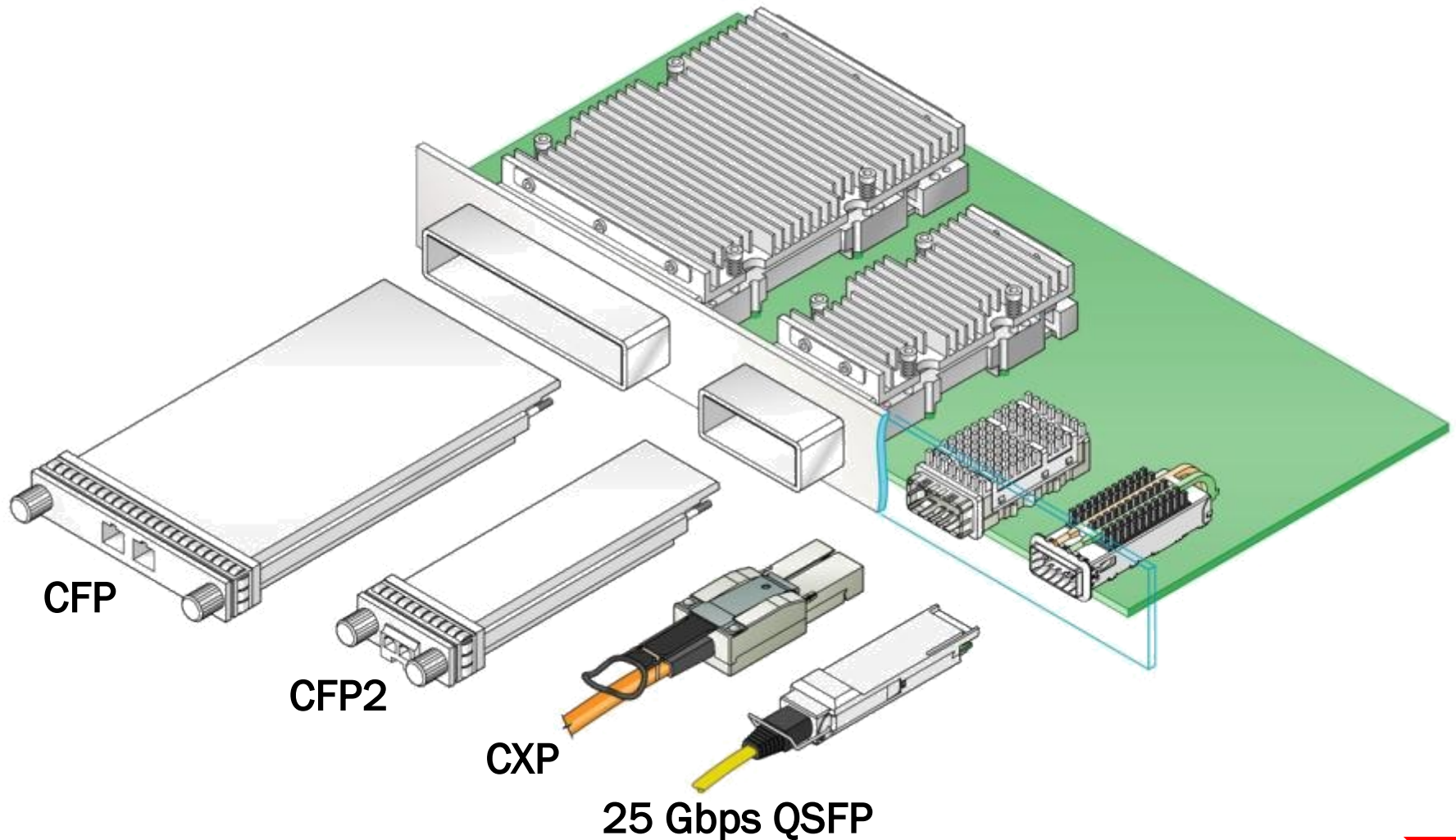
- Two Generations of 100 GbE Expected to Take 5 Years

	1st Generation		2nd Generation		
Module Name (Images not to Scale)					
	CFP	CXP	25 Gbps QSFP	CFP2	CFP4
Approximate Module Dimensions (Length x Width to Scale)					
Front Panel Density	4	16	22 - 44	8	16 - 32
Electrical Interface	CAUI	CPPI	CPPI-4	CAUI-4	CPPI-4
Electrical Signaling (Gbps)	10 x 10	10 x 10	4 x 25	4 x 25	4 x 25
Media Type	SMF	Twinax, MMF	MMF/SMF?	SMF	SMF
Advantages	Long Reach, High Power Dissipation	Small Size, Designed for Passive Cabling	Highest Density, Established Form Factor	Long Reach, Higher Density	Highest Density, Smaller Size,
Disadvantages	Too Big	Short Reach, Too Small	Limited Power Dissipation and Reach	Bigger Size	Unproven Form Factor (vs. QSFP)
Availability (Subject to Change)	2010	2010	2011 (InfiniBand) 2013+ (Ethernet)	2013+	2014+



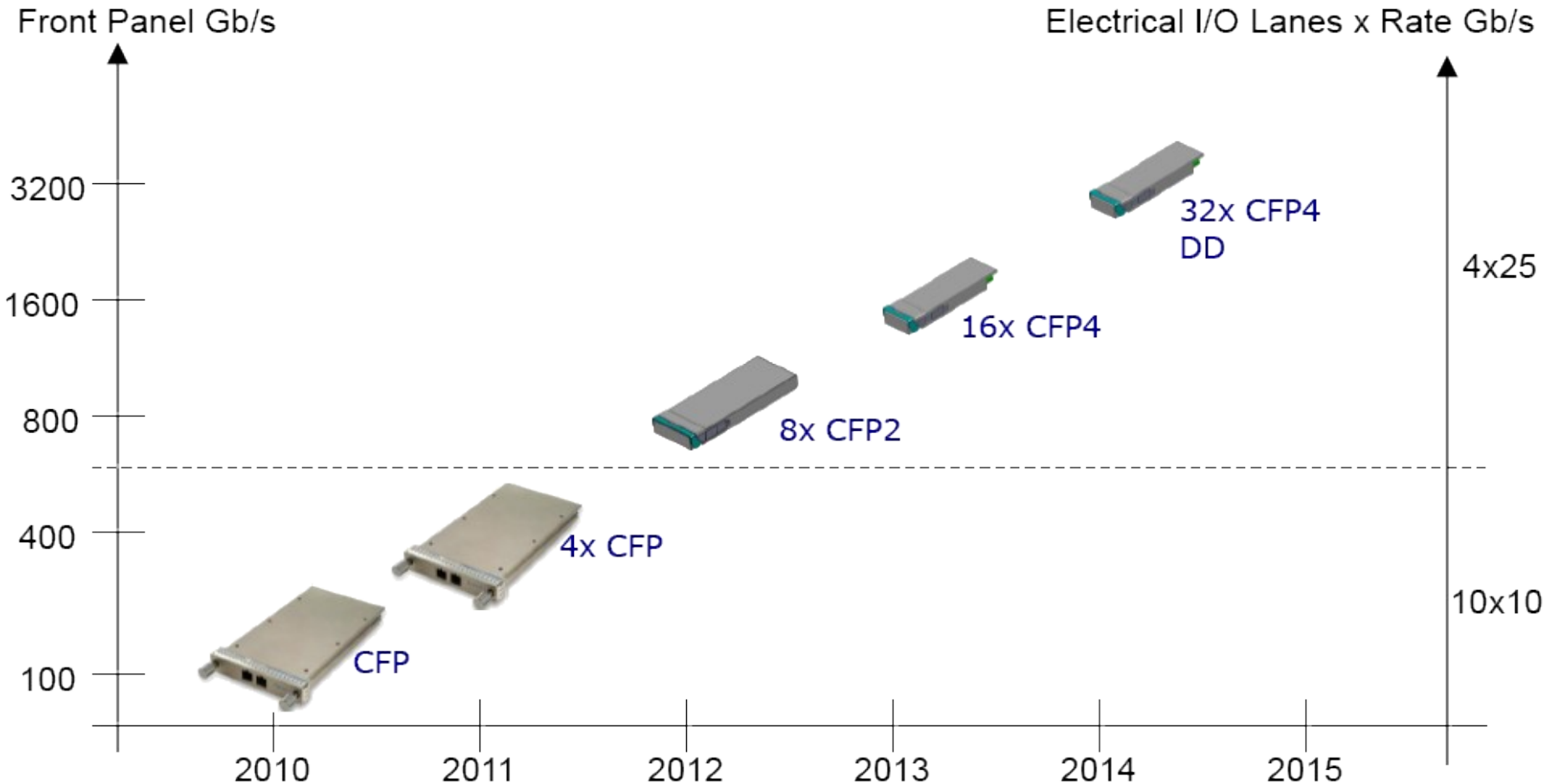
100 Gbps Module Evolution

- Graphical View of Module Form Factors



100 Gbps CFP Module Evolution

- Module Form Factor vs. Front Panel Density



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Recent 100 GbE Developments

- 10x10 MSA finished several projects
 - Up to 26 members including AMS-IX, Facebook and Google
 - Initial 10x10-2km standard published in March, 2011
 - Additional 10x10-10km and 10x10-40km standards finished in August, 2011
- 2nd generation projects based on 4 x 25 Gbps electrical signaling have started
- New IEEE P802.3bj 100 Gb/s Backplane and Copper Cable Task Force was started in September, 2011
 - 100GBASE-KR4: 4 x 25 Gbps over 1 m backplane
 - 100GBASE-CR4: 4 x 25 Gbps over 5 m copper twinax cable



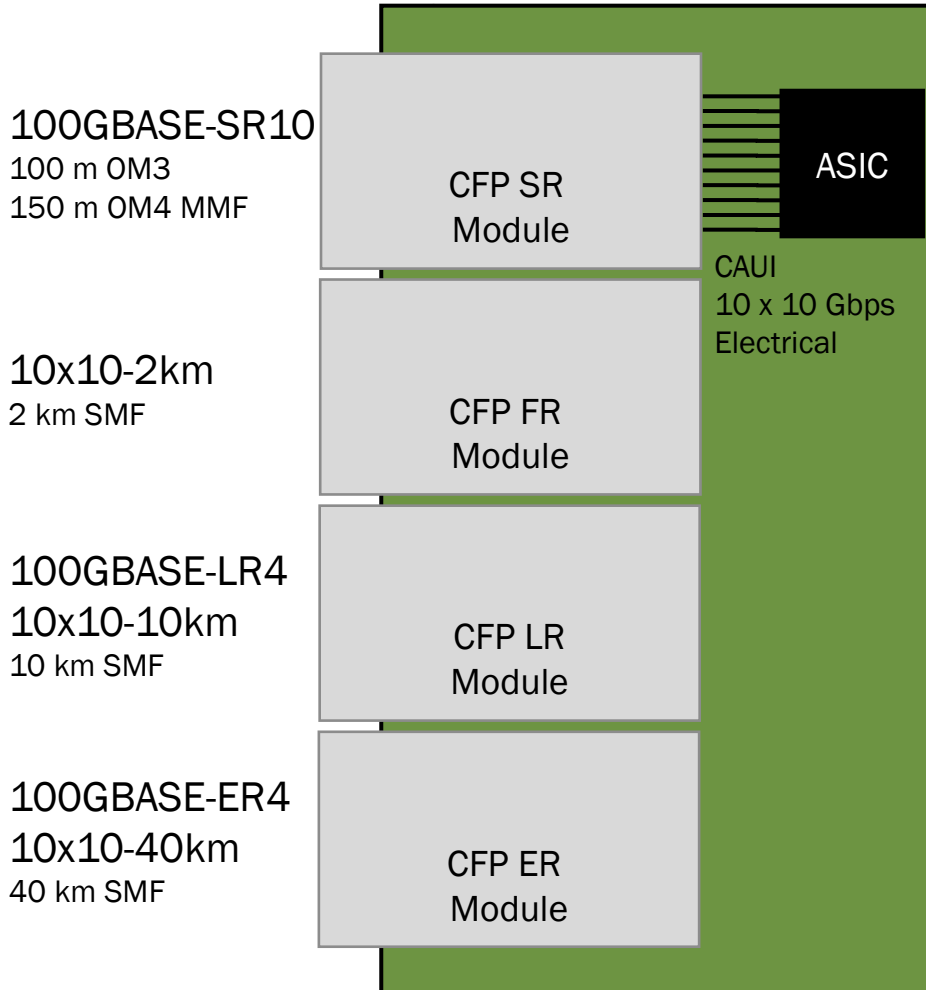
Recent 100 GbE Developments

- New IEEE Next Generation 100Gb/s Optical Ethernet Study Group was started in July, 2011
 - 100GBASE-SR4: 4 x 25 Gbps over 100 m OM3/OM4 MMF
 - 100GBASE-FR4: 4 x 25 Gbps over 500 m? – 2 km? SMF
 - CAUI-4: electrical signaling to the CFP2, CFP4 and QSFP28
 - <http://www.ieee802.org/3/100GNGOPTX/index.html>
- QSFP28 and CFP2 will be competing for the highest front panel density in 2013/2014

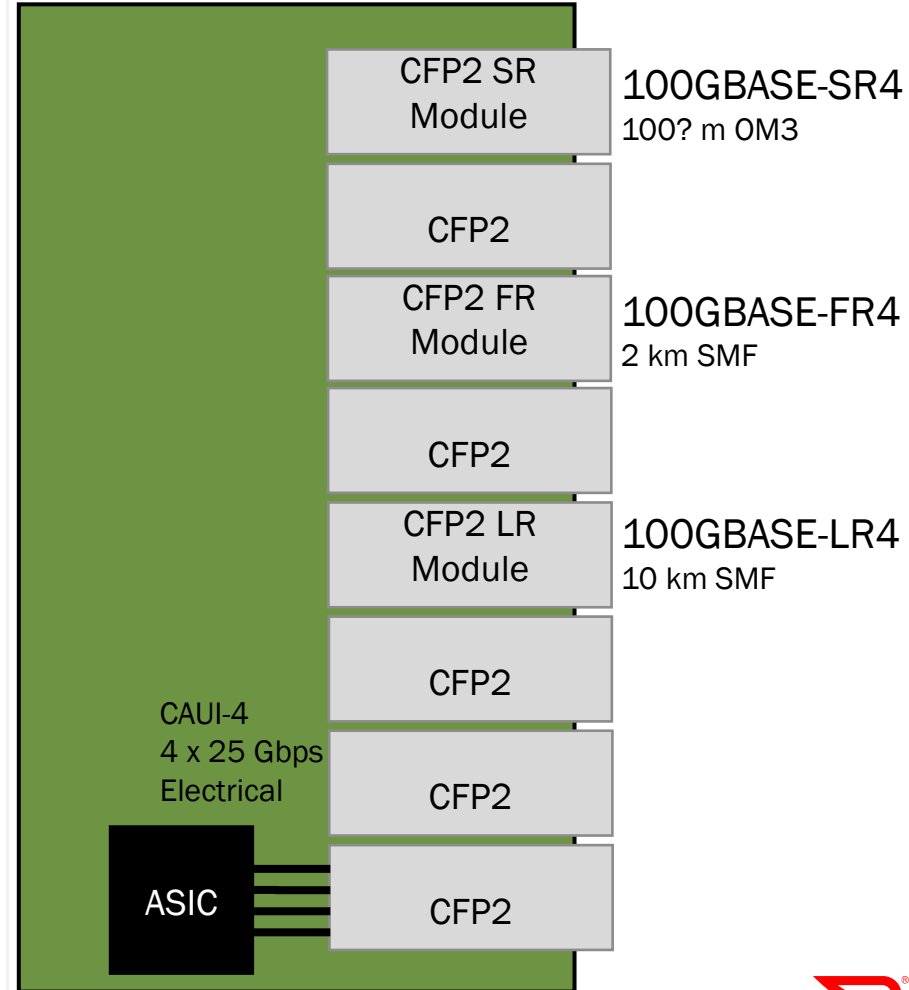


Putting it All Together – 100 GbE Line Card Architectures

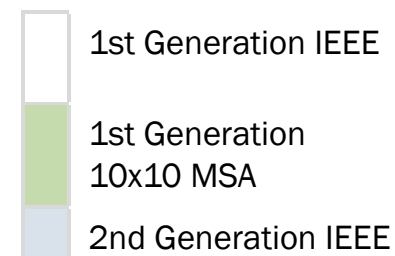
1st Generation 10 Gbps and 25 Gbps



2nd Generation 25 Gbps Signaling



100 GbE Technology Reference



Physical Layer Reach	1 m Backplane	5 m Copper Cable	7 m Copper Cable	100 m OM3/OM4	100 m OM3, 150 m OM4	500 m? – 2 km? SMF	2 km SMF	10 km SMF		40 km SMF	
Name	100GBA SE-KR4	100GBA SE-CR4	100GBA SE-CR10	100GBA SE-SR4	100GBA SE-SR10	100GBA SE-FR4	10x10-2km	10x10-10km	100GBA SE-LR4	10x10-40km	100GBA SE-ER4
Standard Status	Future IEEE 802.3bj	Future IEEE 802.3bj	June 2010 IEEE 802.3ba	Possible Future IEEE	June 2010 IEEE 802.3ba	Possible Future IEEE	March 2011 10x10 MSA	August 2011 10x10 MSA	June 2010 IEEE 802.3ba	August 2011 10x10 MSA	June 2010 IEEE 802.3ba
Electrical Signaling (Gbps)	4 x 25	4 x 25	10 x 10	4 x 25	10 x 10	4 x 25	10 x 10	10 x 10	10 x 10	10 x 10	10 x 10
Media Signaling (Gbps)	4 x 25	4 x 25	10 x 10	4 x 25	10 x 10	4 x 25	10 x 10	10 x 10	4 x 25	10 x 10	4 x 25
Media Type	Backplane	Twinax	Twinax	MPO MMF	MPO MMF	Duplex SMF	Duplex SMF	Duplex SMF	Duplex SMF	Duplex SMF	Duplex SMF
Media Module	Backplane	QSFP28, CFP2	CXP	QSFP28, CFP2	CXP, CFP	QSFP28, CFP2	CFP	CFP	CFP	CFP	CFP
Availability	2014	2014	2010	2014	2012	2014	2011	2011	2010 (CFP2 in 2013)	2012	2012

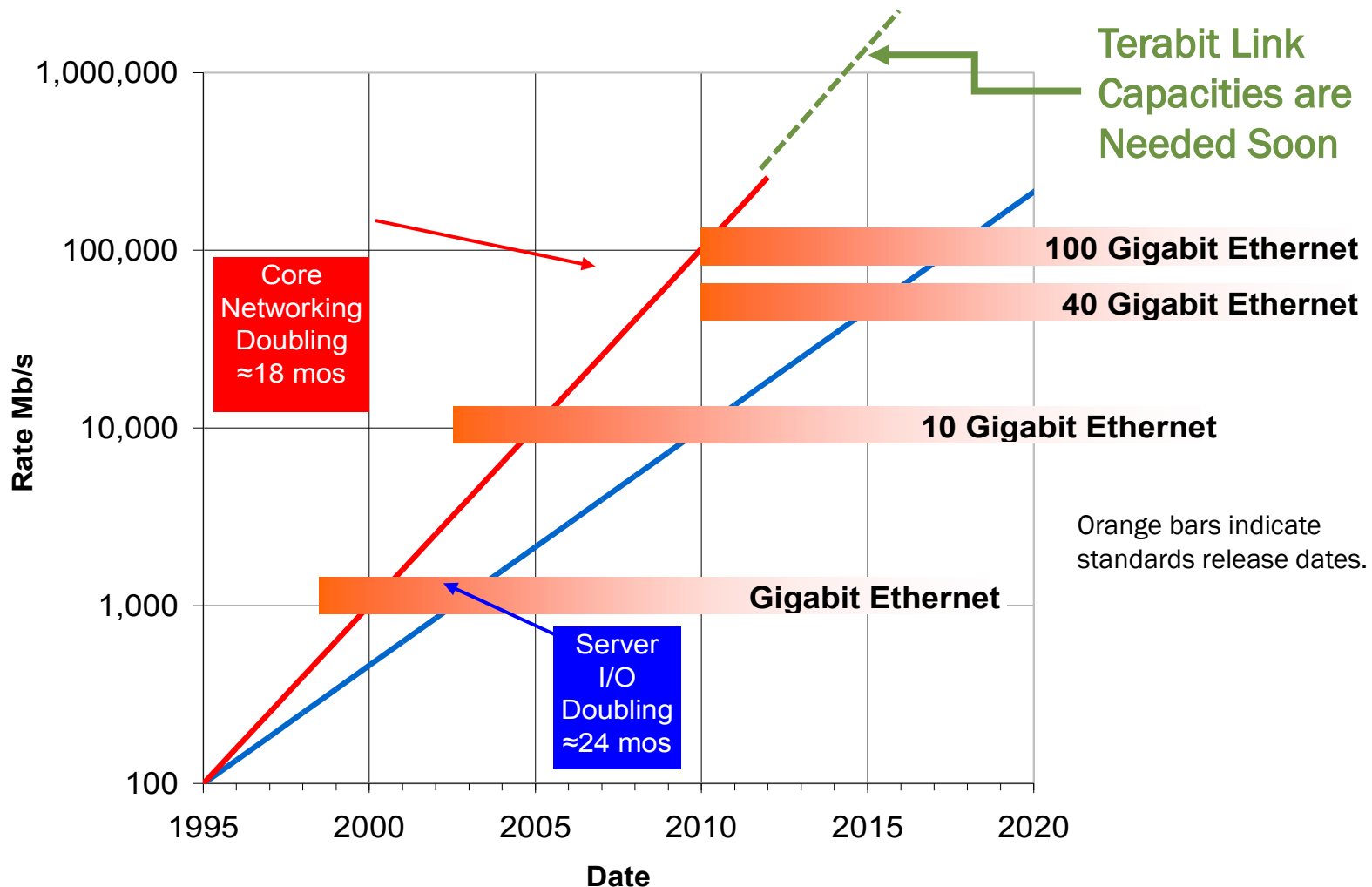


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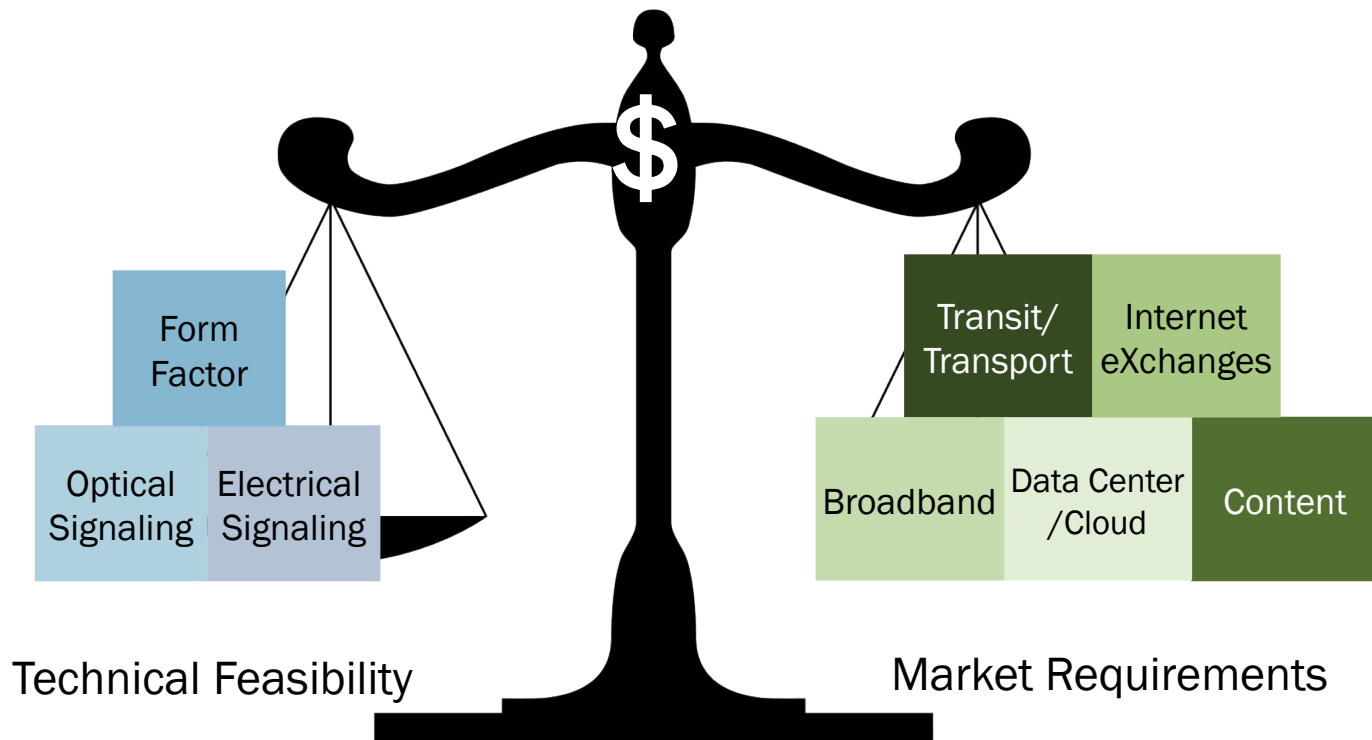
Bandwidth Requirements Projection

- All Solutions are Good, Fast, or Cheap – Pick Any Two



Beyond 100 GbE: Industry Challenges

- 2nd Generation 100 GbE and Higher Speeds



Economics Dictate the Solution

IEEE Provides an Open Industry Forum to Make Decisions

IEEE Ethernet Standards Timelines



- 8 years between 10 GbE and 100 GbE standards
- We need to start immediately in order to finish a new Ethernet speed standard by 2016

IEEE Ethernet Bandwidth Assessment Ad Hoc

- Laying groundwork and investigating industry interest for the next Ethernet speed
 - Evaluate Ethernet wireline bandwidth requirements
 - Provide data and reference material to the IEEE
 - Gather information only, will not make a recommendation

- Web page:

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

- Mailing list:

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

IEEE Ethernet Bandwidth Assessment Ad Hoc

- Network operator input is needed on future requirements
 - Speed, density, distance, cost, topology, anything really
- Presentations can be given on conference calls or at meetings, schedule is opportunistic
- Please get involved... this means *you!!*
- Request for data :

http://www.ieee802.org/3/ad_hoc/bwa/public/anslow_01a_0411.pdf

- Ad Hoc Chair contact:

John D'Ambrosia, <jdambrosia@ieee.org>

Future 100 GbE Projects

- In the short term, 4 x 25 Gbps electrical and optical interfaces will keep the IEEE 802.3 Working Group busy for 2+ years
- 100 GbE serial is still not feasible in the near future
 - 25 Gbps signaling is challenging
 - We'll get a better idea of what is possible as 25 Gbps technology matures
- 3rd generation 100 GbE is likely to be developed several years from now

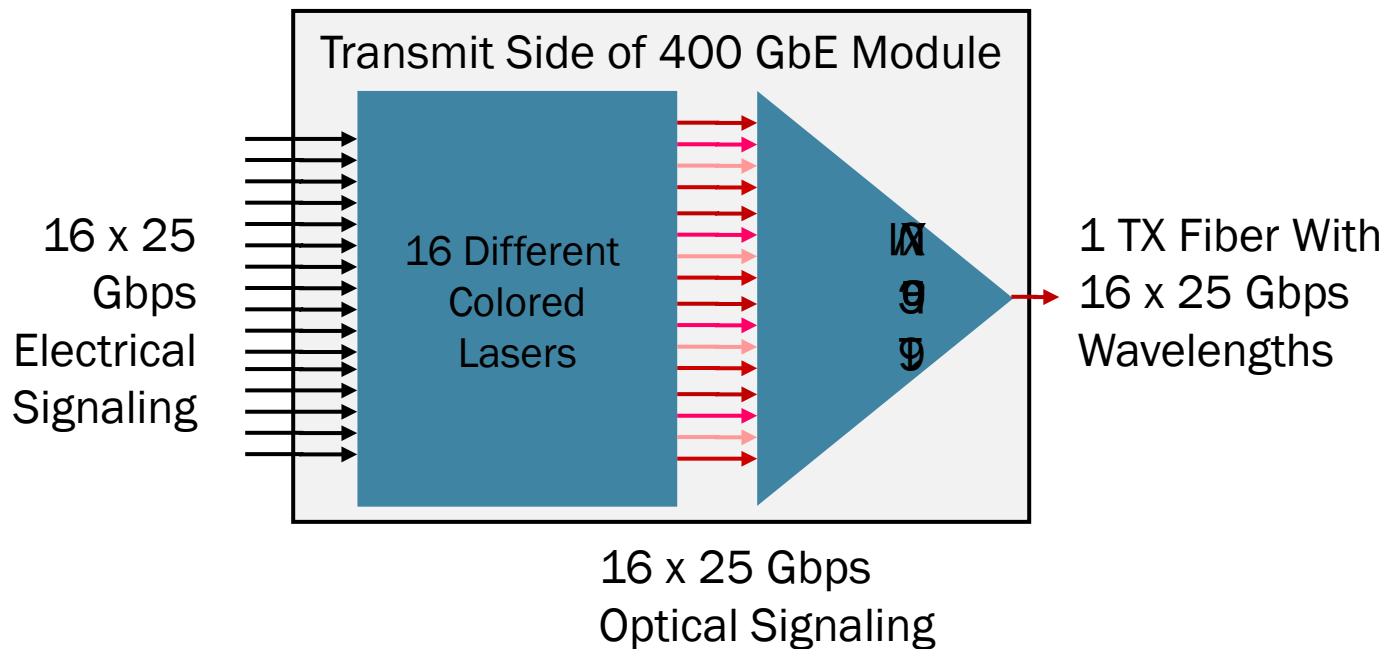
Next Higher Speed Ethernet

- 250 GbE, 300 GbE, 400 GbE, or TbE?
- Using 10 x 25 Gbps signaling the next speed could be 250 GbE
 - The industry wants a larger jump
- 12 x 25 Gbps signaling matches the number of fibers in a high density MMF cable for 300 GbE
 - Unpopular too
- The likely candidate for the next speed is 400 GbE using 16 x 25 Gbps signaling
 - 16 x 25 Gbps wavelengths can be easily muxed/demuxed onto one SMF
 - MMF solutions would need 32 fibers in a high density cable MPO/MTP assembly
 - Evolution to 10 x 40 Gbps signaling
- TbE is simply impractical in the near future
 - 40 x 25 Gbps lanes in and 40 x 25 Gbps lanes out would make a gigantic media module
 - 40 Gbps serial lanes aren't expected to be economical until after 2016, and will take considerable work as electrical losses grow exponentially with super high frequency



400 GbE Module

- The 400 GbE module could be 16 channels wide and would be larger than the current 100 GbE CFP



Summary

- The 1st generation of 100 GbE uses 10x10 Gbps electrical lanes and large CFP media modules
- The 2nd generation of 100 GbE will use 4x25 Gbps electrical lanes and smaller CFP2/CFP4/25 Gbps QSFP modules
- Industry is working on 2nd generation 100 GbE for the next few years
- 400 GbE work may start in 2013+ and could finish by 2016+
- TbE is currently technically and economically unfeasible until 40 Gbps electrical lanes are defined after 2013 with a possible standard following many years later



Questions?

