Data Center Energy Savings in this Decade

UCSB IEE Emerging Technologies Review

Future Data Center Architectures and Increased Energy Efficiency

Session 2: Interconnect Optimization

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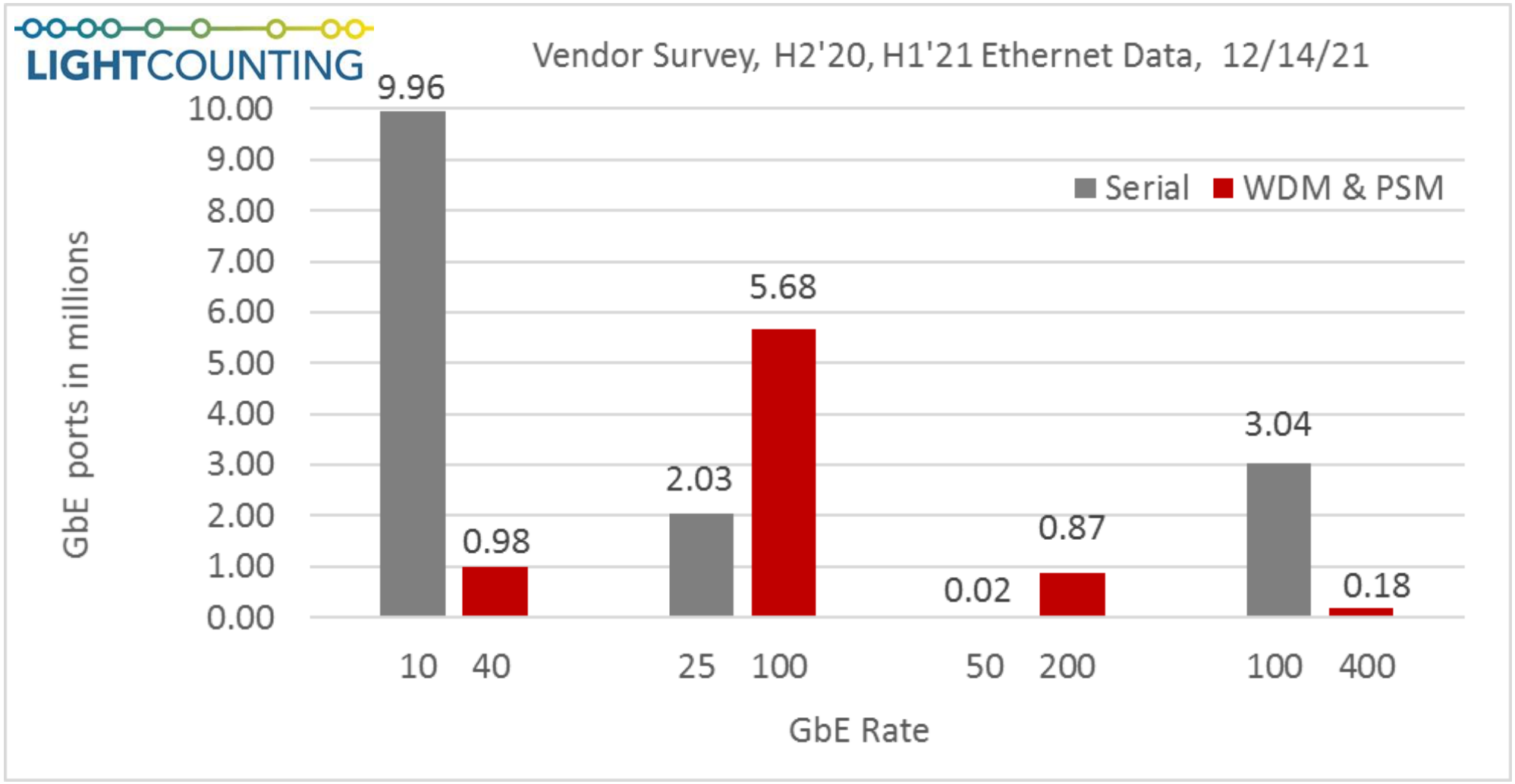
Outline

- Ethernet Optics
  - Today
  - This Decade
  - Observations
- Energy Savings Opportunities

Ethernet High-Volume SMF Optics

Gb/s/λ	10		25		50		100	
ASIC TbE	**0.48**	**1.28**	**3.2**		**12.8**			
ASIC I/O #	**48**	**128**	**128**		**256**			
GbE Rate	10	40	25	100	100	50	200	100	400
Radix	48	32	128	32	128	256	64	128	32
Type 1	LR	LR4	LR	CWDM4	CWDM4	DR1, FR1	2xGR4	4xDR1	FR4
Form factor	SFP+	QSFP+	SFP28	QSFP28	QSFP28	SFP56	OSFP	QSFP-DD	QSFP-DD
Type 2	PSM4/4	PSM4	PSM4/4	PSM4			FR4	DR1, FR1	DR4
Form factor	QSFP+	QSFP+	QSFP28	QSFP28			QSFP56	QSFP28	QSFP-DD

Ethernet SMF Optics Annual Port Shipments H2’20 & H1’21



Ethernet 200 & 400GbE SMF Optics Predictions

1st 802.3 Project	designation	**ae**	**ba**		**bs**						
	GbE Rate	10	40	100	100		200		400		
	start	1999	2007	2006	2013		2015		2013		
	published	2002	2010	2010	2017		2017		2017		
1st shipment	year	1998	2009	2011	2018		2017	2018	2017	2019	
	type	SONET LR	LR4	OTN LR4	DR1	¼ * DR4	Mobile LR4		LR8		
	wavelength	1x10	4x10	4x25	100		4x50		8x50		
	I/O	16x0.622	4x10	10x10	4x25	100	8x25	4x50	16x25	8x50	
	form factor	300-pin	CFP	CFP	QSFP	QSFP-DD	CFP	QSFP	CFP8	QSFP-DD	
1st million shipment	year	2008	2014	2016	2020		2021		2023		
	type	LR	LR4	CWDM4	DR1	¼ * DR4	FR4		FR4		
	wavelength	10	4x10	4x25	100		4x50		4x100		
	I/O	10	4x10	4x25	4x25	¼ * 4x100	2x4x50	4x50	2x4x100	4x100	
	form factor	SFP	QSFP	QSFP	QSFP	QSFP-DD	OSFP	QSFP	OSFP	QSFP	

+4

+6

Future Ethernet High-Volume SMF Optics

Gb/s/λ	50	100	200		100	200		400
ASIC TbE	**25.6**				**51.2**			
ASIC I/O #	**256**				**512 & 256**			
GbE Rate	200	400	200	800	800		1600	400
Radix	128	64	128	32	64		32	128
Type 1	FR4	2xGR4	4xDR1	FR4	FR8	2xGR4	DR8, FR8	4xDR1
Form factor	QSFP56	OSFP	OSFP	OSFP	OSFP	OSFP	OSFP	OSFP
Type 2		FR4		DR4	DR8	2xGR8	DR8, FR8	4xDR1
Form factor		QSFP112		OSFP	OSFP	OSFP-XD	OSFP-XD	OSFP-XD

Ethernet 200(1λ), 800 & 1600GbE SMF Optics Predictions

1st 802.3 Project	designation	ae	ba		df						
	GbE Rate	10	40	100	200		800		1600		
	start	1999	2007	2006	2019		2019		2021		
	published	2002	2010	2010	2025		2025		2025		
1st shipment	year	1998	2009	2011	2026		2022		2025	2027	
	type	SONET LR	LR4	OTN LR4	DR1	¼ * DR4	LR8		LR8		
	wavelength	1x10	4x10	4x25	200		8x100		8x200		
	I/O	16x0.622	4x10	10x10	4x50	200	8x100		16x100	8x200	
	form factor	300-pin	CFP	CFP	QSFP	QSFP-DD	OSFP		OSFP-XD	OSFP	
1st million shipment	year	2008	2014	2016	2028		2029		2031		
	type	LR	LR4	CWDM4	DR1	¼ * DR4	FR4		FR8		
	wavelength	10	4x10	4x25	200		4x200		8x200		
	I/O	10	4x10	4x25	4x50	¼ * 4x200	2x4x200	4x200	2x8x200	8x200	
	form factor	SFP	QSFP	QSFP	QSFP	QSFP-DD	OSFP	QSFP	OSFP-XD	OSFP	

+3 +4 +6

Ethernet SMF High-Volume Optics Energy Use

Gb/s/λ	1	10		25	50	100
GbE Rate	1	10	40	100	200	4x100 & 400
Type	LX	LR	LR4	CWDM4	FR4, GR4	DR4, FR4
Form Factor	GBIC	SFP+	QSFP+	QSFP28	QSFP56, OSFP	QSFP-DD
Watts at 1st million	0.5	1	3	3.3	5	8
pJ/bit at 1st million	500	100		30	25	20
~ ratio of prior rate		500%		300%	130%	120%

Ethernet Optics Observations

- High-volume optics will use 10, 25, 50 & 100Gb/s/λ in this decade
- 200Gb/s/λ optics will not see volume until end of the decade
- Pluggable form factors (QSFP, OSFP types) will fully support all switch ASICs (12.8, 25.6, 51.2T)
- Pluggable modules will be the high-volume form factors
- Investment in 50Gb/s/λ optics has been shifted to 100Gb/s/λ optics
- 50Gb/s/λ optics is the first λ technology generation with large underinvestment
- Industry has prioritized high-performance over energy savings
- As a result, both 50Gb/s/λ and 100Gb/s/λ optics do not significantly save energy over 100GbE 25Gb/s/λ optics

Data Center Energy Savings Opportunities

Ethernet Optics

- Restore some investment in 50Gb/s/λ for modest savings
- Concentrate investment in 100Gb/s/λ for significant savings
- Continue investment in fundamental research for breakthrough savings

Data Center Energy Savings in this Decade

Thank you

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