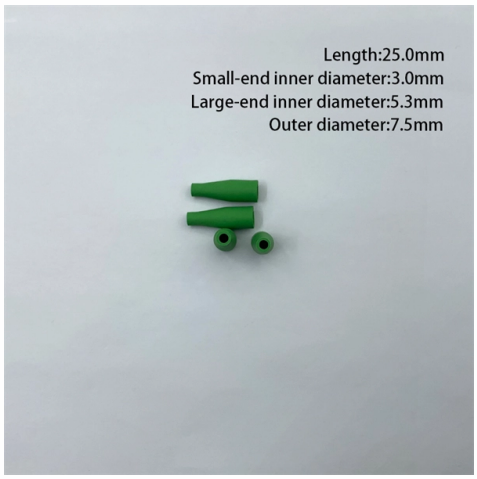
Inter-rack network switches



Overview

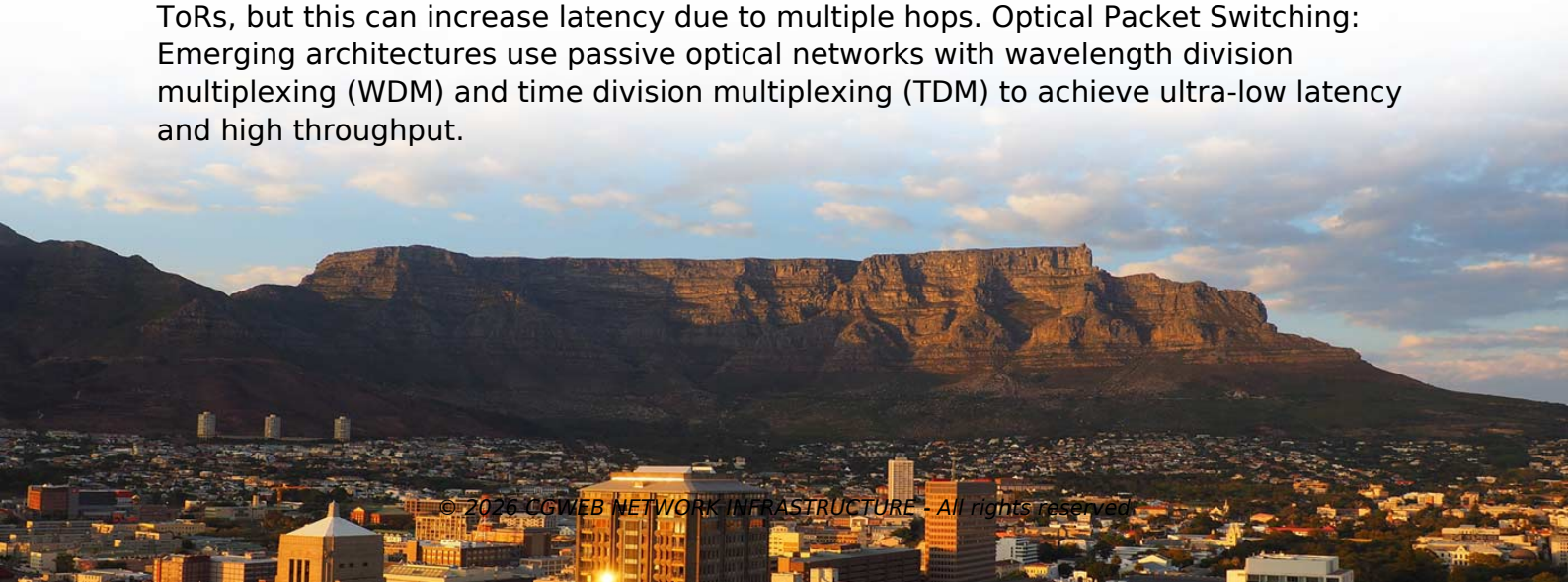
Optical IntraIn this paper we propose a DC network (DCN) architecture that interconnects servers in the intra-rack and inter-rack domain, utilizing optical.

Key Takeaways

Inter-rack network switches connect Top-of-Rack (ToR) switches across different racks, enabling high-speed, low-latency communication in data centers. OverviewInter-rack network switches are critical components in modern data center networks (DCNs), facilitating communication between servers located in different racks. Unlike intra-rack switches, which handle traffic within a single rack, inter-rack switches manage east-west traffic across multiple racks, ensuring efficient server-to-server communication and supporting high-bandwidth applications such as cloud computing, Industry 4.

0, and IoT workloads. Architecture and TopologiesInter-rack networks often use Top-of-Rack (ToR) switches connected via high-speed links. Common topologies include: 2D Torus or Mesh: Provides all-to-all connectivity between racks using optical fibers, enabling multiple lightpaths for redundancy and low latency.

Hierarchical Layers: Traditional designs use multiple layers of switches to connect ToRs, but this can increase latency due to multiple hops. Optical Packet Switching: Emerging architectures use passive optical networks with wavelength division multiplexing (WDM) and time division multiplexing (TDM) to achieve ultra-low latency and high throughput.



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Performance Considerations

Modern inter-rack switches are designed to handle high throughput and low latency: Latency can be as low as hundreds of nanoseconds in optical interconnects. Bandwidth utilization can reach 100% in inter-rack optical networks, with end-to-end server-to-server latency under high load measured in microseconds. Traffic is often classified into priority classes to meet different service delay requirements.

High Availability and RedundancyInter-rack switches also support high availability (HA) through mechanisms like inter-rack route processor (RP) pairing, where RPs in one rack are paired with RPs in another to provide failover in case of rack failures. This ensures continuous operation and minimal traffic disruption.

Simulation and Modeling

Simulation environments, such as Python-based DCN emulators, allow testing of inter-rack switch performance under various traffic patterns, priorities, and configurations. These simulations help optimize buffer sizes, channel allocation, and scheduling policies for both intra- and inter-rack networks.

Emerging Trends

Passive optical interconnects (e.g., POID) are gaining attention for their low power consumption and high throughput, offering up to 82% latency reduction compared to traditional designs. Integration of optical and electrical switching in hybrid architectures is being explored to balance cost, flexibility, and performance. SummaryInter-rack network switches are essential for scalable, high-performance data centers, providing low-latency, high-bandwidth connectivity between racks.

Advances in optical switching, WDM/TDM techniques, and high-availability configurations are enabling modern DCNs to meet the growing demands of cloud services and latency-sensitive applications.

Article Content

Optical Intra

In this paper we propose a DC network (DCN) architecture that interconnects servers in the intra-rack and inter-rack domain, utilizing optical switching at each domain. The proposed interconnection

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Each IT rack has multiple compute servers and network switches which are all connected together using intra-rack networks. Each compute server

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Optical Intra

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Moreover, the software-defined network (SDN) paradigm has been proposed for optical DCN environments [8-9]. The main research interest in this area is the substitution of the conventional

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What is Top-of-Rack Switching? Definition from SearchNetworking

Top-of-rack switching is an architecture design that uses hardware to connect switches in the same or nearby rack. Learn pros, cons and deployment options.

Analysis and experimental demonstration of an optical switching

Optical communication technologies are playing more and more important roles in both intra- and inter- data center networks. Particularly, optical switching network architectures for the

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