Will optical modules be replaced by other technologies



Overview

Co-Packaged Optics — a deep dive | APNIC BlogOptical modules are known to experience both hard and soft failures. Even with high-quality optics, hard failu.

Key Takeaways

Co-Packaged Optics (CPO) is emerging as the primary technology poised to replace traditional pluggable optical modules, with LPO and NPO as complementary solutions.

Co-

Packaged Optics (CPO)CPO integrates optical components such as photonic integrated circuits (PICs) and lasers directly alongside switching ASICs or processors within the same package, eliminating the need for separate pluggable modules. This architecture reduces electrical I/O distance, lowers power consumption, increases bandwidth density, improves signal integrity, and reduces latency compared to traditional optical modules. Nvidia's Spectrum-X switches, for example, embed the optical engine directly into the ASIC, achieving 5x better energy efficiency and 10x reliability over conventional modules.

CP

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O is particularly suited for AI data centers and ultra-large-scale computing platforms, where massive GPU-to-GPU and memory interconnects demand high-speed, low-power optical links. Linear-drive Pluggable Optics (LPO)LPO is a next-generation pluggable solution that removes digital signal processors (DSPs) and clock data recovery circuits (CDRs) from the module, creating a purely analog "linear direct-drive" optical link. The transmitter uses a high-linearity driver to directly modulate the optical signal, while the receiver employs a high-linearity transimpedance amplifier (TIA) for photoelectric conversion.

LP

O offers lower power consumption and reduced latency compared to traditional DSP-based modules, but it currently supports shorter transmission distances and is more suitable for closed-system environments.

Near-

Package Optics (NPO)NPO sits between traditional pluggable modules and CPO, providing highly integrated optical interconnects near the host package. It improves bandwidth, power efficiency, and system performance while maintaining some modularity, making it a transitional technology as data centers evolve toward fully co-packaged solutions.

Industry Trends and Implications

While CP

O is expected to gradually replace pluggable optical modules, both technologies may coexist in the near term, especially in multi-vendor environments. The shift toward silicon photonics and integrated optical interconnects is driven by the scaling demands of AI workloads, hyperscale data centers, and high-performance computing, where traditional 800G and 1. 6T modules face power, thermal, and bandwidth limitations.

Companies like Nvidia, TSMC, Marvell, and InnoLight are actively developing CPO-based solutions, signaling a major architectural shift in optical communication. In summary, CPO represents the most transformative replacement for optical modules, with LPO and NPO providing complementary approaches to improve efficiency, reduce latency, and meet the growing demands of AI and HPC infrastructures.

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The rise of CPO technology has a structural differentiation effect on domestic optical module manufacturers, rather than a one-size-fits-all approach. On the one hand, the market

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From Pluggables to Co-Packaged Optics (CPO): The Transition

IDTechEx''s new report "Co-Packaged Optics (CPO) 2026-2036: Technologies, Market, and Forecasts" examines this transition in detail.

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Traditional optical modules come with high manufacturing and maintenance expenses, limiting their scalability for widespread adoption in more environments. To tackle these challenges,

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Optical module

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