OIF 448G AI WORKSHOP

ethernet alliance

ADDRESSING THE NEXT RATE CHALLENGES: 448GBPS SIGNALING FOR AI

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MISSION

What's our role in this grand scheme? Well, the Ethernet Alliance has a clear mission:

01 Promote the awareness, adoption, and advancement of existing and emerging Ethernet technologies.

02 Educate Ethernet technology consumers using a unified, vendor-neutral voice.

03 Drive Ethernet's multi-vendor interoperability through validation, demonstration, certification, and events.

04 Expand the market by making Ethernet technologies easier to adopt.

ETHERNET WORLD

We bring together the diverse nations of “Ethernet World” – uniting stakeholders, enabling cooperation, and guiding efforts to define problems and solutions.

Uniting Stakeholders

Enabling Cooperation

Guiding Efforts to Define Problems & Solutions

PUBLIC & PRIVATE INTEROPERABILITY TESTING OFC, ECOC, PLUGFESTS

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The Ethernet Alliance works with its members to:

- Ensure “It just works” (in the form of plugfests)
- Prove “It just works” (demos at OFC)
- Explain “It just works” through blogs, webinars, and more.

AI
TEF 2024
ETHERNET IN THE AGE OF AI

50th Anniversary
ECOC2024
FRANKFURT

OFC 50
Celebrating 50 Years of Optical Networking and Communications

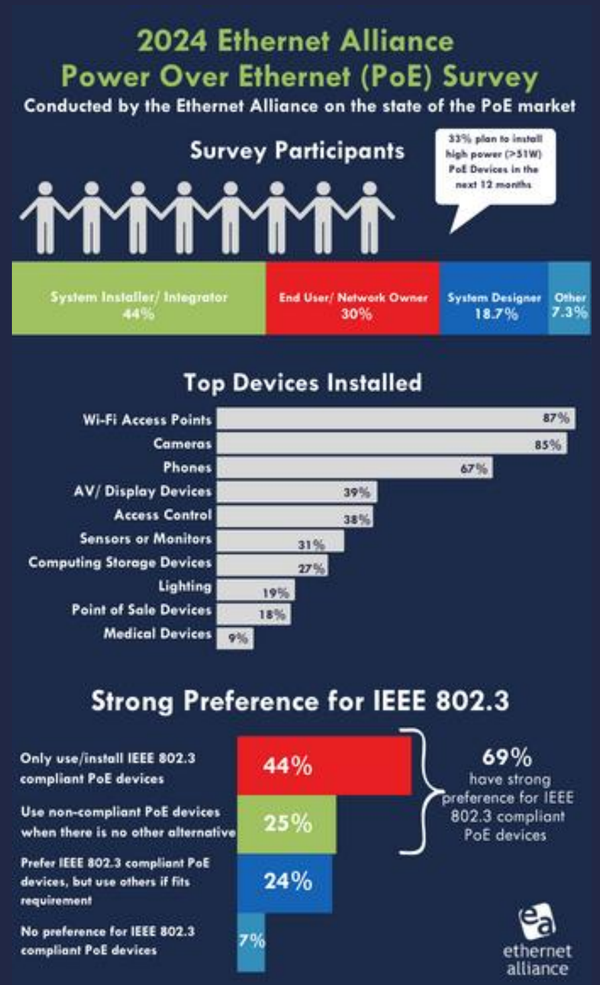
Interoperability Certification

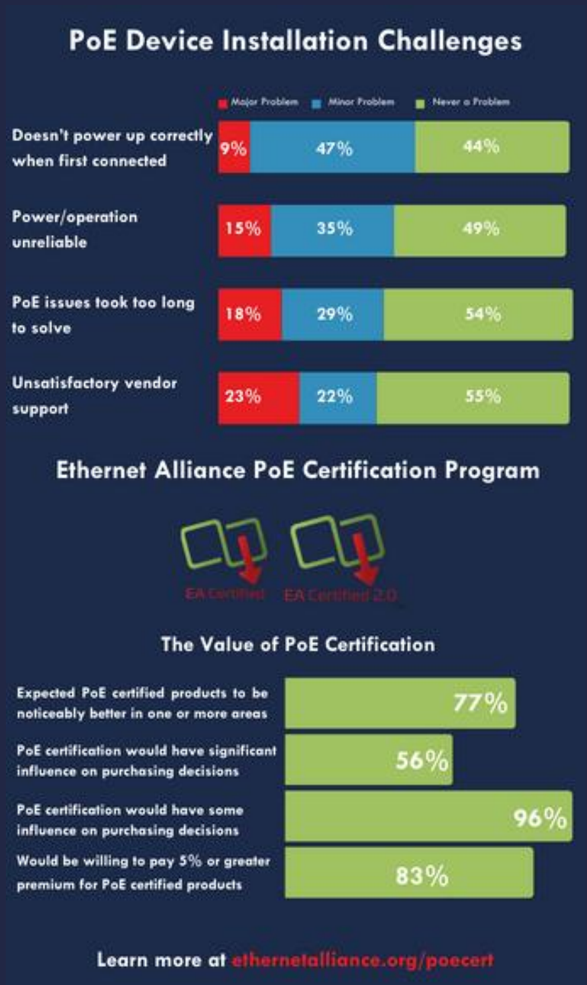
The Ethernet Alliance Power over Ethernet (PoE) Certification Program débuted in 2017 to ensure seamless interoperability by taking the guesswork out of the PoE equation..

Define and Address Installation Challenges

Simplify Integration

Ensures Reliable and Predictable Operation





Technology and Partners

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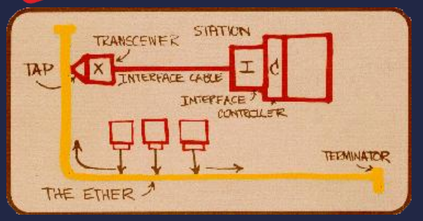

The Ethernet Alliance is “the” central voice for all things Ethernet.

10 YEAR ANNIVERSARY EDITION

ROADMAP

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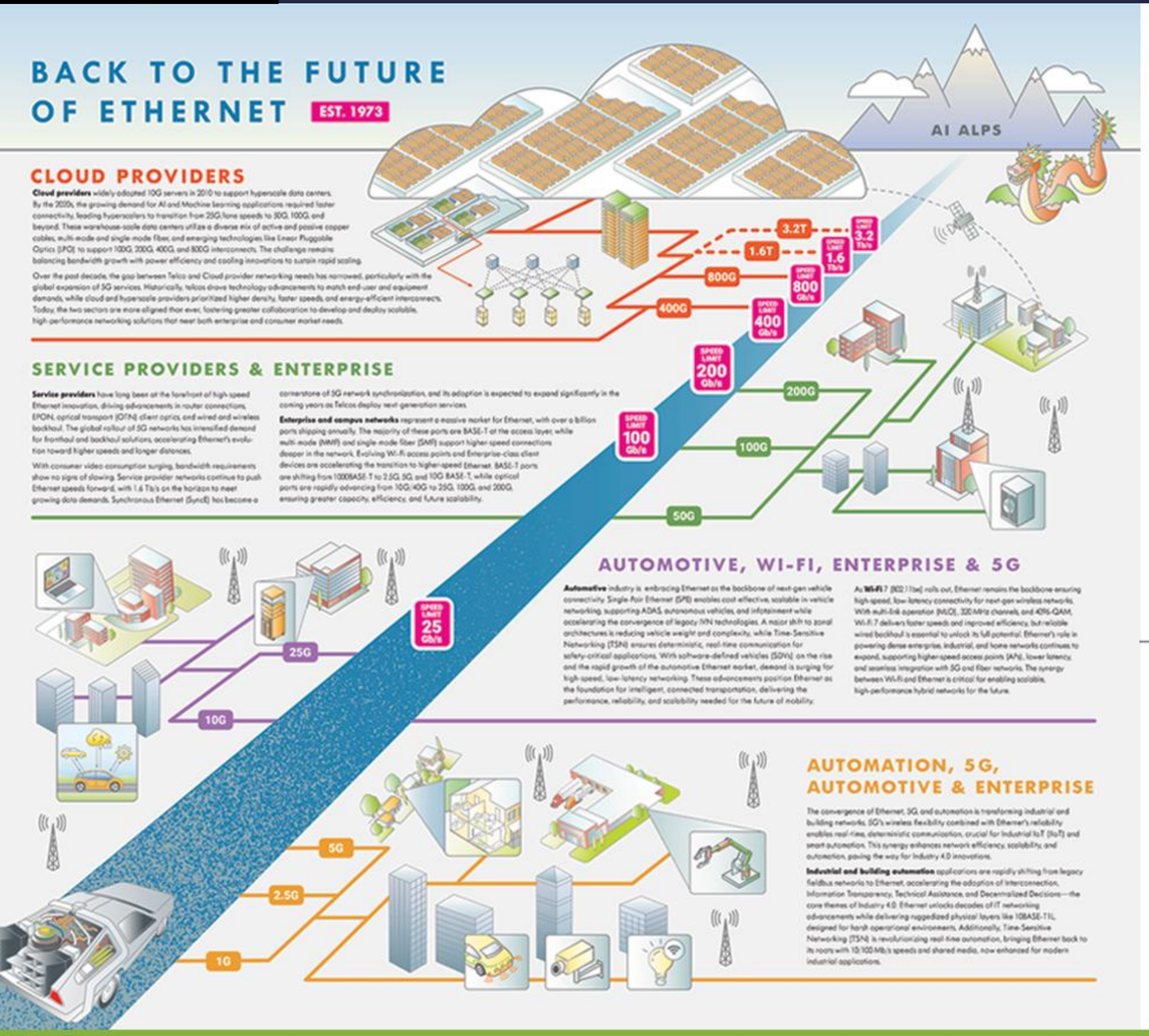
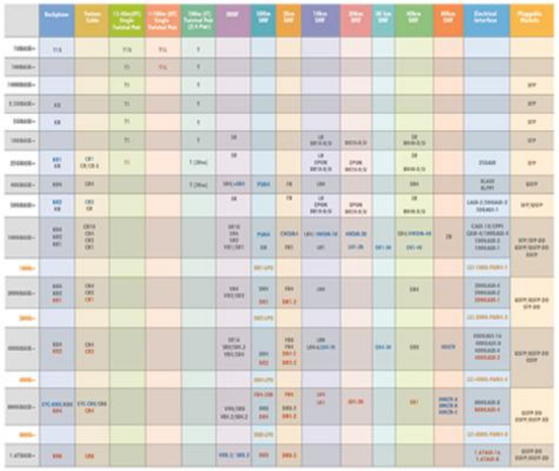
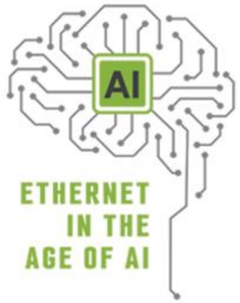


LATEST INTERFACES AND NOMENCLATURE



Grey Text = IEEE Standard Red Text = In Task Force Green Text = In Study Group Blue Text = Non-IEEE standard but complies to IEEE electrical interfaces
Orange Text = LPO MSA specification in early stages of standardization, not compliant with IEEE electrical interfaces.
Warning! The Ethernet landscape is evolving rapidly – technologies listed here are subject to change.

ARTIFICIAL INTELLIGENCE/MACHINE LEARNING (AI/ML)



Artificial Intelligence is rapidly moving beyond 400G Ethernet speeds to support the training and inference of large language models (LLMs). AI and Machine learning (ML) are driving the roadmap extending Ethernet speeds to 1.6T and beyond. The architecture within AI driven data centers is evolving, leveraging a blend of copper and fiber solutions to meet AI's soaring bandwidth demands. Ethernet's progression towards higher speed interfaces, the widening variety of interconnect options, and advancements in power efficiency are ensuring that Ethernet can meet the needs of AI/ML workloads.

To address these demands, the **Ultra Ethernet Consortium** (UEC) is introducing the Ultra Ethernet standard, an open, interoperable, high-performance architecture tailored for AI. Supported by industry leaders across switch, networking, semiconductor, and system providers, as well as hyperscalers, Ultra Ethernet is designed to scale out AI infrastructures efficiently.

Complementing this, the **Ultra Accelerator Link** (UALink) standard focuses on "scale-up" within AI processing clusters to enable efficient communication between 10s to 100s of GPUs. UALink provides the communication primitives and the high-bandwidth, low-latency interconnects essential for the needs of these massive AI accelerator clusters. Together, Ultra Ethernet and UALink address the communications needs for the ever-growing scale of AI networks.

The Ethernet Alliance's latest **Technology Exploration Forum** (TEF 2024) highlighted the critical need for collaboration across the Ethernet ecosystem. Industry experts emphasized the importance of uniting different sectors to tackle the engineering challenges posed by the rapid advancement of AI. This collective effort is ensuring that Ethernet will continue to evolve to provide the network functionality required for next-generation AI networks.

INTERCONNECT TECHNOLOGIES

PLUGGABLE MODULES

Linear Pluggable Optics (LPO) and Linear Receive Optics (LRO)

The current high speed optical market is dominated by retimed optics, but there is rapidly growing interest in linear-based solutions for optical modules which can dramatically reduce the module power consumption. Linear Pluggable Optics (LPO) and Linear Receive Optics (LRO), also known as Transmit Retimed Optics (TRO) and Retimed Transmit Linear Receive (RTLR), are emerging module implementations which remove all/some of the retiming circuitry found in traditional optics.

These implementations utilize common pluggable form factors of QSFP, QSFP-DD, and OSFP and are primarily targeted at 400GbE and higher markets. A fully linear optic can operate at around half of the power of a similar retimed optic. LRO is a half-retimed solution which achieves some of the power reduction while providing a higher quality transmitted optical signal, which may make it an option in configurations where the hardware design cannot support a fully linear solution.

CABLE TECHNOLOGIES

Active Electrical Cable (AEC) – Integrated retimer electronics for signal enhancement
Active Copper Cable (ACC) – Integrated redriver electronics for signal boosting
Active Optical Cable (AOC) – Integrated optical transceivers for low-power, high-speed connectivity

Both AECs and ACCs are active cables providing data transmission over copper cables in applications where standard direct attach cable lengths are insufficient. ACCs provide basic signal boosting for increased cable reach in cost-sensitive applications, whereas AECs offer enhanced signal regeneration capabilities suitable for even longer distances.

AOCs integrate fiber optics and embedded transceivers, providing high bandwidth, low latency, and low power connectivity for short- to medium-range interconnects in high-speed Ethernet applications.

ENERGY EFFICIENCY IN THE AI WORLD

- Blackstone estimates a **40% increase in electricity demand** in the United States over the next decade.[1]
- Gartner estimates the power required for data centers to run incremental AI-optimized servers will reach 500 terawatt-hours (TWh) per year in 2027, which is **2.6 times the level in 2023.**[2]
- The largest data center market globally is in northern Virginia, and the local utility, Dominion Energy, expects **power demand to grow by about 85% over the next 15 years,** with data center demand quadrupling.[3]
- SemiAnalysis forecasts Global Data Center Critical IT power demand will surge from 49 Gigawatts (GW) in 2023 to 96 GW by 2026, of which **AI will consume ~40 GW.**[4]
- By 2026, the AI industry is expected to have grown exponentially to consume at least **ten times its demand in 2023.**[5]

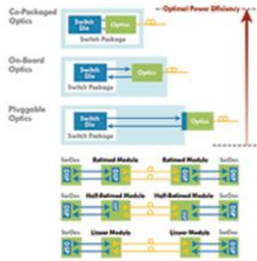
Provision of energy consumption to AI data centers is becoming a controlling limit. A GenAI-based prompt request consumes 10 to 100 times more electricity than a normal search.[4] Data centers will account for about ~2% global electricity use in 2025 and their power usage is expected to double to more than 1,000 TWh by 2030 driven by GenAI.[5]

Ethernet is not the biggest power consumer in the DC, but it is material. Any watt used on the network is a watt not used on the DC workload. It's expected that the Ethernet industry will keep driving down the picojoules per bit with new technologies.

New PHY technologies, copper and optical interconnect advancements, and intelligent workload-aware traffic management are helping optimize energy use. Additionally, collaboration with AI-driven power management is emerging to further reduce energy waste. As Ethernet scales to 1.6T and beyond, balancing performance and energy footprint will be critical in supporting this global technology evolution.

1 "Blackstone (BX: Q2'2024 Earnings Call Transcript" The Motley Fool, July 18, 2024.
2 "Gartner Predicts Power Shortages Will Restrict 40% of AI Data Centers By 2027." Gartner, Nov. 12, 2024.
3 "As Glaciers Ads for More Power, Data Centers Seek More Reliable, Greener Energy Solutions" Deloitte, Nov. 19, 2024.
4 "AI Data Center Energy Dilemma - Race for AI Data Center Space" SemiAnalysis, Mar. 13, 2024.
5 "Electricity 2024 - Analysis and Forecast to 2026 Report." IEA, May 2024.

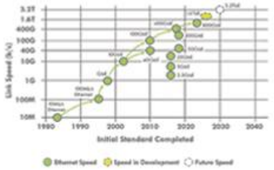
OPTICAL EVOLUTION



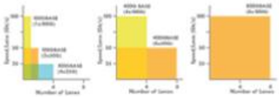
The ever-increasing demand for power efficiency in data centers is driving the transition to new interconnect solutions, such as **Co-Packaged Optics (CPO), On-Board Optics (OBO, and Linear Pluggable Optics (LPO)**. As data centers deploy higher and higher link speeds, the power consumption of the optical module increases significantly. The need for reduced-power optical solutions is fueling innovation and creativity in this market.

To meet diverse deployment needs, **retimed, half-retimed, and linear optical modules** each offer varying levels of signal processing and power efficiency to optimize performance across different network architectures.

ETHERNET SPEEDS



FATTER PIPES

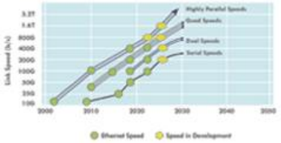


Total throughput (data rate) may be achieved in three general ways, and combinations of them:

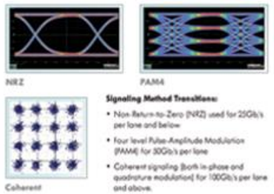
Aggregating multiple lanes | **Increasing the per lane bit rate** | **Increasing the bits transferred per sample (Baud)**

After data rate/lane is chosen, the number of lanes in a link determines the speed. See chart on how multiple lanes can be used to generate similar speeds.

PATH TO SINGLE LANE



SIGNALING METHODS



Signaling Method Transitions:

- Non-Return-to-Zero (NRZ) used for 25Gb/s per lane and below
- four level Pulse-Amplitude Modulation (PAM4) for 30Gb/s per lane
- Coherent signaling (both in-phase and quadrature modulation) for 100Gb/s per lane and above.

2025 ETHERNET ROADMAP

10TH ANNIVERSARY EDITION