IEEE 802.3 NEA AD HOC

IEEE 802.3
CALL FOR INTEREST
“BEYOND 400 GbE“
DRAFT DEVELOPMENT OF
CFI CONSENSUS PRESENTATION

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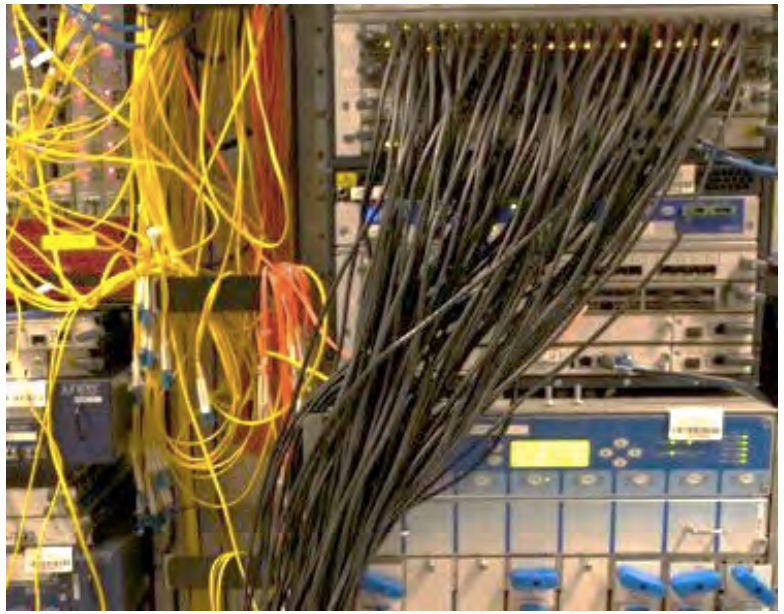
OBJECTIVE FOR THE MEETING

- To *measure the interest* in starting a study group to address *Beyond 400 Gb/s Ethernet*
- We don't need to
  - Fully explore the problem
  - Debate strengths and weaknesses of solutions
  - Choose any one solution
  - Create PAR or five criteria
  - Create a standard or specification
- Anyone in the room may speak / vote
- RESPECT… give it, get it

AGENDA

- Introduction
- Market Perspective
- Achieving Beyond 400 GbE
- Why Now?
- Straw Polls
- Future Work

LINK AGGREGATION

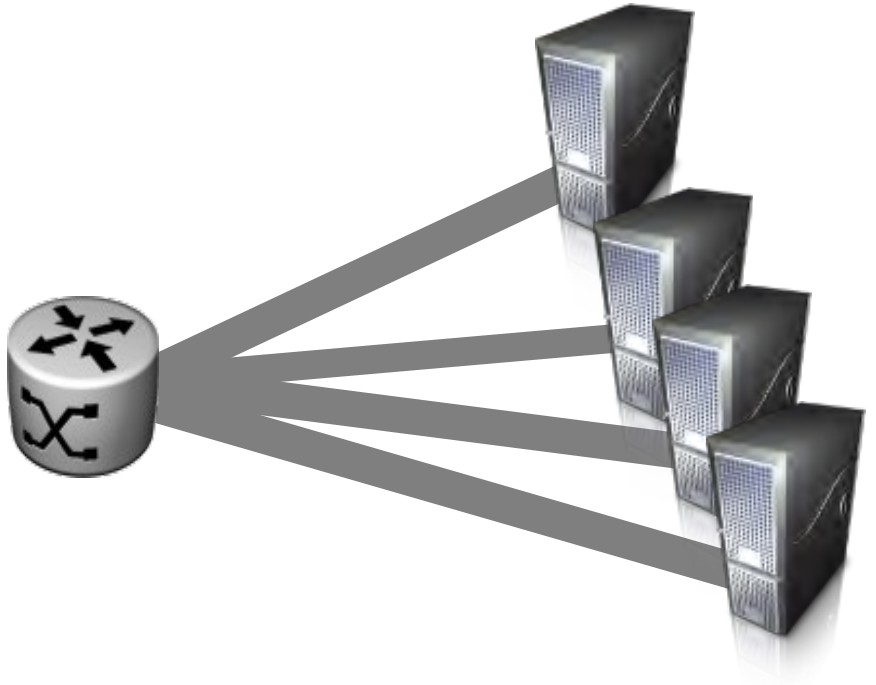


Courtesy, David Ofelt, Juniper.

- Problem: Need to scale the Network (density & cost)
- Temporary Solution: Link Aggregation
- Pros: Addresses bandwidth requirements between releases of faster links
- Cons:
  - Non-deterministic performance
  - Fastest flow limited to individual link speed
  - Exponential bandwidth growth implies:
    - Exponential growth in number of links
    - Growth in operational & management issues
  - Doesn't scale forever.
- Faster links address these issues ***and they will be LAGGed!***

WHAT ARE WE TALKING ABOUT?

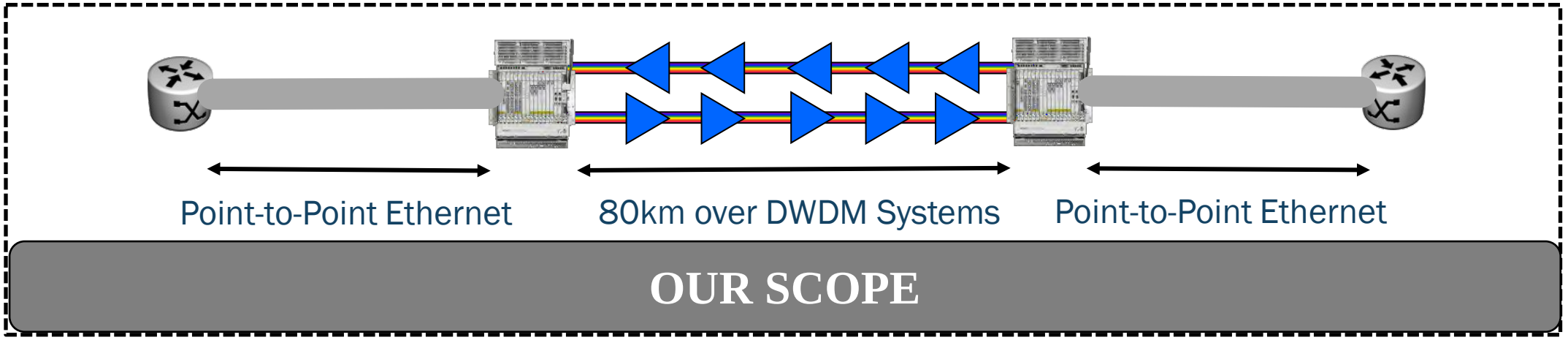
Scenario #1
Point-to-point link



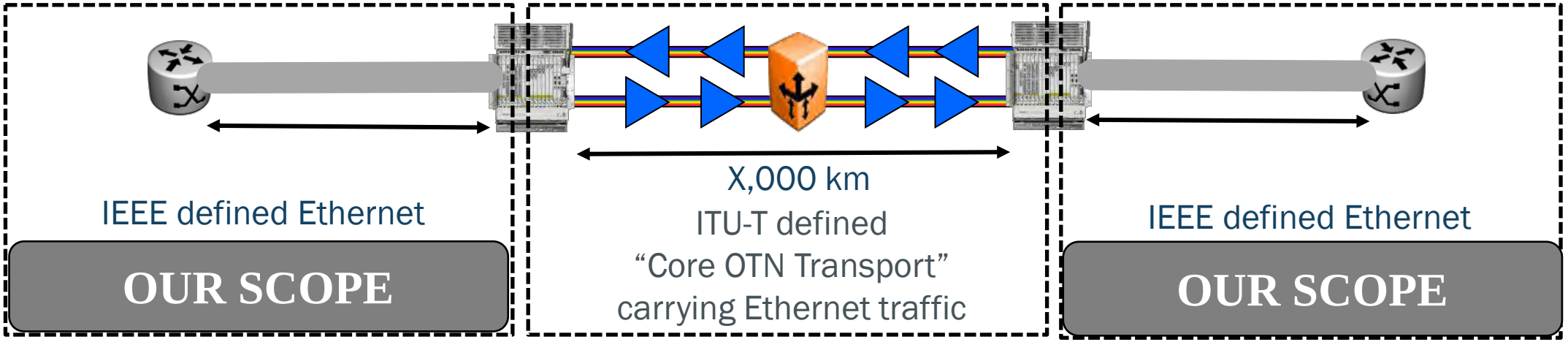
Related Scenario
Port supports Break-out

OTHER SCENARIOS

Scenario #2



Scenario #3

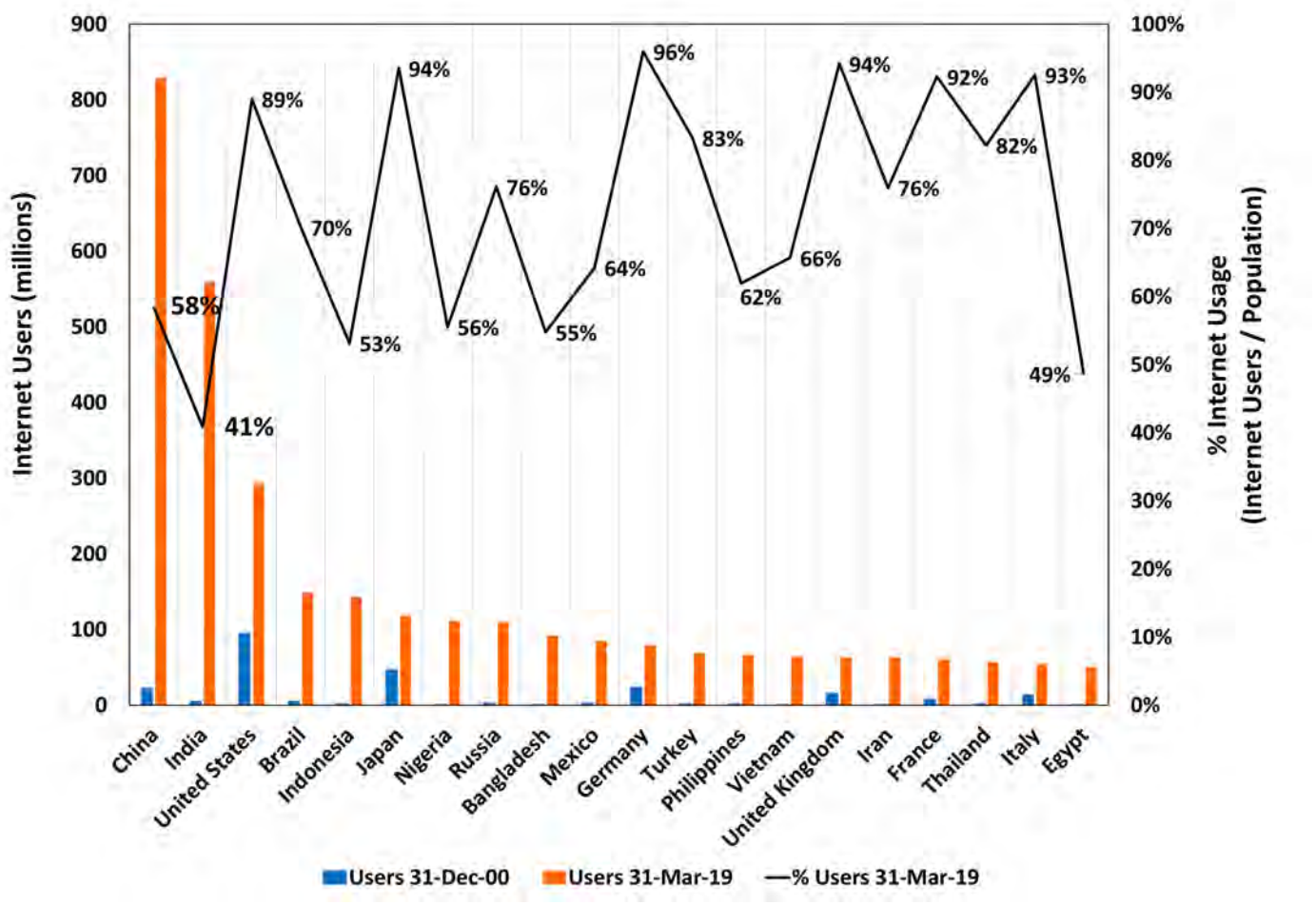


MARKET PERSPECTIVE

THE SONG REMAINS THE SAME

Increased # of users	x	Increased access methods and rates	x	Increased services	=	Bandwidth Explosion

INTERNET USAGE – TOP 20 COUNTRIES



Observations

- Only 8 countries had at least 80% connectivity
- ≈2 billion people in Top 20 countries remain to be connected
- China has the largest number of internet users (829 million), but only 58% of the population was connected
- India has the second largest number of internet users (560 million), but only 41% of the population was connected

Source: Internet World Stats (as of 31 March 2019)

https://www.internetworldstats.com/stats.htm

GLOBAL DEVICES / CONNECTIONS AVERAGE PER CAPITA

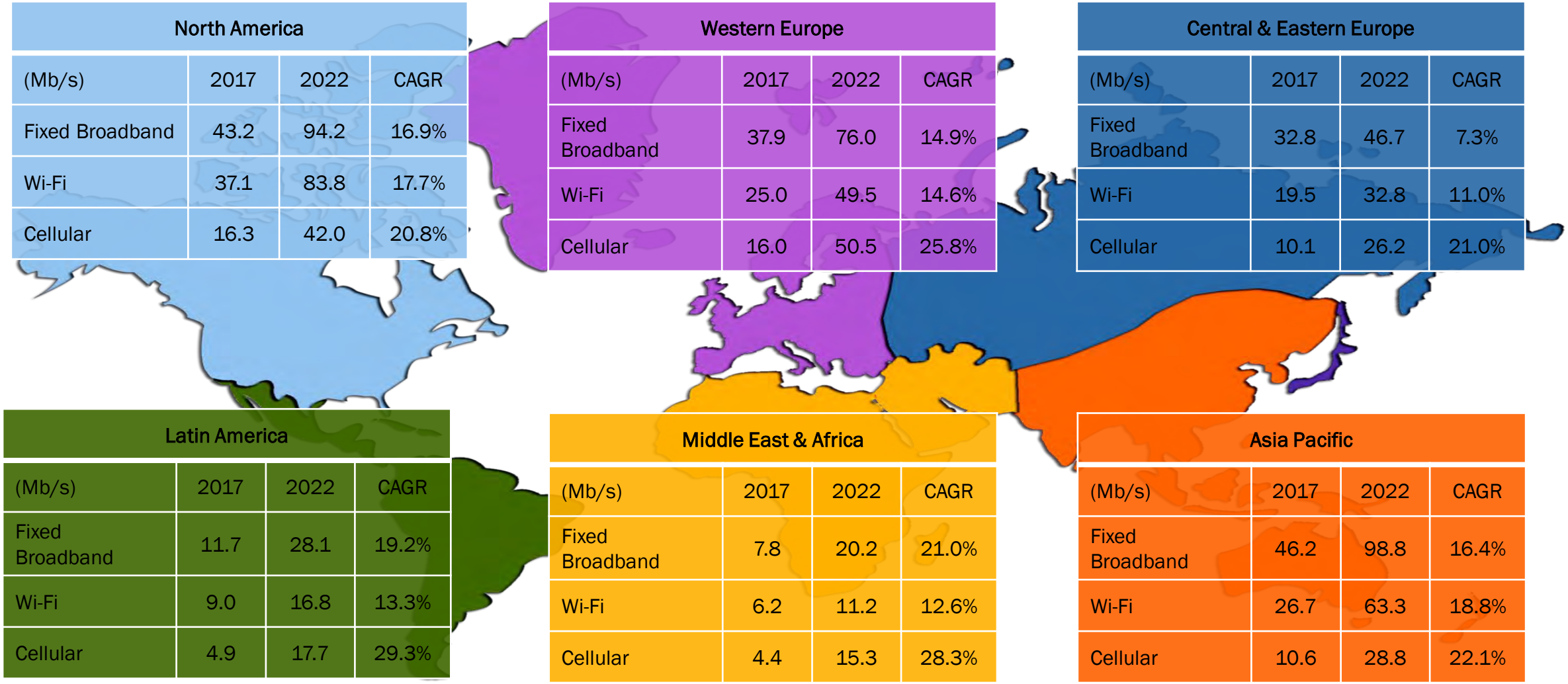
	2017	2022	Growth
Average Number of Devices and Connections per **Capita**	2.4	3.6	50%
Average Traffic per User per Month **GB**	29	85	193%

Number of connected devices per capita is growing

The average traffic per user is growing at a much faster rate

Source: Cisco VNI Forecast Update, http://www.ieee802.org/3/ad_hoc/bwa2/public/calls/19_0624/nowell_bwa_01_190624.pdf

GLOBAL DEVICE CONNECTION GROWTH (AVERAGE)



North America			
(Mb/s)	2017	2022	CAGR
Fixed Broadband	43.2	94.2	16.9%
Wi-Fi	37.1	83.8	17.7%
Cellular	16.3	42.0	20.8%

Western Europe			
(Mb/s)	2017	2022	CAGR
Fixed Broadband	37.9	76.0	14.9%
Wi-Fi	25.0	49.5	14.6%
Cellular	16.0	50.5	25.8%

Central & Eastern Europe			
(Mb/s)	2017	2022	CAGR
Fixed Broadband	32.8	46.7	7.3%
Wi-Fi	19.5	32.8	11.0%
Cellular	10.1	26.2	21.0%

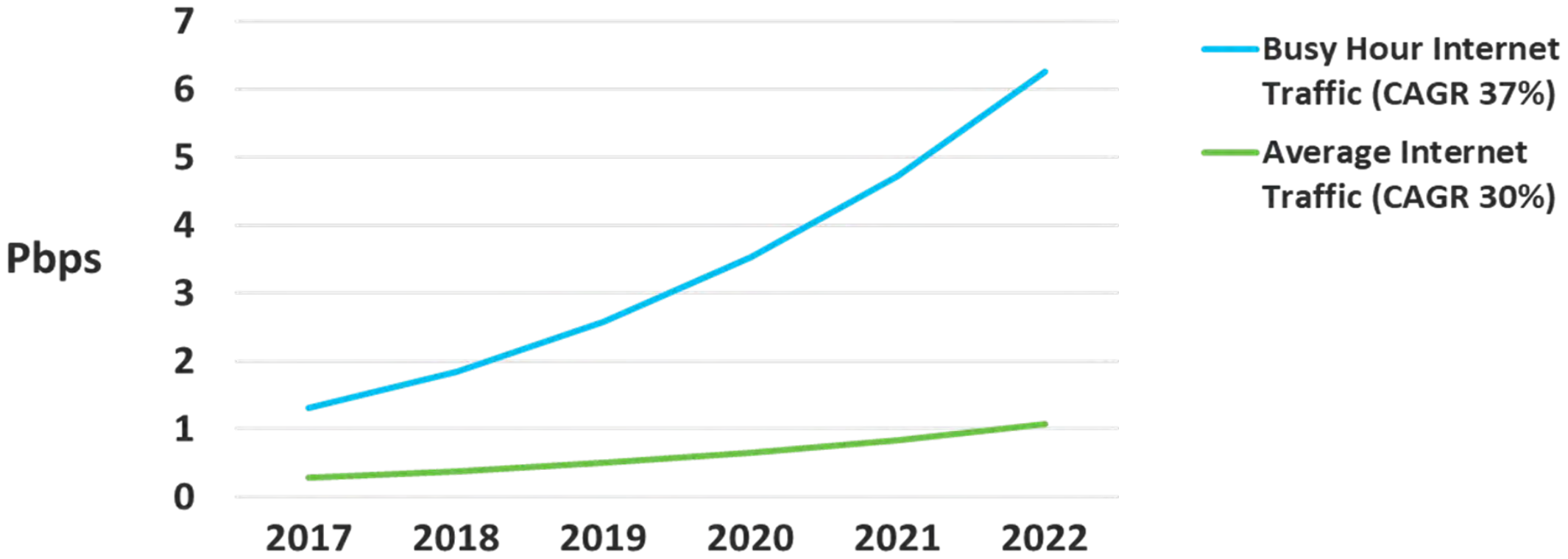
Latin America			
(Mb/s)	2017	2022	CAGR
Fixed Broadband	11.7	28.1	19.2%
Wi-Fi	9.0	16.8	13.3%
Cellular	4.9	17.7	29.3%

Middle East & Africa			
(Mb/s)	2017	2022	CAGR
Fixed Broadband	7.8	20.2	21.0%
Wi-Fi	6.2	11.2	12.6%
Cellular	4.4	15.3	28.3%

Asia Pacific			
(Mb/s)	2017	2022	CAGR
Fixed Broadband	46.2	98.8	16.4%
Wi-Fi	26.7	63.3	18.8%
Cellular	10.6	28.8	22.1%

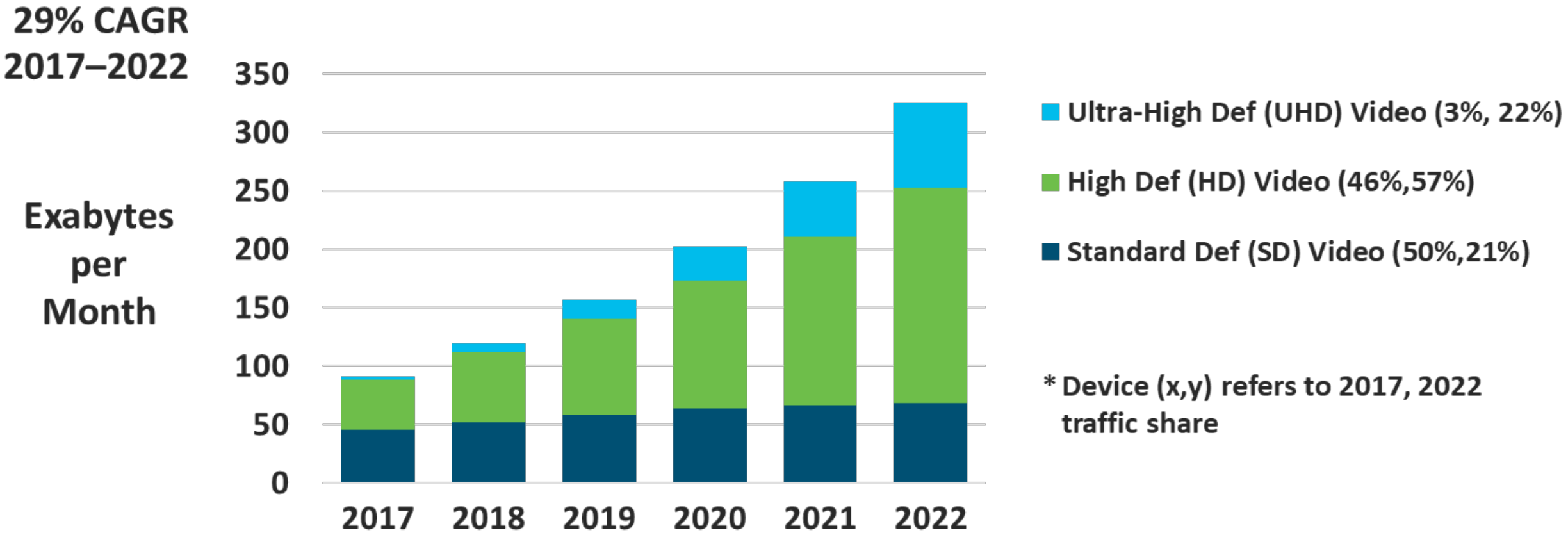
Source: Cisco VNI Forecast Update, http://www.ieee802.org/3/ad_hoc/bwa2/public/calls/19_0624/nowell_bwa_01_190624.pdf

GLOBAL BUSY-HOUR VS AVERAGE HOUR INTERNET TRAFFIC



Source: Cisco VNI Forecast Update, http://www.ieee802.org/3/ad_hoc/bwa2/public/calls/19_0624/nowell_bwa_01_190624.pdf

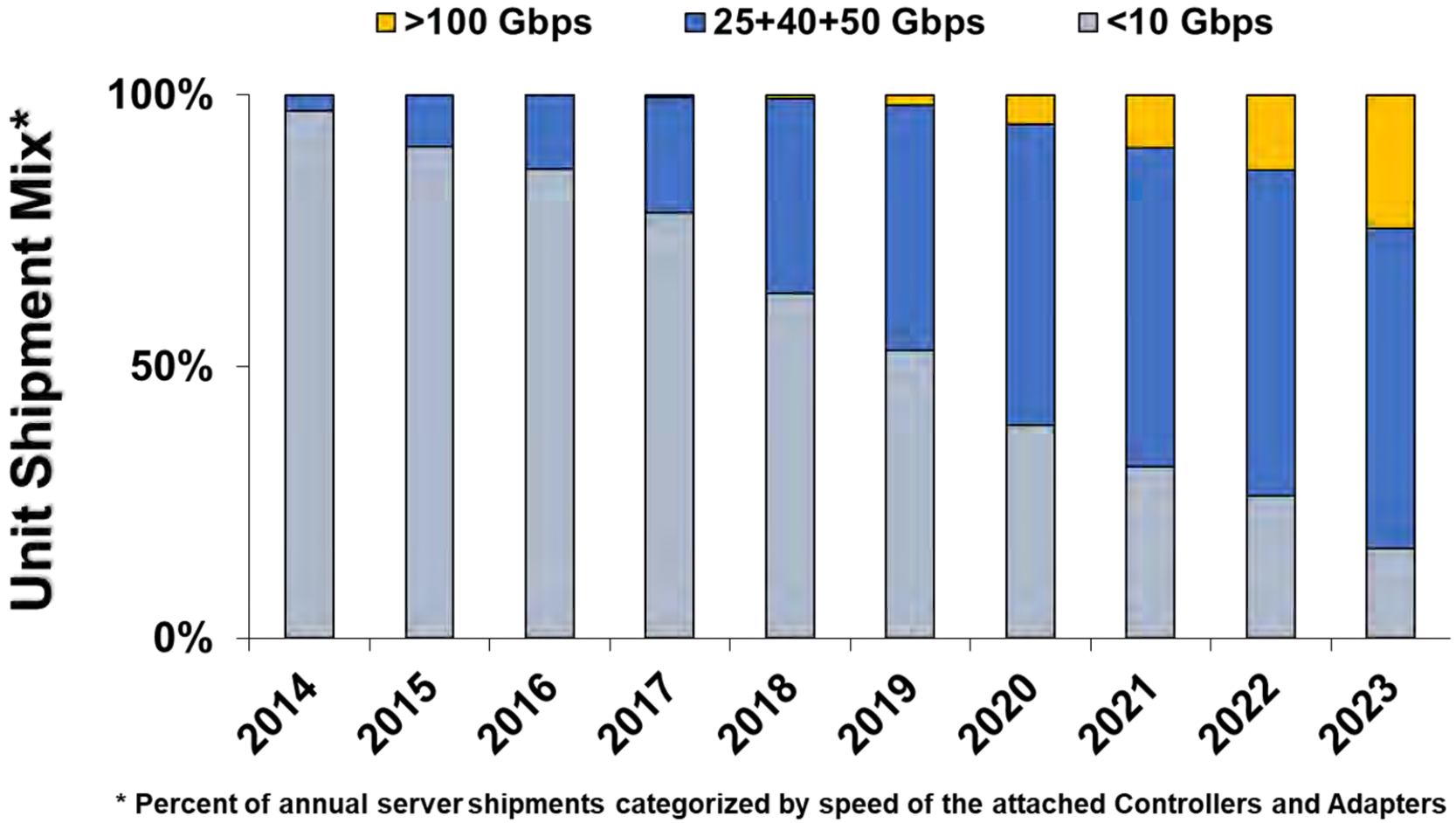
IMPACT OF "DEFINITION' ON IP VIDEO GROWTH



Growth in the adoption of HD and UHD dominate IP video traffic

Source: Cisco VNI Forecast Update, http://www.ieee802.org/3/ad_hoc/bwa2/public/calls/19_0624/nowell_bwa_01_190624.pdf

ENTERPRISE AND CLOUD SERVER UNIT SHIPMENTS



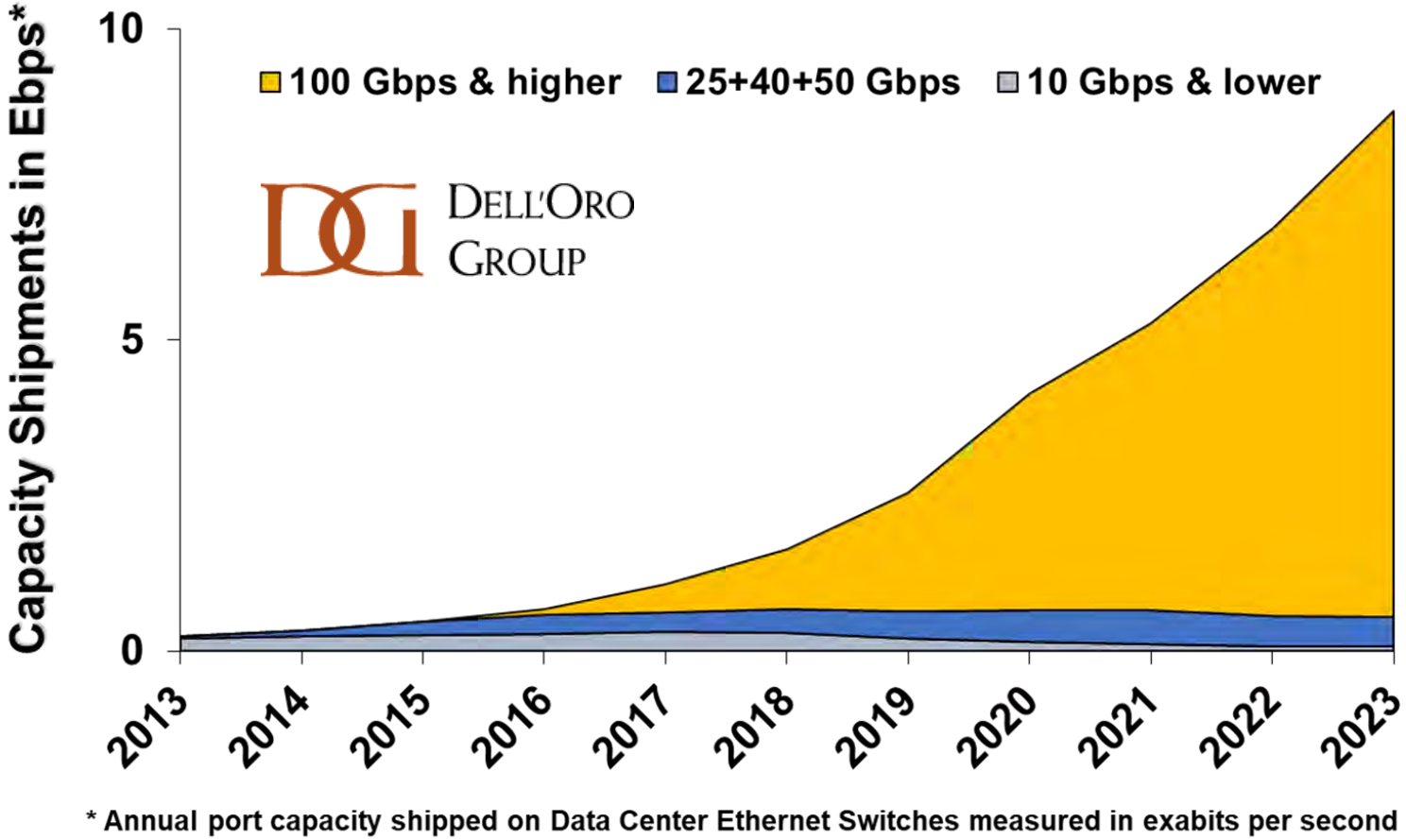
* Percent of annual server shipments categorized by speed of the attached Controllers and Adapters

Dell'Oro Group

Note - Current timeline doesn't take into consideration potential disruption to the supply chain due to COVID-19

Source: Data Center Ethernet Switch and Server Bandwidth Assessment for IEEE, http://www.ieee802.org/3/ad_hoc/bwa2/public/calls/19_0927/fung_bwa_01a_190927.pdf

DATA CENTER ETHERNET SWITCH CAPACITY SHIPMENTS



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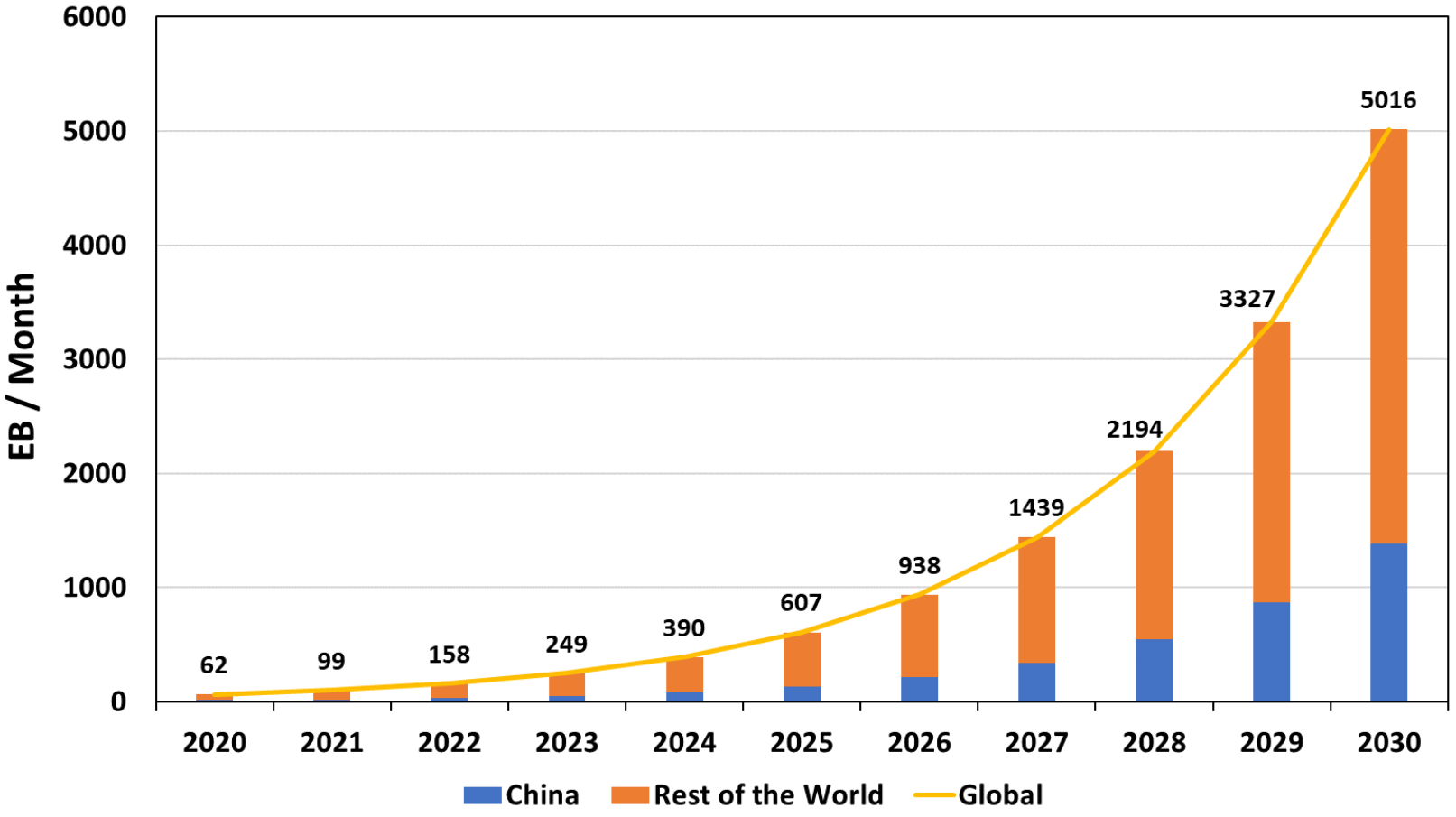
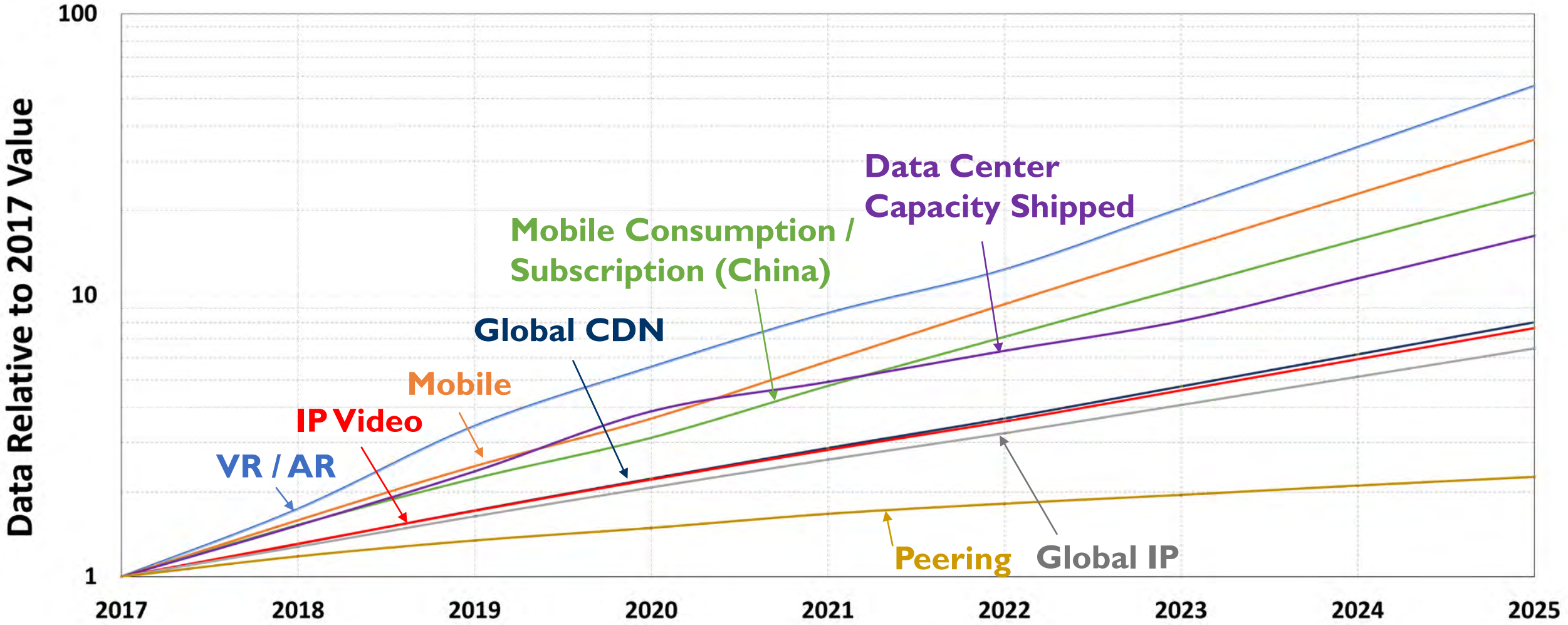
ESTIMATION OF MOBILE TRAFFIC



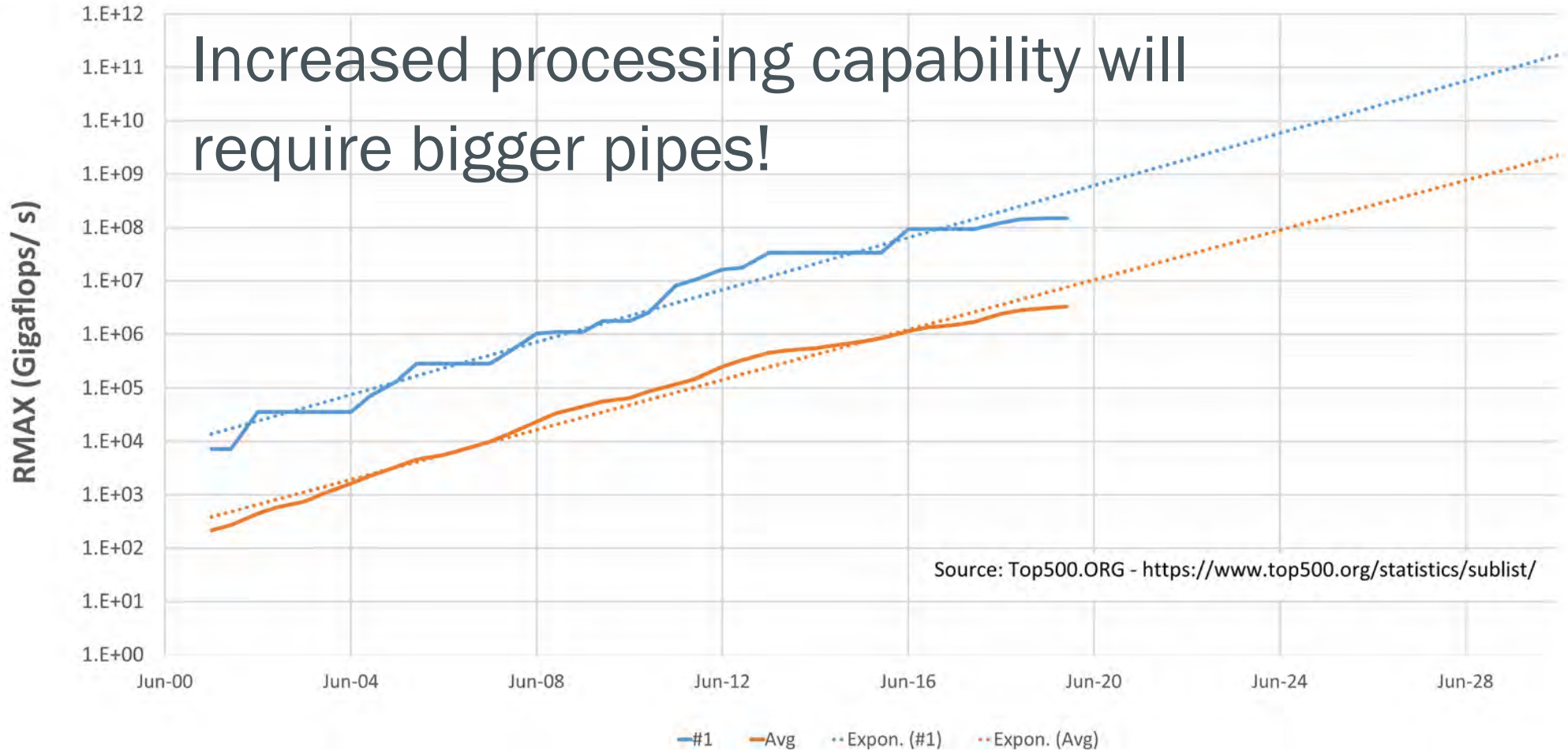
Global mobile traffic is expediential and may even be underestimated

Source: Report ITU-R M.2370-0: IMT traffic estimates for the years 2020 to 2030, https://www.itu.int/pub/R-REP-M.2370-2015

ETHERNET BANDWIDTH ASSESSMENT, PART II



HIGH PERFORMANCE COMPUTING



IMPACT OF AI

Need Input

IMPACT OF 5G

Need Input

COVID-19 TRENDS, APRIL 2020

Source - Inphi blog post 'Bandwidth in the Age of COVID-19' posted 22nd April 2020 by Ford Tamer, President and CEO, Inphi Corporation <https://www.inphi.com/blog/>

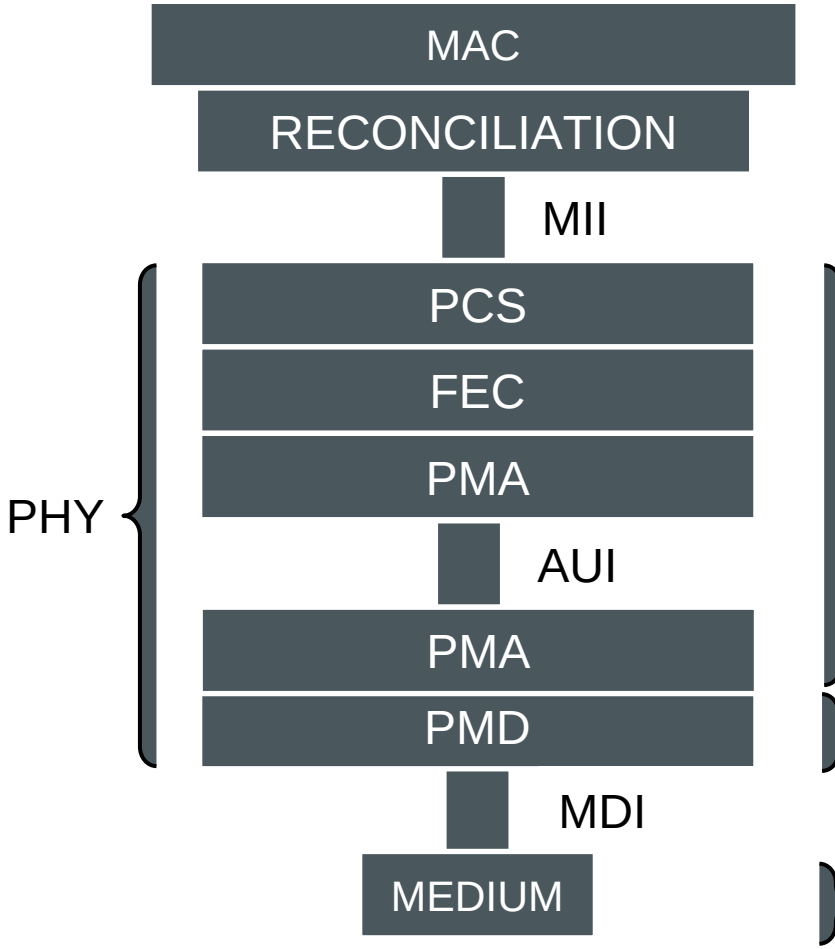
CAGR data from various industry sources and Inphi estimates

SUMMARY

Under Construction

ACHIEVING BEYOND 400 GbE

THE CHALLENGES TO BEYOND 400 GbE



Electrical Functions

- Increase interface channel count?
- Increase interface rate?
- Increase interface modulation order?

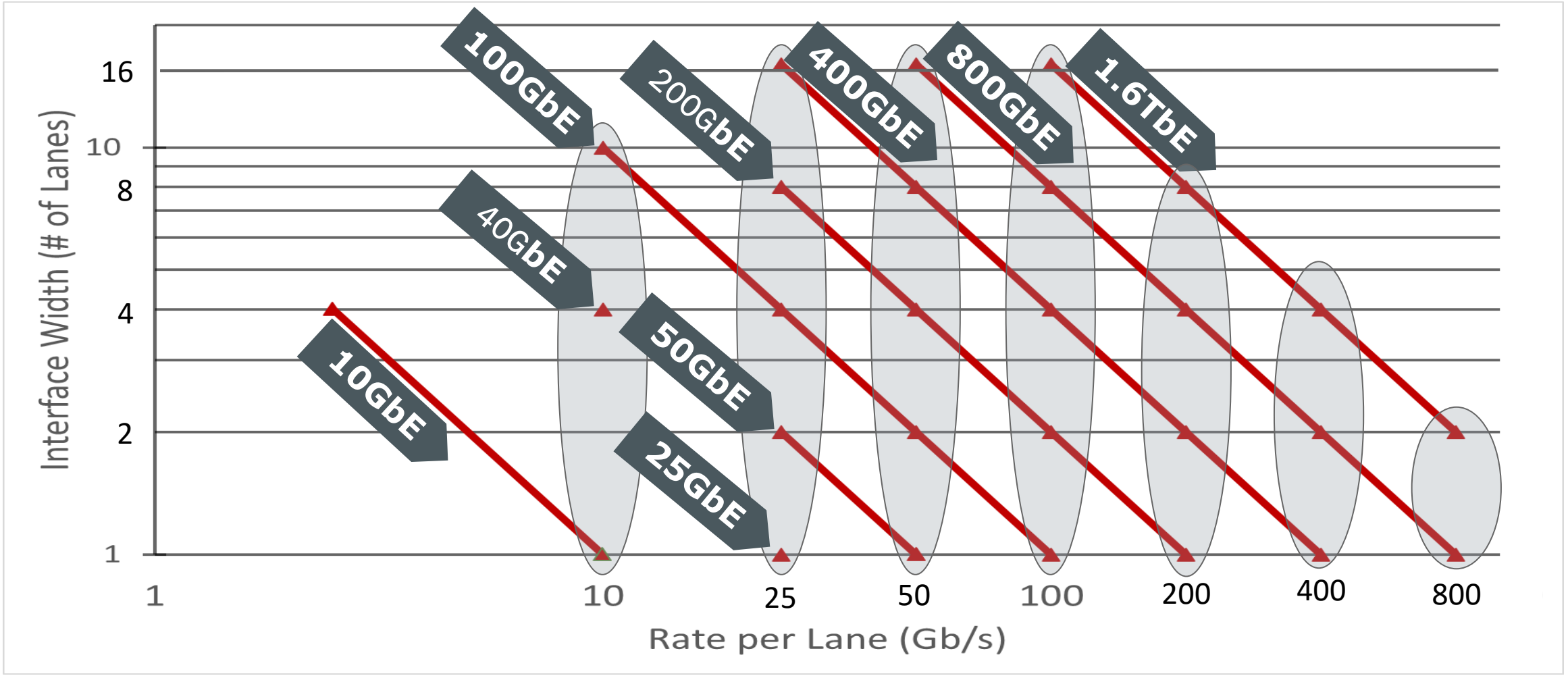
Optical Functions

- Increase interface channel count?
- Increase interface rate?
- Increase interface modulation order?

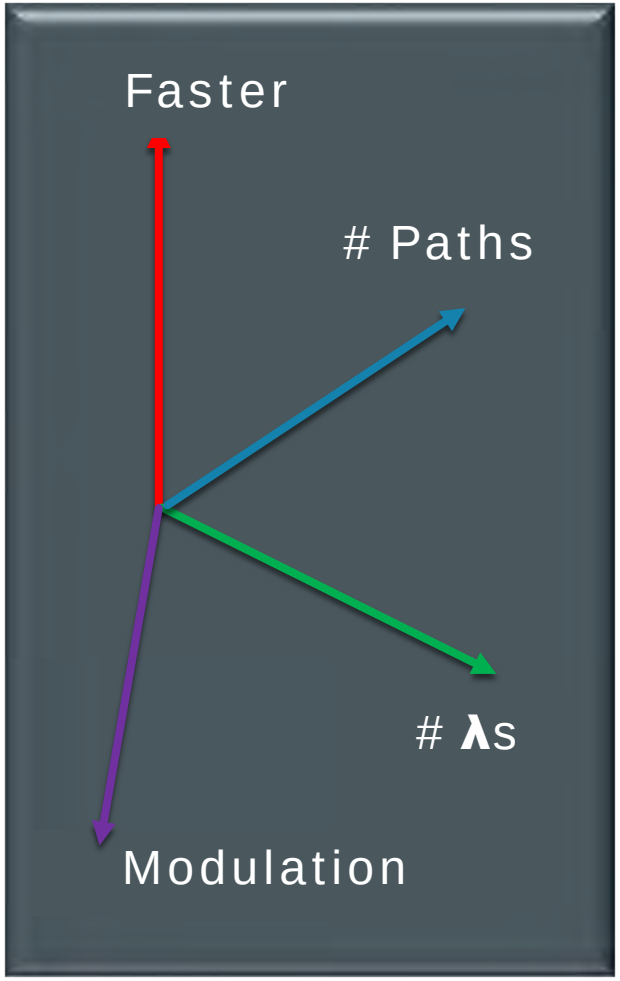
Media

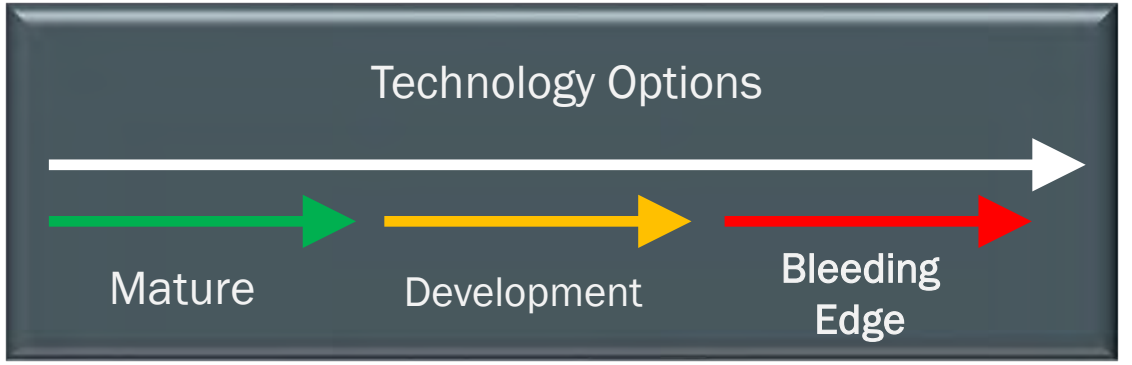
- Increase interface channel count?
- Increase fiber count?
- Increase lambda count?

THE BASIC MATH OF ETHERNET

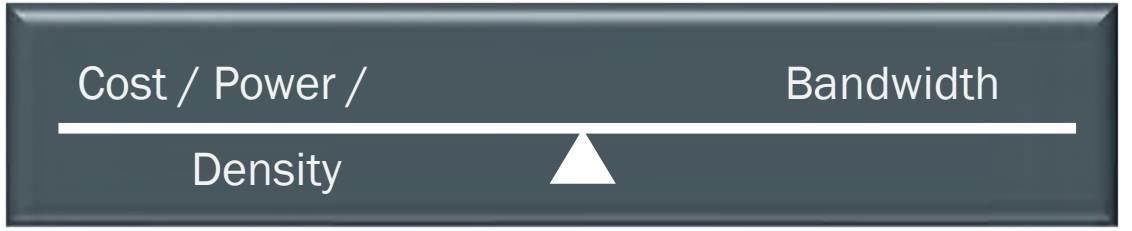


THE PATH TO HIGHER SPEEDS





The never-ending balancing acts!



EXAMPLES 400 GBE FAMILY

	Width	# Fibers / Conductor Pairs (one direction)	λ's per fiber	# Fibers / Conductor Pairs (total)	Modulation	Baud (GBd)
400GAUI	16	16		32	NRZ	26.5625
	8	8		16	PAM4	26.5625
	4	4		8	PAM4	53.125
400GBASE-SR	16	16	1	16	NRZ	26.5625
	8	8	1	8	PAM4	26.5625
	4	4	1	4	PAM4	53.125
400GBASE-SR4.2	4 fibers x 2	8	2 (1 Tx / 1 Rx)	8	PAM4	26.5625
400GBASE-DR4	4	4	1		PAM4	53.125
400GBASE-FR	8	1	8	1	PAM4	26.5625
	4	1	4	1	PAM4	53.125
400GBASE-LR(-6)	8	1	8	1	PAM4	26.5625
	4	1	4	1	PAM4	53.125
400GBASE-ER	8	1	8	1	PAM4	26.5625
400GBASE-ZR	1	1	Tx /Rx may be on 1 or 2	1 OR 2	DP-16QAM	59.84375

SERDES

Need Input

RESEARCH – BEYOND 100 GBd

- Summary of research related to beyond 100 GBd
  - 200 Gb/s PAM4 - B. Baeuerle, et al. "Reduced Equalization Needs of 100 GHz Bandwidth Plasmonic Modulators." JLT 37(9): 2050-2057.(2019).
  - W. Heni, et al.. “Ultra-High-Speed 2: 1 Digital Selector and Plasmonic Modulator IM/DD Transmitter Operating at 222 Gbaud for Intra-Datacenter Applications” J. LightwaveTechnoly. (2020).
  - Others

COHERENT

- 100 Gb/s Coherent
  - ITU-T
  - CableLabs
  - IEEE P802.3ct
- .200 Gb/s Coherent
  - CableLabs
- 400 Gb/s Coherent
  - OIF
  - ITU-T
  - IEEE P802.3cw

INDUSTRY ACTIVITIES

- Ethernet Technology Consortium (https://ethernettechnologyconsortium.org/)
  - "The 800 GbE specification introduces a new media access control (MAC) and Physical Coding Sublayer (PCS)"
- 800G Pluggable MSA (https://www.800gmsa.com/)
  - "…define interface specifications of the 800G pluggable optical modules,…"
- QSFP-DD800 MSA announces initial hardware specification(https://bit.ly/QSFPdd800)
  - "…development of high-speed, double-density QSFP modules which support 800 Gbps connectivity…"
- News– Future of Coherent ?
  - Successful trial of 800 Gb/s single-wave transmission over 950 km - https://bit.ly/2Wdkh8e
  - Platform supporting 200 Gb/s to 800 Gb/s single-carrier - https://bit.ly/2KLpW05
  - "Industry's first 800G tunable ultra-high-speed optical module" - https://bit.ly/2yTYNFK
  - "Verizon says it has successfully transmitted an 800-Gb/s wavelength on its live network" - https://bit.ly/3d2GX1M

SUMMARY

Under Construction

WHY NOW?

Under Construction

THE EXPONENTIAL FACTOR

"The greatest shortcoming of the human race is our inability to understand the exponential function."

Albert Bartlett – American Scholar

CONTRIBUTORS

Under Construction

SUPPORTERS

Under Construction

STRAW POLLS

CALL-FOR-INTEREST

- Should a Study Group be formed for “Beyond 400 Gb/s Ethernet?
- YES
- No
- Abstain

- Room Count

PARTICIPATION

- I would participate in the “Beyond 400 Gb/s Ethernet” Study Group in IEEE 802.3

  Tally:

- I believe my company would support participation in the “Beyond 400 Gb/s Ethernet” Study Group in IEEE 802.3

  Tally:

FUTURE WORK

- To Be Determined by Potential Rules Changes

THANK YOU!