2024: A YEAR OF GROWTH AND INNOVATION

Inevitably, with the new year rapidly approaching, it's tempting to speculate about the direction the industry will take in 2024, so we decided to ask three experts in their fields how they thought the next 12 months would unfold.

SERGE MELLE PRODUCT MARKETING, OPTICAL NETWORKS, NOKIA.

The start of 2023 was exciting for optical networking, with several vendors announcing new high-performance coherent optics able to operate at 1.2Tbps per wavelength, including Nokia's PSE-6 super-coherent optics. Progress in product roll-outs will end the year on a high note, with multiple customers announcing real-world live network field trials of these optics.

My expectation is that technology innovation and new capability announcements will continue in 2024, along three key themes; continued scaling of WDM line systems, optical network automation, and 800G pluggable coherent optics.

One trend that has continued unabated year-over-year is exponential growth in network traffic, on the order of 30-40% per year, with new tailwinds coming from the growth of data-intensive AI/ML traffic. An ever-increasing number of optical network operators are now seeking to grow network capacity over their existing fibre plants and defer costly and time-consuming fibre overbuilds. For 2024, one can expect more deployments of WDM line systems that operate over the C and L bands of the optical fibre spectrum, termed C+L line systems. There will be an increasing range of C+L line system options, including modular C+L that allows gradual in-service expansion to the L-band when needed, and integrated C+L systems that deploy both bands on day 1.

One can expect to see an increased adoption of optical network automation software, that leverages AI and machine learning to automate complex and/or repetitive tasks in areas such as network planning and optimization, analytics and trouble-shooting, and service provisioning.

Finally, following on the success of 400Gbps pluggable coherent optics such as 400ZR, ZR+, and CFP2, we will see several vendors introduce 800G pluggable coherent optics to bring increased network scale to metro and edge/access applications. Expect to see 800G pluggable optics supporting several standards or interoperability agreements, such as 800ZR, 800ZR+, and 800G OpenROADM, in a variety of form factors including QSFP-DD800, OSFP, and CFP2.

ROB SHORE, SVP MARKETING, INFINERA

2024 promises to be an interesting year for optical networking. The industry should be past the post pandemic recovery including having most of the supply chain and subsequent backlog buildups behind us. As such, network operators can truly get back to looking forward, growing their networks and planning for future evolutions.

One of the big trends you are likely to see in 2024 is the 400G pluggable revolution finally ramping up in network applications. To date, 400G pluggables deployments have been dominated by low output power (-10dBm) ZR and ZR+ technology and have been deployed largely in simple direct fibre DCI networks for hyperscalers. Traditional network operators have been slower to adopt 400G pluggables as their networks require a higher performance pluggable including 0dBm launch power and incremental operational features such as direct management, out-of-band noise suppression, and a higher OSNR. These network-grade pluggables (sometimes referred to as ZR++) started to become available in 2023 and will likely see a significant uptick in deployments in 2024 in service provider networks.

Another significant trend in 2024 is a shift in direction for increasing fibre capacity. Historically, network operators could expect a 20-30% improvement in spectral efficiency with each new generation of coherent optical engine. However, with the 6th generation coherent technology (such as Infinera's ICE6), the industry has drawn close enough to Shannon's limit such that successive generations will provide only modest (~10%) incremental gains. As such, network operators will begin exploring alternative ways to increase the amount data that can be carried by each of their fibres. The most straightforward solution is to increase the amount of usable spectrum. Some equipment providers have answered this call with solutions that expand the usable spectrum from the extended C-band (4.8Thz) to the Super C-band (6.1Thz). This technology provides nearly 30% increase in fibre capacity. With the latest generation of transponder technology and in conjunction with the Super L-band, these solutions can now provide nearly 100T of capacity per fibre. 2024 will

see network operators begin selecting and deploying this newer generation of expanded spectrum optical line systems.

The final prediction relates to 800G pluggable optics. 2024 will see the release of the first generation of 800G pluggable optics based on 5nm DSP technology. While this technology will see some deployments in niche applications, the bulk of the market will wait for the next generation of 3nm DSP solutions that provide a number of incremental critical features. These features include multi-vendor interoperability and probabilistic constellation shaping that both simplify operations, reduce power consumption, and dramatically improve performance.

JURGEN HATHEIER, INTERNATIONAL CTO, CIENA

"AI has been around for years, but the step into Generative AI has created new possibilities and unprecedented hype. While many network infrastructure providers are focused on how they can adopt GenAI into operations, some have surged ahead and are looking at how they can generate new revenues. This is critical as the competitive edge will not be won by reducing OPEX, but by offering new cutting-edge services.

In 2024, we will see a massive demand for compute and connectivity requirements at the network edge which will require operators to build network edge fabrics that are open to machines allowing consumption of resources through APIs. This will be an important monetization factor for service providers and cloud providers alike. There will be a forced marriage of applications and the network to deliver to customers' needs as inference scales on the edge."

Massive amounts of large-scale data center buildouts are still happening across large parts of Asia and Australia. While this has slowed a little in North America and Europe, in 2024 I believe we will see edge data centres popping up and operators preparing to peer in multiple locations rather than central peering points.

One of the major drivers for more data centres at the edge of the network will be to reduce power consumption on the grid in central locations to improve sustainability. It will be interesting to see if countries like Norway, with massive renewable energy and cool temperatures, will see an influx of data centres given that their international terrestrial and domestic connectivity has been upgraded significantly in the last couple of years. It will remain a global challenge for us to power data centers where no renewable energy is available, and where a large and dense population requires additional access to compute. India is a great example where lots of data centres are powered by coal and the capacity per capita is only a tenth of what it is in North America or Europe.

"'Altnet' may not have quite made it to be word of the year, but the awareness of alternative network providers has grown in FTTH 'gold rush' countries like the UK and Germany. In these markets, money has been poured in by private equity and government subsidies, but in greater volumes than the market actually requires. While the 'homes passed' metric is increasing, the penetration rate is still really low. This means 2024 will be a year of consolidation because it simply needs to happen."

HOWARD KIDORF, MANAGING PARTNER, PIONEER CONSULTING

Three major developments in undersea telecom cables will be noticeable in 2024. As we have been advising our clients at Pioneer Consulting, the price of DWDM terminal equipment – Submarine Lightwave Terminal Equipment as we call it – will continue to drop as evaluated on a per-terabits per second basis. Of course, the major suppliers of SLTE – Ciena, Infinera, Nokia, and Cisco – can pursue these price drops due to the volume of equipment demanded by high-capacity undersea cables. This continuing decline in price is enabled by similar economics as drive Moore's law: faster electronics and a growing manufacturing base. Without declines in the cost per terabits per second, the interlinked year-over-year increase in undersea cable capacity could not be sustained.

Since the capacity of a transmission fibre is bound by the Shannon Limit and the fixed bandwidth of the erbium doped optical amplifier, SLTE suppliers are mostly focused on advantages that allow lower cost per terabit per second.

The second major development is that sellers of the undersea plant are now focused on increasing the number of optical paths in their cables. This is their contribution to the lowering of the cost per bit in long-haul transmission. They will be announcing new technology as well as deploying the technology they have been promoting for the past few years. Mostly, the impact will be made by: 1) continuing to increase the number of fibre pairs carried by a single cable (and amplified by a single repeater), and, 2) deploying multi-core fibres as another means to achieving the same goal as increased fibre count.

Lastly, we are seeing some changes to the locations and architecture of networks as artificial intelligence begins to drive investment in data centres. Locations for data centres are no longer bound by the desire for low latency for user populations or data privacy regulations. Some data centres appear to be driven by the need for training models for machine learning and wider deployment of generative AI.

The operators of undersea cables are more than happy to take advantage of the lower cost per bit of transmission. Ongoing decreases in equipment cost enables operators to lower their "raw material" costs and increase margins. If the cost per bit ever stops declining (which no one is predicting) the price of transmission capacity will stop declining.

Operators and investors in new cables are focused on the demand for data centres and how they are being used. As much of the global web of cables exists to interconnect data centres (the rest interconnect population centres), where these tens of billions of dollars in data centres will be located will drive the need for undersea cables in the next five years.

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