NOKIA

Nokia PON for Data Center Management

White paper

Modern data centers, particularly those supporting Artificial Intelligence (AI) workloads, are relied upon for always-available services, making their resiliency and uptime paramount. High availability is essential for data center operators to attract new customers and maintain the competitiveness of the services they provide. Additionally, research shows that the average cost of downtime is approximately $500k, making failures expensive as well as reputationally damaging.

A critical component of robust data center infrastructure is the Out-of-Band Management (OOBM) network. Often referred to as the "network of last resort," OOBM provides a completely independent pathway to access data center network elements (NEs) such as AI servers and Terabit-speed Ethernet switches. It enables full remote lifecycle management, encompassing monitoring, diagnostics, firmware maintenance, remote access to console ports, and essential recovery operations.

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Introduction

While current OOBM solutions address reliability challenges, they are no longer aligned with new data center demands. The AI supercycle is driving a step change in data center power consumption and operational efficiency. As power and space become increasingly constrained, OOBM must deliver the lowest possible energy and physical footprint, helping data center operators minimize overhead while maintaining always-on control.

At the same time, the AI supercycle is transforming how data centers are built and operated. Where rack designs were once standardized and fixed, AI workloads now introduce significant variability in power density, cooling methods, and connectivity requirements. This rack-by-rack diversity dramatically increases operational complexity at scale.

OOBM based on Passive Optical Network (PON) technology delivers a powerful solution to these challenges, aligning perfectly with the needs of modern AI data centers, and offering the following benefits compared to traditional OOBM solutions:

- **Up to 50% lower OOBM power consumption**.
- **Up to 90% reduction in OOBM switch footprint** through a simpler, more centralized design
- **Higher resilience** by dramatically reducing the number of active switches and potential failure points
- **Technology diversity** from the in-band network, minimizing shared failure risks.
- **A robust Layer 2 architecture** with a smaller attack surface and easier day-to-day operations.
- **Up to 80% less operational** effort through automation, design flexibility and scalability.

Nokia's end-to-end PON solution is specifically engineered to deliver the operational simplicity, power and physical footprint savings required for modern AI data center builds. As a leader in PON technology for more than 20 years, Nokia delivers PON solutions for mission-critical government and military networks, enterprise infrastructure, mobile network backhaul and large-scale broadband, and stands as a uniquely qualified partner for implementing highly efficient solutions across all data center OOBM applications.
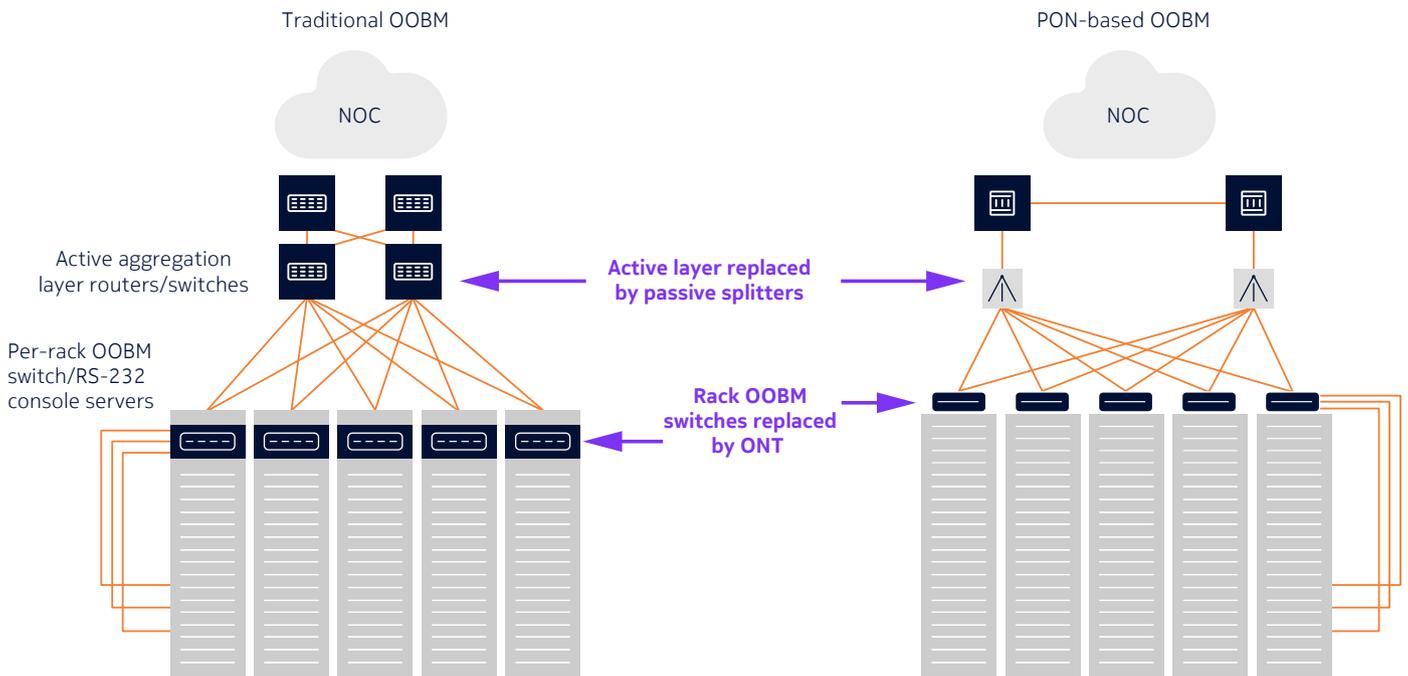
Why PON for data center management?

Traditional data center/OOBM management networks are hosted in the Network Operations Center (NOC) and use a layered Ethernet distribution network, such as Clos network configurations, to connect through to management switches hosted in each row or in each data center rack. From there, copper cabling is used to connect to each management and/or RS-232 port on individual servers.

These traditional setups often involve substantial amounts of copper cabling between rack positions and the end of the row for management Ethernet and console server connectivity. Copper trays are larger and more complex than fiber trays, leading to increased physical footprint, cooling, and maintenance overheads.

By contrast, Passive Optical Networking (PON) provides the same baseline connectivity (RJ-45 based management/console port access) to in-rack NE, while offering critical advantages in power and footprint savings.

PON is a highly standardized, point-to-multipoint networking technology. The main components of PON-based OOBM are the OLT (Optical Line Terminal), - a central switch that connects thousands of end points, and the ONTs (Optical Network Terminals), - stateless modems that terminate fiber and provide interfaces to management ports. PON is designed to remove all active/powered elements between the OLT and up to the end connection points, the ONTs. Single-mode fiber, with one or more stages of passive optical split, creates the point-to-multipoint networking topology. This passive cabling and splitting eliminate the need to power active aggregation elements between the NOC and server racks, significantly reducing power consumption in data center management solutions.

Designed for high availability

Nokia's Aurelis solution is designed with robust features to ensure high availability in critical data center environments. Our data center management Aurelis OLTs have on-chassis designs for critical component redundancy, including network uplink, network switching, chassis database, power source, and inter-chassis link redundancy. Building on this per-OLT resiliency design, Nokia OLTs can be grouped as protected pairs to offer a full suite of PON protection mechanisms for active/standby and even active/active configurations. The result are solutions that meet, and are capable of exceeding, data center availability targets or "five-9s" and "six-9s".

Aurelis Solution for Data Centers

Scalable
- High density
- Compact design
- Low energy consumption

Simple
- Easy to install and use
- Automated operations
- Open APIs, easy integration

Secure
- Six nines availability
- Full redundancy to the rack
- Data & messages encryption

Aurelis Command Center

MF-2 OLT

MX-44C-A ONU

80%
Less switches

>80%
Less IMAC effort

>50%
energy savings

Designing for implementation flexibility

Nokia's Aurelis OLT and ONT solutions have evolved into a highly flexible architecture, having been integrated into the management ecosystems of over 1,000 networks globally, including mission-critical government, military and enterprise networks. Specific to data center management architectures, Nokia provides a range of ONT models featuring different port density and form factors to fit different data center environments. This accommodates, for example, ONT placements in the server rack or Top of Rack, or even hybrid deployment models where PON aggregates existing OOBM Ethernet switches.

Designed for easy operations

Nokia Aurelis OOBM is designed for ease of use with automation-first operations. Built on open and standardized northbound interfaces, it integrates easily with existing NOC and operational tools using network management protocols such as NETCONF, REST, and gNMI. Nokia PON solutions carry a 90% lower integration effort and have been successfully integrated into more than 200 NOCs. A programmable architecture supports intent-based, template-driven provisioning and standardized data models, enabling zero-touch deployment and lifecycle management.

With fast telemetry and large-scale data collection, Nokia PON-based OOBM also enables proactive monitoring and rapid troubleshooting, helping operations teams detect issues early and resolve them faster, resulting in up to 40% less OPEX.

Designed for the future

Nokia builds on its industry-leading PON technology to navigate the future evolution of the data center. OOBM in data centers will continue to evolve with subsequent AI server generations and new automation requirements. Nokia's ability to support simultaneous hosting and expansion of new ODN architectures/splits, as well as new ONT termination types, provides flexible options for future network expansion.

Nokia systems deployed today are also prepared for port-by-port upgrades to 25 Gb/s (25G PON) without replacing other subsystems in the OLT chassis. While XGS-PON's shared 10 Gb/s link is sufficient for current data center management traffic loads, the ability to flexibly increase PON bandwidth provides security for future bandwidth needs. This includes unforeseen automation communication required with AI data center elements, as well as the possibility of adding facilities management technologies, like security cameras, and facility access tools to a PON network already qualified and designed as security infrastructure.

Conclusion

PON-based OOBM is becoming a strategic foundation for next-generation data centers, including the ultra-dense AI facilities defining the future of digital infrastructure. By delivering high availability, resilience, energy efficiency, and scalable simplicity, data center PON elevates out-of-band management from an operational necessity to a competitive advantage. With a clear vision and proven leadership, Nokia is positioned to shape this next era, enabling data centers that scale faster, operate leaner, and are built for long-term sustainability