Publication date:
September 13, 2024
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AI-ready metro optical network

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Omdia commissioned research, sponsored by Huawei

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Artificial intelligence (AI) is the new optical network driver

The emergence of AI has captured the industry's attention and elevated it to a worldwide phenomenon in early 2023. The construction of AI infrastructure is currently underway. AI providers are building large-scale AI training centers populated with high-power GPUs/CPUs/IT and, over time, will add additional "inference data center" capacity in metros closer to clients. The AI backends are interconnected with very short-reach optics "inside the data center"—a market that underwent significant growth from 2023 to 2024.

Since 2023, Omdia has been researching the potential influence of AI on metro optical networks, including metro access, the middle mile, and the metro core. Industry leaders are now openly discussing network expansion plans to prepare the metro optical networks for the emerging AI ecosystem. AI will drive growth in various aspects of the metro optical network, including:

- Capacity growth for data movement from enterprise data lakes to AI training centers
- Middle mile upgrades to support AI traffic
- Increased capillarity to interconnect more key enterprise sites optically
- Growth in private lines with deterministic low latency and a shift to higher capacity solutions

The new AI traffic requirements

Communications service providers (CSPs) have a long list of tasks to tackle. They continue to upgrade their networks to support 5G and residential PON. Additionally, many enterprises are now utilizing cloud services, which is increasing their network requirements. And on top of all these, along comes AI.

AI will require enterprise data lakes to transition into AI training centers. The volume of data movement will be substantial, with traffic expected to grow at a rate of at least 30% CAGR by 2029. As enterprises develop their AI and data strategies, an updated network will be necessary. Industry innovators are rapidly increasing their access services to 100Gbps to meet the needs of AI. When

this new access dynamic is scaled up for many enterprises, verticals, and regions, the significant impact on the metro network becomes clear.

Performance expectations are also improved in the following ways:

- Enterprises are increasingly latency-savvy, aiming for 1ms targets for primary and protect paths.
- They desire the full payload of uncontended bandwidth from their data lake to the AI cloud.
- Enhanced reliability is achieved through high-capacity connections to multiple availability zones.

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AI-refresh for metro optical network

A refreshed metro optical network core

The priorities of CSPs will include reducing network complexity and upgrading to a simplified, de-layered network with enhanced automated operations.

The new metro network requires the following characteristics:

- High performance and low latency by removing unneeded optical-electrical-optical (OEO) conversions (one-hop)
- Robust high availability with mesh options for clients with diverse routes
- Zero packet loss to ensure an optimal client experience

CSPs also want an optimized cost profile, aligning costs directly with revenue growth:

- Ability to expand network capacity on demand as opposed to over-provisioning
- Fiber utilization reduction from multiple fibers to one fiber pair

Modernized operations and maintenance capabilities include:

- Rapid and one-click network element commissioning
- Online and automated wavelength planning, allocation, optimization, and provisioning
- OTDR functionality for precision photonic network visibility

Extending the optical edge closer to enterprises

Leading enterprises are increasingly moving toward 100G access, which means the optical network must be extended closer to client sites. For the largest clients, optical links can be extended all the way to the customer premises through optical customer premises equipment (CPE).

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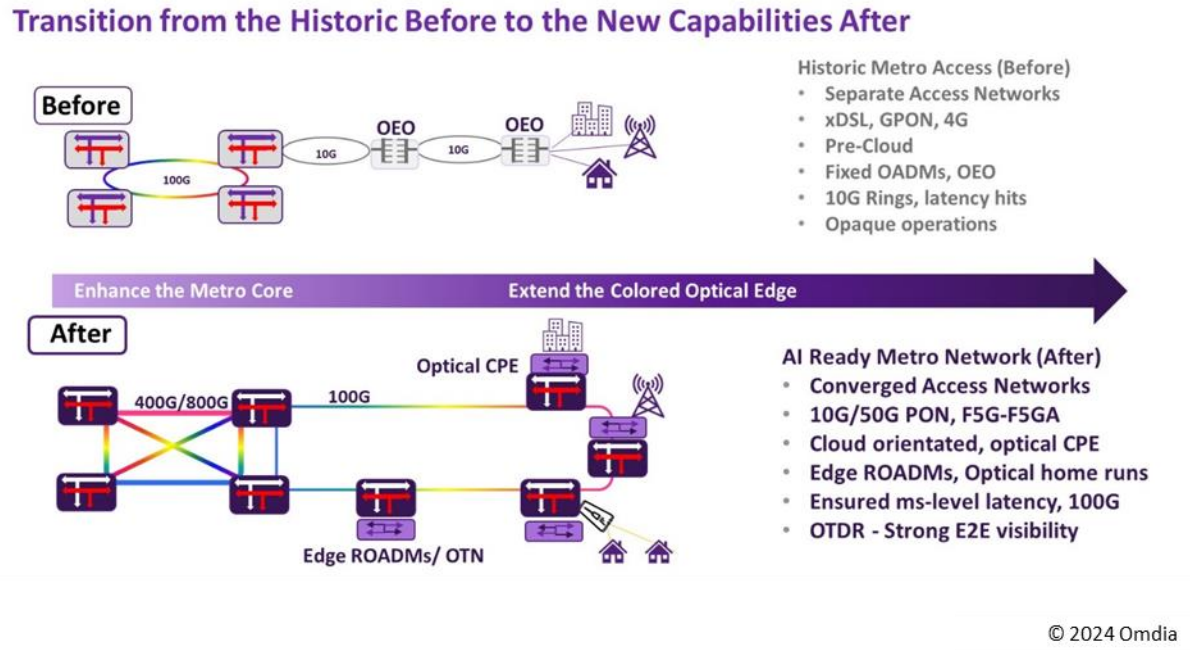
One practical solution is to extend it to a sub-central office (CO). The sub-CO site could house optical line terminal (OLT) and mobile cell site functionality, in addition to supporting enterprise access.

The optical edge requirements are an extension of the metro core requirements and include:

- Optical CPE for very high-bandwidth enterprise clients
- Higher capacity wavelengths and optical transport network (OTN) to the sub-CO
- Extending the optical edge with edge-optimized reconfigurable optical add-drop multiplexers (ROADMs)

Figure 1: AI-ready metro optical network architecture



Source: Omdia

One key benefit of the T-shape network architecture is that within metros, the latency from the client to cloud sites can potentially be reduced to 1ms.

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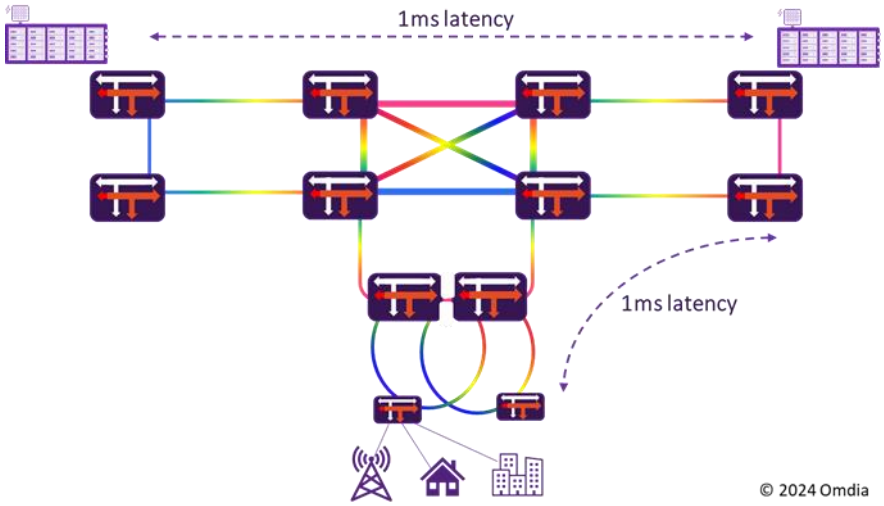
Figure 2: The T-shape architecture: Extending the optical edge



Source: Omdia

Blog summary

Modernized networks offer numerous improvements, including increased system capacity and a more agile, reconfigurable network with improved operations. These advances result in significant capex and opex savings per bit.

The future AI-ready metro target architecture must have the following attributes:

- **Refreshed metro core**
  - All optical metro cores with:
    - Optical mesh configuration, very high port count ROADMs with FlexGrid
    - 400G/800G/1.2T transmission speeds
- **Refreshed optical edge**
  - Increased capacity to the distributed CO, expanding the optical edge
    - 100G/200G wavelengths to the distributed CO/first aggregation point
    - Edge-optimized ROADMs
  - Simplified architecture

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- Direct connection to a leaf and spine with no intermediate OEO required
- OTN to the distributed CO/first aggregation point

- **Refreshed operations, administration, and maintenance (OAM)**
  - Modernized operations and maintenance
    - Edge-optimized ROADMs for flexible wavelength management
    - eOTDR for detailed visibility and network control
  - Network automation
    - Network element auto-commissioning
    - Wavelength auto-allocation and commissioning for higher efficiency to support operations and maintenance efficiency as wavelength division multiplexing (WDM)/OTN migrates to the metro access

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Appendix

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Our unique combination of authoritative data, market analysis, and vertical industry expertise is designed to empower decision-making, helping our clients profit from new technologies and capitalize on evolving business models.

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