

The State of Ethernet

John D'Ambrosia
“The Ethernet Evangelist”

Regarding the Views Expressed

John's Industry Involvement

- Senior Principal Engineer, IP Standards Team North America, Futurewei
- Chairman, Ethernet Alliance Board of Directors
- Chair, IEEE P802.3bs 400GbE Task Force
- Chair, IEEE 802.3 Beyond 10km Optical PHYs Study Group
- Chair, IEEE 802.3 Next Generation Enterprise, Data Center, Campus Ad Hoc
- Recording Secretary, IEEE 802 Executive Committee



The views I am expressing on IEEE standards and related products should NOT be considered the position, explanation, or interpretation of the Ethernet Alliance.



Per IEEE-SA Standards Board Bylaws, Dec 2016

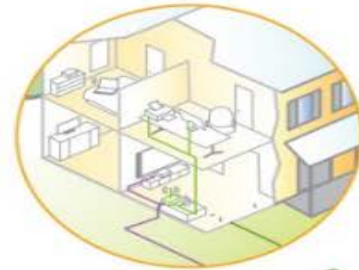
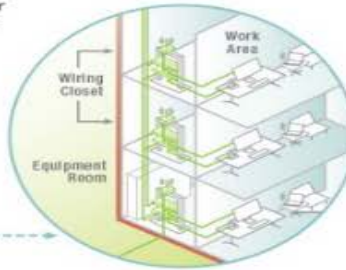
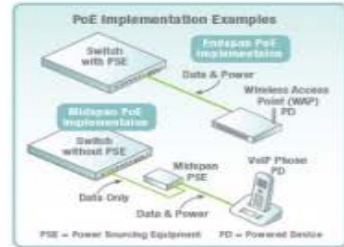
“At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.”

ENTERPRISE AND CAMPUS

Power over Ethernet is a growing Ethernet application that delivers power and data over Category cabling that has 4 twisted pairs of wires, with Cat 5 or better cabling recommended. 4-Pair PoE is being standardized to deliver over 70W of power over all 4 twisted pairs instead of the two pairs in PoE and PoE+.

| PoE Types and Classes | PoE+ - Type 2 | | | | 4-Pair PoE In Standardization | | | | |
|-----------------------|---------------|------|------|------|-------------------------------|----|----|----|----|
| | PoE - Type 1 | | | | 5 | 6 | 7 | 8 | |
| Class | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| PSE Power (W) | 15.4 | 4 | 7 | 15.4 | 30 | 45 | 60 | 75 | 90 |
| PD Power (W) | 13 | 3.84 | 6.40 | 13 | 25.5 | 40 | 51 | 62 | 71 |

4 - Pair PoE - Type 3
4 - Pair PoE - Type 4



RESIDENTIAL AND CONSUMER

Most homes have wireless access points (WAPs) with 4 or more Ethernet ports. Smart TVs, network attached storage (NAS) and other household products come with Ethernet ports that can be used to create the smart home.

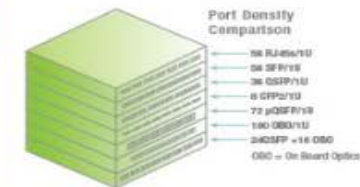
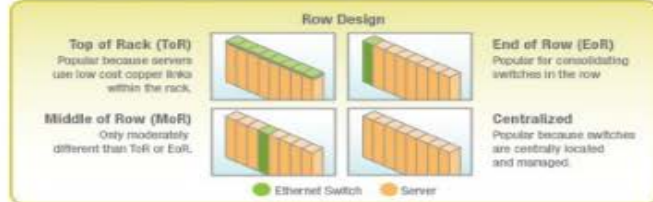
Automotive Ethernet
Ethernet is being deployed in automobiles and will become the default standard for automobile networks by 2020. Because of requirements for lightweight autos, Ethernet was developed to deliver data and power over a single pair of wires to distances of 15 meters at 100Mb/s and 1Gb/s.

Power Over Data Lines (PoDL)
PoDL delivers data and power to cameras, lights, entertainment systems, controls and other devices throughout the car.

Wireless Connectivity
Connected cars are expected to drive increased traffic to wireless networks that result in more wireless backhaul traffic over Ethernet.

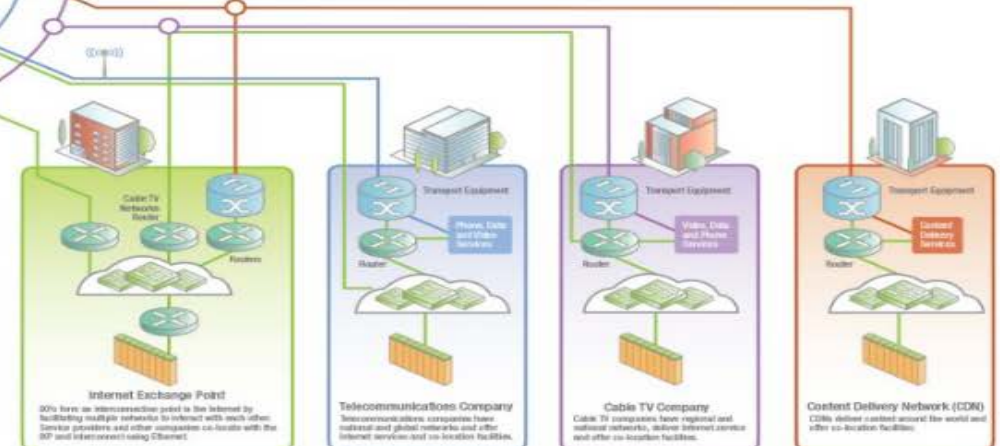
BACKBONE TO OTHER CITIES

BACKBONE TO OTHER CITIES



NEXT ETHERNET ERA
ethernet alliance

MANs
Metropolitan Area Networks (MANs) come in many varieties and deliver services to a variety of enterprises, organizations and consumers. Some MANs are based on Ethernet, but the largest MANs are based on Optical Transport Networks (OTN) technologies.



Hyperscale data centers drive amazing Ethernet volumes when hundreds of thousands of servers are connected on one site.

HYPERSCALE DATA CENTER

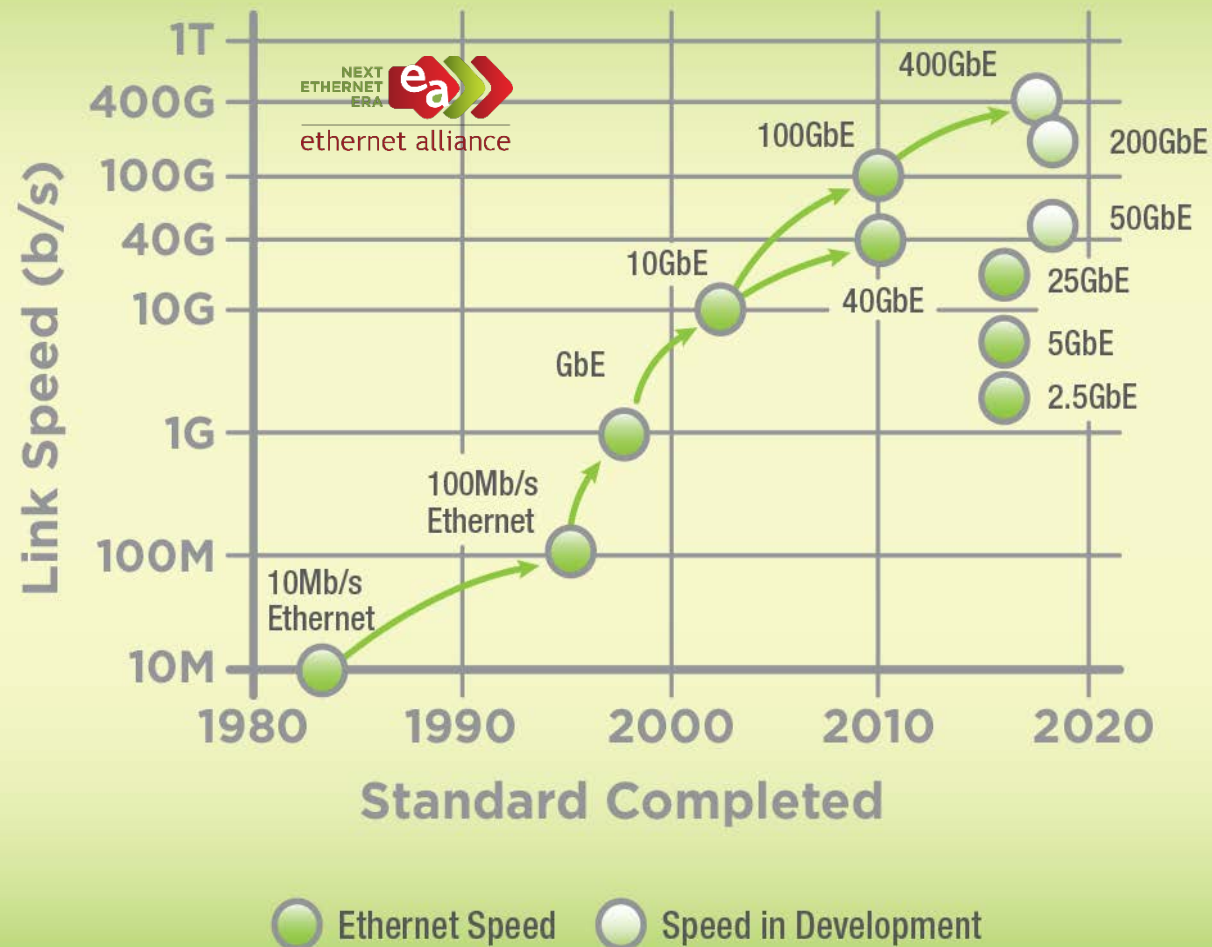
Service Providers deploy MANs and WANs to connect businesses and consumers. Some carriers deploy hyperscale data centers as well.

SERVICE PROVIDERS

Ethernet's Rates

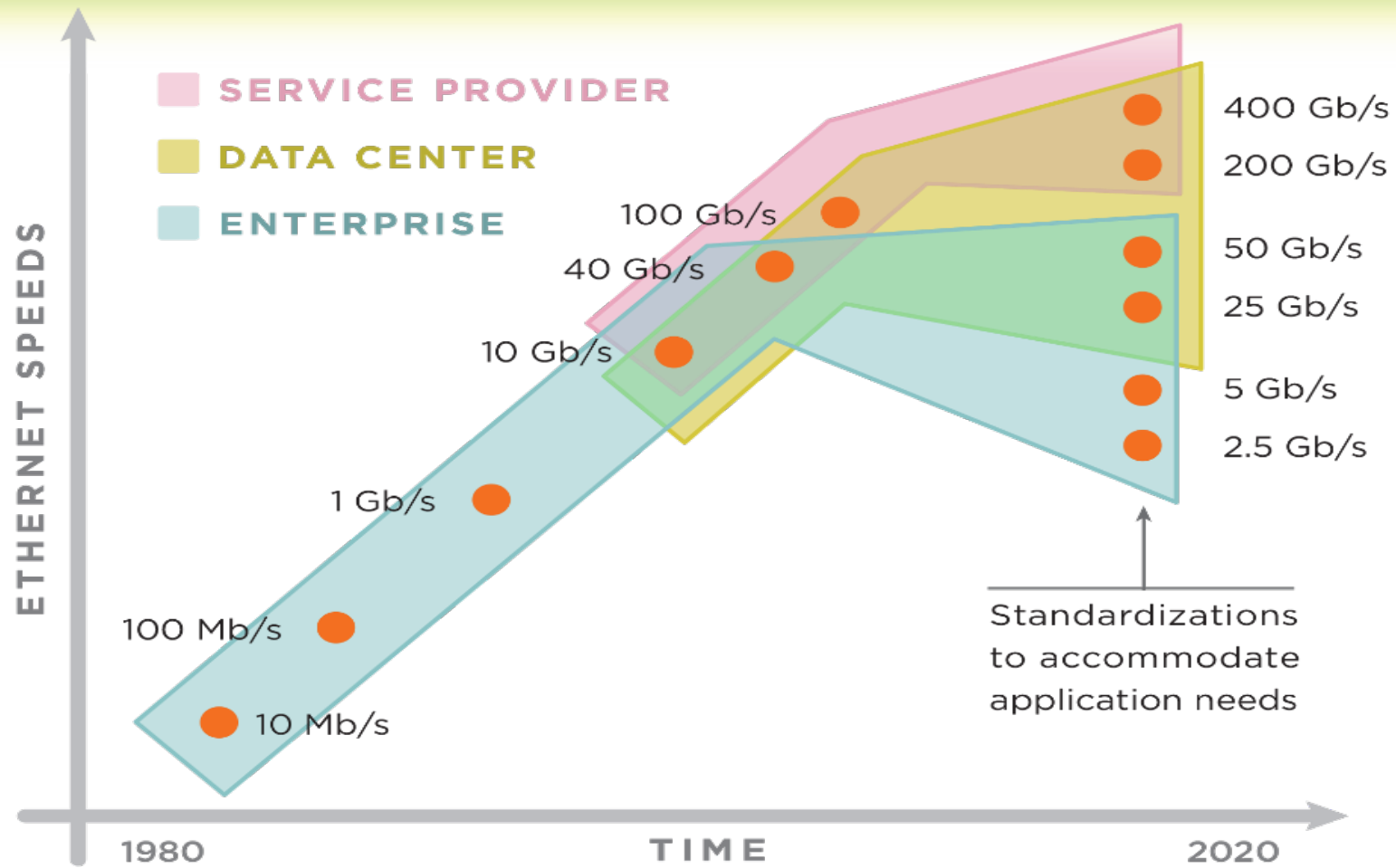


ETHERNET SPEEDS



昵图网 nopic.com/

IEEE ETHERNET STANDARDS



● The first time a new rate is standardized



ETHERNET INTERFACES AND NOMENCLATURE

| | Electrical Interface | Backplane | Twin-ax | BASE-T (4 Pair) | MMF | 500m SMF | 2km SMF | 10km SMF | 40km SMF |
|-----------|---|-------------------|-----------------------------|-----------------|---------------------------|----------------|---------------------|----------|----------|
| 10GBASE- | XSBI, XAUI, XFI, SFI | KX4 KR | CX4 | T | SR | | | LR | ER |
| 25GBASE- | 25GAUI | KR | CR/CR-S | T | SR | | | LR | ER |
| 40GBASE- | XLAUI | KR4 | CR4 | T | SR4/eSR4 | PSM4 | FR | LR4 | ER4 |
| 50GBASE- | LAUI-2/50GAUI-2 50GAUI-1 | KR | CR | | SR | | FR | LR | ER? |
| 100GBASE- | CAUI-10 CAUI-4/100GAUI-4 100GAUI-2 CAUI-1? | KR4 KR2 KR? | CR10, CR4, CR2 CR? | | SR10 SR4 SR2 SR? | PSM4/DR4 DR | 10X10 CWDM4/CLR4 | LR4 | ER4 |
| 200GBASE- | 200GAUI-8 200GAUI-4 200GAUI-2? | KR4 KR2? | CR4 CR2? | | SR4 SR2? | DR4 | FR4 | LR4 | ER4? |
| 400GBASE- | 400GAUI-16 400GAUI-8 400GAUI-4? | KR4? | CR4? | | SR16 SR8? SR4? | DR4 | FR8 FR4? | LR8 | ER8? |

Gray Text = IEEE Standard Red Text = In Standardization Green Text = Future Possible Standard
Blue Text = Non-IEEE standard but complies to IEEE electrical interfaces

IEEE 802.3 Ethernet Standards Activities

| Project | Description | Scheduled Completion |
|--------------------------------------|---|----------------------|
| <u>IEEE p802.3bs</u> | 200 Gb/s and 400Gb/s Ethernet (electrical interfaces / optical PHYs) | Dec 2017 |
| <u>IEEE p802.3bt</u> | 4 Pair Power-Over-Ethernet | >= Q1 2018 |
| <u>IEEE p802.3ca</u> | 25Gb/s, 50 Gb/s, 1000Gb/s EPON | Apr 2020 |
| <u>IEEE p802.3cb</u> | 2.5Gb/s and 5Gb/s Backplane | Dec 2017 |
| <u>IEEE p802.3cc</u> | 25 Gb/s Ethernet over SMF (10 / 40 km) | Oct 2017 |
| <u>IEEE p802.3cd</u> | 50Gb/s, 100 Gb/s ,200Gb/s Ethernet (electrical interfaces, Copper PHYs, Optical PHYs) | Sept 2018 |
| <u>IEEE p802.3.2</u> | YANG Data Models | June 2018 |
| <u>IEEE p802.3cg</u> | 10 Mb/s Single Twisted Pair | June 2019 |
| <u>IEEE p802.3ch</u> | Multi-gig Automotive Ethernet | Undefined |
| <u>Study Group</u> | Beyond 10km Optical PHYs (50Gb/s, 200Gb/s, and 400Gb/s Ethernet) | |

Leveraging BASE-T and PoE Technologies



Wireless
Infrastructure



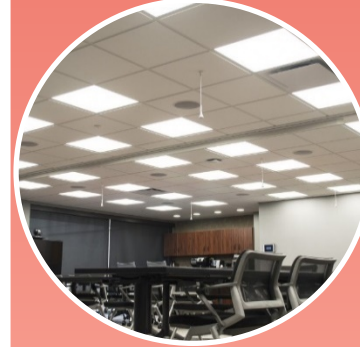
Industrial



Home
Automation



Automotive



Lighting

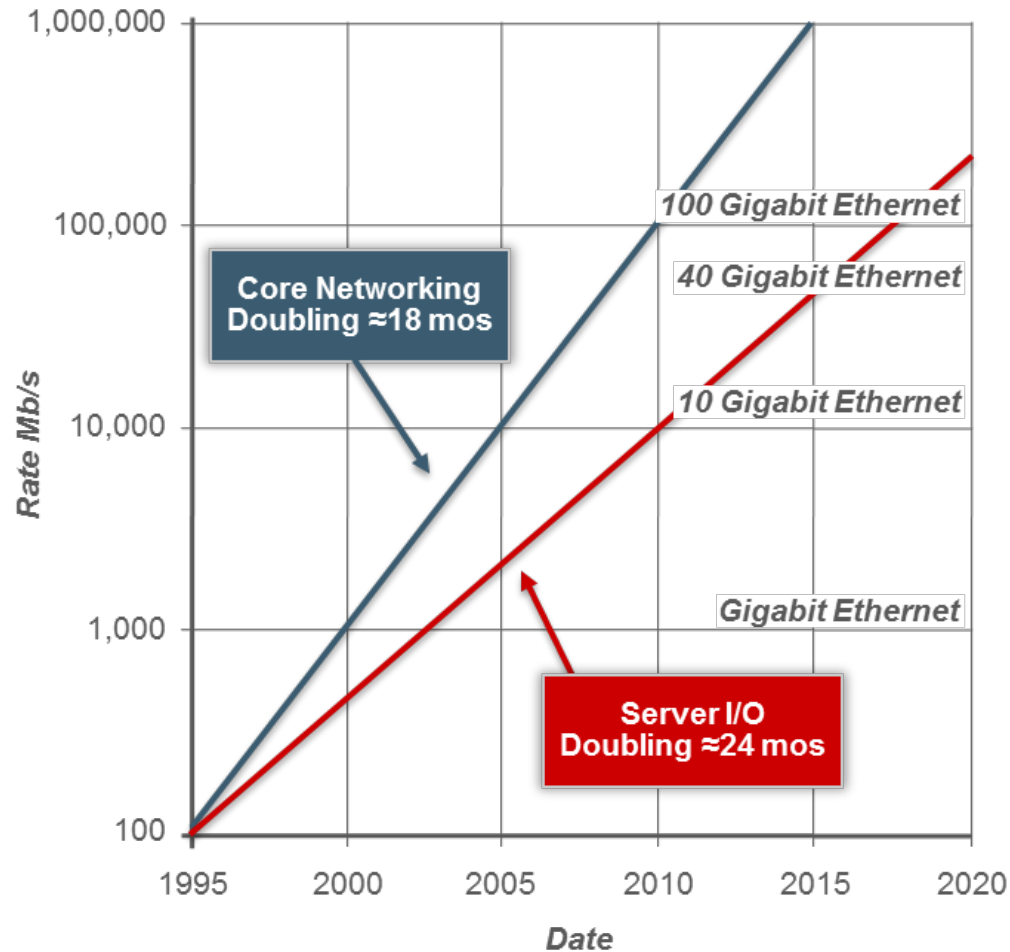


Other...

Twisted Pair Cabling

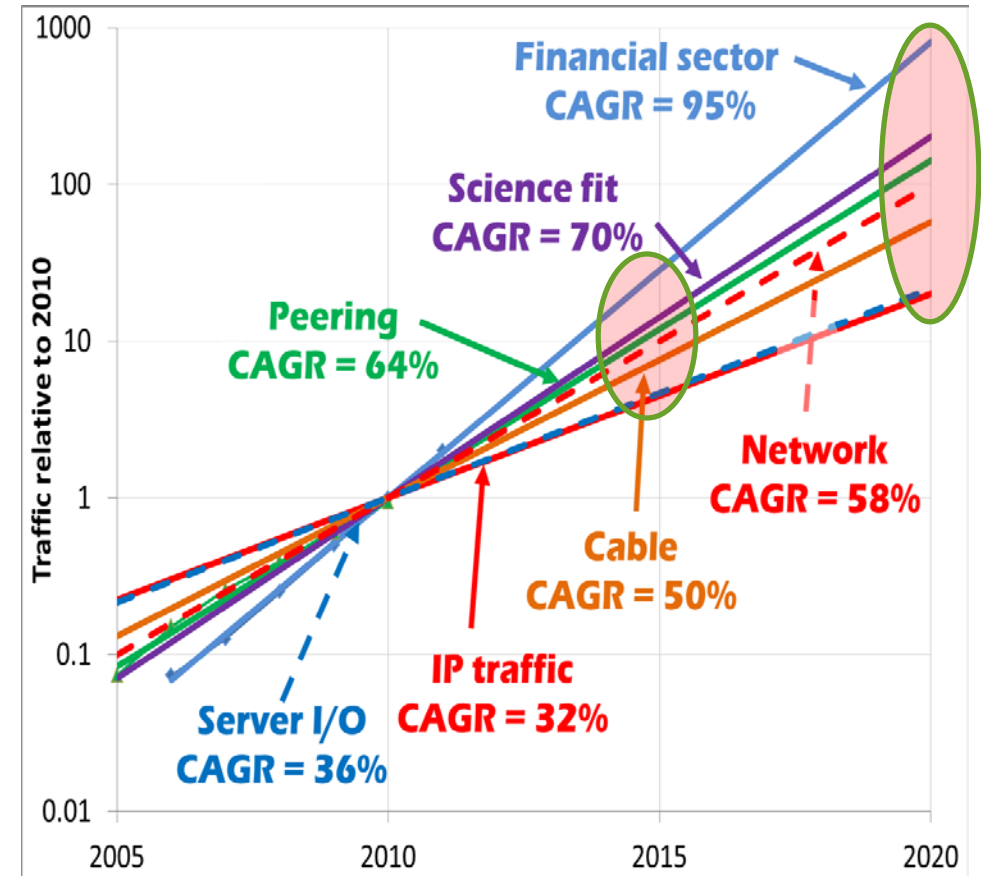
Market Diversity Examples

IEEE 802.3 HSSG - 2007



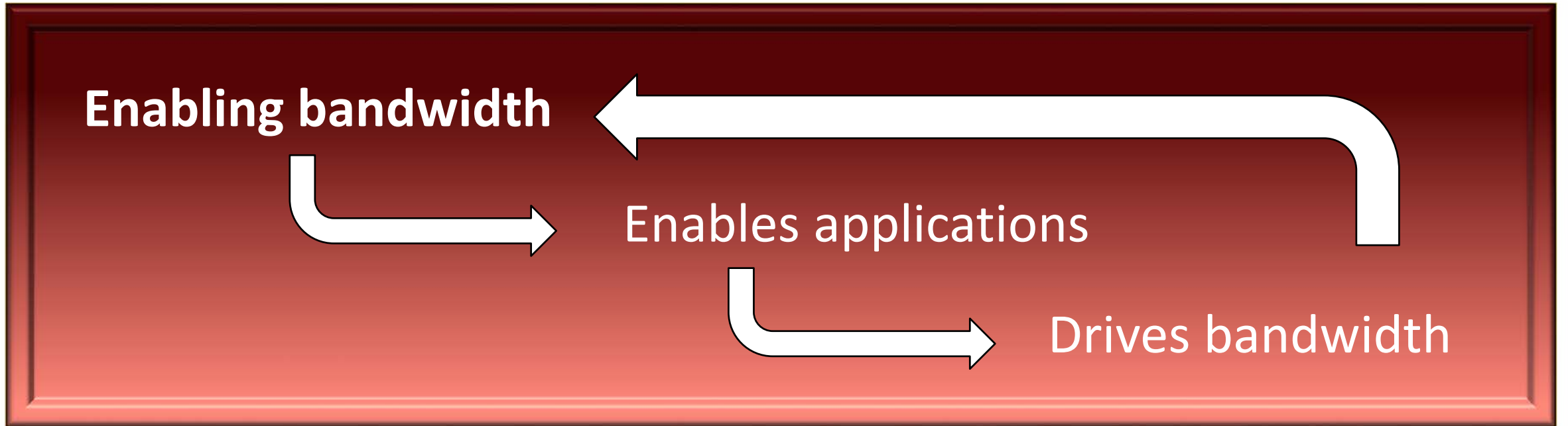
Source: http://www.ieee802.org/3/hssg/public/nov07/HSSG_Tutorial_1107.zip

IEEE 802.3 BWA - 2012



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

The Story Remains the Same....



The Connected Car is the Next Chapter

For the Ethernet Ecosystem

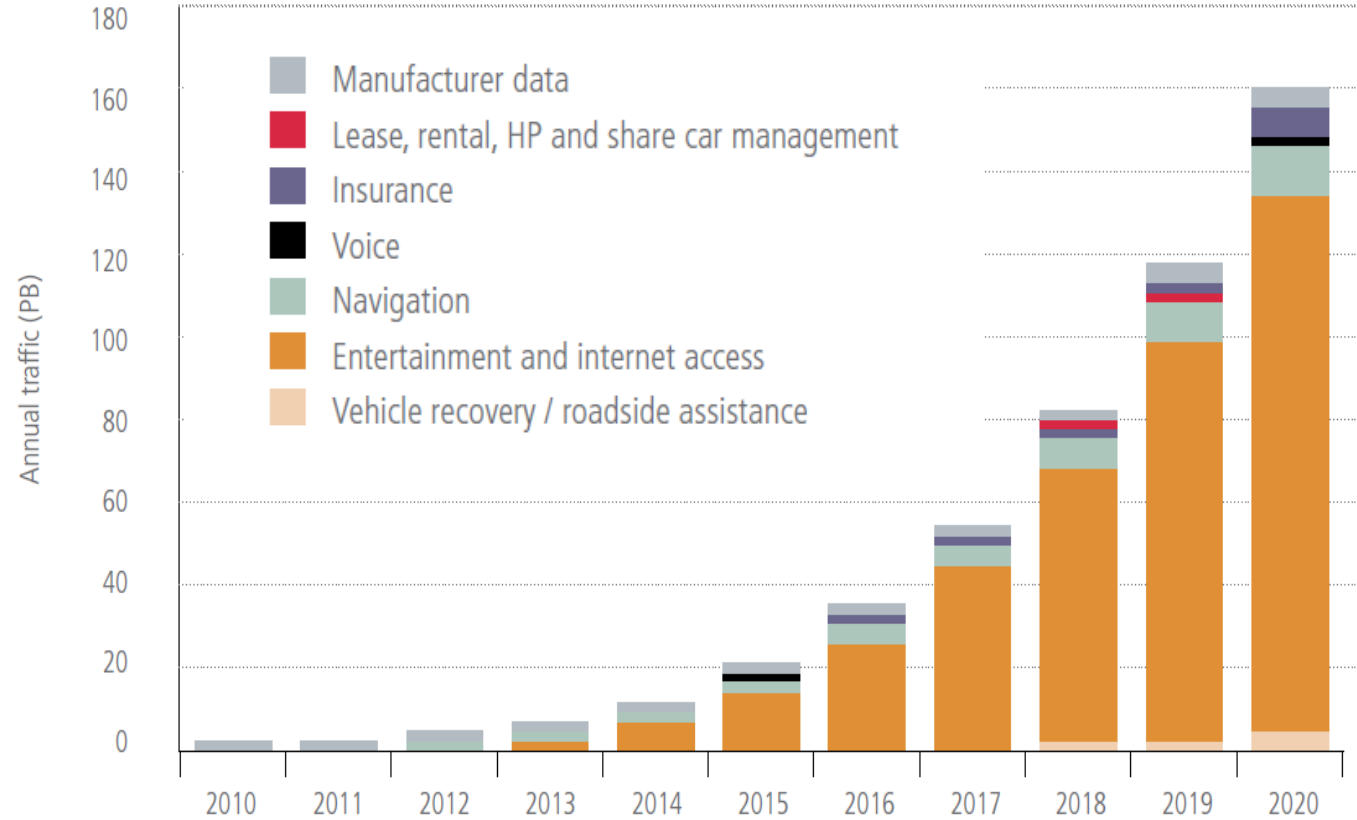
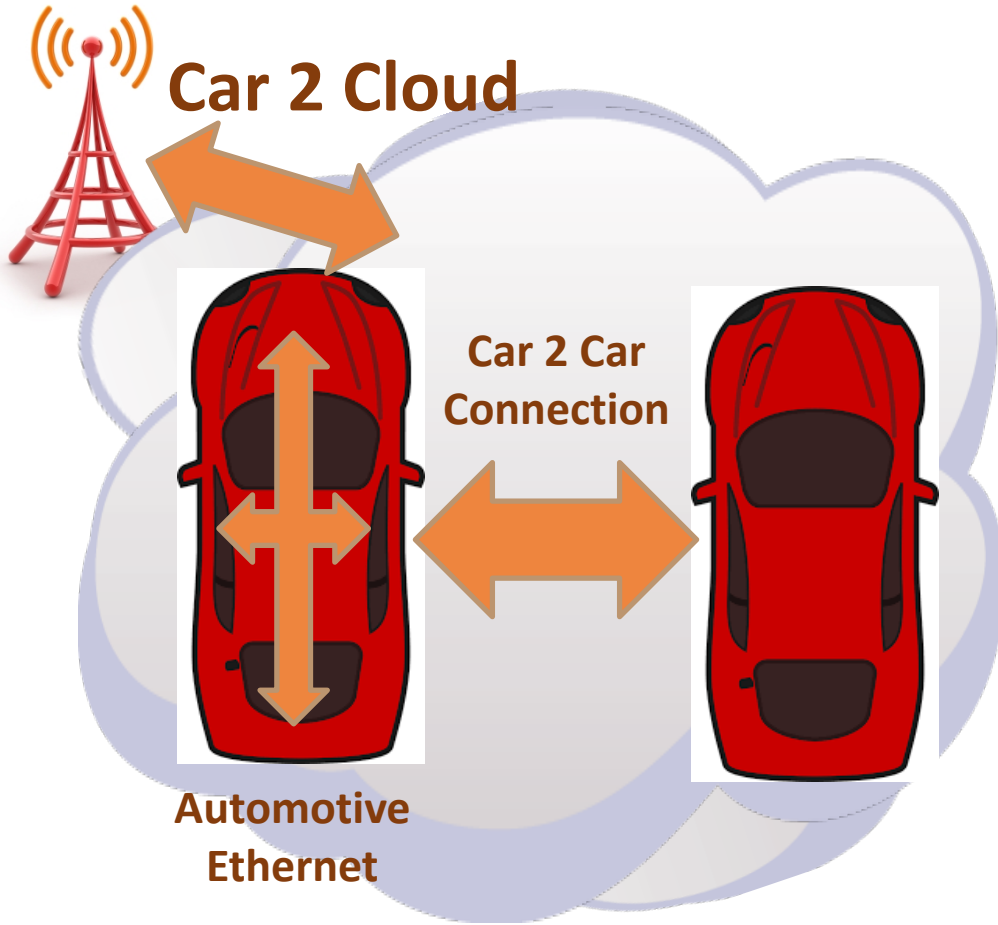
The Automobile – the Next End Station



Metcalfe's Law: The value of a telecommunications network is proportional to the square of the number of connected users of the system

-Dr. Robert Metcalfe, inventor of Ethernet

Connected Cars – Driving Bandwidth on Mobile Networks



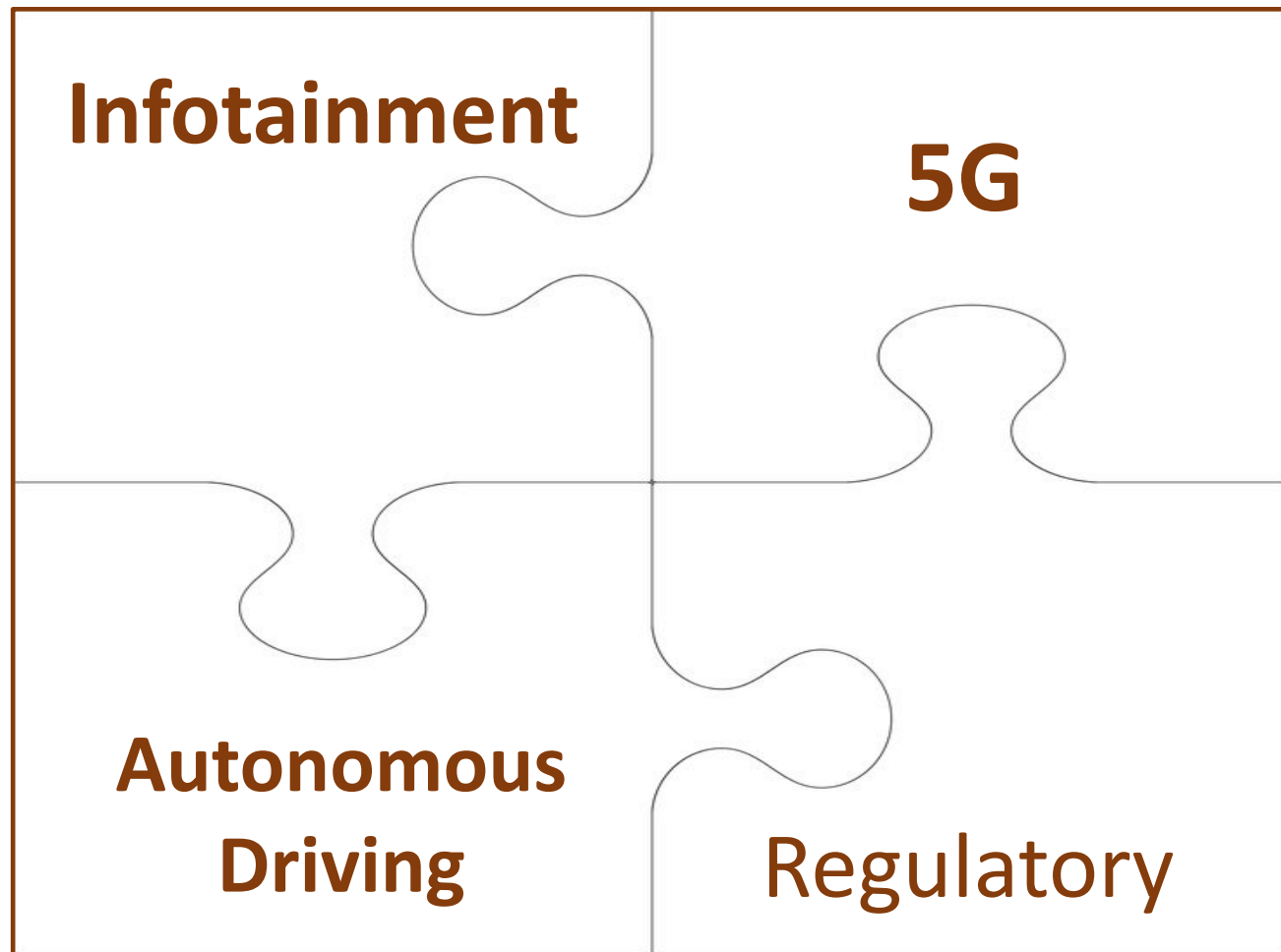
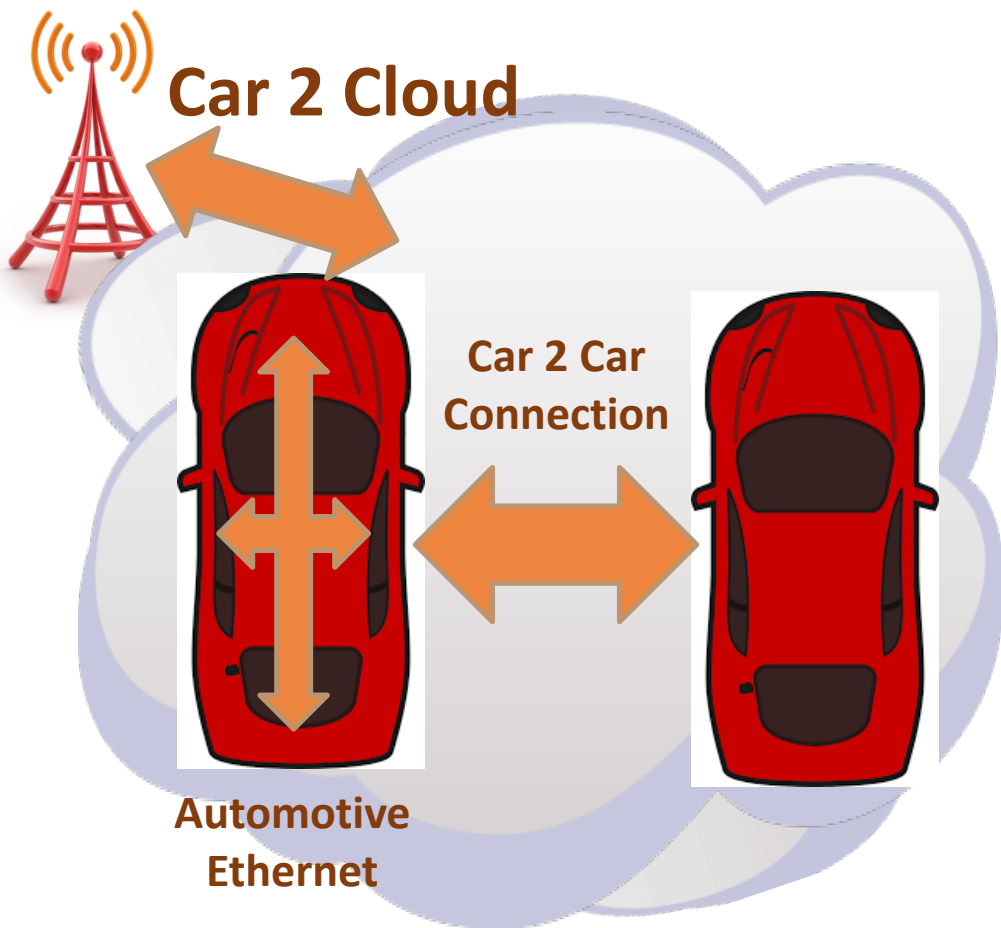
2011 Forecast for Global Wireless Traffic Generated by Embedded Mobility by Application

Source - GSMA, Connecting Cars: The Technology Roadmap, February 2013,
https://www.gsma.com/iot/wp-content/uploads/2013/02/GSMA_mAutomotive_TechnologyRoadmap_v2.pdf

2019- 117 Million Vehicles to be produced *

* CFI Multi-Gig Automotive Ethernet PHY, http://www.ieee802.org/3/cfi/1116_1/CFI_01_1116.pdf.

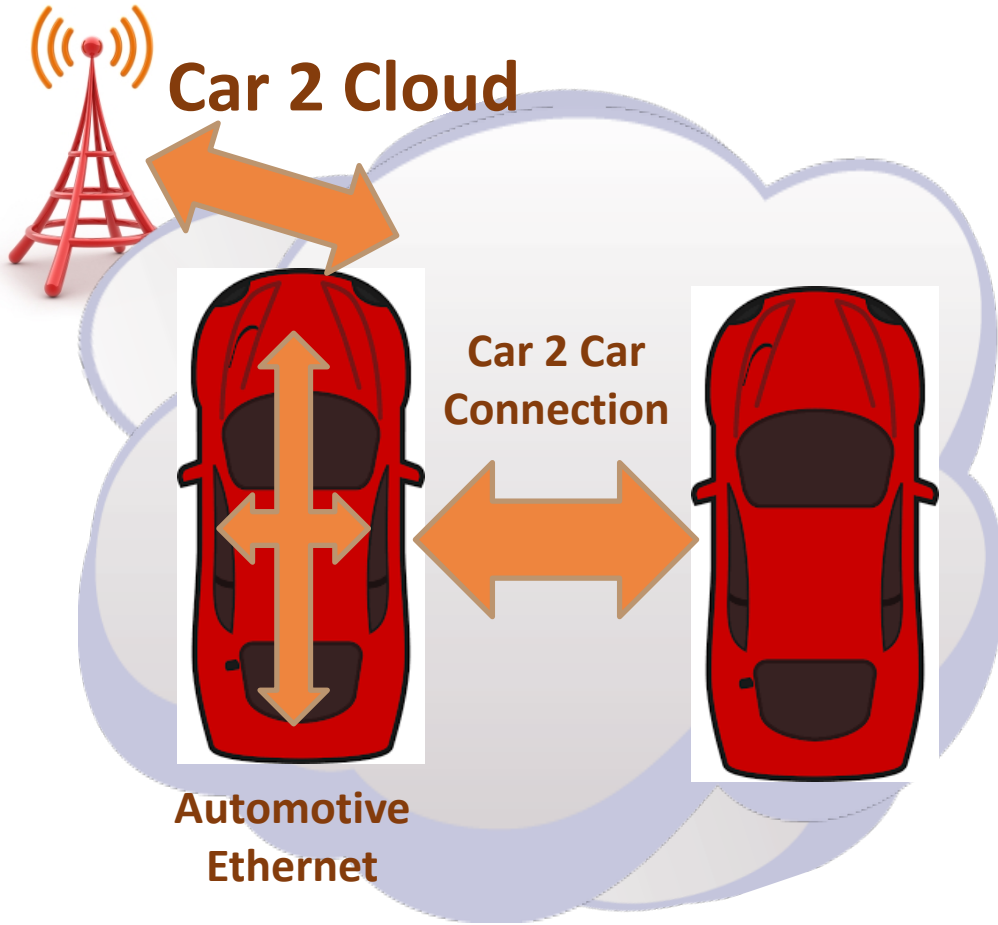
Connected Cars – Driving Bandwidth on Mobile Networks



2019- 117 Million Vehicles to be produced *

* CFI Multi-Gig Automotive Ethernet PHY, http://www.ieee802.org/3/cfi/1116_1/CFI_01_1116.pdf.

Connected Cars – Driving Bandwidth on Mobile Networks

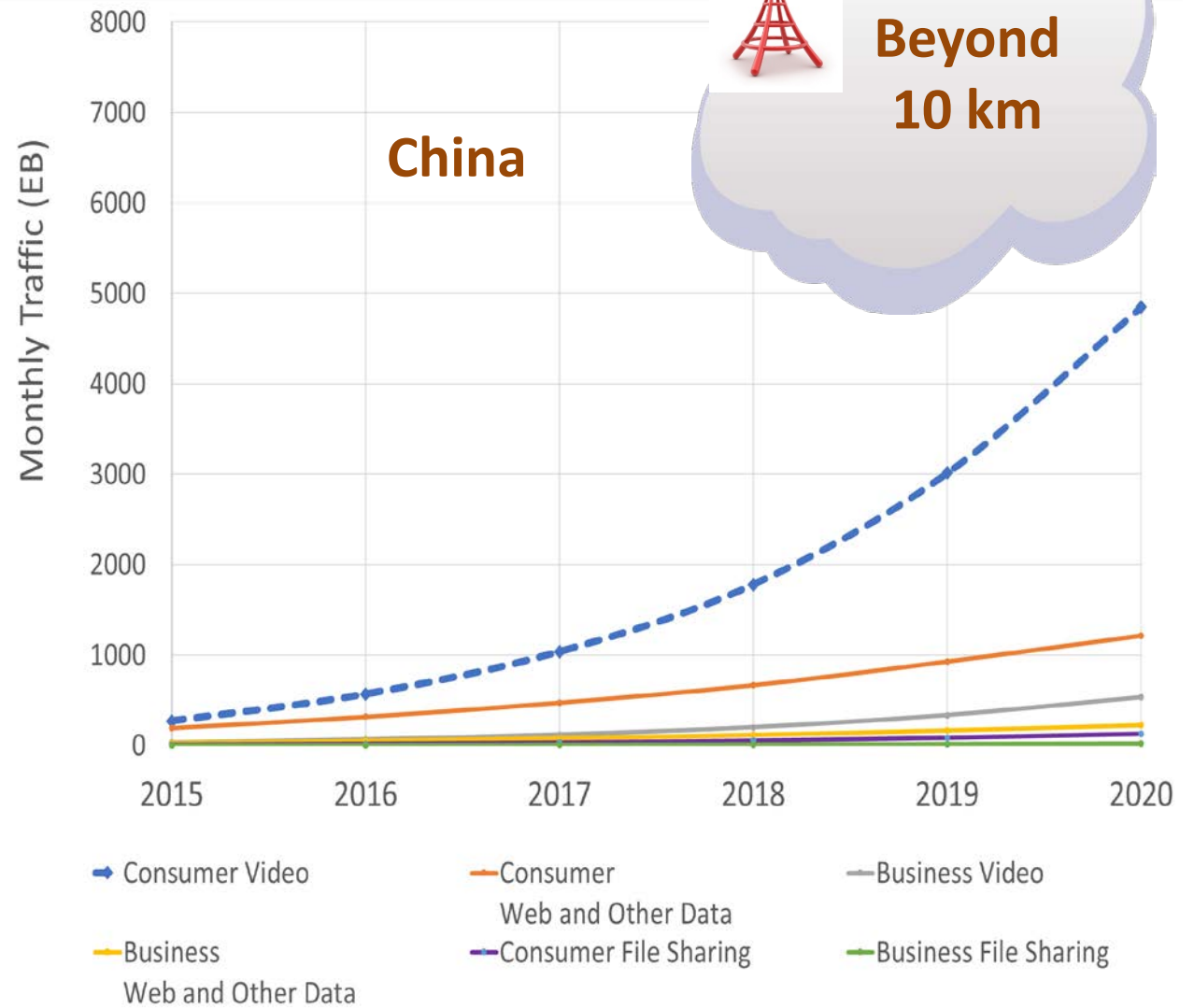
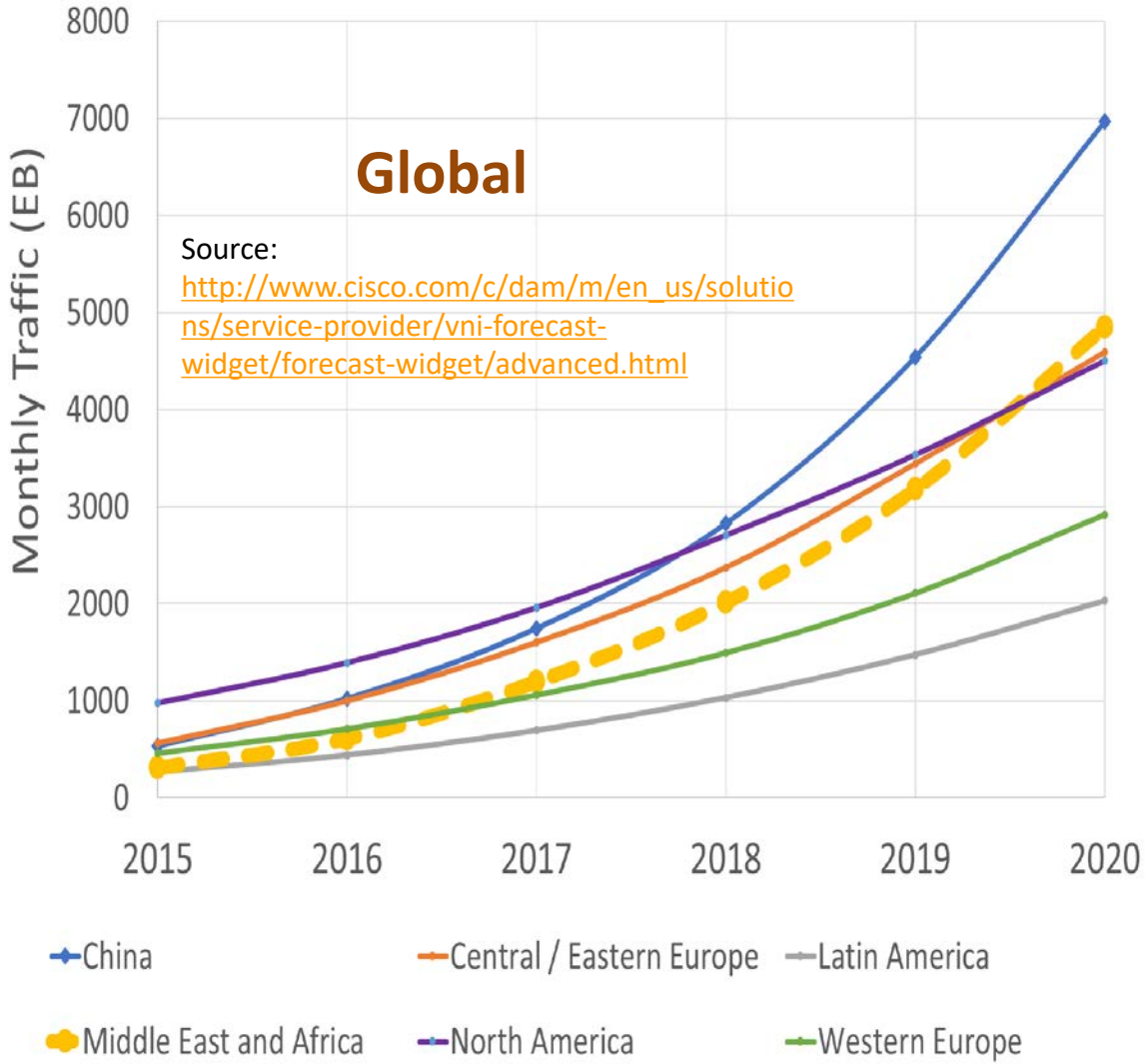
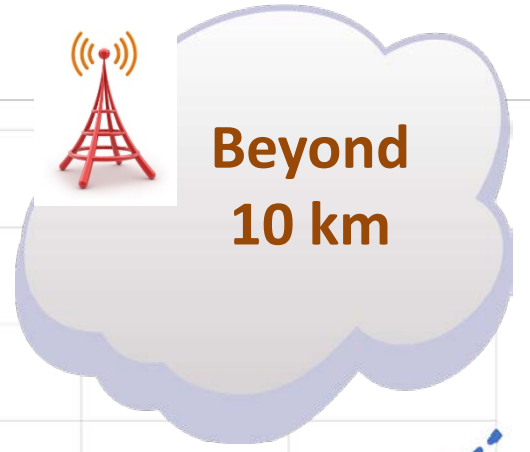


What
Else?

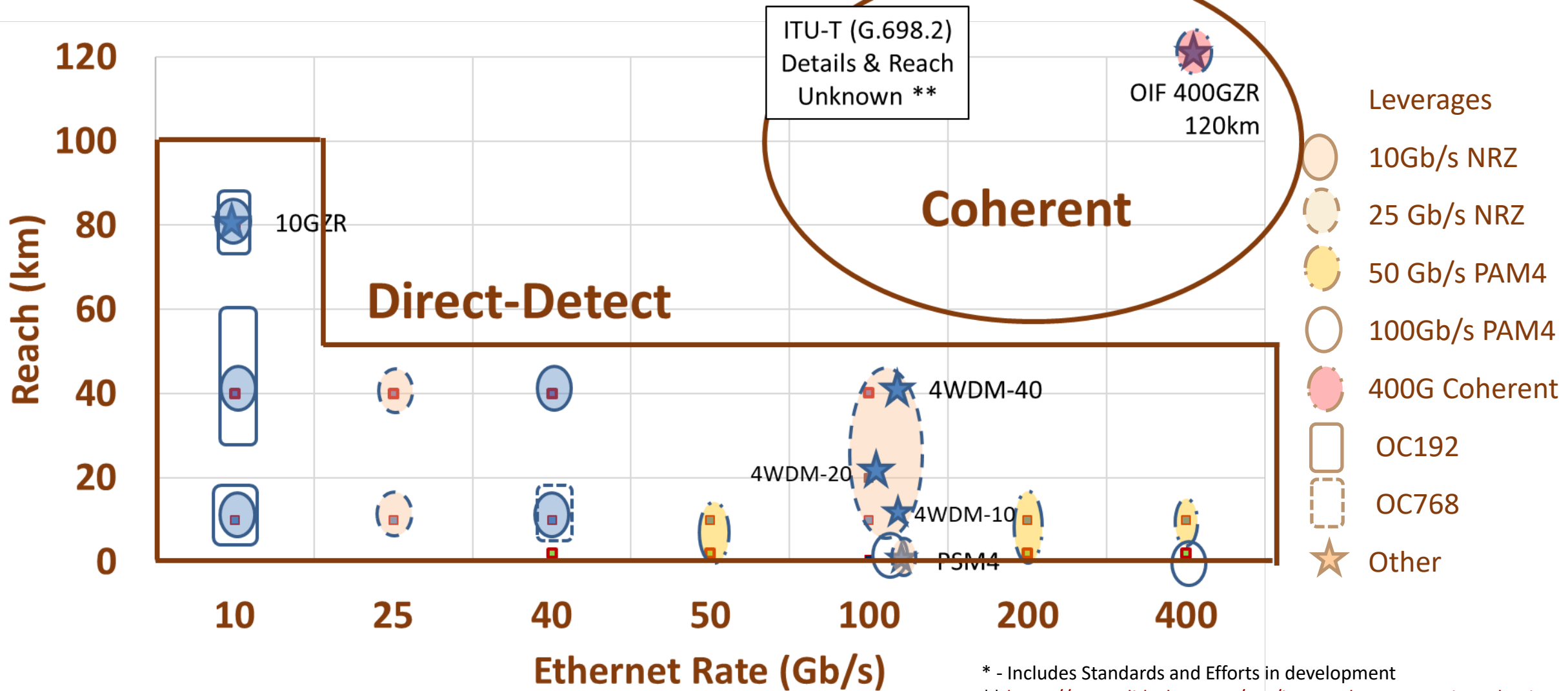
2019- 117 Million Vehicles to be produced *

* CFI Multi-Gig Automotive Ethernet PHY, http://www.ieee802.org/3/cfi/1116_1/CFI_01_1116.pdf.

Mobile Networks Bandwidth Trends



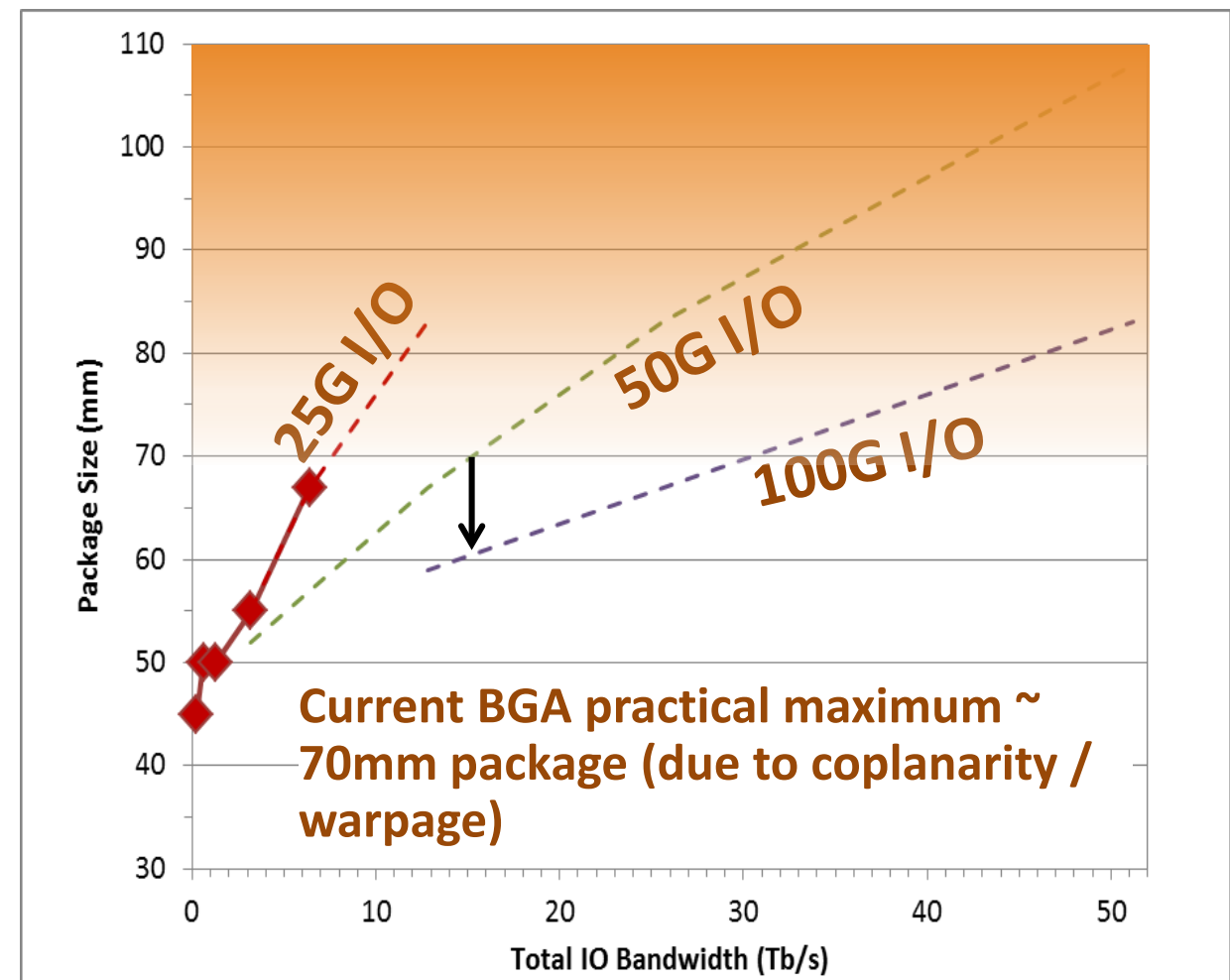
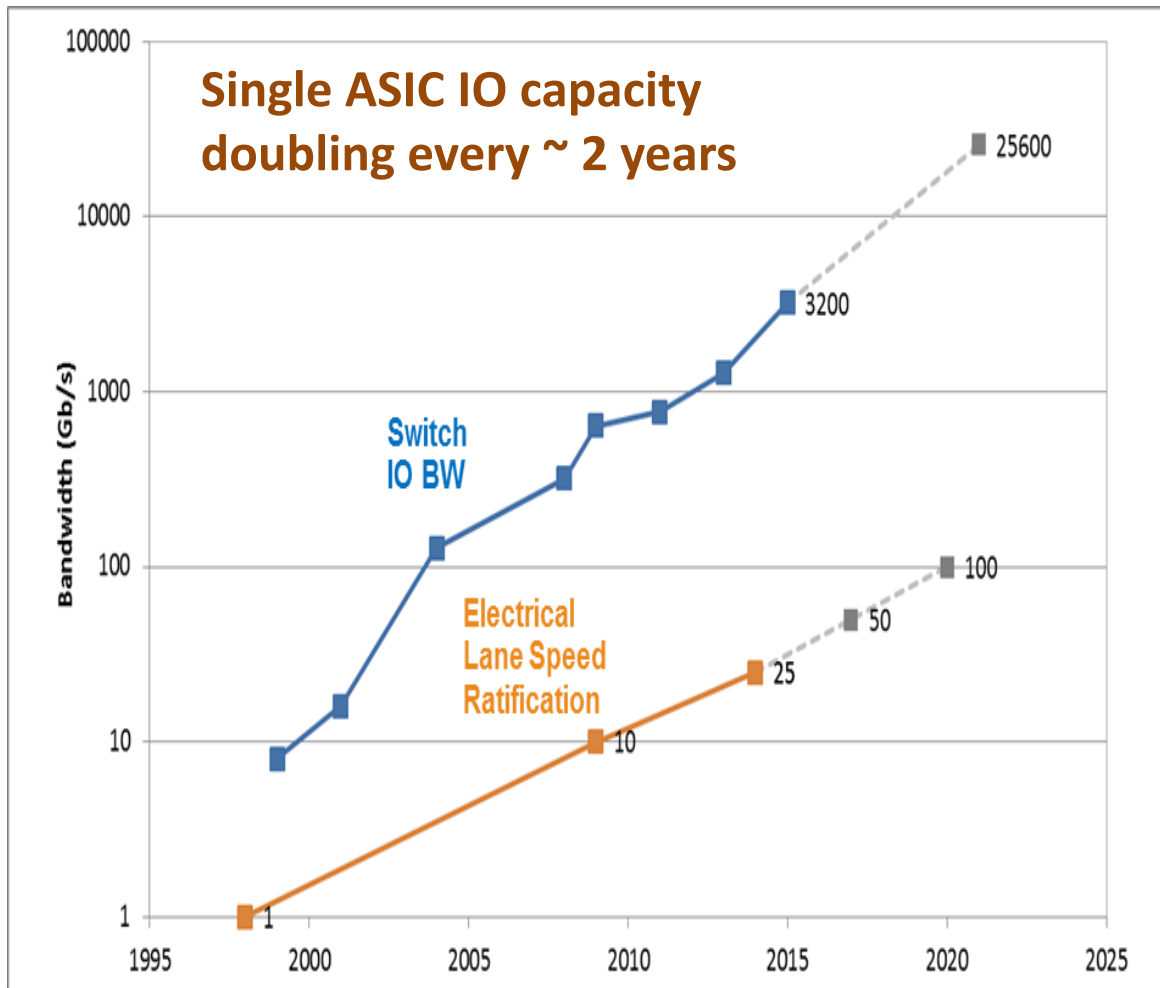
The SMF Optical Landscape *



* - Includes Standards and Efforts in development

** <https://www.slideshare.net/ITU/itut-study-group-15-introduction>.

I/O Escape Forcing Transition to Higher Lane Speeds



Source: http://www.ieee802.org/3/ad_hoc/ngrates/public/17_03/goergen_nea_01a_0317.pdf

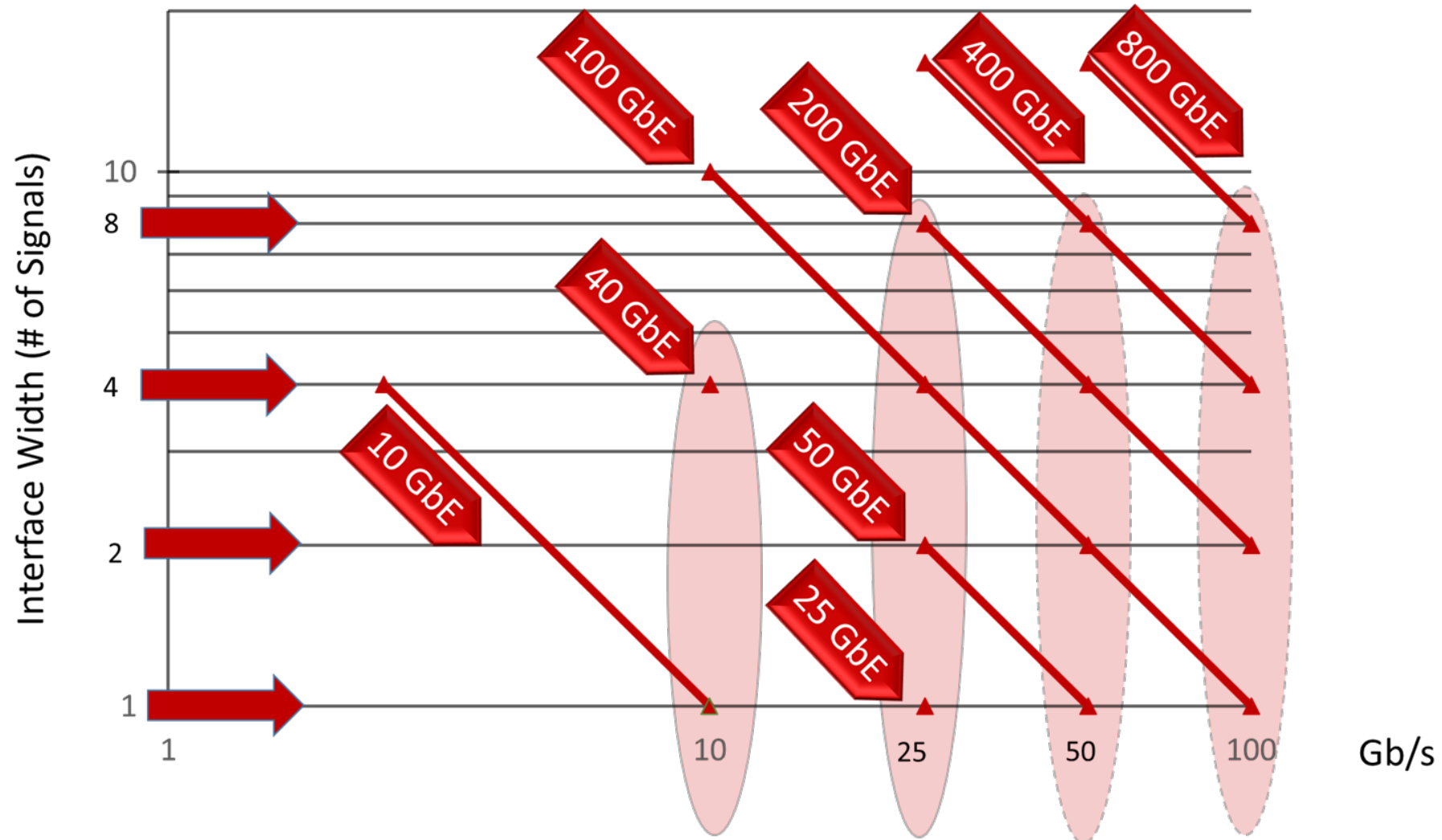
The Impact of 100 Gb/s Per Lane Electrical Signaling

| | Signaling (Gb/s) | Electrical Interface | Backplane | Twin-ax | MMF | 500m SMF | 2km SMF | 10km SMF | 40km SMF |
|-----------|------------------|----------------------|-----------|---------|------|-------------|-----------------------------|----------|----------|
| 100GBASE- | 10 | CAUI-10 | | CR10 | SR10 | | <u>10X10</u> | | |
| | 25 | CAUI-4 / 100GAUI-4 | KR4 | CR4 | SR4 | <u>PSM4</u> | <u>CWDM4</u> <u>CLR4</u> | LR4 | ER4 |
| | 50 | 100GAUI-2 | KR2 | CR2 | SR2 | | - | | |
| | 100 | ? | ? | ? | | DR | | | |
| 200GBASE- | 25 | 200GAUI-8 | | | | | | | |
| | 50 | 200GAUI-4 | KR4 | CR4 | SR4 | DR4 | FR4 | LR4 | |
| | 100 | ? | ? | ? | | | | | |
| 400GBASE- | 25 | 400GAUI-16 | | | SR16 | | | | |
| | 50 | 400GAUI-8 | | | | | FR8 | LR8 | |
| | 100 | ? | ? | ? | | DR4 | | | |

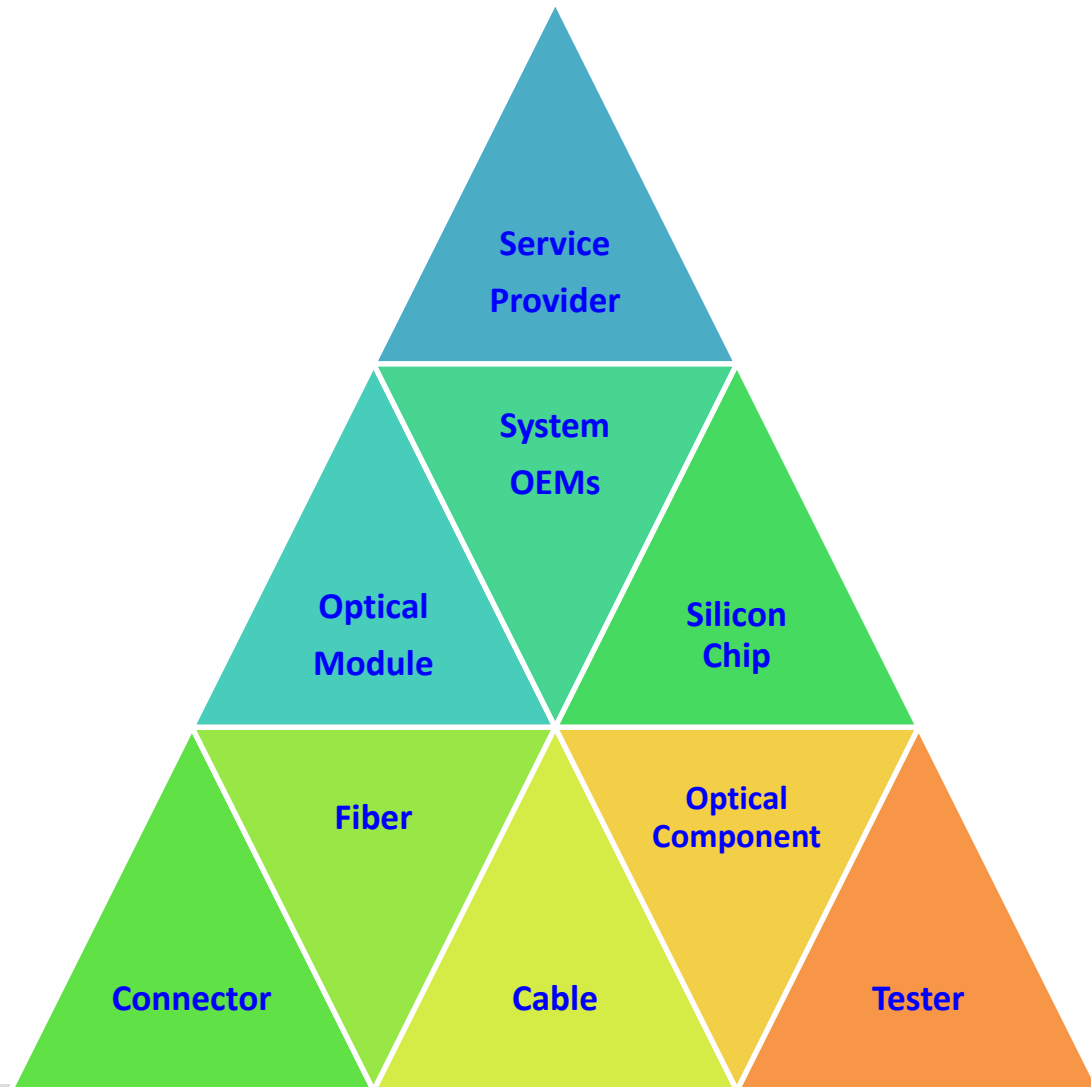
Includes Ethernet standards in development

Underlined – indicates industry MSA or proprietary solutions

The New Ethernet Paradigm: Follow the SerDes



Standards & The Eco-system



**Standards enable
all aspects of the
Eco-system to
work together**

Introducing the Ethernet Alliance

A global community of end users, system vendors, component suppliers and academia

➤ Mission

- Promote existing and emerging IEEE 802 Ethernet standards
- Accelerate industry adoption
- Demonstrate multi-vendor interoperability

➤ 2017 Strategic Priorities

- Support Existing Technology Deployment
- Support IEEE 802 Standards Development
- Marketing & Education

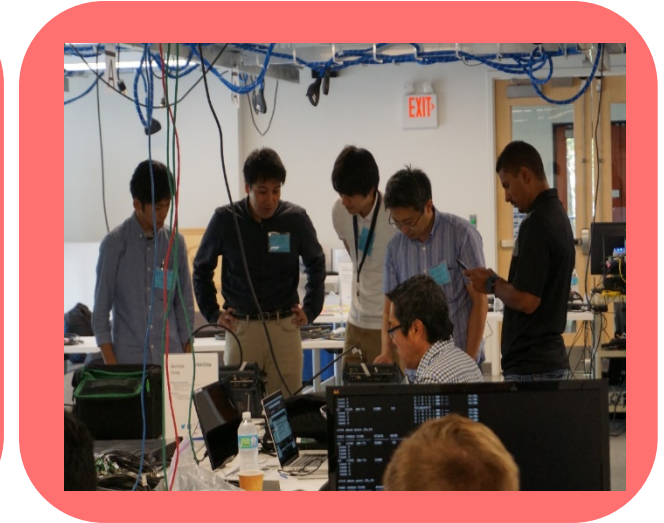


The Voice of Ethernet

The Importance of Multi-vendor Interoperability

Industry investment

- **On-going Work**
 - PoE (802.3af / 802.3at)
 - 2.5G / 5G / 10G BASE-T
 - 25GbE
 - 100GbE
- **Future**
 - 4 Pair PoE
 - 25 GbE (10 km / 40 km)
 - 50 GbE
 - 200 GbE / 400 GbE
 - New Signaling
 - New Optical Form Factors



Ethernet Alliance PoE Certification Program

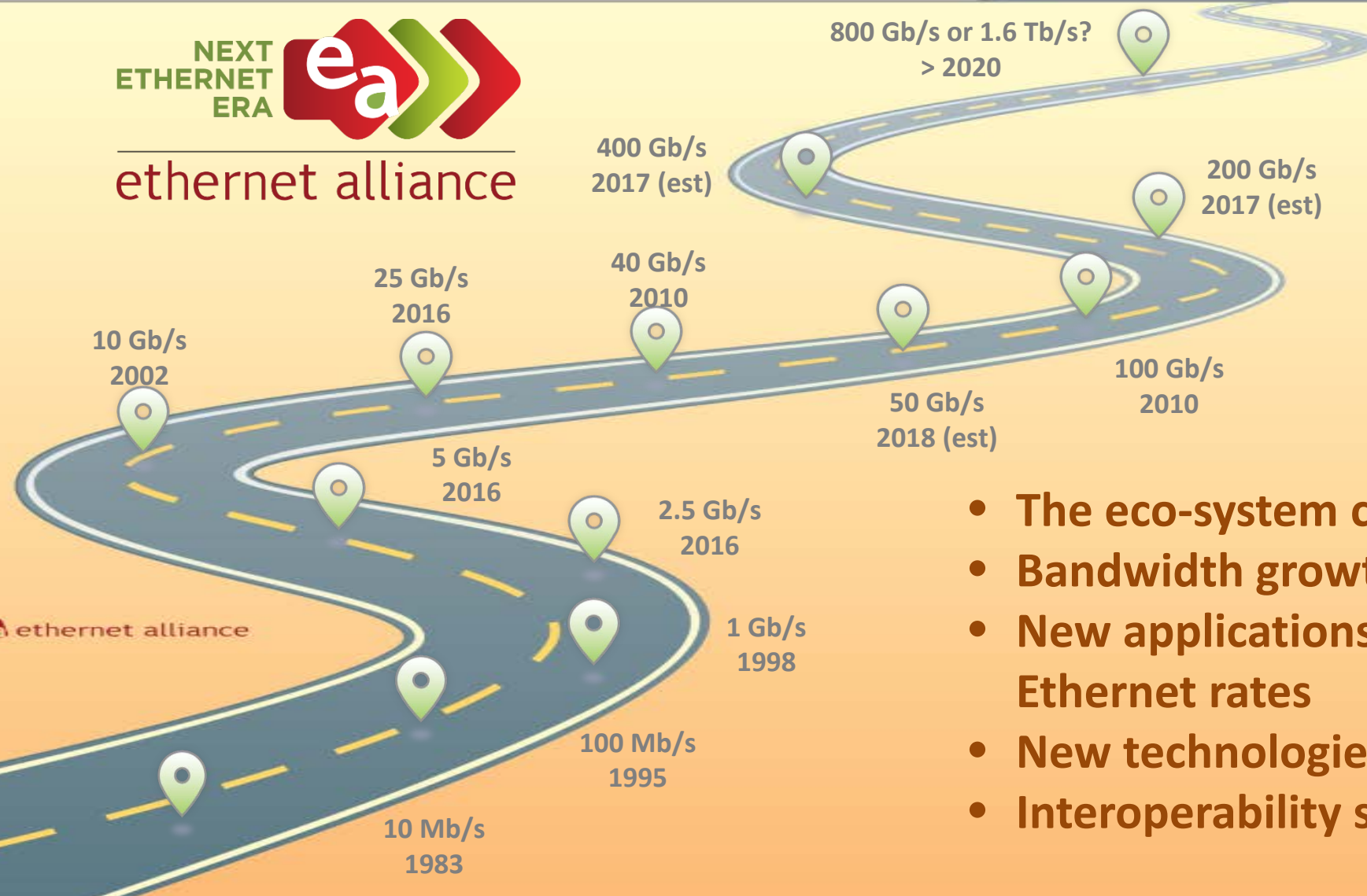
- Distinguishes products based on IEEE 802.3 standards in the market
- Ethernet Alliance PoE Certification Program (IEEE Std 802.3-2015™) to be released
 - White Paper [Available](#)
- UNH-IOL PoE Certification Test Event week of Oct 2
- Work to begin on Gen 2 (IEEE P802.3bt)



THE ETHERNET ALLIANCE™, EA™, THE EA LOGO™, EA CERTIFIED & PD Logo™, and EA CERTIFIED & PSE Logo™ are trademarks, service marks, and certification marks of The Ethernet Alliance in the United States and other countries. Unauthorized use strictly prohibited.



ethernet alliance



- The eco-system continues to expand
- Bandwidth growth continues unabated
- New applications > new life for lower Ethernet rates
- New technologies and standards
- Interoperability still key



Questions?

A photograph of a conductor in a tuxedo, standing on a podium and leading an orchestra. He is holding a baton in his right hand and gesturing with his left hand. The background is dark, and the foreground shows the backs of several orchestra members seated at their instruments.

No one can whistle a symphony.

It takes a whole orchestra to play it.

H.E. Luccock (1885–1961)

Thank You!

Thank You!



John D'Ambrosia
The Ethernet Evangelist
Senior Principal Engineer
IP Standards Team, North America, Huawei
Email – jdambrosia@ieee.org

Follow me @jodam on Twitter

Follow me on [LinkedIn](#)

- Ethernet Alliance: visit www.ethernetalliance.org;



Follow @EthernetAllianc on Twitter



Join the Ethernet Alliance [LinkedIn group](#)



Visit the Ethernet Alliance [Facebook](#) page