ETHERNET APPLICATIONS

INTEROPERABILITY AND CERTIFICATION

The Ethernet Alliance is committed to leading the charge to instilling industry confidence in Ethernet standards through its multi-vendor interoperability demonstrations and plugfests. Our PoE Certification Program takes this mission to the next level!

Our industry-defined PoE Certification Test Plan is based on the Ethernet PoE standard, and products passing this test will be granted the Ethernet Alliance PoE Certification Logo. The trademarked logo provides instant recognition for products based on the IEEE 802.3 PoE standard, and increases multi-vendor interoperability between products bearing it. The logos indicate the power class and product type providing clear guidance on which devices will work with each other.

The first generation of the program (Gen 1) certifies Type 1 and Type 2 products that use 2-Pair of wires (PoE 1). The second generation of the program (Gen 2) certifies Type 3 and Type 4 products using 2-Pair and 4-Pair of wires (PoE 2). See table below for details:

PoE Types and Classes	PoE 1 2-Pair PoE – Type 2							
	PoE 1 2-Pair PoE – Type 1				PoE 2 4-Pair PoE 2			
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	6.49	13	25.5	40	51	62	71.3
	PoE 2 4-Pair PoE – Type 3					PoE 2 4-Pair PoE Type 4			

EA Certified™   EA Certified 2.0™

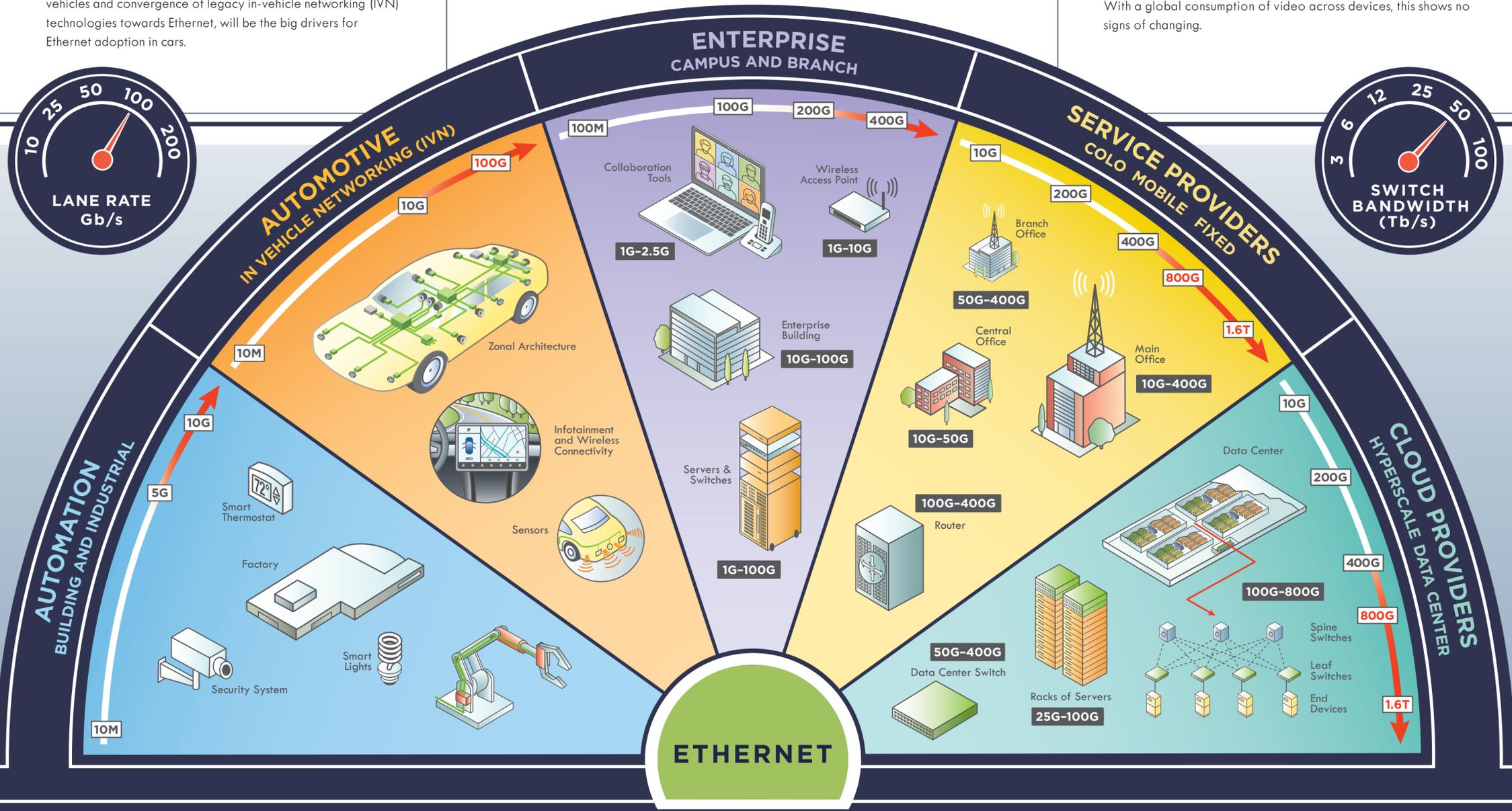https://ethernetalliance.org/poecert/

AUTOMOTIVE is one of Ethernet's latest success stories. Forecasts predicted up to 500 million ports of Ethernet will ship in over 100M vehicles by 2021. Ethernet links within cars provide data using Single-Pair Ethernet (SPE) to reduce the cost and weight in vehicles while providing economies of scale and interoperability. Richer multimedia experience, autonomous driver assistance systems (ADAS), roll-out of autonomous vehicles and convergence of legacy in-vehicle networking (IVN) technologies towards Ethernet, will be the big drivers for Ethernet adoption in cars.

ENTERPRISE and Campus applications are a huge market for Ethernet with over a billion ports shipping per year. Most of these ports are BASE-T at the access layer, with both multi-mode and single-mode fiber links (MMF/SMF) further into the network.
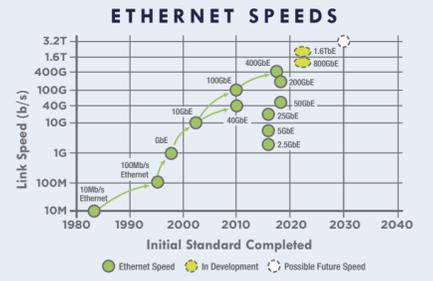
The changing needs of Wi-Fi access points and Enterprise class client devices are driving technology transitions. BASE-T ports are making the transition from 1000BASE-T to 2.5G/5G/10G BASE-T, and optical ports are moving from 10G/40G to 25/100G.

SERVICE PROVIDERS have driven higher speed Ethernet solutions for decades. Their multi-service aggregation needs continue to grow with support for router connections, EPON, transport network (OTN), and wired and wireless backhaul. In particular, the 5G mobile deployment is driving dramatic increases in both fronthaul and backhaul applications, which continues to push Ethernet requirements for higher rates and longer distances. With a global consumption of video across devices, this shows no signs of changing.

LANE RATE Gb/s
10 25 50 100 200

SWITCH BANDWIDTH (Tb/s)
3 6 12 25 50 100

AUTOMOTIVE
IN VEHICLE NETWORKING (IVN)
- 100G
- 10G
- 10M
- Zonal Architecture
- Infotainment and Wireless Connectivity
- Sensors

ENTERPRISE
CAMPUS AND BRANCH
- 100M · 100G · 200G · 400G
- Collaboration Tools — 1G-2.5G
- Wireless Access Point — 1G-10G
- Enterprise Building — 10G-100G
- Servers & Switches — 1G-100G

SERVICE PROVIDERS
COLO · MOBILE · FIXED
- 10G · 200G · 400G · 800G · 1.6T
- Branch Office — 50G-400G
- Central Office — 10G-50G
- Main Office — 10G-400G
- Router — 100G-400G
- Data Center Switch — 50G-400G

CLOUD PROVIDERS
HYPERSCALE DATA CENTER
- 10G · 200G · 400G · 800G · 1.6T
- Data Center — 100G-800G
- Spine Switches
- Leaf Switches
- Racks of Servers — 25G-100G
- End Devices

AUTOMATION
BUILDING AND INDUSTRIAL
- 10G · 5G · 10M
- Smart Thermostat
- Factory
- Smart Lights
- Security System

ETHERNET

AUTOMATION, BUILDING, AND INDUSTRIAL

applications are moving from older fieldbus style networks to Ethernet. This move has been accelerating over the last decade, with Ethernet as a key enabling technology for the Fourth Industrial Revolution aka Industry 4.0. The main themes of Industry 4.0 are Interconnection, Information Transparency, Technical Assistance and Decentralized Decisions [1]. Adopting Ethernet provides OT access to all the networking technology that IT has been developing over the last 40 years, as well as physical layers developed specifically for harsh OT environments , e.g., 10BASE-T1L.

[1] M. Hermann, T. Pentek and B. Otto, "Design Principles for Industrie 4.0 Scenarios," 2016 49th Hawaii International Conference on System Sciences (HICSS), 2016, pp. 3928-3937, doi: 10.1109/HICSS.2016.488

ETHERNET SPEEDS

Link Speed (b/s): 10M, 100M, 1G, 10G, 40G, 100G, 400G, 1.6T, 3.2T
Initial Standard Completed: 1980, 1990, 2000, 2010, 2020, 2030, 2040

● Ethernet Speed   ✦ In Development   ◌ Possible Future Speed

CLOUD PROVIDERS

were the first to adopt 10GbE servers on a large scale in 2010 for hyperscale data centers. With voracious appetites for applications like AI and Machine Learning, hyperscale servers have moved to 25GbE, and are transitioning to 50GbE, 100GbE and beyond. Unique networking architectures within these warehouse scale data centers have driven a mix of copper cables, multi-mode fiber and single-mode fiber solutions at 100, 200 and 400 GbE. The bandwidth demands of both hyperscale data centers and service providers continue to grow exponentially and they are adopting similar technologies.
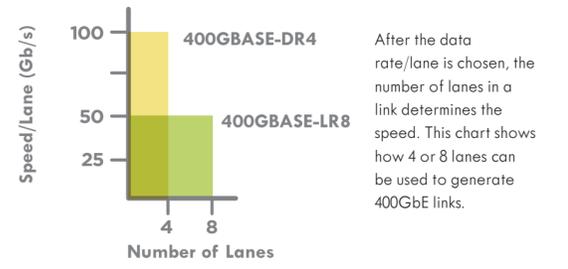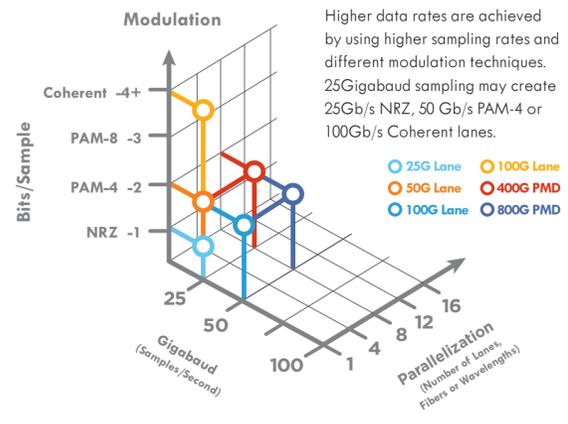

For digital version of the roadmap and for latest Ethernet industry resources, please visit: www.ethernetalliance.org

LATEST INTERFACES AND NOMENCLATURE

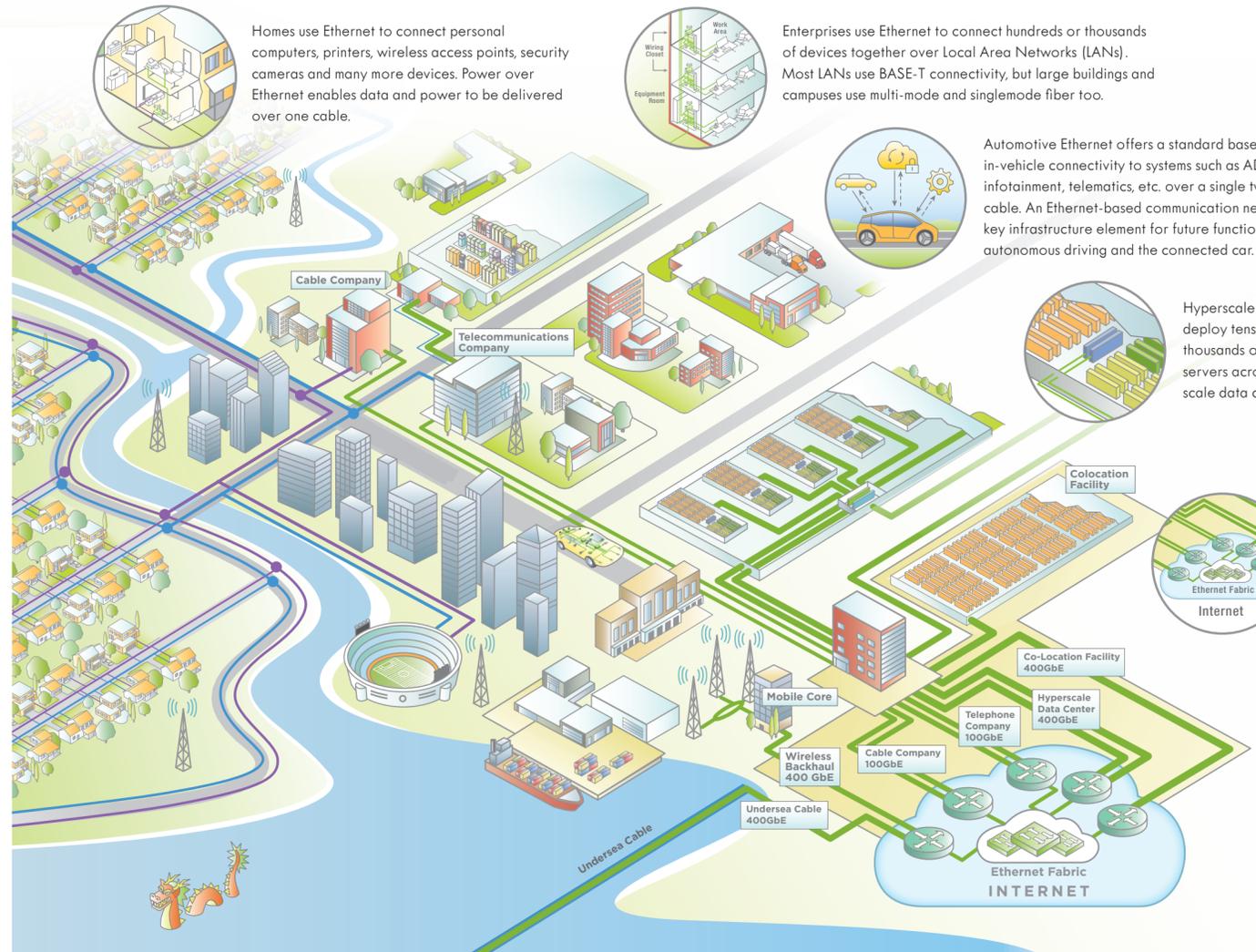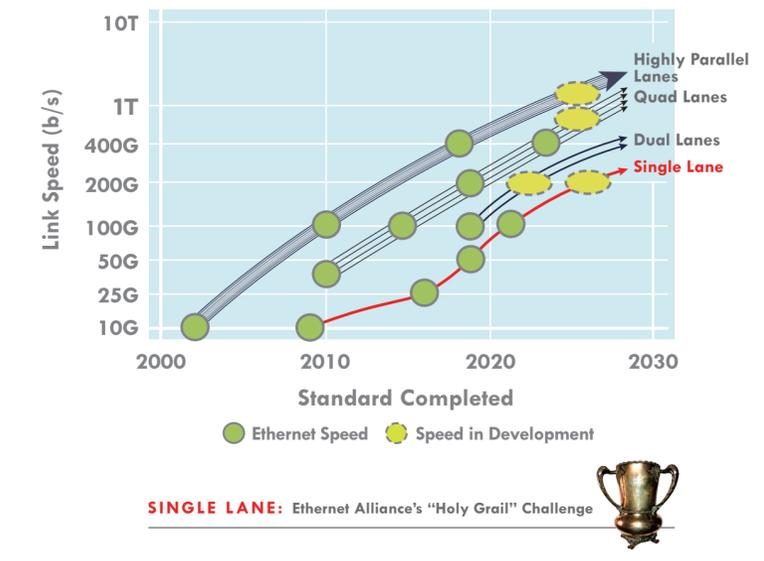|	Backplane	Twinax Cable	15-40m(OT) Single Twisted Pair	>100m (OT) Single Twisted Pair	100m (IT) Twisted Pair (2/4 Pair)	MMF	500m PSM4	2km SMF	10km SMF	20km SMF	40km SMF	80km SMF	Electrical Interface	Pluggable Module
10BASE—	T1S		T1S	T1L	T									
100BASE—		T1		T1L*	T									
1000BASE—			T1		T									
2.5GBASE—	KX		T1		T									
5GBASE—	KR		T1		T									
10GBASE—			T1		T									
25GBASE—	KR1 KR	CR1 CR/CR-S	T1		T (30m)	SR			LR EPON BIDI Access	EPON BIDI Access	ER BIDI Access		25GAUI	SFP
40GBASE—	KR4	CR4			T (30m)	SR4/eSR4	PSM4	FR	LR4				XLAUI XLPPI	QSFP
50GBASE—	KR2 KR	CR2 CR	T2			SR		FR	EPON BIDI Access LxR	EPON BIDI Access	BIDI Access ER		LAUI-2/50GAUI-2 50GAUI-1	SFP/QSFP
100GBASE—	KR4 KR2 KR1	CR10 CR4 CR2 CR1	T4			SR10 SR4 SR2 VR1 SR1	PSM4 DR	CWDM4 FR1	LR4 4WDM-10 LR1	4WDM-20	ER4 4WDM-40	ZR	CAUI-10 CPPI CAUI-4/100GAUI-4 100GAUI-2 100GAUI-1	SFP QSFP/QSFP-DD OSFP
200GBASE—	KR4 KR2	CR4 CR2 CR1*				SR4 VR2 SR2	DR4 1pair*	FR4 1 pair*	LR4		ER4		200GAUI-4 200GAUI-2 200GAUI-1*	QSFP/QSFP-DD SFP-DD
400GBASE—	KR4*	CR4 CR2*				SR16 SR8/SR4.2 VR4 SR4	DR4 2 pair*	FR8 FR4 400G-FR4	LR8 LR4-6 400G-LR4-10		ER8	ZR	400GAUI-16 400GAUI-8 400GAUI-4 400GAUI-2*	QSFP/QSFP-DD OSFP
800GBASE-	ETC-KR8 KR8*	ETC-KR8 CR8* CR4*				VR8* SR8*	8 pair* 4 pair*	8 pair* 4 pair* 4 lambda*	TBD*		TBD*		800GAUI-8* 800GAUI-4*	QSFP/QSFP-DD OSFP
1.6TBASE-		CR8*				8 pair*	8 pair*						1.6TAUI-16* 1.6TAUI-8*	QSFP/QSFP-DD OSFP/OSFP-XD

Gray Text = IEEE Standard   Red Text = In Task Force   Green Text = In Study Group

Blue Text = Non-IEEE standard but complies to IEEE electrical interfaces   * Note: As of publication, subject to change
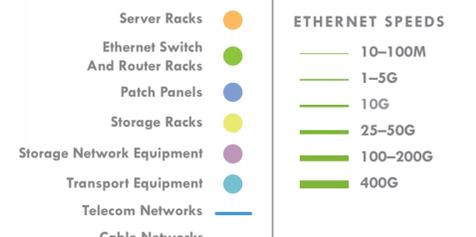
FATTER PIPES

Modulation

Higher data rates are achieved by using higher sampling rates and different modulation techniques. 25Gigabaud sampling may create 25Gb/s NRZ, 50 Gb/s PAM-4 or 100Gb/s Coherent lanes.

- ○ 25G Lane ○ 100G Lane
- ○ 50G Lane ○ 400G PMD
- ○ 100G Lane ○ 800G PMD

Bits/Sample — Coherent -4+, PAM-8 -3, PAM-4 -2, NRZ -1

Gigabaud (Samples/Second): 25, 50, 100

Parallelization (Number of Lanes, Fibers or Wavelengths): 16, 8, 4, 1

Speed/Lane (Gb/s)

- 400GBASE-DR4
- 400GBASE-LR8

After the data rate/lane is chosen, the number of lanes in a link determines the speed. This chart shows how 4 or 8 lanes can be used to generate 400GbE links.

Number of Lanes: 4, 8

PATH TO SINGLE LANE

Link Speed (b/s): 10T, 1T, 400G, 200G, 100G, 50G, 25G, 10G

- Highly Parallel Lanes
- Quad Lanes
- Dual Lanes
- Single Lane

Standard Completed: 2000, 2010, 2020, 2030

- ● Ethernet Speed
- ● Speed in Development

SINGLE LANE: Ethernet Alliance's "Holy Grail" Challenge

SIGNALING METHODS

Coherent

PAM-4

NRZ

Signaling for higher lane rates has transitioned from non-return-to-zero (NRZ) used for 25Gb/s per lane to four level Pulse-amplitude modulation (PAM-4) for 50 Gb/s per lane and above. Coherent Modulation uses more complex modulations for 100Gb/s per lane and above.
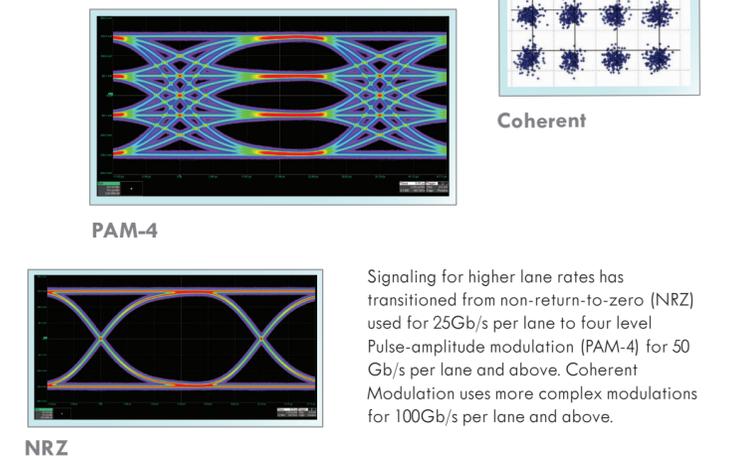
ETHERNET ECOSYSTEM

As streams turn into rivers and flow into the ocean, small Ethernet links flow into large Ethernet links and flow into the Internet. The Internet is formed at Internet Exc hange Points (IXPs) that are spread around the world. The IXPs connect Telecommunications Companies, Cable companies, Providers and Content Delivery Networks over Ethernet in their data centers.

The Internet Exchange Point (IXP) is where the Internet is made when various networks are interconnected via Ethernet. Co-location facilities are usually near the IXP so that they have excellent access to the Internet and long haul connections. 5G's next-generation network architecture is changing our connected world. It has the potential to support thousands of new applications in both industrial and consumer segments, and with speeds and throughput exponentially higher than current networks, the possibilities for 5G appear to be almost limitless.

Homes use Ethernet to connect personal computers, printers, wireless access points, security cameras and many more devices. Power over Ethernet enables data and power to be delivered over one cable.

Enterprises use Ethernet to connect hundreds or thousands of devices together over Local Area Networks (LANs). Most LANs use BASE-T connectivity, but large buildings and campuses use multi-mode and singlemode fiber too.

Automotive Ethernet offers a standard based in-vehicle connectivity to systems such as ADAS, infotainment, telematics, etc. over a single twisted pair cable. An Ethernet-based communication network is a key infrastructure element for future functions like autonomous driving and the connected car.

Hyperscale Data Centers deploy tens or hundreds of thousands of homogeneous servers across warehouse scale data centers in pods.

Cable Company
Telecommunications Company
Colocation Facility
Ethernet Fabric — Internet
Co-Location Facility 400GbE
Mobile Core
Hyperscale Data Center 400GbE
Telephone Company 100GbE
Wireless Backhaul 400 GbE
Cable Company 100GbE
Undersea Cable 400GbE
Ethernet Fabric INTERNET
Undersea Cable
Work Area
Wiring Closet
Equipment Room

Legend:
- Server Racks
- Ethernet Switch And Router Racks
- Patch Panels
- Storage Racks
- Storage Network Equipment
- Transport Equipment
- Telecom Networks
- Cable Networks

ETHERNET SPEEDS
- 10–100M
- 1–5G
- 10G
- 25–50G
- 100–200G
- 400G

OPTICAL EVOLUTION

Co-Packaged Optics

Switch Die | Optics — Switch Package

Optimal Power Efficiency

On-Board Optics

Switch Die → Optics — Switch Package

The ever-increasing demand for power efficiency will drive the transition to co-package optics.

Pluggable Optics

Switch Die → Optics — Switch Package

Pluggable Modules: SFP, QSFP, QSFP-DD, SFP-DD, OSFP