

Development of Optical Interconnect Technology in Data Centers



Overview

AI Data Center Interconnect 2026: CPO, Optical Interconnect and. Explore AI data center interconnect trends in 2026, including CPO, optical interconnect.

Key Takeaways

Optical interconnects are rapidly replacing electrical links in data centers, driven by AI workloads, high bandwidth demands, and the need for energy-efficient, low-latency communication. Overview of Optical Interconnects

Optical interconnects use light to transmit data between devices, typically via optical fibers or waveguides, and consist of a light source (laser), modulator, optical channel, and photodetector. Compared to traditional copper interconnects, optical links offer higher bandwidth, lower latency, reduced electromagnetic interference, and improved energy efficiency, making them essential for modern data centers handling massive internal traffic and AI workloads .

Historical Evolution

Initially, optical interconnects were used for long-haul and transcontinental communications, but over the past two decades, improvements in bandwidth, reliability, and cost have enabled their adoption at rack and chip scales. Modern data centers now rely heavily on optical links for east-west traffic, which constitutes the majority of internal data center communication .

Key Technological Developments Co-Packaged Optics (CPO)

CPO integrates optical engines directly with switch ASICs, significantly reducing the electrical path length, improving signal integrity, and lowering power consumption. This approach is particularly suited for AI scale-up architectures, where thousands of GPUs must be interconnected efficiently. While CPO is considered the long-term solution, current deployments remain hybrid, with copper still used within racks for cost, reliability, and serviceability reasons .

Near-Packaged Optics (NPO)

NPO is an intermediate step that shortens the high-speed electrical connection between ASICs and optical devices by placing the optical engine closer to the chip. This reduces insertion loss and power consumption compared to traditional pluggable modules, while still allowing modularity .

Silicon Photonics

Silicon photonics enables high-density, low-cost optical integration on silicon chips, supporting 400G and beyond data rates. It allows for modular WDM (wavelength-division multiplexing) and expansion into C+L or S+C+L spectral bands, extending capacity beyond single-wavelength limits .

Drivers of Optical Interconnect Adoption

- **AI Workloads:** Exponential growth in AI inference and training demands high-throughput, low-latency interconnects to feed compute clusters efficiently .
- **Bandwidth Scaling:** Traditional copper links face physical limits at high data rates (800G → 1.6T and beyond), making optical solutions necessary .
- **Energy Efficiency:** Optical interconnects reduce power consumption per bit, critical as rack-level power density approaches hundreds of kilowatts .
- **System Integration:** Optical interconnects are increasingly treated as core infrastructure, requiring co-design with cooling, power delivery, and packaging .

Future Directions

- **Full optical adoption:** Within the next five years, all high-bandwidth interconnects in AI data centers are expected to transition to optical links .
- **Higher spectral efficiency:** Expanding beyond the C-band to C+L and S+C+L bands will continue to drive capacity growth .
- **Integration and miniaturization:** Advances in CPO, NPO, and silicon photonics will enable denser, more scalable, and lower-latency interconnect architectures.
- **AI-driven network optimization:** Intelligent routing and adaptive optical networks will further enhance throughput and reliability in large-scale AI clusters . Optical interconnect technology is thus central to the evolution of modern data centers, enabling the high-speed, energy-efficient, and scalable infrastructure required for AI and cloud computing at scale.

Article Content

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Explore AI data center interconnect trends in 2026, including CPO, optical interconnect, OCS, and the real challenges

Optical Interconnects for Data Centers

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Optical Interconnect

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Optical interconnects have emerged as a promising solution, offering significant advantages over traditional electrical

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There have already been considerable advances in high-bandwidth pluggable optical interconnects for the data center. Large-scale

Optical Interconnect

Optical interconnects refer to the use of light emitters and detectors to facilitate communication between integrated circuits, allowing

Optical interconnects for data centers

We discuss requirements and challenges of optical interconnects for data center networks, including both intra- and

Optical Interconnects for Scale-Out Data Centers

Optical interconnects, with reach between 10 m to 2 km, are of utmost importance for datacenters. Regardless of

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The Future of Optical Interconnects for Data Centers: A Review of Technology Trends
Slavisa Aleksic, IEEE Senior Member

Chapter 2 Optical Interconnects for Scale-Out Data Centers

a communicat to support full-bandwidth communication among all servers. While seemingly outlandish, the technology, both on the

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This also holds potential for optical I/O. Second, because optical interconnect is, in some cases, still a relatively

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A clearer understanding of the requirements and technology challenges of the new applications which are changing the

Optical Interconnects for Data Centers

Optical interconnects are revolutionizing the data center landscape, offering significant advantages over traditional

Optical Interconnect Market Size, Share & Trends

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