IEEE 802.3 NEA Ad hoc

IEEE 802.3 Call for Interest
Draft Development

"Beyond 400 GbE"
CFI Consensus Presentation

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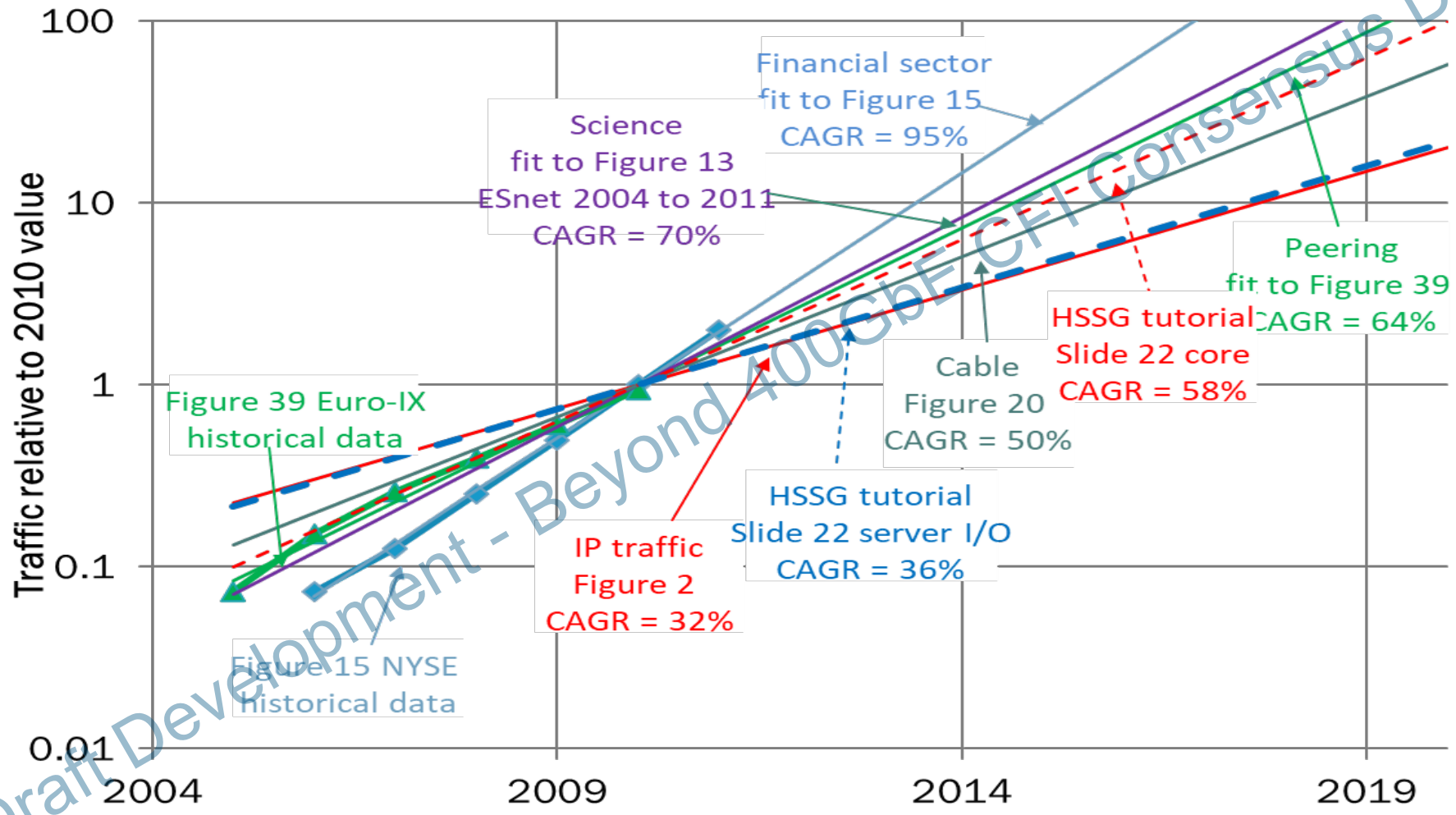
OBJECTIVE FOR THE MEETING

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

THE BEGINNING OF 400 GIGABIT ETHERNET

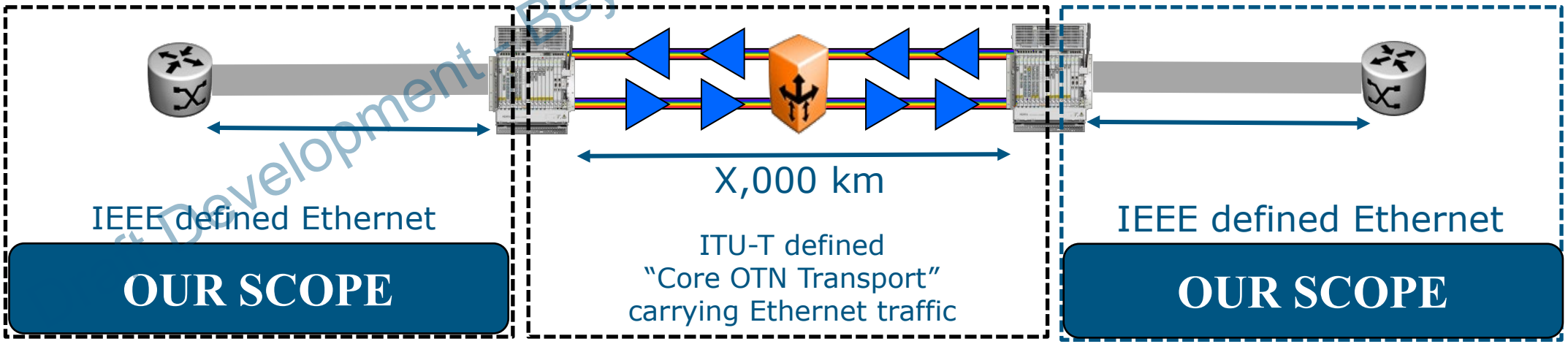


Source: http://www.ieee802.org/3/ad_hoc/bwa/BWA_Report.pdf

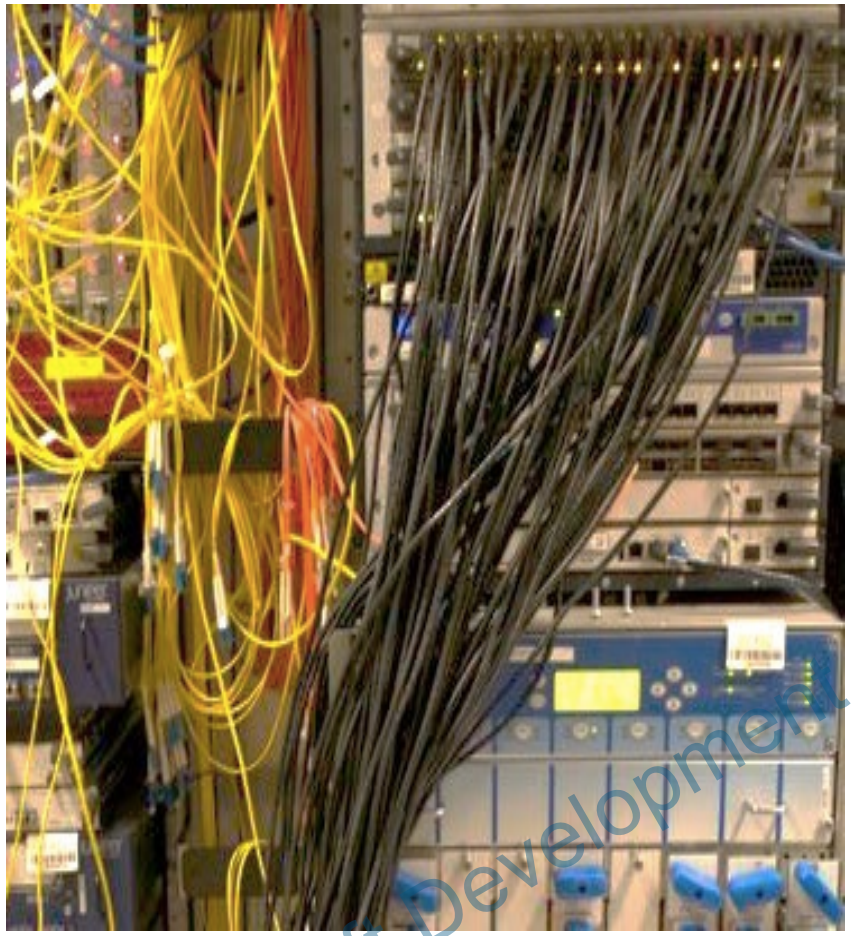
THE SCOPE OF ETHERNET TODAY

Scenario #1

Scenario #2



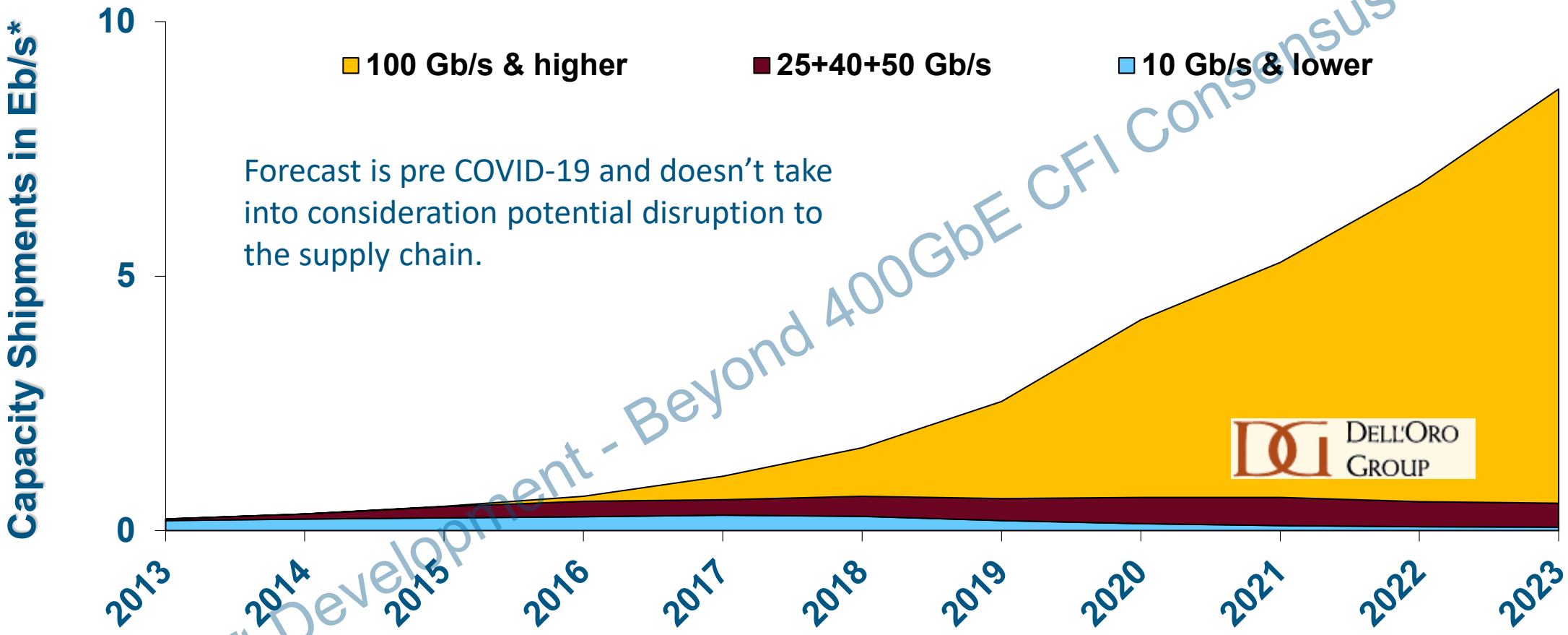
LINK AGGREGATION WILL NOT SUFFICE



Courtesy, David Ofelt, Juniper.

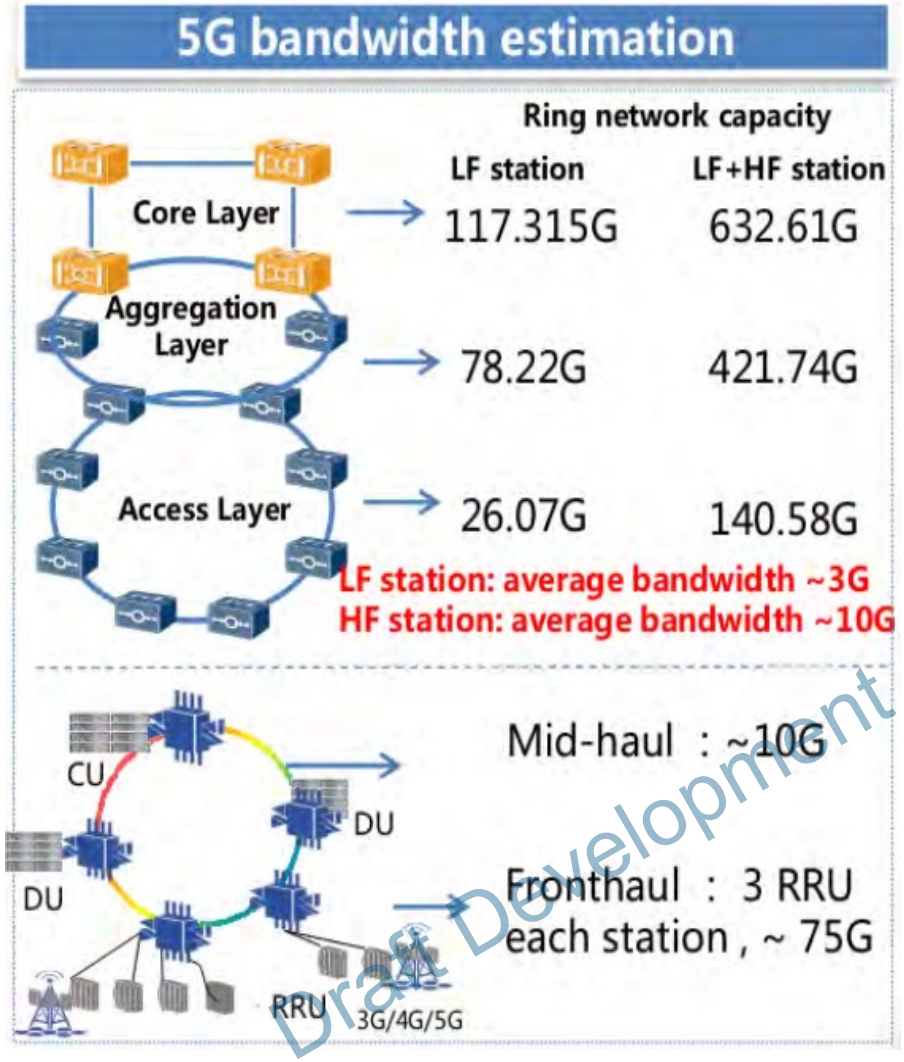
- **Problem: Need to scale the Network (density & cost)**
- **Temporary Solution: Link Aggregation**
- **Pros: Addresses bandwidth requirements between releases of faster links**
- **Cons:**
  - **Non-deterministic performance**
    - **Fastest flow limited to individual link speed**
    - **Exponential 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!***

DATA CENTER CAPACITY CONTINUES TO GROW



- **Annual port capacity shipped on Data Center Ethernet Switches measured in exabits per second**
- **Source – Dell'Oro Group, "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**

EMERGING APPLICATIONS – 5G BACKHAUL



Source: http://www.ieee802.org/3/B10K/public/18_01/wang_b10k_01b_0118.pdf

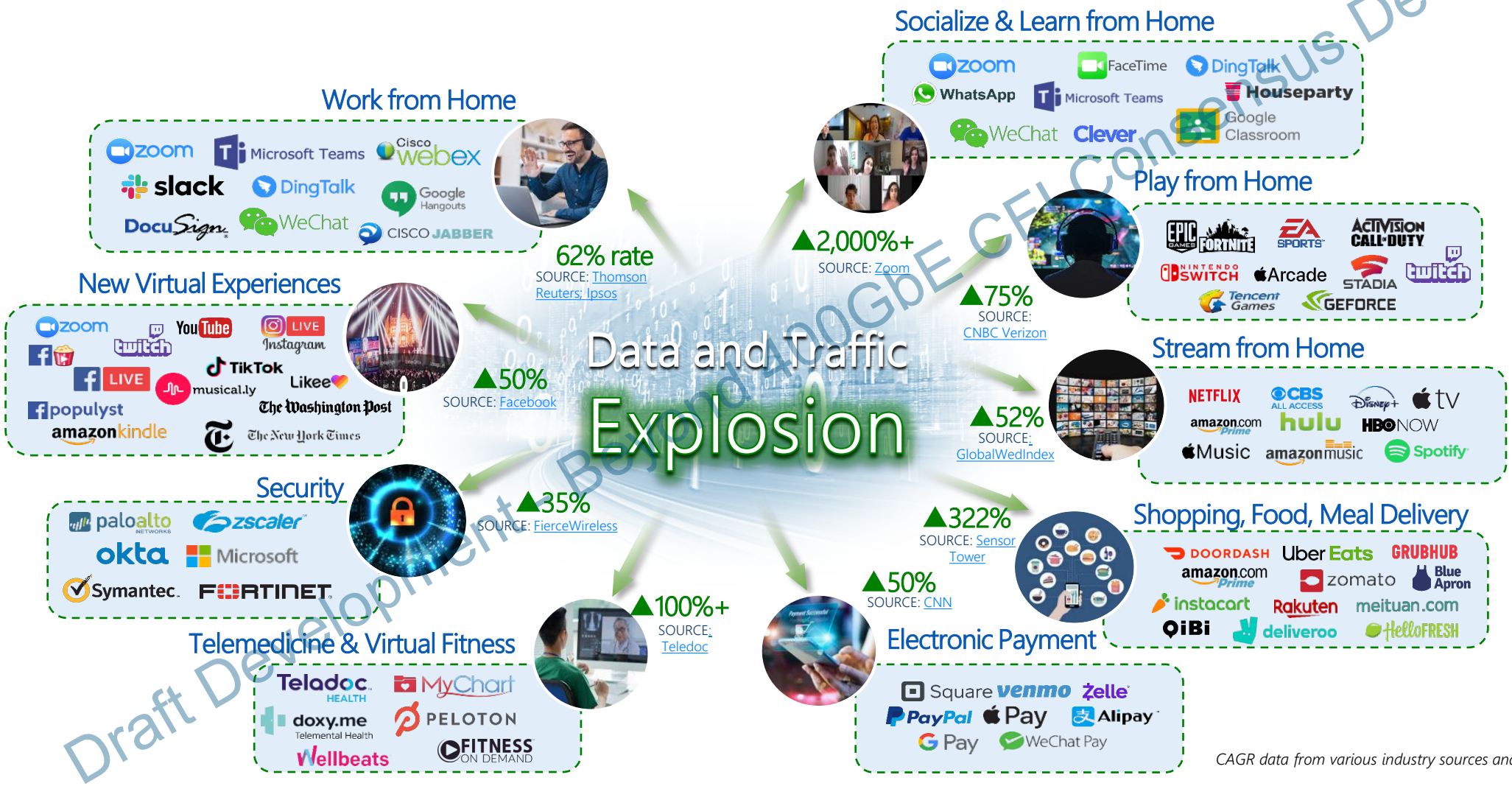
	LTE	LTE Advanced	5G
Africa	145	42	4
Asia & Pacific	162	72	23
Eastern Europe	93	59	11
Latin America & Caribbean	127	50	7
Middle East	44	29	12
U S & Canada	20	9	7
Western Europe	88	70	29
Global Totals	679	331	93

Source: https://www.5gamericas.org/resources/deployments/

- **Omdia projects 91 million global 5G connections by end of 2020**

Source: https://www.5gamericas.org/5gs-year-one-fast-start-and-healthy-growth/

COVID-19 TRENDS, APRIL 2020



CAGR data from various industry sources and Inphi estimates

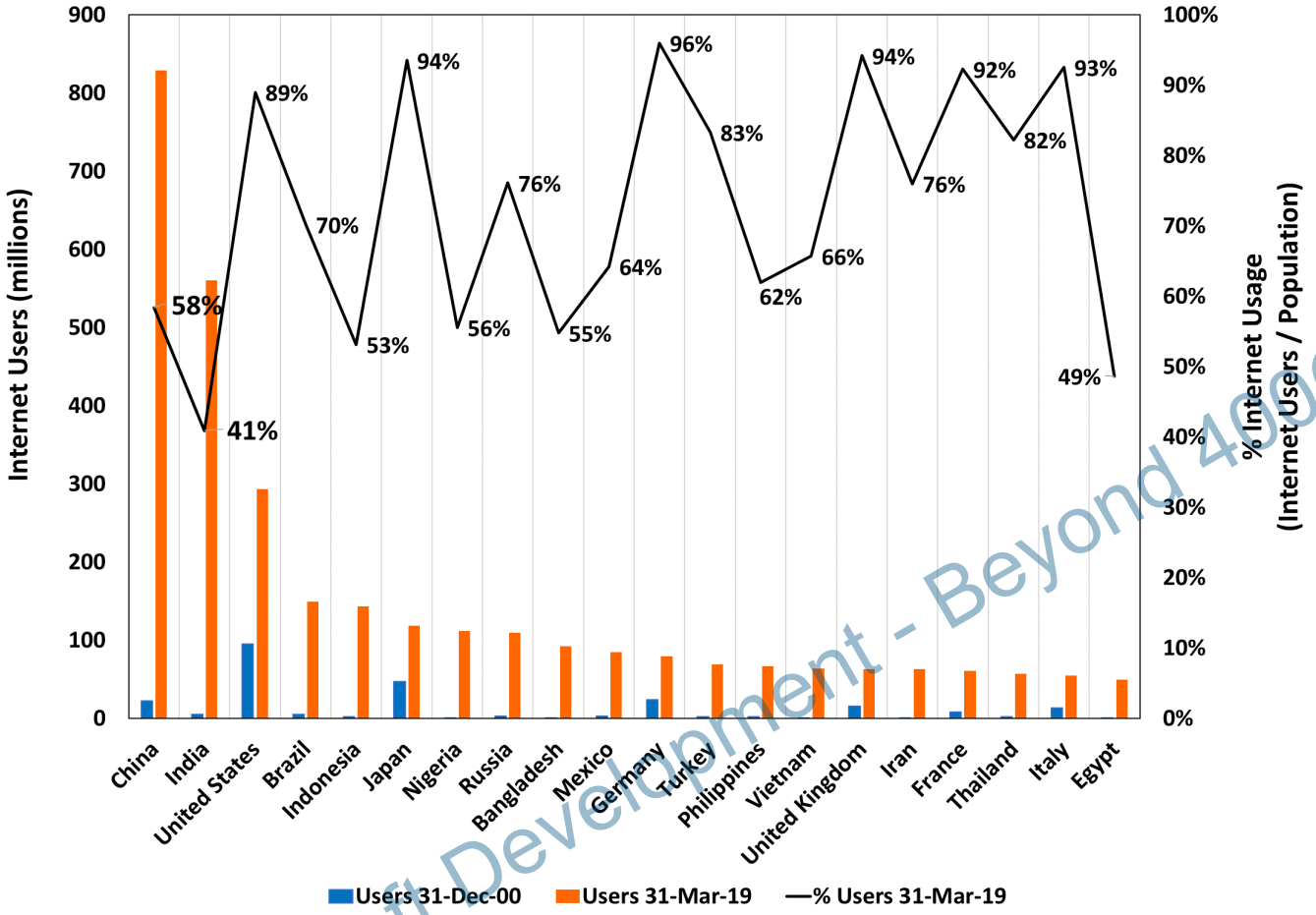
Source - Inphi blog post 'Bandwidth in the Age of COVID-19' posted 22nd April 2020 by Ford Tamer, President and CEO, Inphi Corporation <https://www.inphi.com/blog/>

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

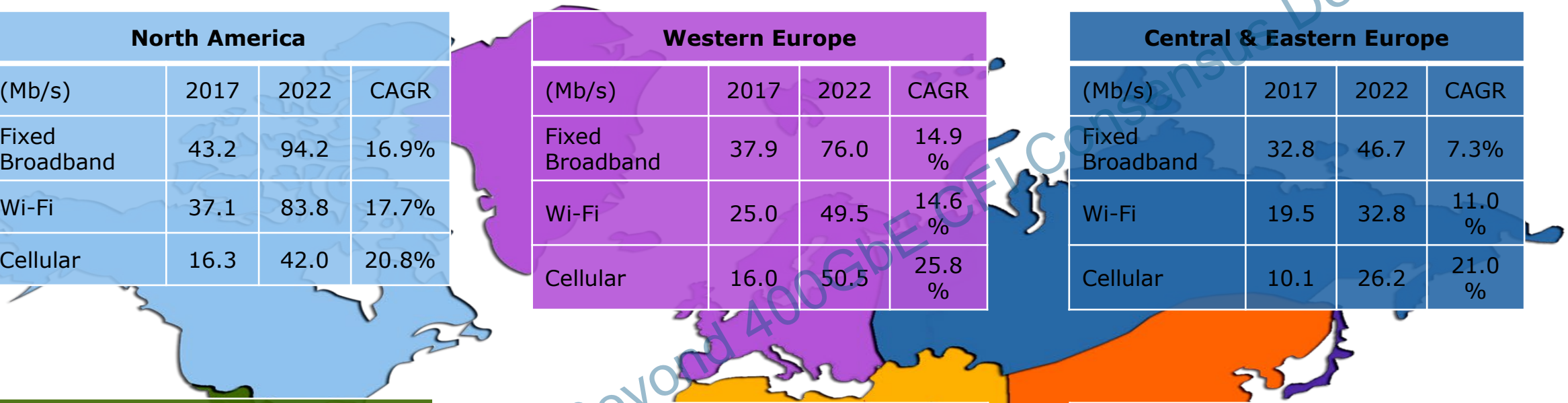
GLOBAL DEVICES / CONNECTIONS AVERAGE PER CAPITA

	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 %

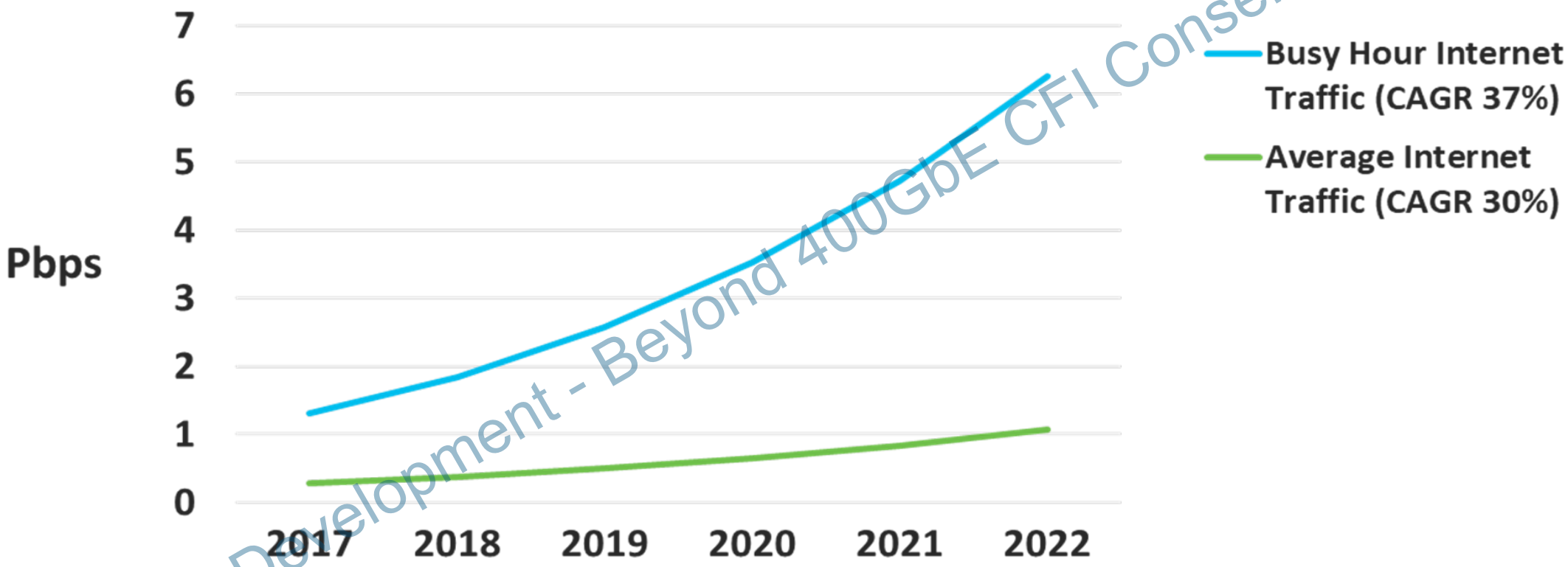
Latin America			
(Mb/s)	2017	2022	CAGR
Fixed Broadband	11.7	28.1	19.2 %
Wi-Fi	9.0	16.8	13.3 %
Cellular	4.9	17.7	29.3 %

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 %

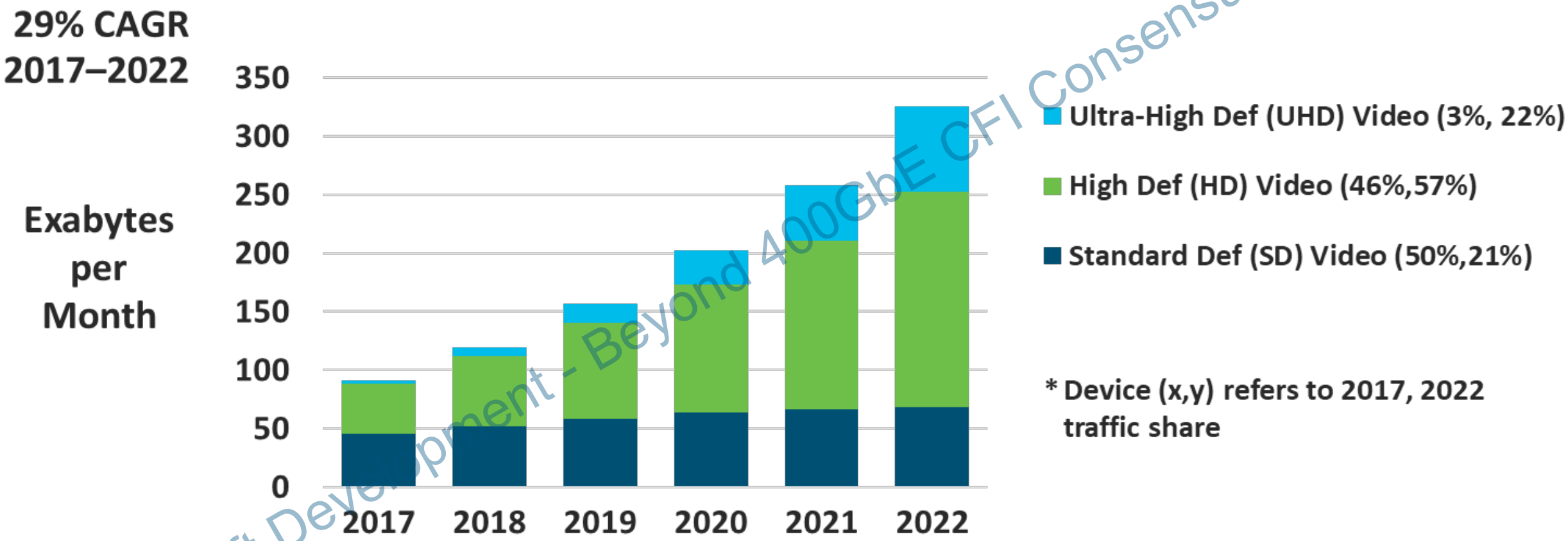
Source: Cisco VNI Forecast Update, http://www.ieee802.org/3/ad_hoc/bwa2/public/calls/19_0624/nowell_bwa_01_190624.pdf

GLOBAL INTERNET TRAFFIC BUSY-HOUR VS AVERAGE HOUR



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

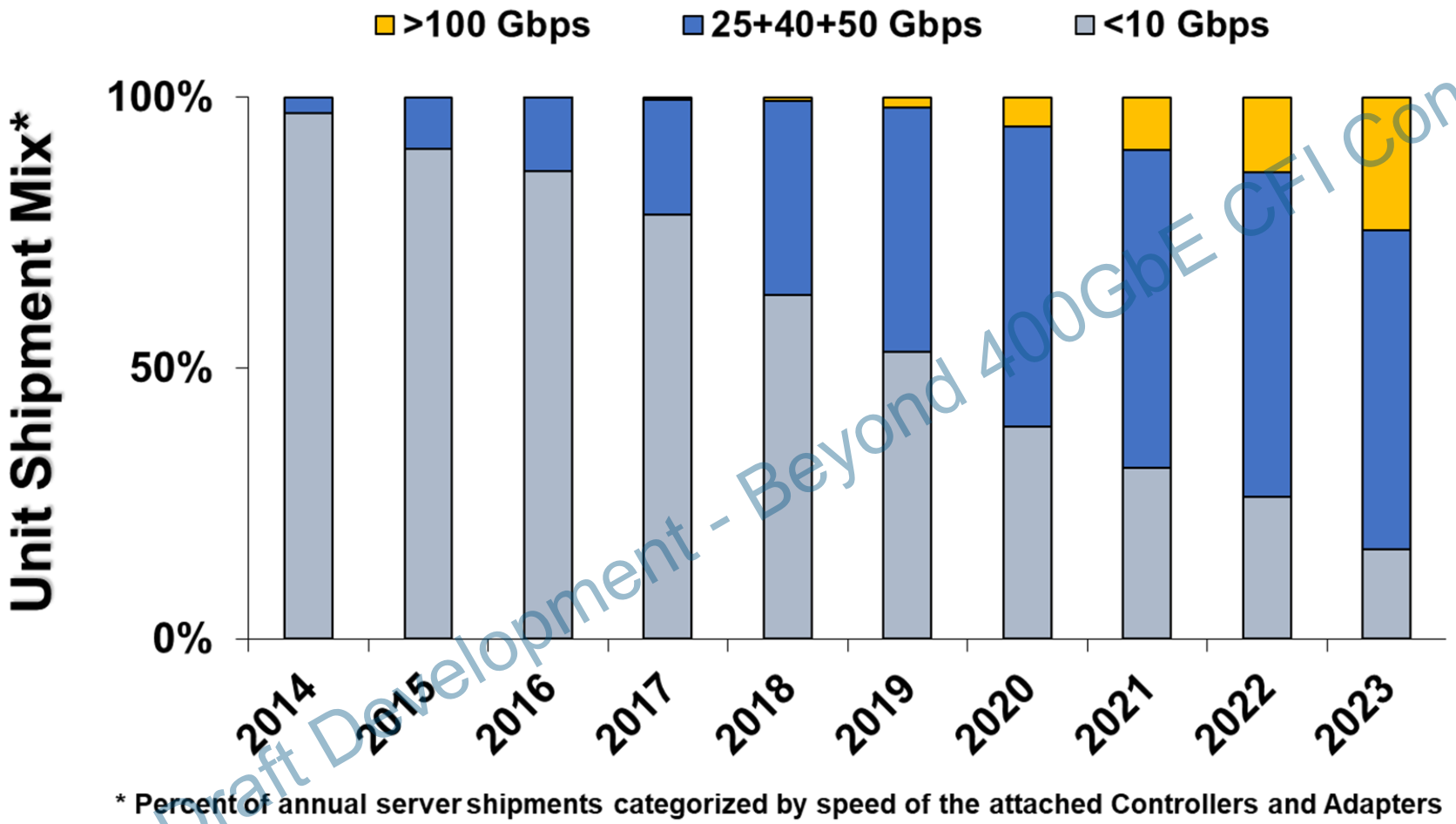
IMPACT OF "DEFINITION' ON IP VIDEO GROWTH



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



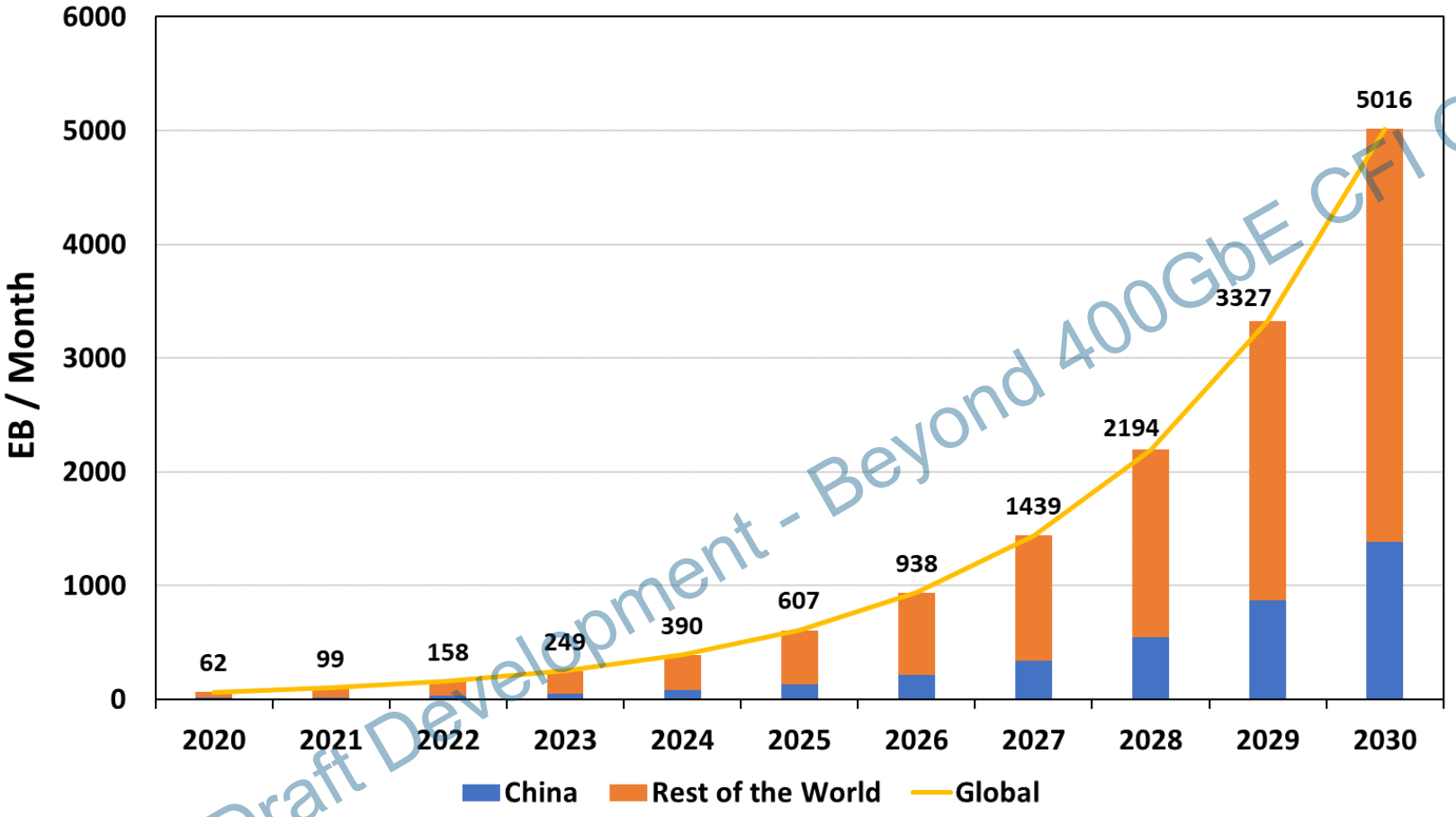
* Percent of annual server shipments categorized by speed of the attached Controllers and Adapters

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

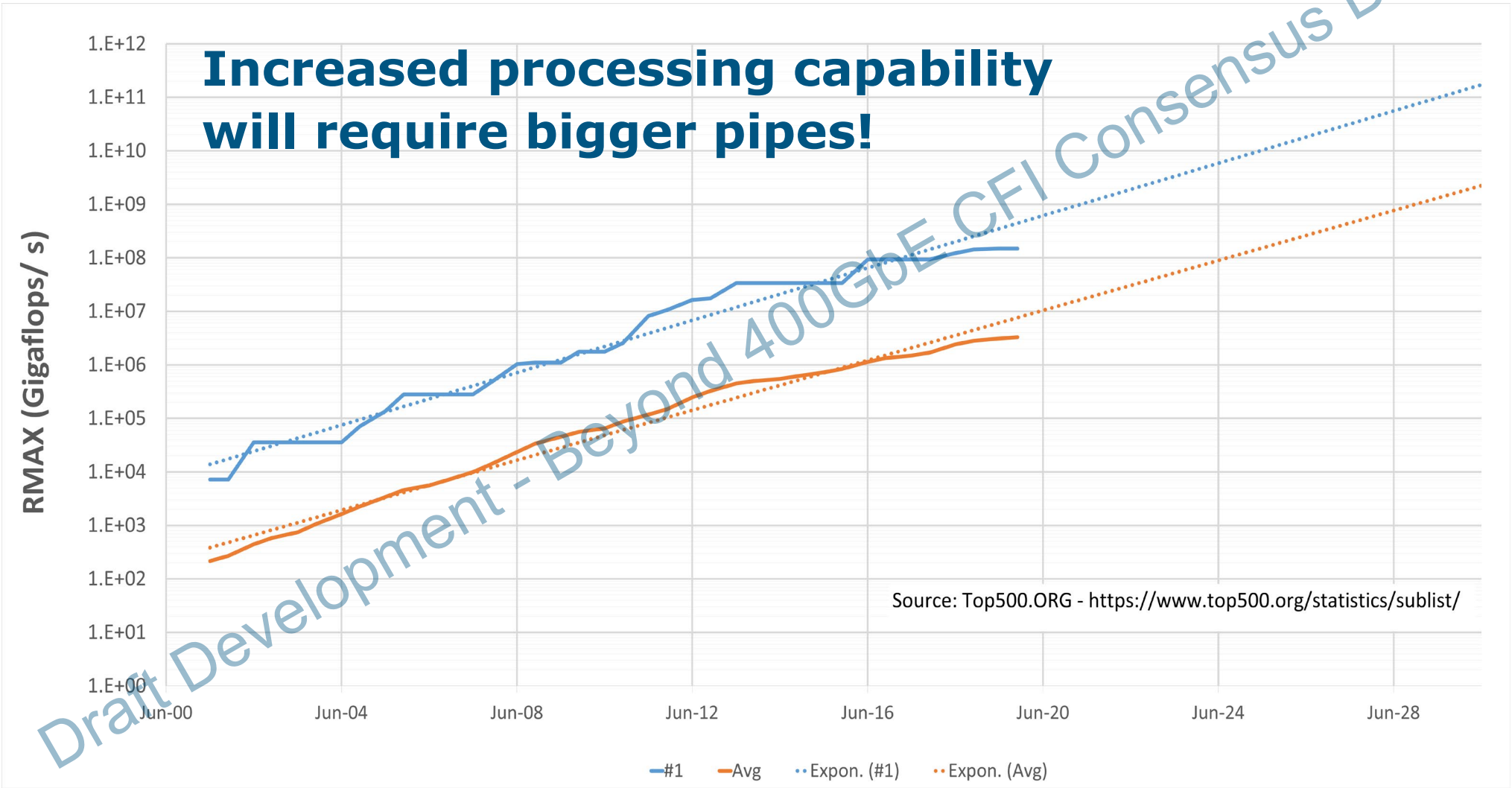
ESTIMATION OF MOBILE TRAFFIC



Global mobile traffic is expediential and may even be underestimated

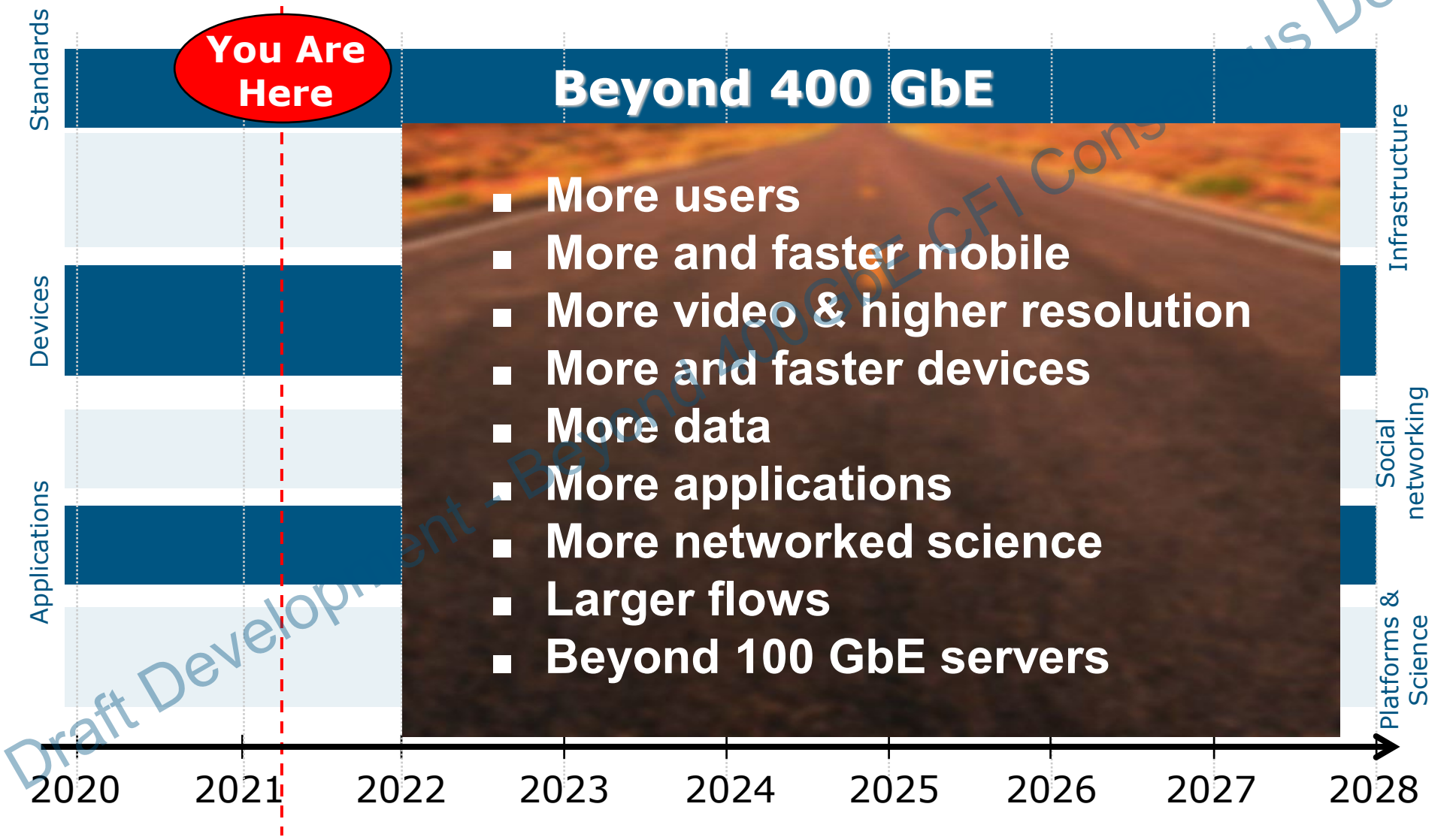
Source: Report ITU-R M.2370-0: IMT traffic estimates for the years 2020 to 2030, https://www.itu.int/pub/R-REP-M.2370-2015

HIGH PERFORMANCE COMPUTING



IMPACT OF ARTIFICAL INTELLIGENCE

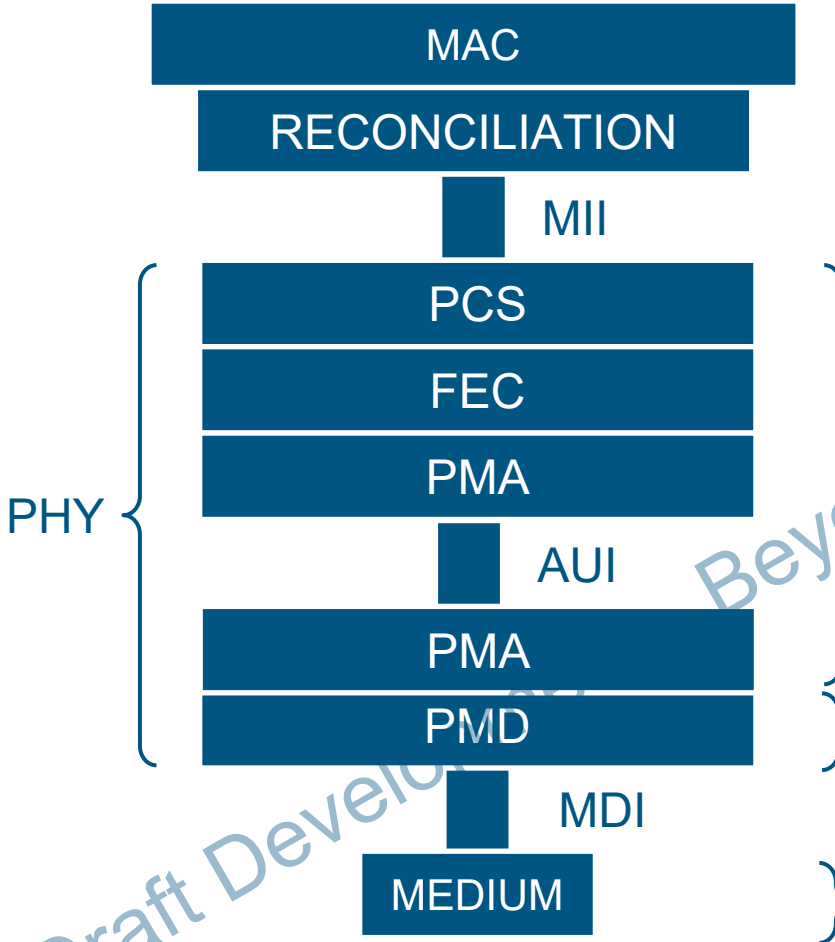
MORE OF THE SAME…..



SUMMARY

ACHIEVEING BEYOND 400 GBE

THE CHALLENGES TO BEYOND 400 GBE



Electrical Functions

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

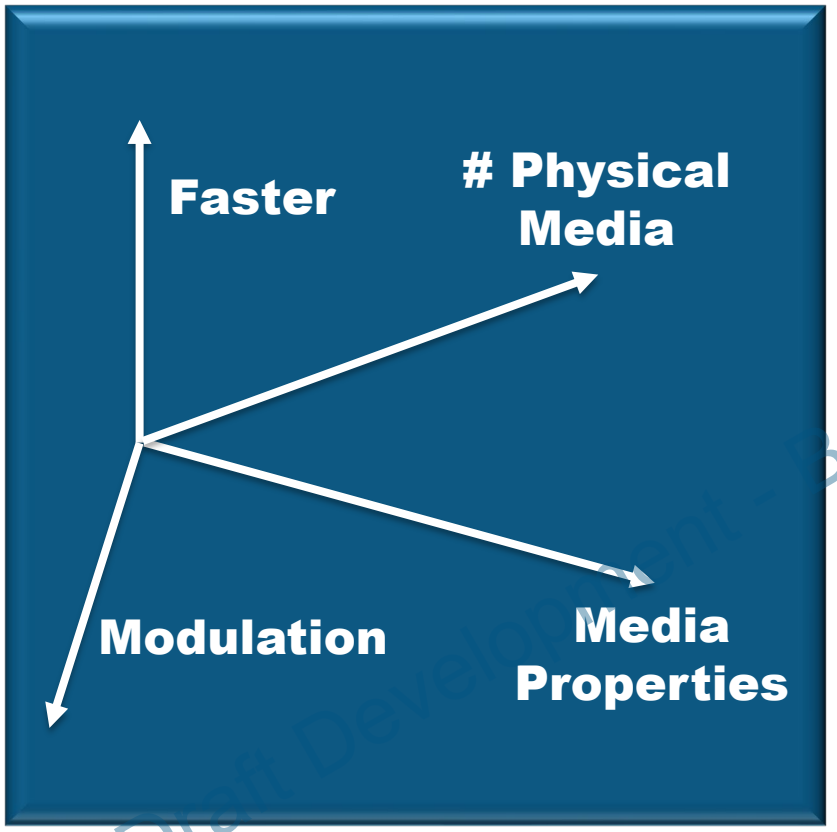
Optical Functions

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

Media

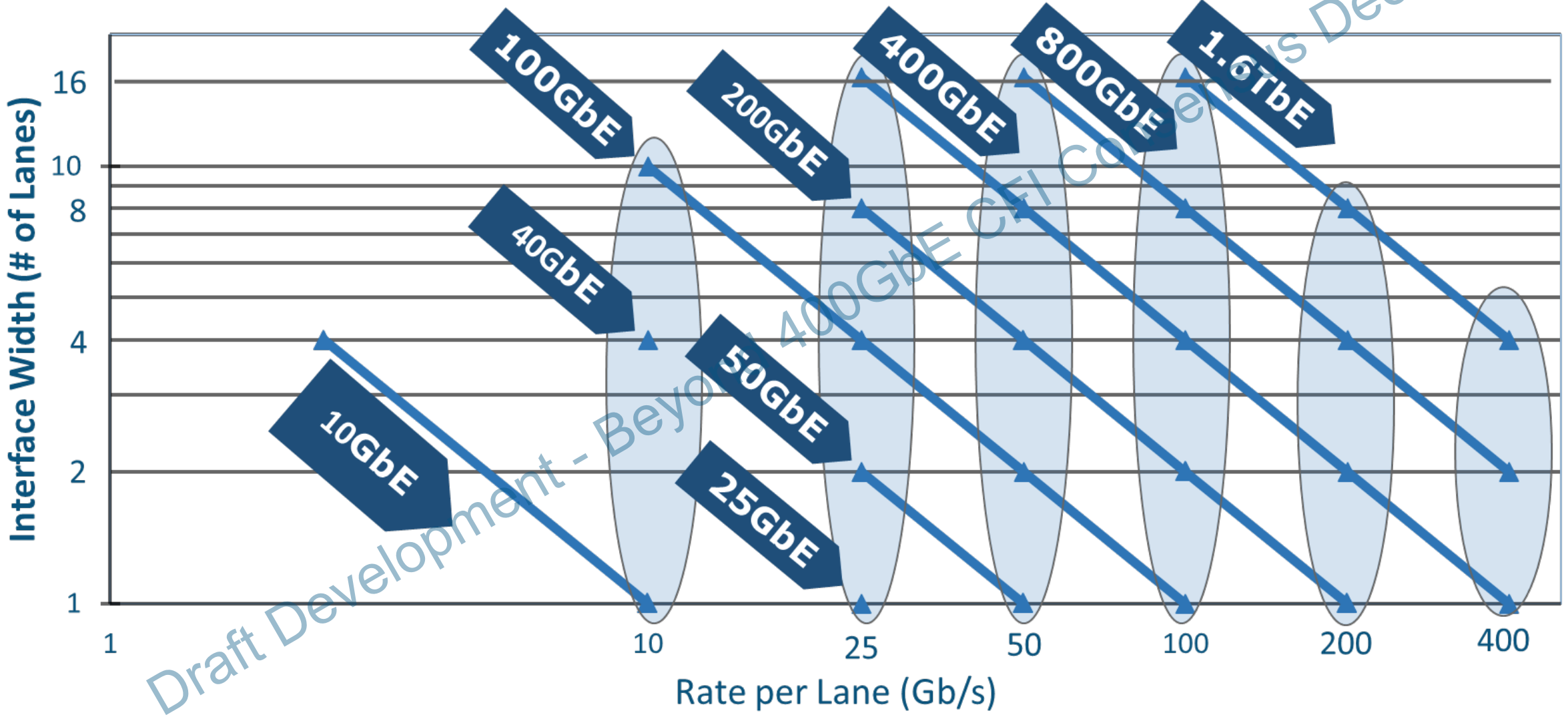
- Increase interface channel count?
- Increase fiber count?
- Increase lambda count?

THE PATH TO HIGHER SPEEDS



The never-ending balancing acts!

THE BASIC MATH OF ETHERNET



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

Industry activities

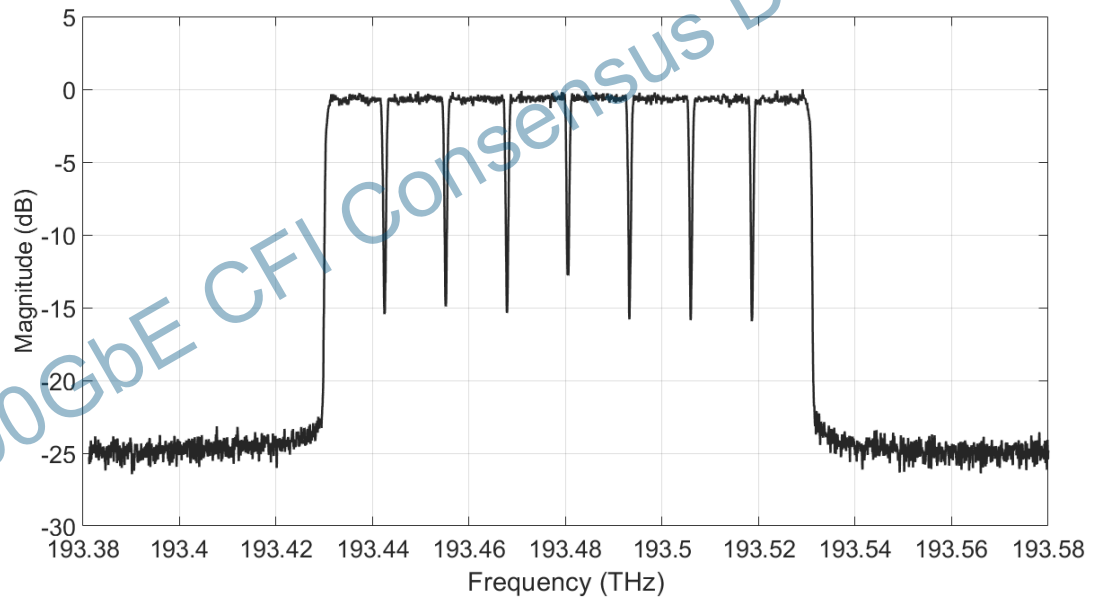
- **Ethernet Technology Consortium (https://ethernettechnologyconsortium.org/)**
  - **"The 800 GbE specification introduces a new media access control (MAC) and Physical Coding Sublayer (PCS)"**
- **800G Pluggable MSA (https://www.800gmsa.com/)**
  - **"…define interface specifications of the 800G pluggable 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**

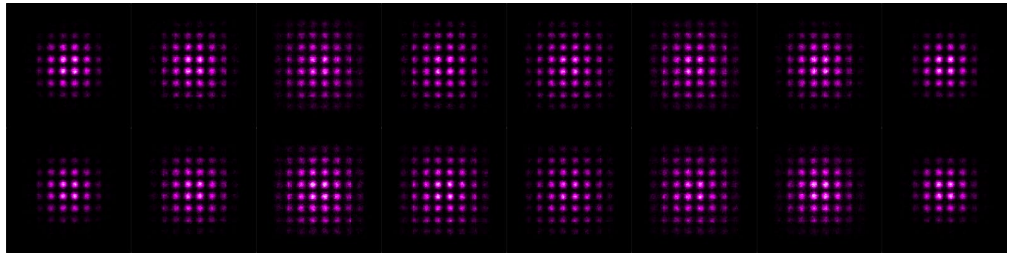
coherent

- 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

800 Gb/s Single Wavelength Transmission

800 Gigabits per second single wavelength transmission achieved over 730km in real world long-haul network





8 subcarrier constellation

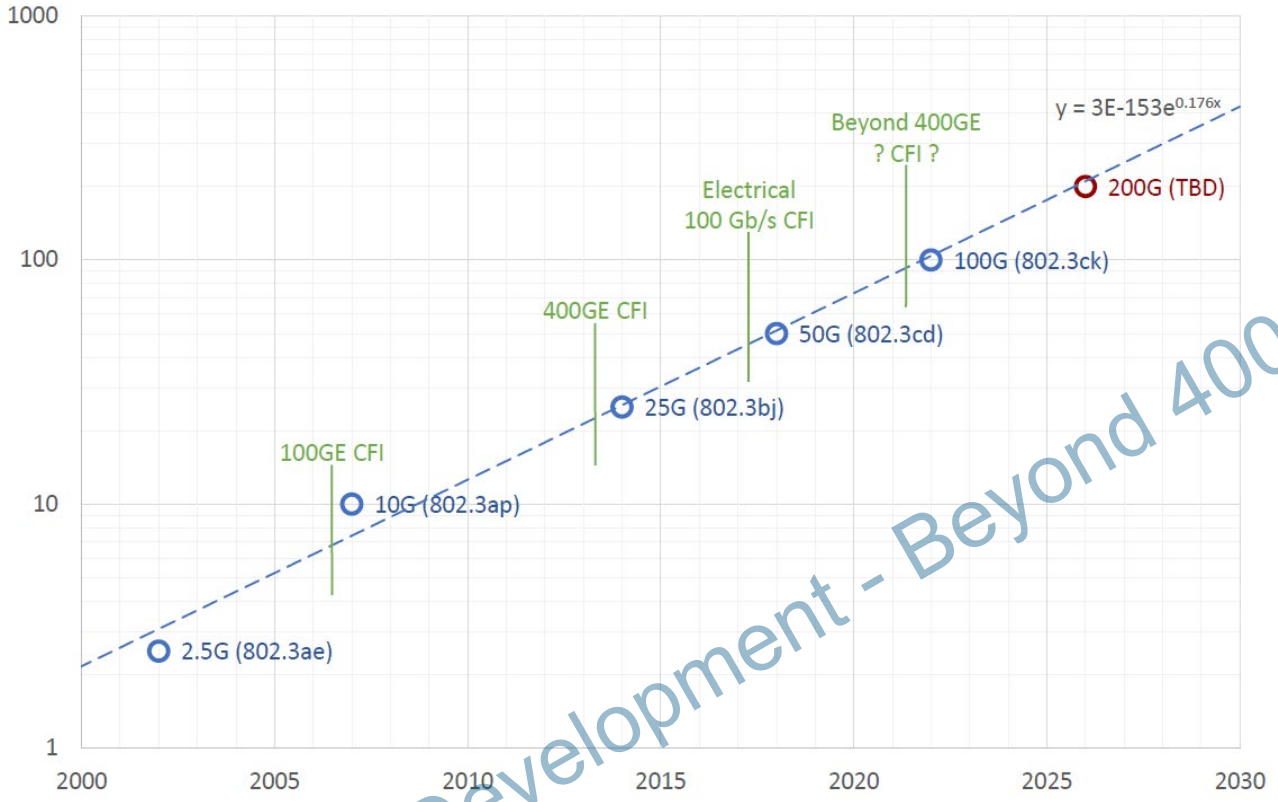
https://www.lightreading.com/optical-ip/infinera-windstream-tout-optical-networking-milestone/d/d-id/761738

Source: Ted Sprague, Infinera

SUMMARY

ACHIEVEING BEYOND 400 GBE

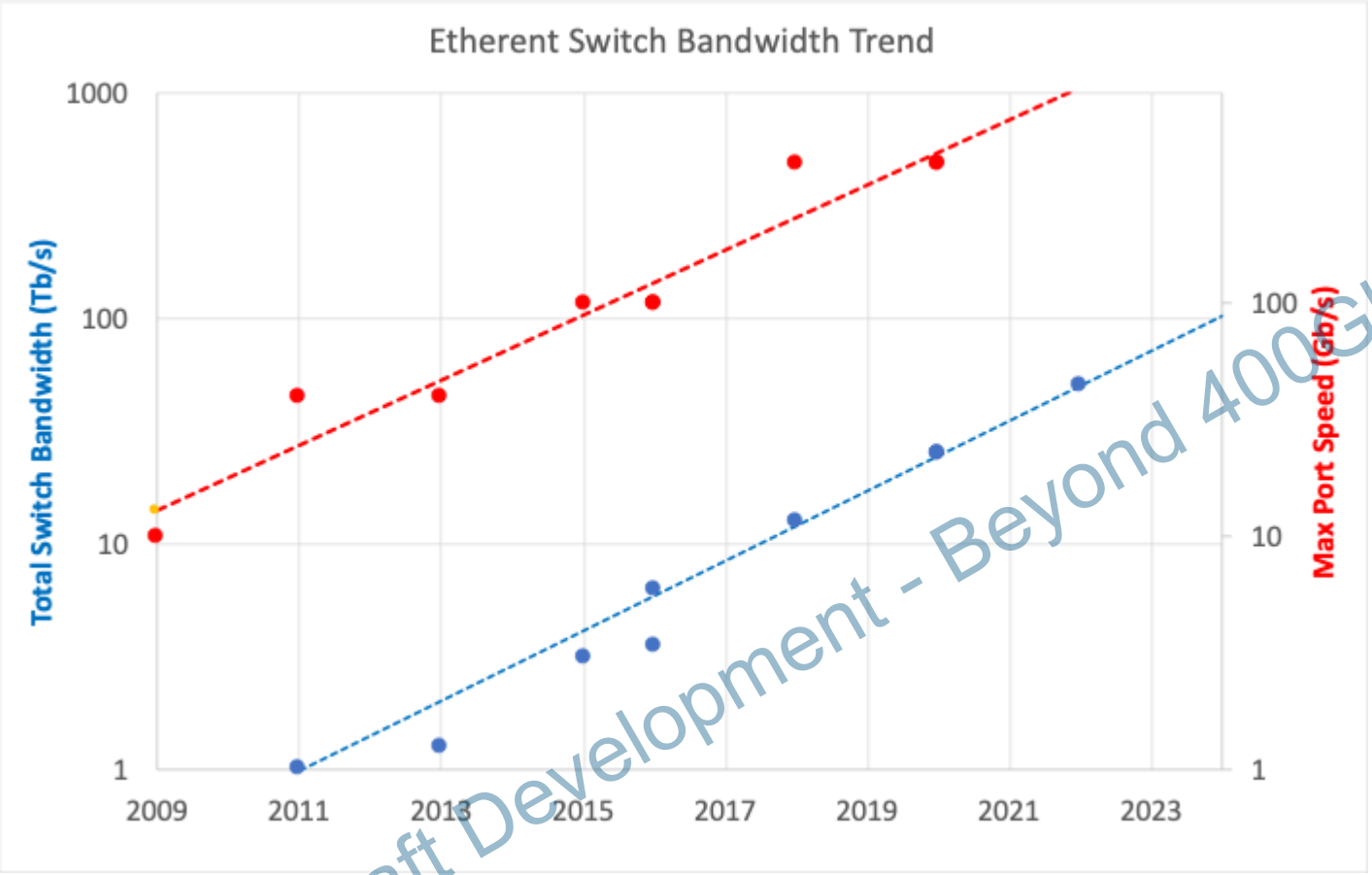
TRENDLINE – SERDES DEVELOPMENT



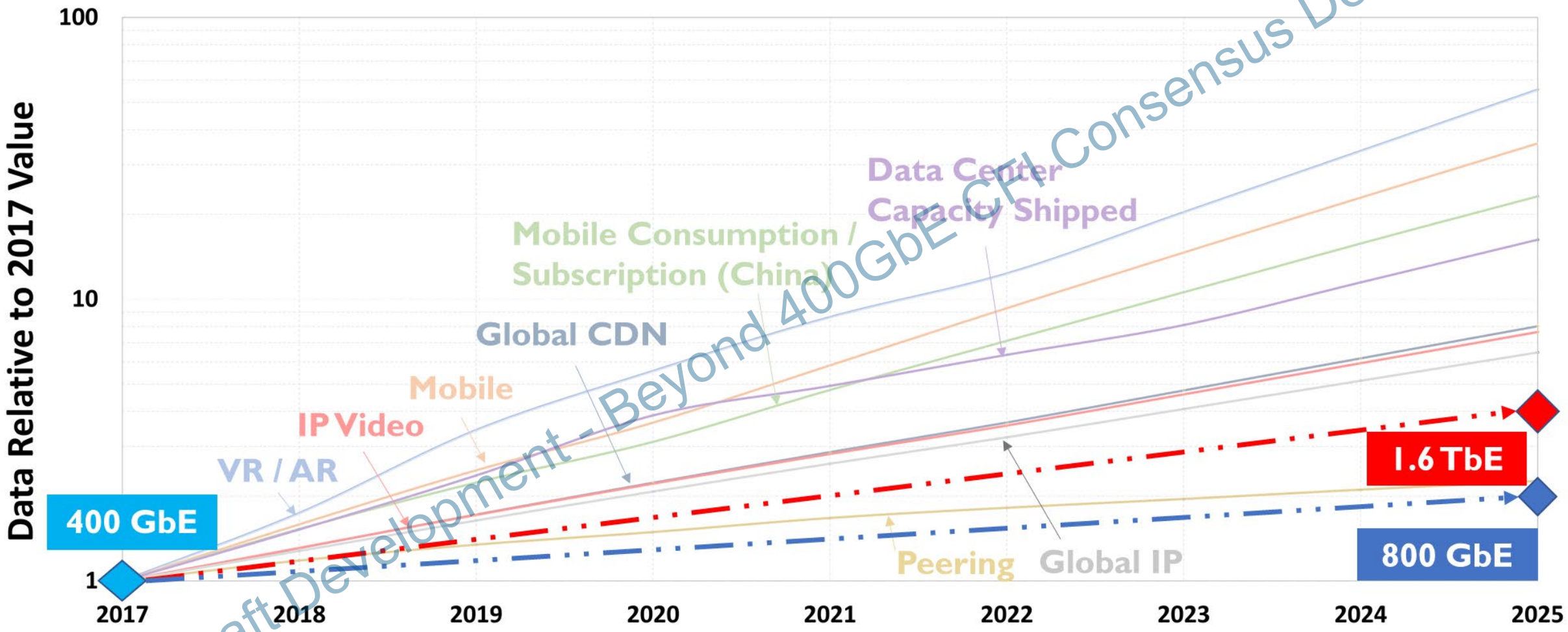
Assuming a 4 year project 200 Gb/s electrical interfaces will maintain historical trend

Source: Matt Brown, Huawei

TRENDLINE – SWITCH CAPACITY



CONSIDERING THE NEXT ETHERNET RATE



Source: https://bit.ly/802d3bwa2

SUMMARY

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!