Do supercomputers need optical modules



Overview

For GPUs, AI accelerators, and high-performance CPUs in large-scale clusters, optical modules have become inevitable.

Key Takeaways

Optical modules are critical components in modern supercomputers, enabling high-speed, low-latency, and energy-efficient interconnects between processors and racks.

Role of Optical Modules

Optical modules in supercomputers serve as high-bandwidth interconnects that transmit data using light rather than electrical signals. This approach overcomes the limitations of traditional copper-based connections, which face resistance, heat generation, and bandwidth bottlenecks as computational power scales. By using photons, optical modules allow nearly lossless data transmission at the speed of light, reducing latency and energy consumption while supporting massive parallel processing workloads in AI, scientific simulations, and data-intensive applications.

Implementation in Leading Supercomputers

Google TP

U v7: Each TPU chip uses 1. 5 optical modules for intra-rack communication and an additional 2. 6 modules for inter-rack links, forming a 3D torus network within racks and a multi-layer data center network for cross-rack traffic.

This ensures sufficient bandwidth for large-scale AI model training while balancing cost and performance.

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Google TP

U v4: Optical circuit switches (OCSes) dynamically reconfigure interconnect topologies, improving scalability, utilization, and energy efficiency. Optical components account for less than 5% of system cost and 3% of power, yet significantly enhance performance for large language models.

NVIDI

A Rubin Platform: Uses co-packaged optics and Spectrum-X Ethernet Photonics switches to achieve higher efficiency, longer uptime, and reduced power consumption for AI supercomputing. Optical modules enable facilities separated by hundreds of kilometers to operate as a single AI environment.

Advantages of Optical Interconnects

High Bandwidth: Supports massive data transfer rates required for AI and HPC workloads. Low Latency: Reduces delays between processors, improving overall system utilization. Energy Efficiency: Optical transmission consumes less power than electrical interconnects, mitigating thermal issues.

Scalability: Facilitates modular supercomputer designs, allowing dynamic reconfiguration and expansion without major hardware changes. Reliability: Optical modules are less prone to interference and signal degradation over long distances, enabling robust data center networks.

Conclusion

Optical modules are now a key enabler of next-generation supercomputers, particularly for AI and data-intensive applications. By replacing traditional electrical interconnects with photonic links, supercomputers achieve higher performance, lower energy consumption, and greater scalability, making them essential for exascale computing and large-scale AI model training.

Article Content

Why Do Computing Chips Need Optical Modules? | Weyland

For GPUs, AI accelerators, and high-performance CPUs in large-scale clusters, optical modules have become inevitable. The core reason is that as computing performance scales rapidly,

Lightmatter®

Lightmatter has joined the NVIDIA NVLink Fusion ecosystem, bringing our photonic interconnects to the AI infrastructure powering the world''s most advanced models. Discover how our Co-Packaged Optics

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Why future supercomputing requires optics

In principle, supercomputers based on optical technology may help to mitigate the heat generation that plagues electronic computers.

Seng Tiong Ho Photonics in Supercomputers: Pushing the

One of the most promising applications of photonics in supercomputing lies in the development of optical interconnects, which replace conventional copper-based wiring with high

OPTICAL CIRCUIT SWITCHING FOR AI AND

Switches, links, and optical modules fail regularly, and even short outages can disrupt long-running workloads, reduce system utilization, and increase operational costs.

Google''s TPU v7: How 1.5 & 2.6 Optical Modules per Chi | BestHub

The article explains how Google''s TPU v7 supercomputer uses a simple yet powerful networking scheme—1.5 optical modules per TPU for intra-rack communication and an additional 2.6

The Leading Player in 4-3-4 CPO: Google''s Co-Packaged Optics

⚰ Chapter Four: The 2028 Deadline — Optical Module Manufacturers'' Identity Crisis This CPO revolution is creating an "identity crisis" for today''s thriving optical module giants. If optical

Networking chips and modules for AI data centers: Infiniband, Ultra ...

“Once you move beyond a few tens of thousand, or 100,000, processors, you cannot connect anything with copper—you have to connect them with optics,” Velaga says.

Optical interconnects for extreme scale computing systems

Most optical links in today''s supercomputers are based on multi-mode optical fibers and Vertical Cavity Surface Emitting Lasers (VCSELs). They are also generally built around a one

The Application of Optical Modules in High-Performance Computing

Optical modules deliver high bandwidth, low latency, and scalable connectivity for high-performance computing, enabling efficient data center operations.

Understanding Optical Modules: A Comprehensive Guide

Optical Module Basics: Understanding the Core ConceptsOptical modules are compact devices that convert electrical signals into optical signals

Liquid cooling: The past and the future of

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So we need to keep them cool. A technician next to blue hoses carrying Fluorinert to the CPU and memory modules. Taking a dip in Fluorinert

Optical interconnection networks for high-performance systems

We see that there is a current need for high band-width density links in both systems into the server and compute node down to the board and chip module level. At the same time to improve energy

Photons Light the Way to Useful Quantum Computing

“Optical fiber is the most efficient way to transmit information between chips and between modules, and that''s why photonic quantum computing is so

Embedded Optical Modules Expected to Grow 50% CAGR by 2033

The embedded optical module market is about to explode. Recent forecasts point to a 50% compound annual growth rate (CAGR) through 2033—one of the fastest in the tech world right

Get on the Optical Bus

In these near-future supercomputers, electrical connections will supply only the power, the ground, and the control signals. All the data will shoot through optical interconnects at the speed

(PDF) Optical Interconnects in Future Servers

Optical interconnects are common in today''s petascale supercomputers, and will become pervasive at the exascale during this decade. Technologies that can meet the challenging

Optical Computing: What It Is, And Why It Matters

Two decades ago, GPUs were starting to supplant CPUs. What does the future look like for optical computing?

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