OFC 2017

The Fracturing and Burgeoning Ethernet Market

March 21, 2017

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Disclaimer

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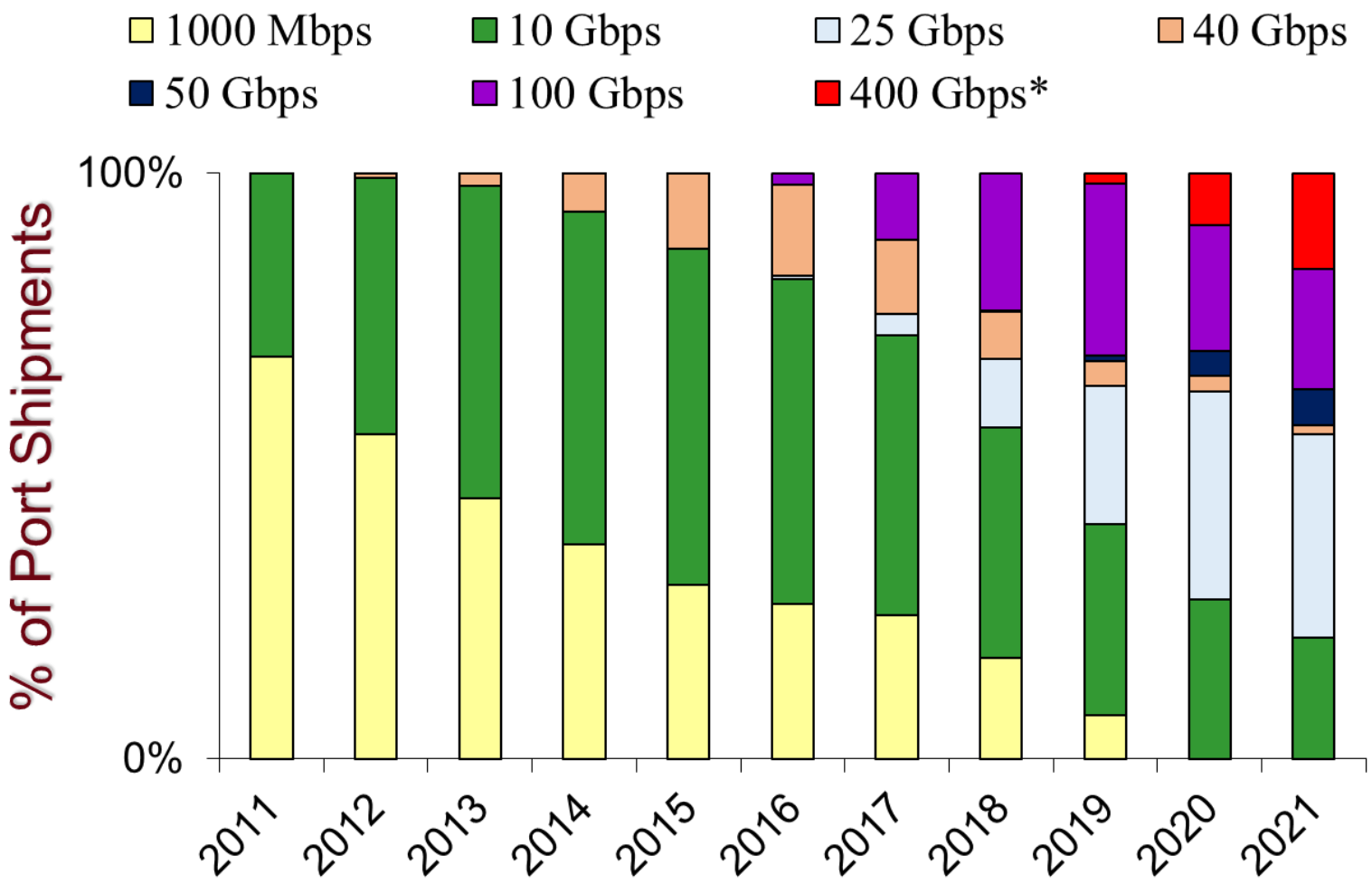
Introductions

- Moderator
  - John D'Ambrosia, Futurewei
- Panelists
  - Chris Cole, Finisar
  - Paul Brooks, Viavi
  - Mark Nowell, Cisco

Ethernet Switch – Data Center Shipments



*includes 200 Gbps

DELL'ORO GROUP

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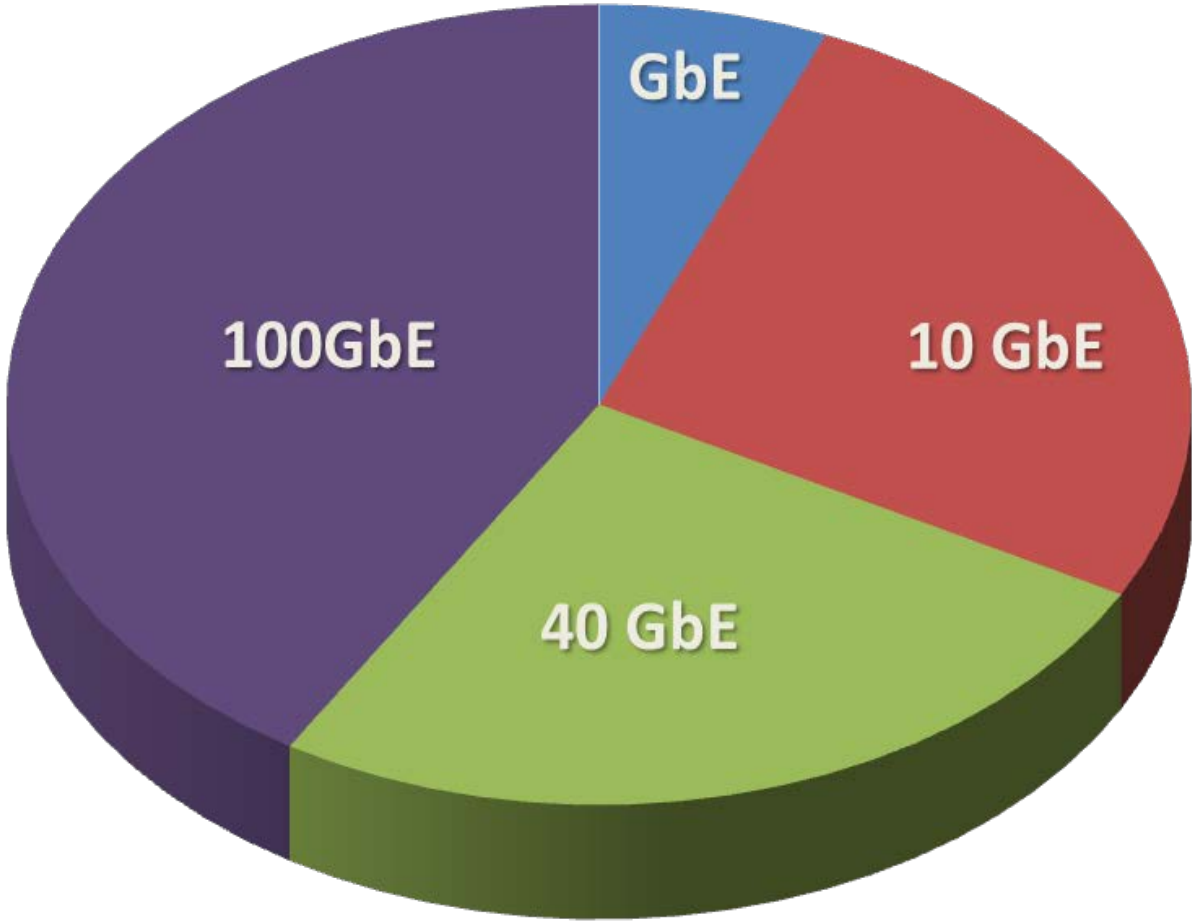
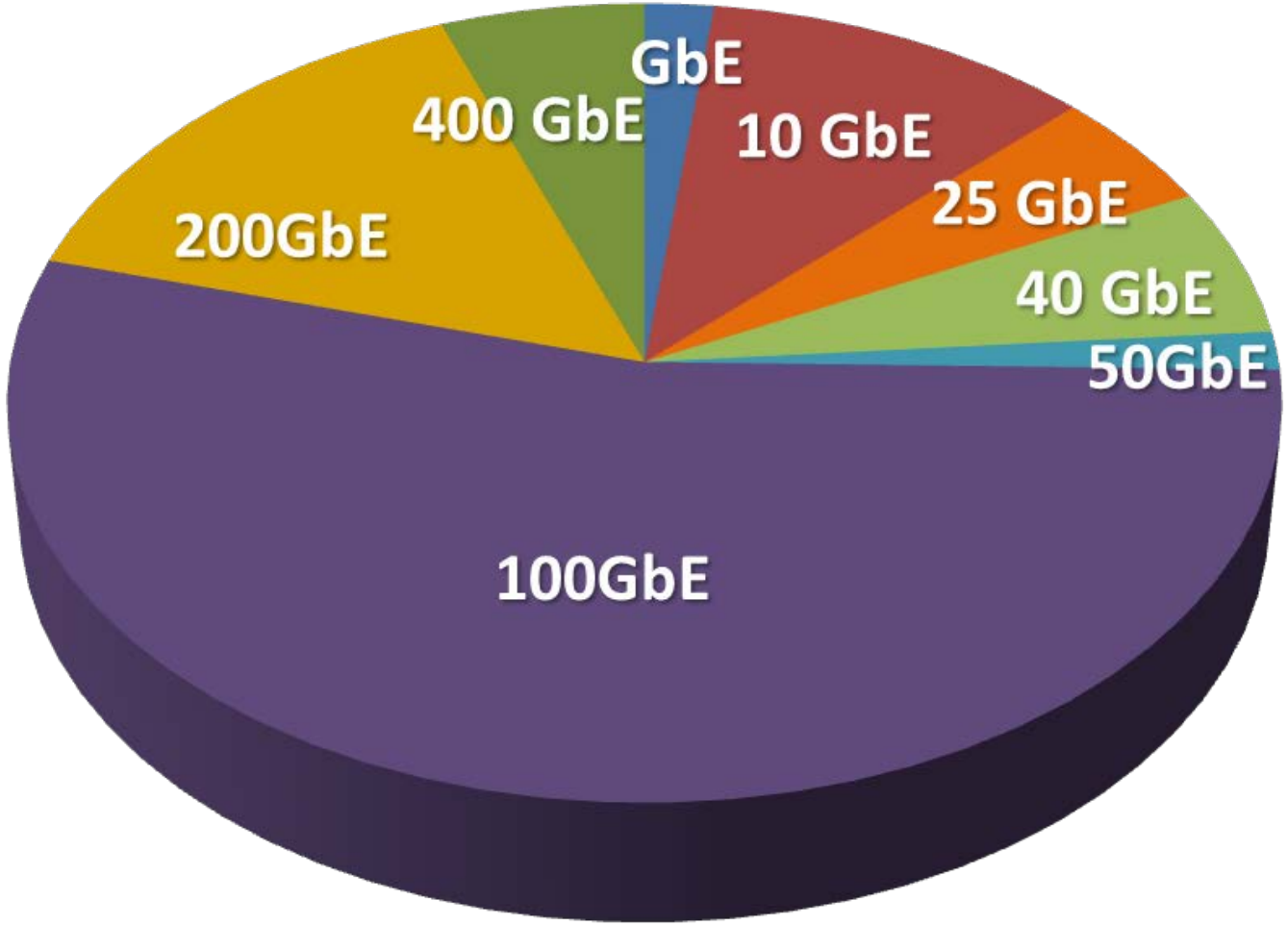
Ethernet Optical Module Market Value 2016



$2.5 billion total market

LIGHTCOUNTING Market Research

Ethernet Optical Module Market Value 2021



$4.4 billion
Total Market

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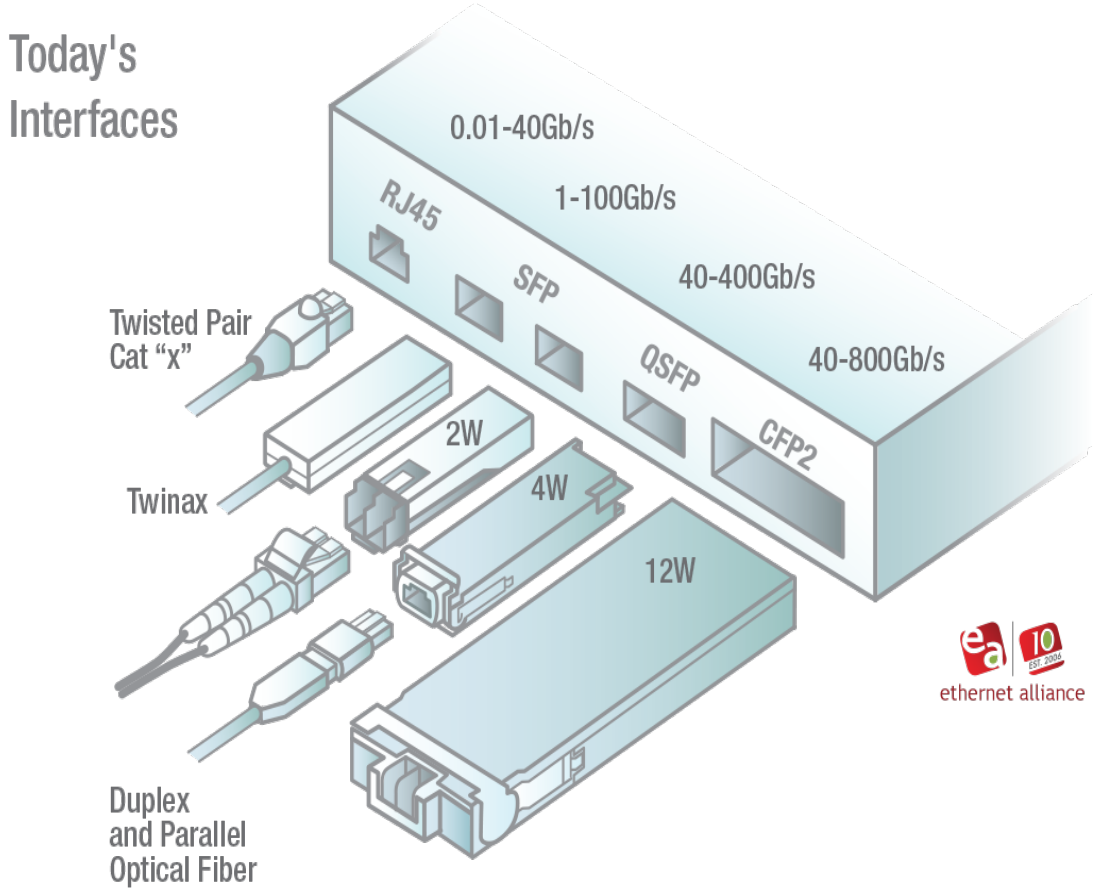
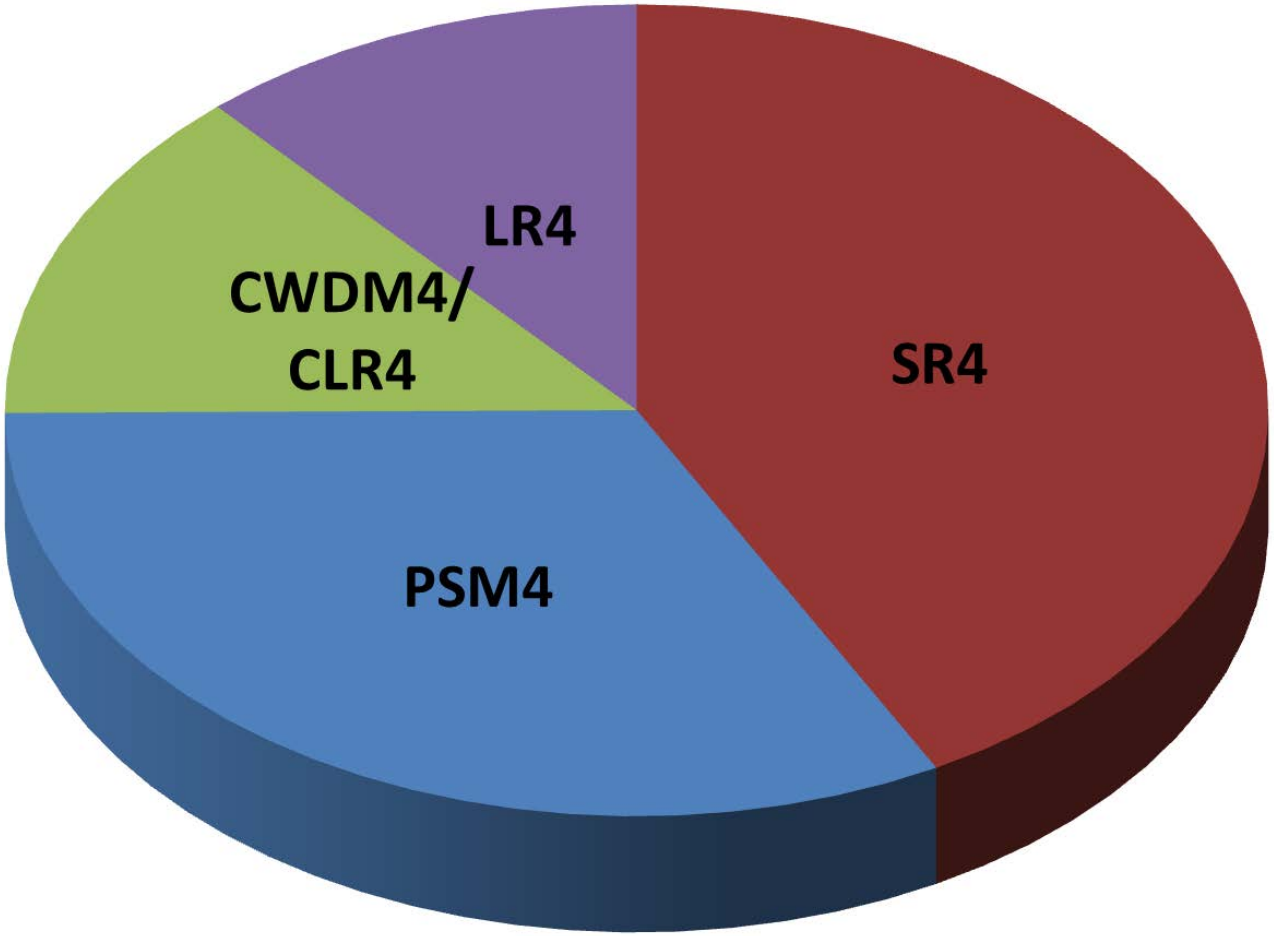
Optical Modules



IEEE 802.3 defined chip-to-module (C2M) interfaces enabled non-IEEE 802.3 optical specifications for 40GbE / 100GbE

100GbE QSFP28 Consumption in 2016



- SMF modules have majority share
- SR4 modules largest individual share

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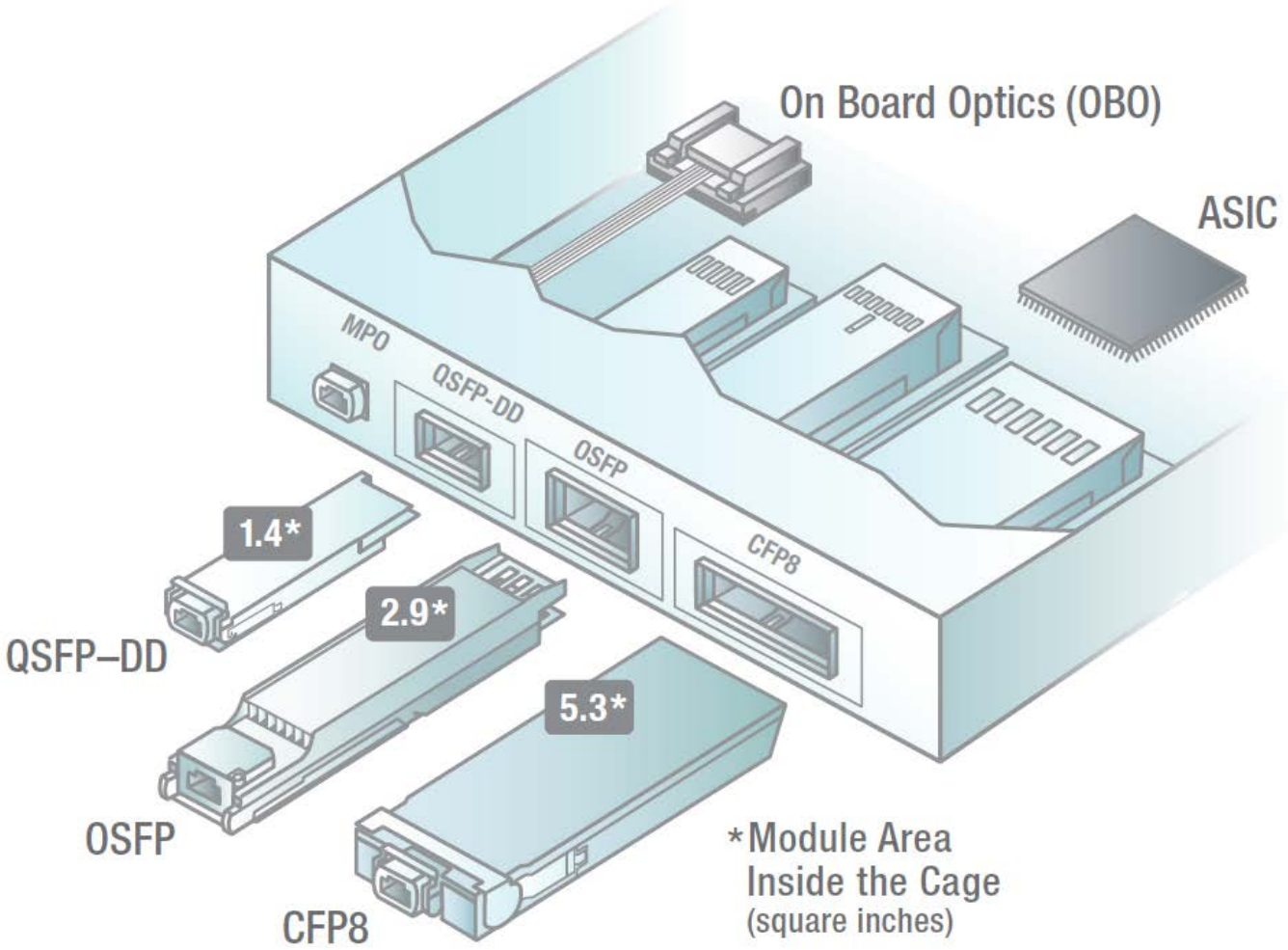
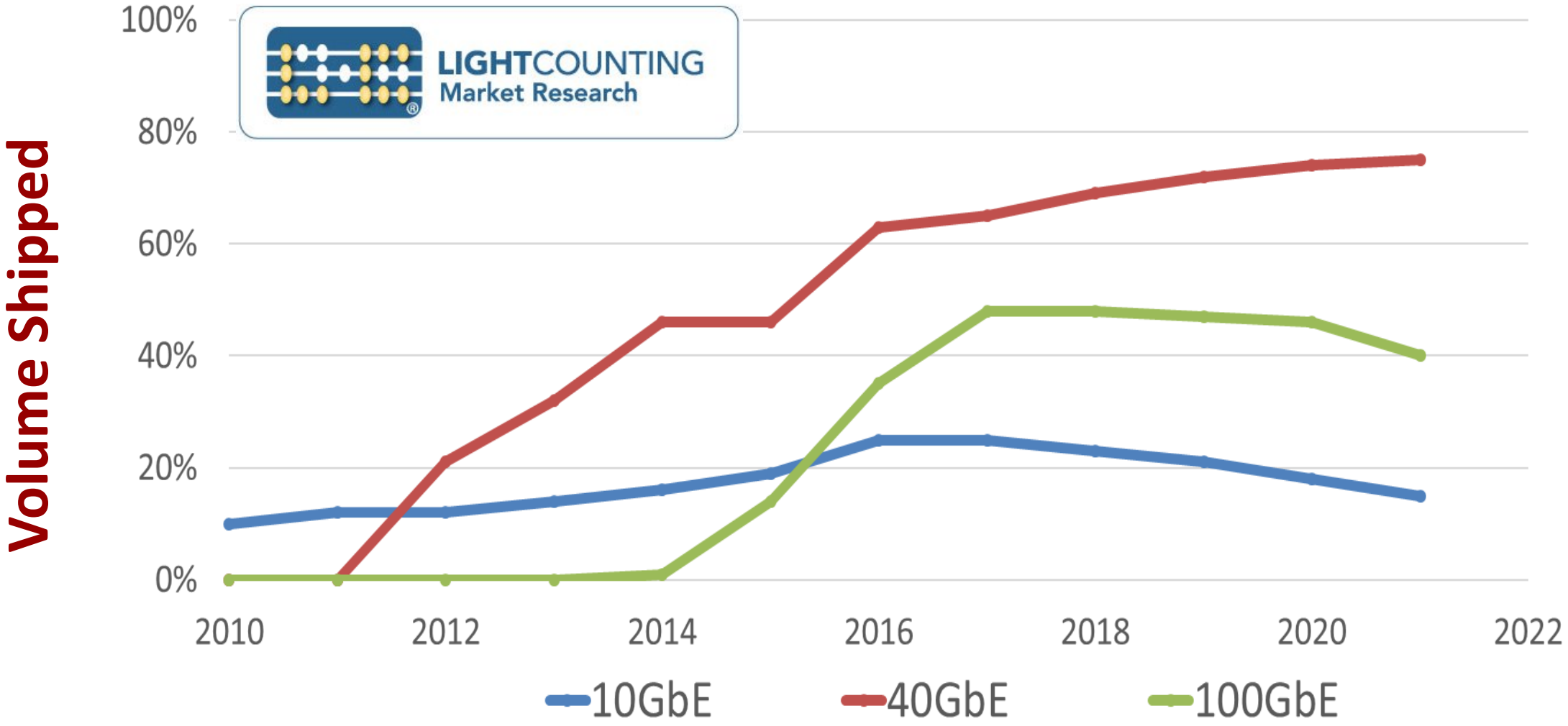
400 GbE Optical Solutions



Standard vs Proprietary Ethernet Optics

		10 GbE	40 GbE	100GbE
Standard		• 10G-SR • 10G-LR • 10G-LRM • 10G-ER	• 40G-SR4 • 40G-FR • 40G-LR4	• 100G-SR10 • 100G-SR4 • 100G-LR4 • 100G-ER4 • 100G-SR2 • 100G-DR
Proprietary	Reduced Standard	• 10G-SR (Sub) • 10G-LR (Sub)	• 40G-LR4(Sub)	• 100G-LR4 (Lite) • 100G-ER4 (Lite)
	Extended Standard		• 40G-eSR4	• 100G-eLR4
	Other		• 40G-Bidi/SWDM • 40G-PSM4	• 100G-PSM4 • 100G-CWDM4 / CLR4 / Lite

Standard vs Proprietary Ethernet Optics



ETHERNET OPTICS WHAT'S THE SAME WHAT'S DIFFERENT

Chris Cole, Finisar

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Optics History: 10G

Data Rate	Attribute	First Tech.	Gen 1	Gen 2	Gen 3	Long Term
10G	**Form Factor**	Line Card	300-pin (16x)	XENPAK/X2 (4x)	XFP (1x)	SFP (1x)
	Optics λs	1x 10G	1x 10G	1x 10G	1x 10G	1x 10G
	Start Year	1995	1998	2000	2002	2005

Optics History: 100G

Data Rate	Attribute	First Tech.	Gen 1	Gen 2	Gen 3	Long Term
10G	Form Factor	Line Card	300-pin (16x)	XENPAK/X2 (4x)	XFP (1x)	SFP (1x)
	Optics λs	1x 10G	1x 10G	1x 10G	1x 10G	1x 10G
	Start Year	1995	1998	2000	2002	2005
100G	Form Factor	300-pin (16x)	CFP (10x)	CFP2/CPAK (4x)	CFP4/QSFP (4x)	SFP (1x)
	Optics λs	1x 40G	4x 25G	4x 25G	4x 25G	1x 100G
	Start Year	2001	2007	2010	2012	2017

Optics History

Data Rate	Attribute	First Tech.	Gen 1	Gen 2	Gen 3	Long Term
10G	Form Factor	Line Card	300-pin (16x)	XENPAK/X2 (4x)	XFP (1x)	SFP (1x)
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	Optics λs	1x 40G	4x 25G	4x 25G	4x 25G	1x 100G
	Start Year	2001	2007	2010	2012	2017
400G	Form Factor		CFP8 (16x)	OSFP Start	QSFP-DD (8x)	QSFP (4x)
	Optics λs		8x 50G	8x 50G, 4x 100G	8x 50G, 4x 100G	4x 100G
	Start Year		2015	2015	2015	2017

10G & 100G Ethernet Optics Development

- Preceded by multi-year technology development and some deployment
- IEEE & MSA standardized known technology
- Many cost/size/power optics generations
- Sequential multi-year development of each optics generation
- General acceptance of 10G sequential development paradigm
- Severe criticism of 100G sequential development paradigm

400G Ethernet Optics Development

- Preceded by no technology development and no deployment
- IEEE & MSA standardizing unknown technology
- Many cost/size/power optics generations
- Parallel development of 1st three cost/size/power optics generations
- Strong demand from for introduction of advanced technology at long-term high-volume pricing

Discussion Questions

- 400G optics are being developed using a new and different paradigm from 10G and 100G optics development
- Has the optics industry has gotten dramatically smarter and more efficient to enable skipping multiple generations of development?
- How will end user expectation of advanced technology at high volume cost be reconciled with corporate ROI requirements?

TEST & MEASUREMENT IN A 'BUSY' ETHERNET WORLD

Paul Brooks – Viavi Solutions

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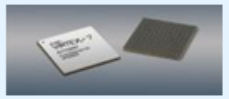
Our Ecosystem

From chips to systems – getting everyone to play together nicely

Components



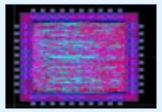
ICs

IP

ROSA / TOSA

Modules

ASICS or FPGAs



pluggables

Transponders

Linecards & Sub-Systems

Muxponders,
Switching Fabrics
Wavelength Man-Agent

Line Cards

Network Elements and Networks

Transmission Systems,
Cross-Connects, ADMs,
ROADM Nodes…

400G emerging	100G entering mainstream	10G mature

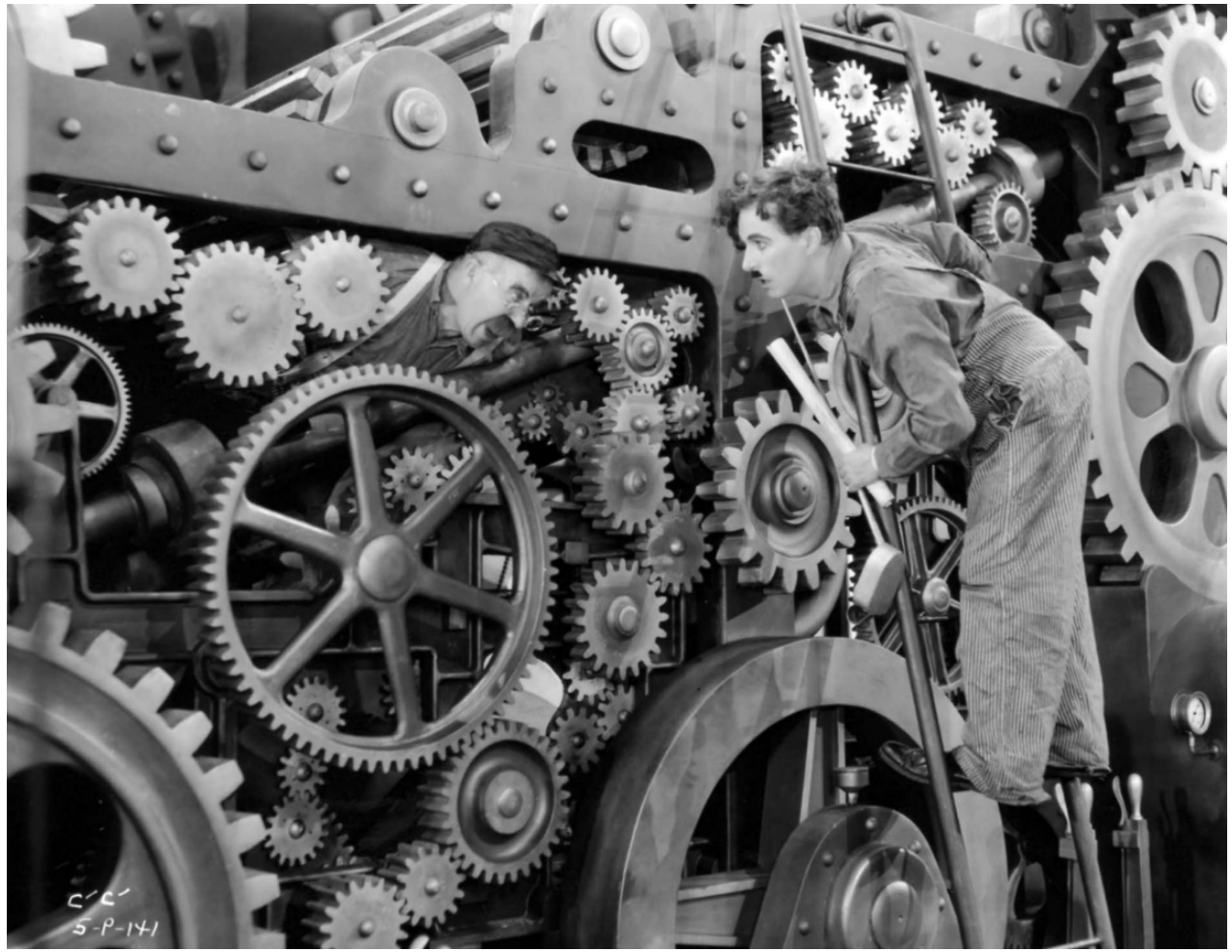
The Role of Test and Measurement

- R&D - Can I build it?
  - Experts doing deep H/W dives
  - May be pre-standard
- Production - Did I build it right?
  - Not just one in San Jose but 1000's a day at my CM
- Field & deployment - A multi-vendor ecosystem
  - Multi-skilled, may not be an expect!
  - Right pluggables, PMD, type of service

T&M learning from 100G

- 100G a walk in the park?
  - It is hard, even doing one thing with conservative & mature technology
  - 10G I/O + 25G optics + gearbox
- Which form factor & when?
  - CFP – CFP2 – CPAK - CFP4 - QSFP28
  - Every form factor chosen needs a T&D solution – lab, SVT, production, field
- Which PMD is right for me?
  - LR10, LR4, SR10, SR4, PSM4, ER4, ER4lite, CWDM4…
  - And when they don't (quite) interoperate – odd bit error?
- 25GE – consortium/IEEE, 50GE, next gen 100G…..
- We cannot support every FF, PMD and Ethernet flavour in one go!

Remember the 100G Gearbox?



Proliferation in any direction has a cost!

- Form factor
  - Every form factor needs a test slot/adapter in R&D
  - And do you really want to have a field tester with multiple FF slots?
- PMDs
  - Every optical PMD means precision test, especially in inter-op
  - And again in the field – will every field tech need to support all the PMDs?

Remember!

- Guiding Principle
  - Once it leaves the lab/production line it MUST play nicely with others!
  - Not engineered links but in an open ecosystem with the ‘lowest touch’ deployment.
  - The ecosystem exists for a long time.
- Every new form factor will need adapters & test fixtures
  - Host compliance, module compliance, electrical breakout
  - AND you need them BEFORE modules

DEMYSTIFYING THE ETHERNET MARKET REQUIREMENTS FOR OPTICS

Mark Nowell, Distinguished Engineer, Cisco

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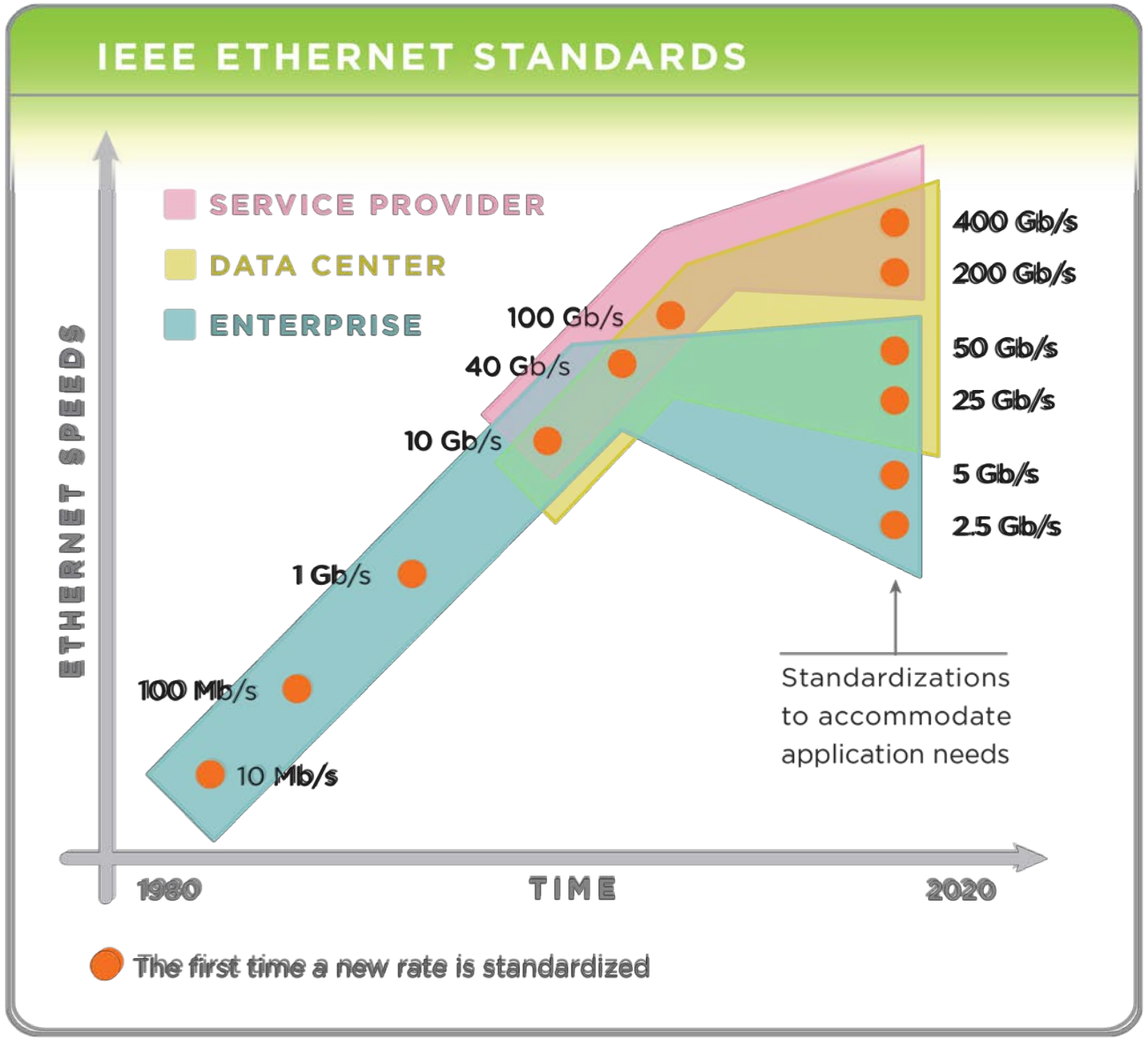
Markets driving technologies



Success of Ethernet protocol has shifted adoption to wider range of applications and markets

When market timing differences occur, different solutions emerge.

When market timing overlaps, common solutions emerge and succeed.

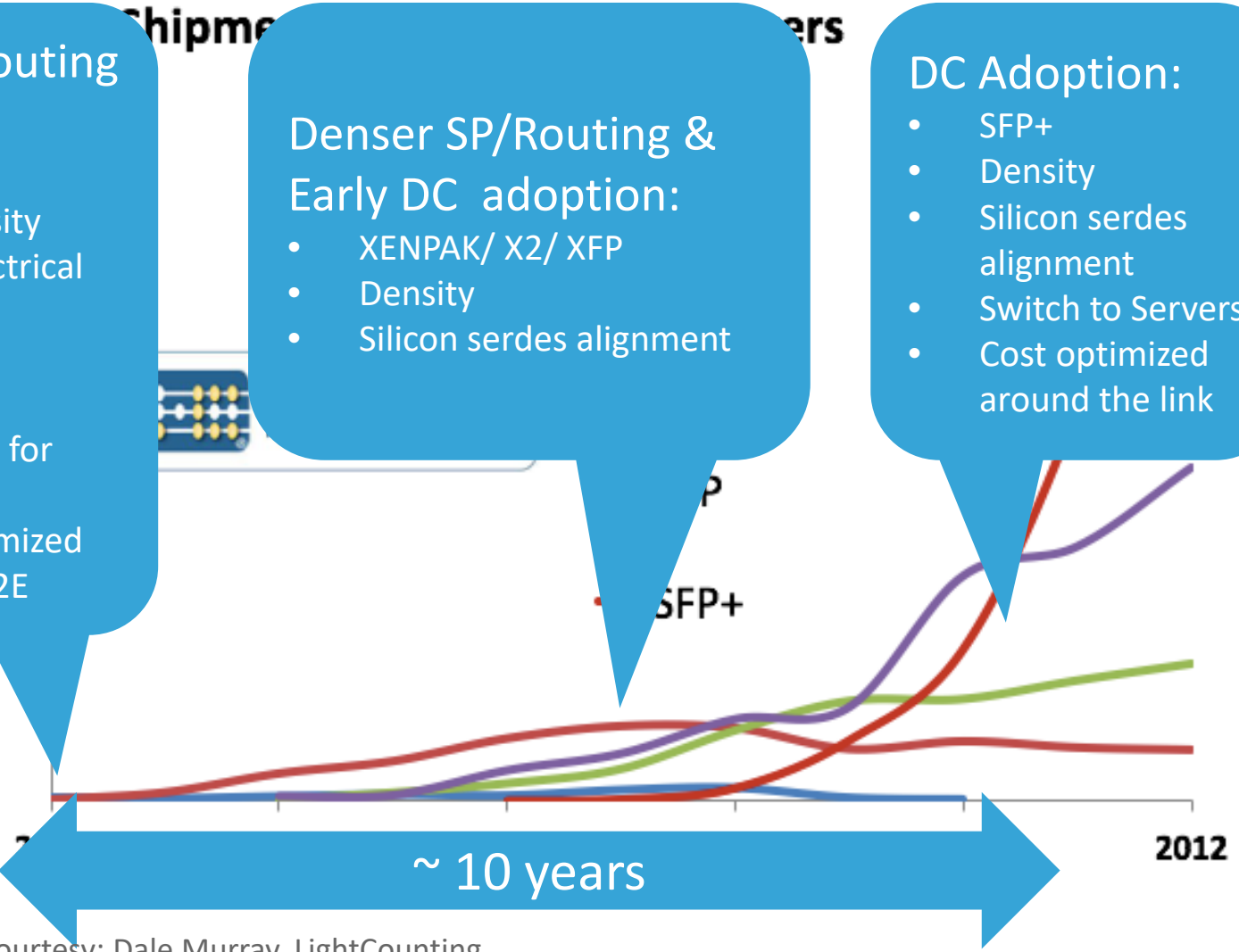
All markets benefit from economy of scale and converged technologies

How market adoption drives form factors: Example 10G

Early SP/Routing adoption:
- 300pin
- Low Density
- Wide electrical interface
- Driven by spectral efficiency for long haul
- Cost optimized around E2E

Denser SP/Routing & Early DC adoption:
- XENPAK/ X2/ XFP
- Density
- Silicon serdes alignment

DC Adoption:
- SFP+
- Density
- Silicon serdes alignment
- Switch to Servers
- Cost optimized around the link

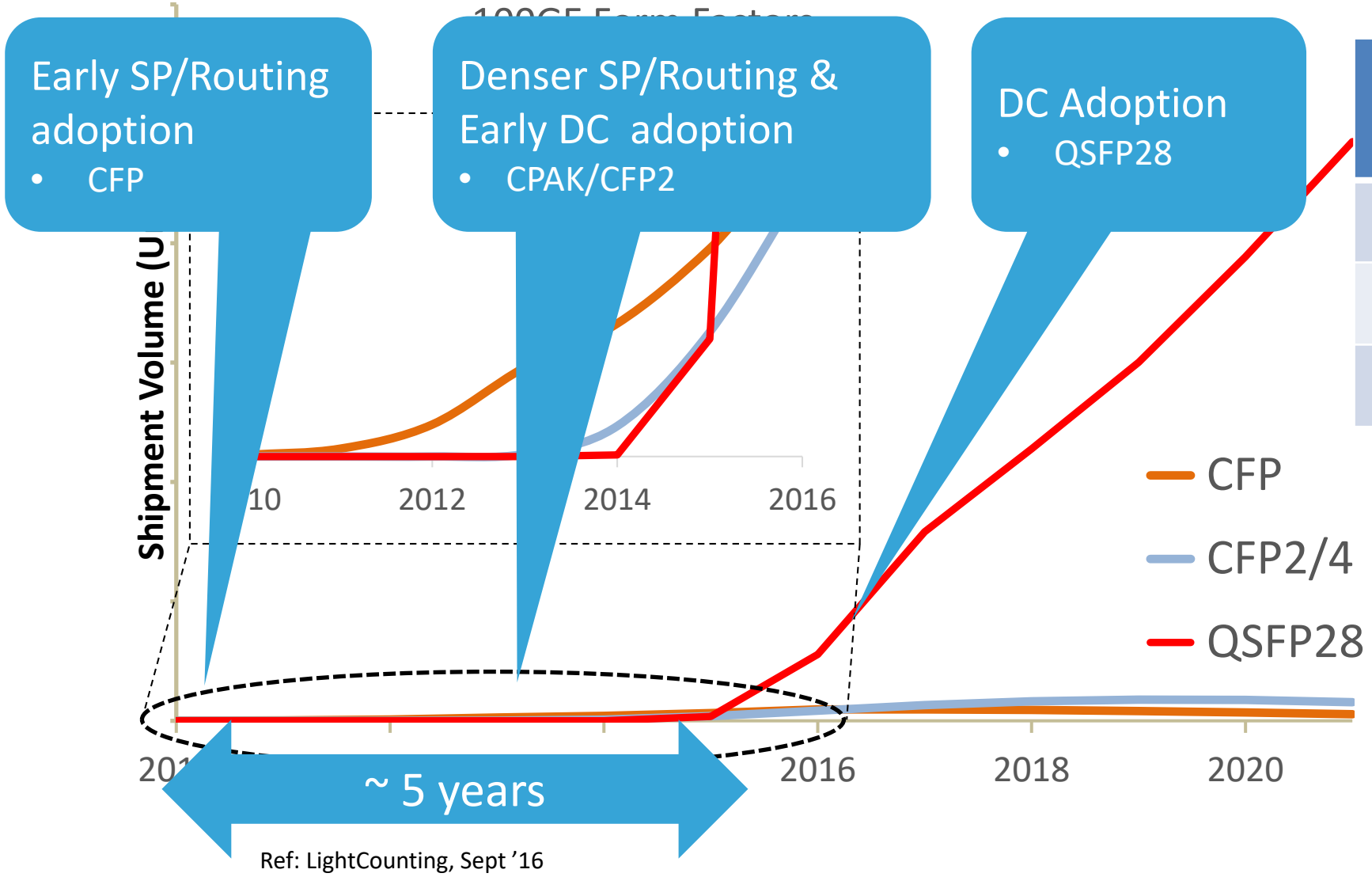


	SP	Ent. DC	Cloud DC
300 pin	✓		
XENPAK /X2	✓	✓	
XFP	✓	✓	
SFP+	✓	✓	✓

SFP+ dominates when it supports all markets

Courtesy: Dale Murray, LightCounting

How market adoption drives form factors: Example 100G



Ref: LightCounting, Sept '16

	SP	Ent. DC	Cloud DC
CFP	✓		
CFP2/4	CFP2	CFP2	CFP4
QSFP28	✓	✓	✓

Timing span of adoption of 100 GE by multiple markets compressed compared to 10 GE

400 GbE Market Adoption

3 major markets planning to adopt in near term

- Service Provider, Cloud DC, Enterprise DC

Span of separation of initial market adoption falls within a single generation of technology development

Current industry debate on what is the right one

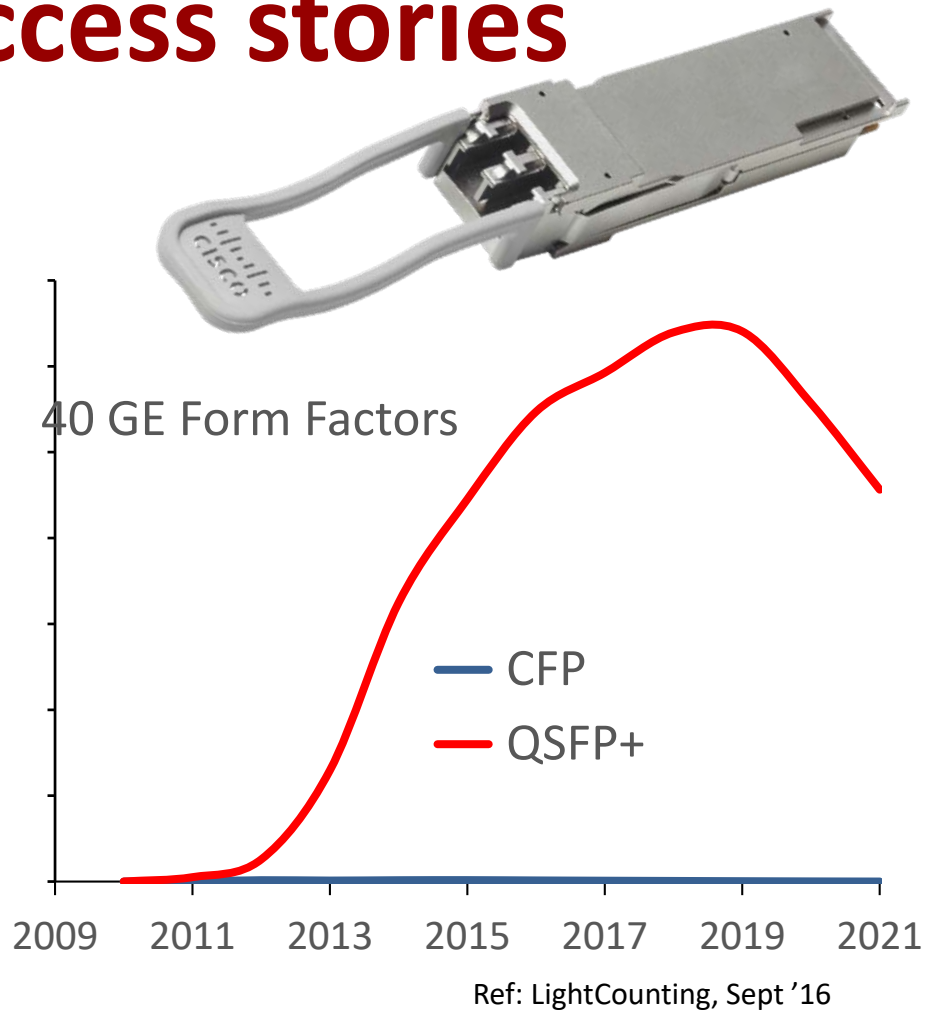
Optical component market success stories

40 GbE

- Cloud Data Center required 32 port solutions to support network architecture (Leaf-Spine)
- ASIC technology at the time (10 Gb/s Serdes) meant 40 GbE was the only option to support the necessary radix
- QSFP+ form factor met the requirements for both port density and electrical I/O

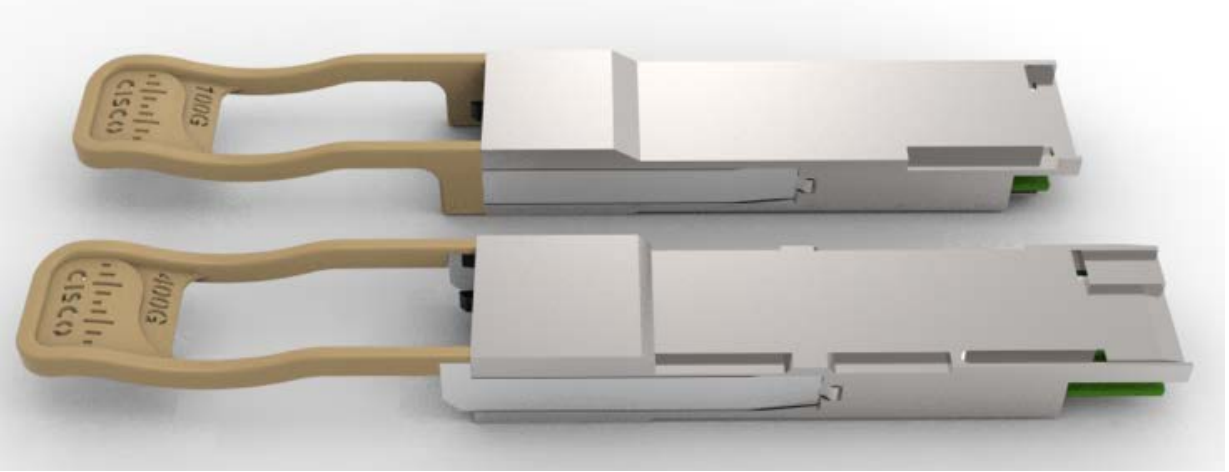
100 GbE

- CFP → CPAK/CFP2 → CFP4/QSFP28 (Form factors follow silicon/system requirements)
- QSFP28 dominates again due to alignment with: market (cloud); ASIC technology (25G serdes); system requirements (density)… and backwards compatibility



Ref: LightCounting, Sept '16

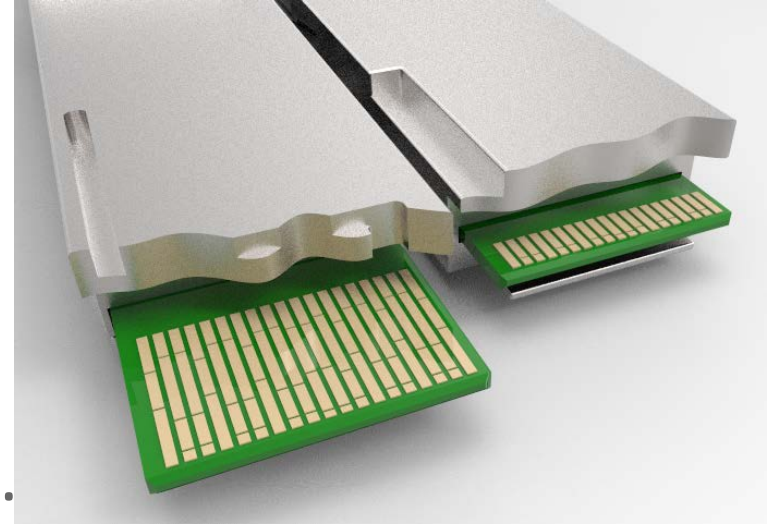
The importance of being backwards compatible



- ASICs support multiple MAC rates
- Minimizes system design (line card) variants
- Eases transition to new Ethernet rates
- Avoids need to “replicate” existing optics into new form factors (maximizes investment)
- Lack of backwards compatibility were main issues with CFP4, µQSFP

Backwards compatibility is critical for optical module industry health

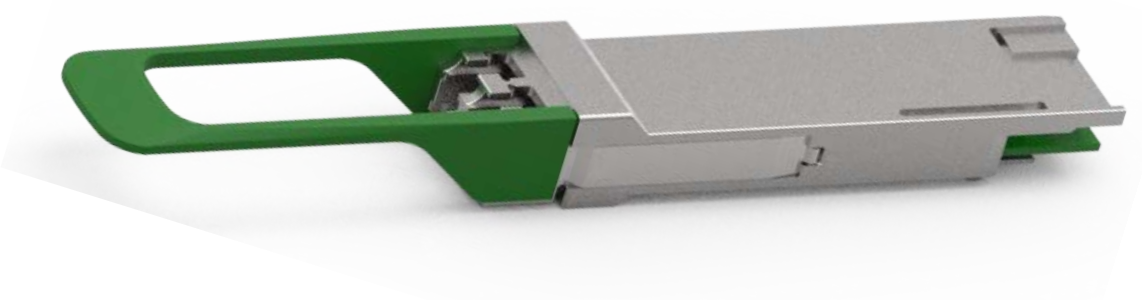
Recipe for future success @ 400GE and dense 100GE



- As always, align with ASIC IO (8x 50G PAM4 necessary).
- Support network requirements for system density: 32 & 36 ports
- Support necessary thermal/SI for implementation (all optical and copper reaches)
- Maintain backwards compatibility with QSFP28 to enable smooth network transition and avoid cost impacts associated with replicating solutions

QSFP-DD meets all the requirements for market success

Key takeaways



- Optics continues to be under cost and technology pressures
- Important to focus development efforts on highest probability of market success
- Lessons learned help guide these key success contributors:
    - Align with system and network requirements for density
    - Align with ASIC IO requirements
    - Maintain backwards compatibility with previous generation to support users

QSFP-DD will drive 400 GbE Success

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