

Article Overview

Optical interconnects and high-speed optical transceivers are transforming data centers by enabling higher bandwidth, lower latency, and improved energy efficiency for modern AI and cloud workloads.

Role of Optical Interconnects

Optical interconnects replace traditional copper connections with light-based signaling, allowing data to travel farther and faster without signal degradation or electromagnetic interference. This is critical in high-density data centers where copper wires face limitations in speed, distance, and power consumption . Optical fibers and silicon waveguides carry data as pulses of light, supporting techniques like Wavelength Division Multiplexing (WDM), which allows multiple data streams to travel simultaneously on a single fiber, dramatically increasing bandwidth .

Optical Switching

Optical switching is being explored to overcome the bandwidth limitations of electrical switches in large-scale data center networks. Optical switches can reduce latency and improve throughput by routing light signals directly without converting them to electrical signals at each node. However, challenges such as packet contention and the lack of optical buffers must be addressed for practical deployment . Companies like Google have implemented free-space optical switches to reduce latency and power consumption, achieving higher throughput and lower operational costs .

High-Speed Optical Transceivers

Modern data centers, especially those supporting AI workloads, require extremely high bandwidth for east-west traffic between GPUs and servers. 1.6T optical transceivers are emerging as a key technology, offering up to 1.6 terabits per second per port. These transceivers improve network scalability, reduce the number of interconnects, and enhance overall efficiency, enabling faster AI model training and better utilization of infrastructure . Innovations like 224G PAM4 signaling, silicon photonics, and thin-film lithium niobate (TFLN) are driving higher integration, performance, and thermal management in these devices .

Benefits for AI and Hyperscale Data Centers

- o Higher bandwidth density supports distributed AI training and large-scale cloud computing.
- o Lower latency ensures faster communication between processing nodes.
- o Energy efficiency reduces power consumption and heat generation compared to electrical interconnects.
- o Scalability allows data centers to expand without proportionally increasing complexity or cost .

Future Trends

Optical technologies are moving deeper into the data center, from top-of-rack interconnects to direct integration with processors and accelerators. The adoption of co-packaged optics (CPO) and fully integrated optical modules is expected to further enhance performance, reduce energy usage, and simplify network architectures . As AI workloads continue to grow, optical solutions will remain a critical enabler for next-generation data center networks.

A research team led by The Chinese University of Hong Kong (CUHK) has developed a novel integrated all-optical

Huawei's Data Center Interconnect (DCI) optical network solution builds ultra-broadband, simplified, and intelligent DCI to help

It developed its own OCS and deployed it in all of its data centers at the top of the switching

The proposed all-optical switch can help to realize all-optical switching without any electric control for optical data

Switching the traffic in the optical domain has been considerably investigated as a future-proof solution to overcome

Your data center needs to be streamlined, automated and reliable. With all-optical (OOO) switching solutions in your data center, you

Photonics has emerged as a transformative solution, offering unparalleled bandwidth, energy efficiency, and

Sivers Semiconductors" laser arrays will be integrated into reference designs built on GF's silicon photonics platform.

Optical Interconnects for Data Centers Optical interconnects at Top-of-Rack for energy efficient data centers
J. Chen, Y. Gong, M.

Based on the D5130 series MEMS all-optical circuit switch, FS solution builds a dynamic optical interconnect layer for AI and HPC

Deliver scalable optical data center interconnect and data center connectivity to meet growing AI demands

Analog Devices" optical networking solutions address a wide range of applications in data center, enterprise,

and telecom markets.

An explosion of data, driven by more sensors everywhere and the inclusion of AI/ML in just

Optical Circuit Switching is presented as a fundamentally efficient alternative to traditional Electrical Packet Switching (EPS) for

Modern data centers increasingly rely on interconnects for delivering critical communications connectivity among numerous servers,

In this paper, a novel flex-grid all-optical interconnect scheme that supports transparent multi-hop connections in data

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