

Expanding coherent pluggable deployment models with thin transponders

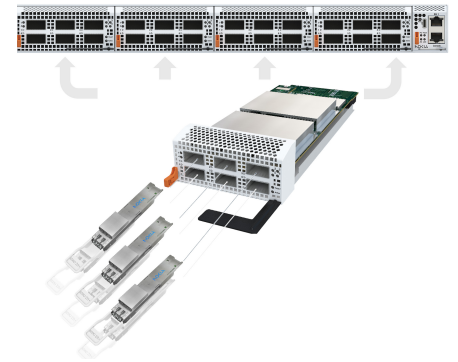
Market drivers

Major improvements in increasing fiber capacity have come from the evolution of optical engines – from direct-detect to coherent, and from increased wavelength bit rate enabled by the higher order modulation schemes. However, optical engines are approaching the Shannon limit. As a result, fiber capacity has begun to flatten as spectral efficiency is becoming constrained.

This has triggered service providers and network operators to begin looking at new strategies for increasing the capacity of their networks including the use of multi-fiber solutions to connect locations. As network operators shift to these multi-fiber strategies, it can cause a significant shift in their priorities when selecting network solutions.

When networks are designed using a single fiber pair between locations, capacity per fiber is typically the most important factor in selecting an optical engine. However, when multi-fiber strategies are used, capacity per fiber becomes significantly less important enabling network operators to focus on other factors – such as power and space efficiency.

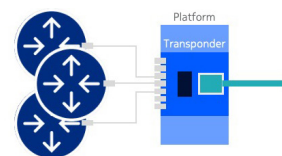
This shift in priorities is aligning perfectly with the evolution of coherent pluggables. Advances in DSP and CMOS technology – from 28nm to 7nm to 3nm – have led to significant enhancements in optical performance, increasing capacity-reach in compact form factors such as QSFP-DD and OSFP. And while these coherent pluggable optical engines provide less fiber capacity compared to their embedded optical engine counterparts, they provide a significant reduction in power consumption and footprint per bit. While every application will have its own set of drivers, with embedded engines continuing to be the technology of choice when fibers are scarce and adding incremental fibers comes with a high cost, the compelling economics of coherent pluggables, coupled with the shift in priorities away from maximizing fiber capacity and toward cost, space, and power efficiency, is significantly expanding the applications scope.



Current deployment models

There have historically been two main deployment models of coherent optical engines:

1. High-performance optical engines embedded in a transponder card in an optical transport platform



2. Coherent pluggables hosted in IP/Ethernet platforms such as switches and routers.



Embedded optical engine-based transponders are designed and built from the ground-up to maximize fiber capacity with best-in-class optical performance (capacity-reach). They aggregate traffic from various types of client interfaces onto one or two high bit-rate wavelengths such as 1.2 Tb/s. Designed for deployment in fully-fledged optical transport platforms, they typically support multiple client ports for aggregation in addition to a full suite of integrated optical functions designed for traffic grooming, aggregation, hairpinning, protection, alarm correlation, and so on.

In addition to the performance and host of traffic management features, another advantage of embedded transponders is the operational domain separation, acting as a demarcation point between the IP and the optical domain. This is useful in lawful interceptions or enforcing SLAs through setting clear boundaries and business demarcation. However, transponders come with trade-offs such as high power consumption and large footprint.

The second model is the deployment of coherent pluggables directly into routers, commonly referred to as IP over DWDM (IPoDWDM). This model has the advantages of low CapEx, low power consumption, and reduced footprint by eliminating the need for an optical transport platform. Moreover, coherent pluggables benefit from a complete ecosystem of Multi-Source Agreements (MSA) and interoperability forums for seamless line interworking and service provisioning.

However, IPoDWDM presents operational challenges related to management and compatibility across different host devices and operating systems. Furthermore, this model does not come at par with fully-fledged transponder-based platforms due to the lack of complete traffic aggregation capabilities and operational functionality.

Additionally, the IPoDWDM model has a direct one-to-one mapping between the router port speed and the pluggable speed – for example, where 400G pluggables are deployed in 400G router ports and 800G pluggables in 800G router ports. Nonetheless, in specific applications, the coherent pluggables must be dialed down to operate at a lower bit rate, such as 600 Gb/s or 400 Gb/s to close a specific link which results in a wasted router port capacity. Moreover, pluggables cannot fully replicate the optical functionality of embedded transponders.

Expanding the deployment modules with thin transponders

Thin transponders provide a third deployment model that combines some of the strengths from the other models without their related disadvantages. Thin transponders are a set of small modules or “sleds” that are optimized for coherent pluggables and normally equipped in compact modular platforms or an optical platform, where two or four of them can be equipped in a single rack unit. Thin transponders offer multiple client ports (100G, 200G, 400G, or 800G) for grey optics to carry traffic from other platforms such as routers, and multiple line ports for high-capacity coherent pluggables such as 400G ZR, 400G ZR+, and 800G ZR or ZR+. Similar to IPoDWDM solutions, thin transponders offer lower CapEx, lower power consumption, and a smaller footprint but without the operational challenges mentioned earlier. They also combine some of the advantages of embedded transponders such as multiple client-side aggregation, operational domain separation, and some of the optical capabilities of fully-fledged embedded transponders.

Thin transponders also enable a technology lifecycle separation between the photonic layer and the IP layer. This allows network operators to benefit from the latest generation of coherent pluggables, such as ICE-X 800G ZR/ZR+, in existing 400G routers. This leads to a maximized ROI and operational flexibility by avoiding the network-wide upgrade of all routers to the latest 800G-capable generation.

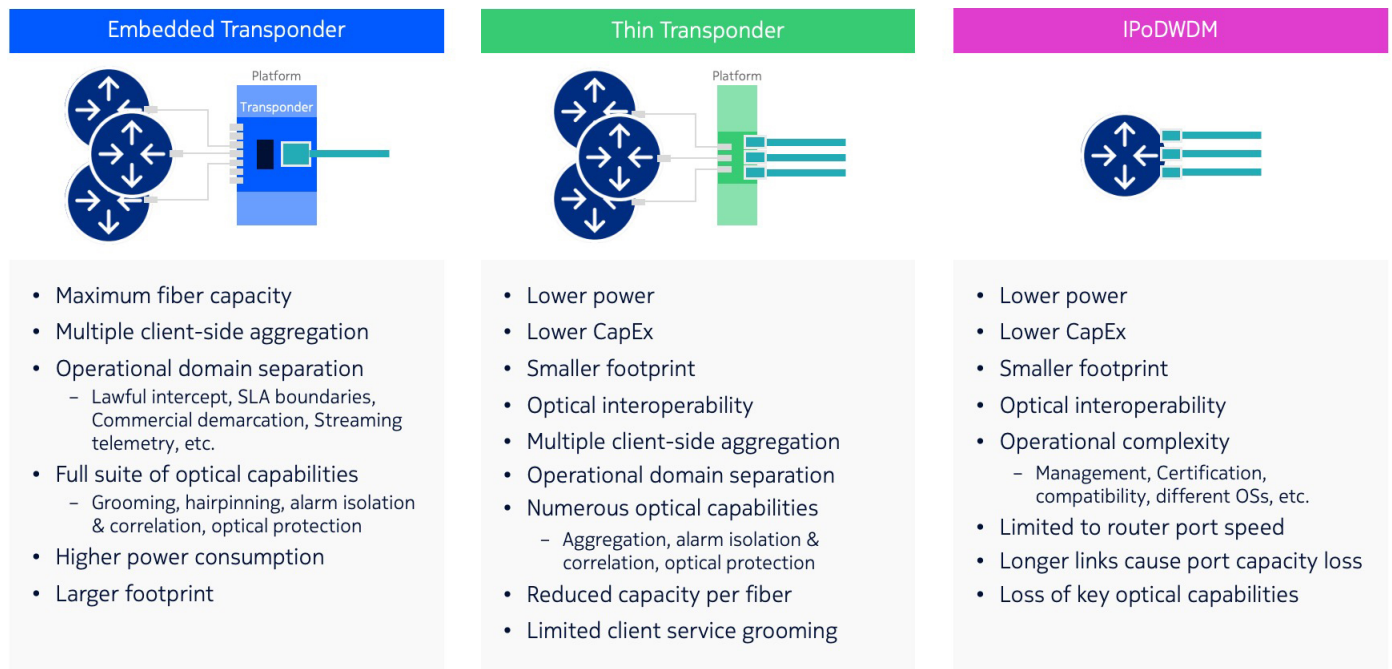


Figure 1: Expanding deployment models with thin transponders

Nokia thin transponder solutions

Nokia offers a full suite of thin transponders, supported on a wide set of platforms, to address each application requirements as depicted in Table 1. The first set of thin transponders support up to 400G coherent pluggables and can be deployed in the following platforms: the 1830 PSI-M and the 1830 GX G31/G32/34c. The second set of thin transponders are designed to host high-capacity coherent pluggables such as Nokia's ICE-X 800G ZR/ZR+ or multi-haul and supported on the 1830 GX G31/G32, the 1830 PSS-4II/8/16II platforms and the PSS-4hc/10hc platforms.

800 Gb/s thin transponders

Name	Ports	Chassis	Module/Chassis
S2AD800R	3 x QSFP-DD	PSS-4II/8/16II	• 4 per PSS-4II • 6 per PSS-8 • 16 per PSS-16II
CHMQ6	6 x QSFP-DD	G31/G32	• 4 per G31 • 8 per G32
CHMS8	8 x OSFP	G31/G32	• 2 per G31 • 4 per G32
15CP12T	30 x QSFP-DD	PSS-4hc, PSS-10hc	• 4 per PSS-4hc • 10 per PSS-10hc

400 Gb/s thin transponders

Name	Ports	Chassis	Module/Chassis
DD2M4	2x CFP2-DCO	PSI-M	• 4 per PSI-M
CHM1R	2x CFP2-DCO	G31/G32	• 4/8
DDQT2	4x QSFP-DD	PSI-M	• 4 per PSI-M
SPN2/SPN2c	4x QSFP-DD	G31/G32/G34c	• 2 per G31 • 4 per G32 • 4 per G34c

Table 1. Nokia thin transponders

Use cases

As previously mentioned, thin transponders combine key attributes of embedded transponders and IPoDWDM to offer cost-effective, flexible, and highly reliable optical transport leveraging the latest generation of coherent pluggables. Thin transponders are the solution of choice when space and power are limited, and a low variety of client services is required. Thin transponders offer a significant reduction in CapEx and OpEx, driven by the compact footprint and the low power consumption of coherent pluggables. Thin transponders can also be used to increase the reliability of IP traffic leveraging the optical control plane and protection and restoration schemes of optical networks. Furthermore, some thin transponders offer traffic-aggregating functions to maximize throughput and avoid bandwidth waste. Leveraging a feature called “virtual bandwidth,” two 800GE client interfaces can be carried over four 400 Gb/s coherent wavelengths, or three 800GE client interfaces over four 600 Gb/s wavelengths. Thin transponders are also used to increase the reliability of IP traffic leveraging the optical control plane and protection and restoration schemes. Figure 2 depicts two applications where thin transponders are used in an optical transport application and as a regeneration site for an IPoDWDM application.

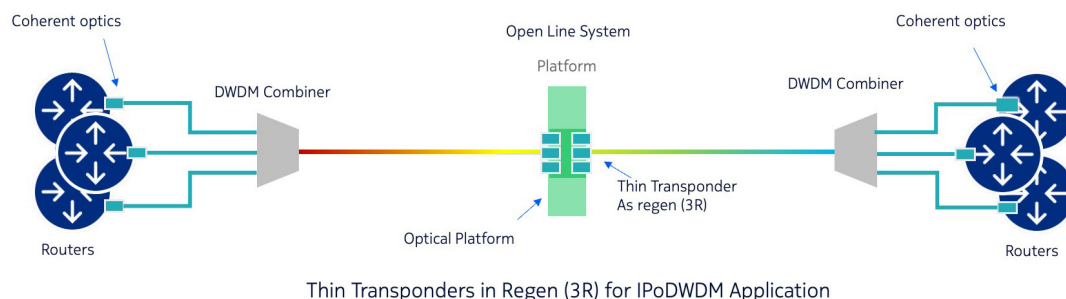
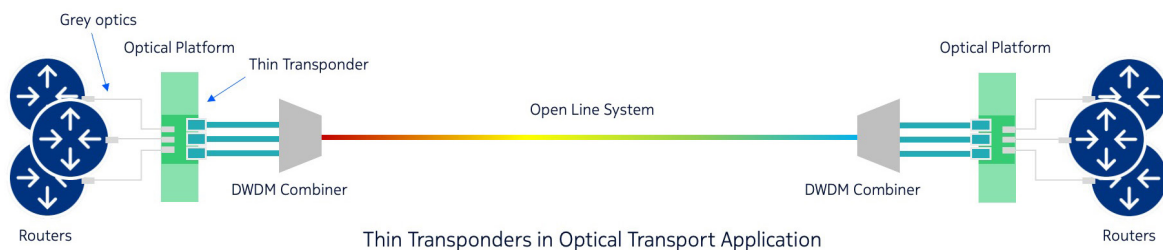


Figure 2: Thin transponder applications

Case study

To quantify the benefits of thin transponders, a network analysis was performed on a full-filled (C-Band) 1,000 km-long optical link where all three deployment options were compared side-by-side. Compared to embedded transponders, thin transponders offer compelling reduction in CapEx (\$/G), power consumption (W/G), and footprint (RU). However, they offer slightly less (20% less) capacity per fiber.

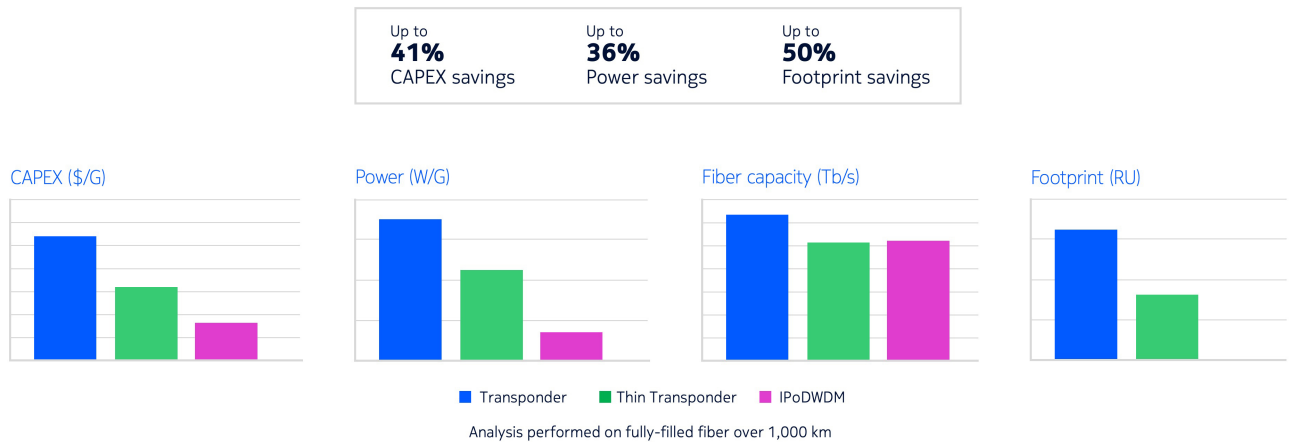


Figure 3: Benefits of thin transponders over a fully filled 1,000 km optical link

Conclusion

In conclusion, thin transponders combine some of the strengths from embedded transponders and IPoDWDM to enhance deployment flexibility while providing very compelling economics of reducing CapEx, power consumption, and footprint. Nokia's thin transponder solutions, designed to host high-capacity coherent pluggables such as Nokia's ICE-X 800G ZR/ZR+, offer a comprehensive suite of options to meet various application requirements.

About Nokia

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