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Toward 100Tbps Optical Backbone

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100Tbps Optical Network required to meet demand

Advanced artificial intelligence (AI), cloud, video and at-home services, along with the latest high-capacity fixed and wireless access technologies, are crystalizing the need for the 100Tbps optical core. Many leading Communications (CSPs) have deployed modernized at-home networks and 5G RAN with the xHaul upgrade. Many leading enterprises have deployed advanced hybrid and multi-cloud IT architectures. AI has progressed and matured to the point where it will begin to consume more compute, storage, data control network (DCN), and DCI WAN network resources.

The global digital economy resides in a vast network of fit-for-purpose data centers. The global optical network is the arterial connectivity for enhanced intelligence. “The digital economy drove the last five years of optical network growth, AI will drive the next five years.” (Omdia *2024 Trends to Watch: Optical Networks*). The green 100Tbps optical core will be the lifeblood of tomorrow’s communications.

The optical network market connects a vast digital economy ecosystem;

- The here and now digital economy
- Cloud services for the enterprise market, a greater than $250 billion market
- Wider usage of AI will make a more significant contribution to the ecosystem in coming years

The optical network backbone connectivity growth is tied to the ongoing data center construction roadmap which includes:

- Greater numbers of data centers to support data sovereignty
- Greater need for security and diversity of data centers
- Greater reach of the ecosystem to reduce the digital divide
- New data center construction drawing on sustainable power supplies
- Growth of the overflow campuses. Eg. Singapore data center growth is limited due to real estate and power constraints. New growth shifting to Johor, Malaysia.
- Ultimately, the global data center map, will involve from a small number of massive concentrated campuses, to a much of a more distributed model

The digital economy ecosystem with the expanding data center footprint will require both a more robust access-egress network and a modernized 100T optical network core.

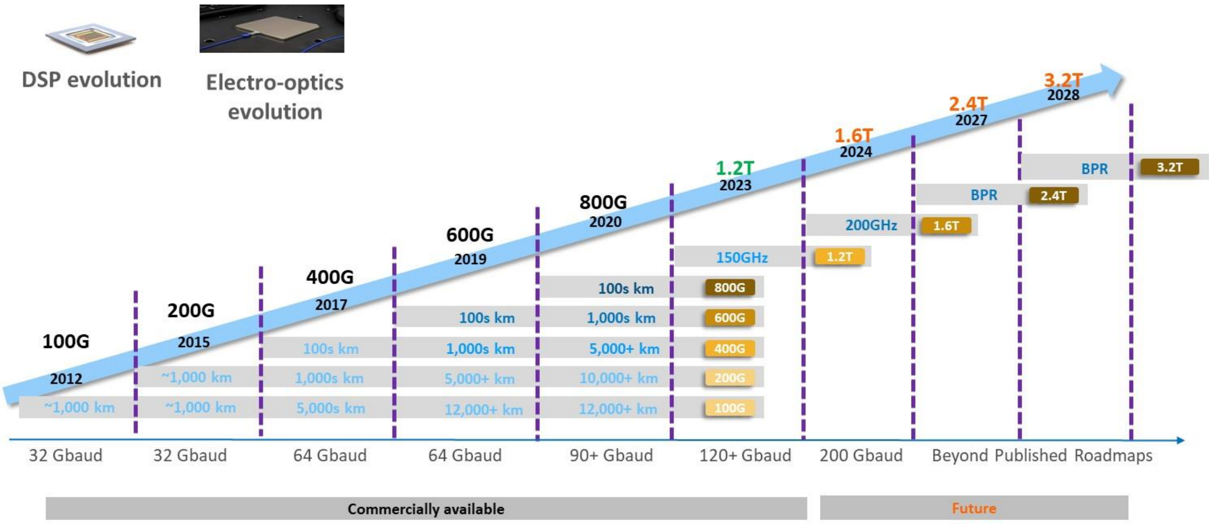
Toward 100Tbps Backbone

Fundamental technology advances

GBaud is the unit of measurement of the symbol rate—the speed of transmission. As each generation of optical technology is brought to market, the GBaud rate available steps up for better performance and faster transmission speeds. There is also a relationship with system reach. Higher-capacity transmission can be used for DCI reach requirements. Ultra-long-haul distances can be supported with a lowering of the transmission speed.

Figure 1 highlights the current generation of baud rates, 120GBaud, one future rate 200GBaud, and three earlier generations. Additionally, the typical transmission rates are matched to typical reach categories. The table gives a simplified view to portray a quick summary of a decade of coherent transmission progress. The important takeaway is that each generation of transmission technology enables a maximum capacity for a given reach category. The industry is constantly striving to maximize the capacity-reach product.

Figure 1: Baud rate generations, highlighting typical capacity-reach capabilities



Source: Omdia

CSP priorities for backbone networks

Optical backbone routes endure for decades. CSPs require their optical backbone cores are built to last. Long-haul amplification common equipment can be deployed in many remote and unstaffed sites. Ideally, deployments at these sites require minimal maintenance over long timeframes.

Optical backbones need to be able to rapidly scale as new network demands arise. Optical backbones need a certain amount of agility to respond to new, high-capacity, revenue-generating opportunities. Optical cores can be used for both carrier infrastructure and very high-capacity services. In the carrier infrastructure case, revenue-generating lower-speed services are aggregated and transported across the optical core. In the high-capacity wholesale case, wavelengths can be sold directly off the optical platform. Networks that interconnect key data center assets, subsea cable landing points, and intercarrier peering points will be well placed to deliver wholesale, transit, and DCI services.

CSP priorities for the optical backbone cores are:

- Low capex cost per bit from the perspective of the equipment, the site, and fiber
- Low opex cost per bit for ongoing operations and maintenance
- Support for rapid turnup to facilitate revenue-generation opportunities
- 99.999% service availability

100Tbps 3D backbone target architecture

Today's modern target architecture has the following attributes:

- 100Tbps total system capacity
- 400G/800G/1.2Tbps wavelength options
- 3D mesh with express layer
- Very High Port Count (VHPC) & FlexGrid ROADMs
- Maximum spectrum utilization up to 9.6-12THz in the C and L band
- OTDR utilization for strong end to end visibility
- High availability with 99.999% ASON
- IP + Optical synergy and co-ordination, aiding planning, operations and performance optimization.

100Tbps systems compared to historical 8Tbps system offer more overall system capacity per fiber pair with a lower cost and power consumption per bit.

Increasing wavelength options from historical 100G/200G to 400G/800G/1.2Tbps enables service providers to maximize the "capacity-reach product". Maximum continental reaches can be served with 400G. 1.2T can be used in shorter reach metro network scenarios. These capabilities enable network planning flexibility and enable lower cost and lower power consumption per bit.

3D mesh with express layer is capability improvement over historical flat network topologies. A-Z traffic patterns can more closely match the network configuration, helping “right-size” network equipment quantities.

Flexgrid and Very High Port Count (VHPC) ROADMs are an improvement over historical fixed grid and low port count ROADMs. The Flexgrid ROADMs support the latest high-speed wavelengths of 400G, 800G and 1.2T that require more than the classic 50GHz space. VHPC ROADMs support high density switching applications in network core minimizing power consuming electronic switching.

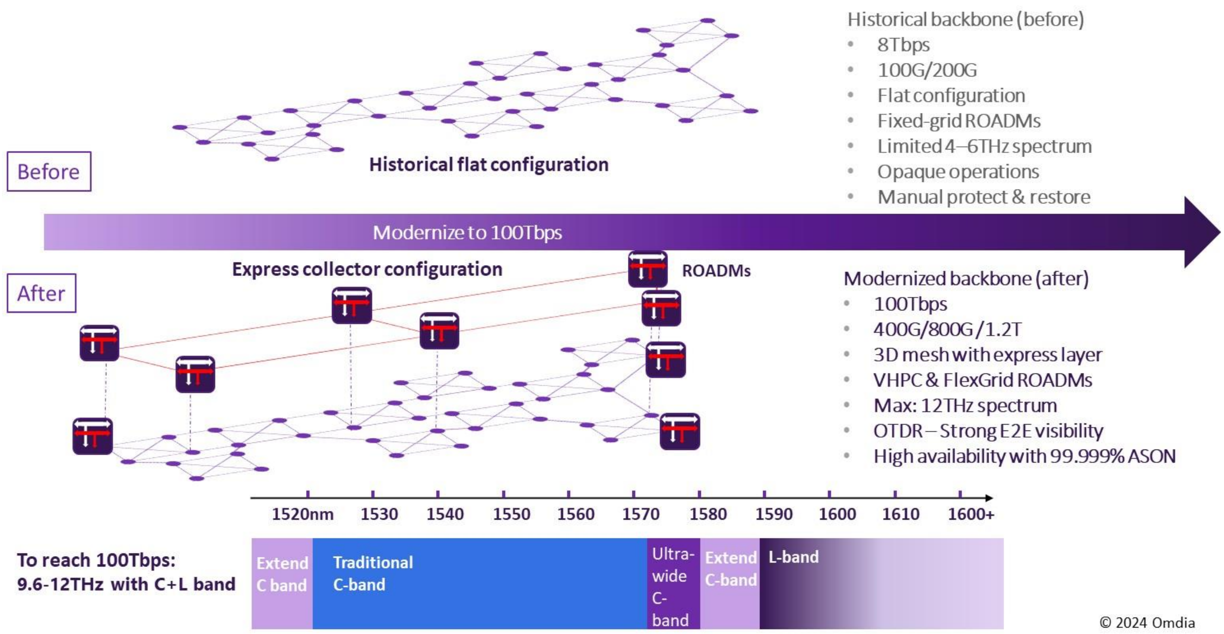
Historic networks utilized 4 THz of spectrum traditional C-band. With advances and cost reductions in the amplification and wavelength switching technologies, the spectrum available has increased up to 9.6 to 12 THz range. The increased spectrum underpins the major capacity advance per fiber pair. The increased spectrum is invaluable in fiber constrained cases.

Historically, network operators were somewhat blind to optical network performance, had difficulty pinpointing precise failure locations and difficulty catching network degradations prior to catastrophic failure. With advances in OTDR technology, along with size and cost reduction and advanced OAM software capabilities, more powerful OAM capabilities can be in the hands of network operators, addressing the noted OAM challenges.

Historically, network recovery was a much more labor intensive and manual affair. Today, with ASON and diverse networks, networks can be equipped with a rapid and automated failover capability enabling 99.999% availability.

Historically, IP + Optical had minimal inter-layer visibility, synergy or co-ordination leading to suboptimal resource deployments and uncoordinated alarm management. Today, with modernized network planning and management systems, critical information can be shared across the networks layers enabling optimized network planning and network management for both capex and opex savings.

Figure 2: Modernizing the backbone core to 100T 3D mesh with express layer



Source: Omdia

Blog Summary

Modernized networks offer a multitude of improvements, including much greater system capacity, a much more agile and reconfigurable network with substantially improved operations. All of the advances taken together result in substantial capex savings per bit and substantial opex savings as well.

Appendix

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