BlueAlly | Infinera®

Infinera's ICE-X Portfolio of Intelligent Coherent Pluggables

Innovative Point-to-Point and Point-to-Multipoint Coherent Optics that Slash Network TCO and Enhance Networking Flexibility

The optical networking industry is on the cusp of several exciting architectural changes that offer the opportunity to radically evolve the way networks are designed, deployed, and operated. The most significant of these changes are the expansion from point-to-point optical architectures to additional point-to-multipoint architectures and the development of intelligent pluggable optics that bring high-performance coherent DWDM capabilities directly into third-party host devices such as switches, routers, and even servers and access devices such as 5G radios.

Infinera is taking a leading role in the development of these networking capabilities, including the development of the ICE-X portfolio of intelligent coherent pluggables. The ICE-X portfolio spans a broad range of architectures, features, and capabilities, including:

- Record-breaking ZR+ optical modules providing industry-leading performance and reach for point-to-point applications
- Digital subcarrier-based XR optics modules supporting both point-to-point and point-to-multipoint optical architectures
- Coherent optics line rates at 100G, 200G, 400G, 800G, and beyond
- Industry-standard form factors including QSFP-DD and CFP2 today and planned support for OSFP and QSFP28 in the future
- Conventional C-temp operational support and extended-temperature industrial I-temp optics for sites with harsh environmental conditions
- Host-independent management as outlined in the Open XR Management Architecture Specification

Figure 1: ICE-X intelligent coherent pluggables in CFP2 and QSFP-DD form factors

BENEFITS OF ICE-X IN SERVICE PROVIDER NETWORKS

- **Maximize** optical network efficiency with industry-leading performance in point-to-point applications
- **Simplify** networks with host-agnostic pluggables ideally suited to third-party devices
- **Optimize** network management strategies with ICE-X's Open XR Management Architecture Specification-compliant solution
- **Minimize** the number of optical transceivers and eliminate intermediate packet aggregation devices with point-to-multipoint XR optics
- **Reduce** OpEx in terms of power consumption, footprint, number of aggregation sites, product support costs, and truck rolls

INDUSTRY RECOGNITION

- **2023**
  - Light Reading Leading Lights Award
  - Fiber Connect Most Innovative Award
  - Lightwave Innovation Reviews 4.5/5.0

- **2022**
  - Deutsche Telecom Green Future Best Practice Award
  - Fierce Telecom Innovation Award

- **2021**
  - Lightwave Innovation Reviews 4.5/5.0
  - NGON & DCI World Best New Gamechanger or Innovation

- **2020**
  - ECOC Most Innovative Product Award
  - Light Reading Leading Lights Most Innovative Telecom Product

Industry-leading Vertical Integration

The ICE-X portfolio leverages Infinera's unique vertical integration capabilities to bring industry-leading optical performance to both point-to-point and point-to-multipoint applications. Both of the major building blocks of pluggable transceivers, the digital signal processor (DSP) and the transmit-receive optical sub-assembly (TROSA), are designed in house by Infinera. The TROSA is also manufactured by Infinera and contains a single monolithic indium phosphide (InP) photonic integrated circuit (PIC) produced at Infinera's own optical semiconductor fab in Silicon Valley, California.

This ownership of these key design and manufacturing stages enables a high degree of vertical integration to optimize the performance of the individual components. It also enables a holistic co-design approach that enhances the overall performance of the transceiver.
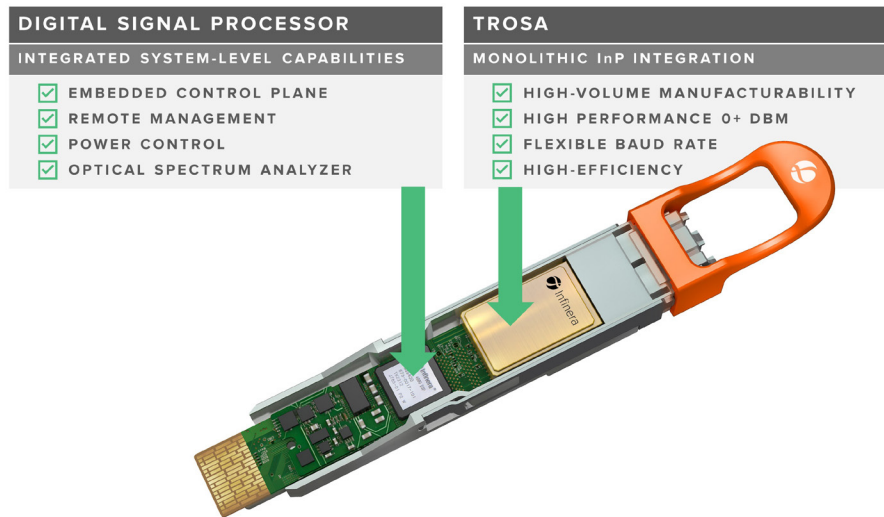

Figure 2: ICE-X intelligent coherent pluggables

The ICE-X Intelligent Coherent Pluggables Portfolio

The ICE-X portfolio includes the following transceivers:

- **ICE-X 100G XR**, an innovative solution enabling edge-optimized transmission, software configurability from 25 Gb/s to 100 Gb/s, and support for both point-to-point and point-to-multipoint configurations. Enabling 100G transmission in only 25 GHz, ICE-X 100G XR provides twice the capacity per fiber when compared to traditional 100G transport connectivity solutions. ICE-X 100G XR is available in both QSFP-DD and CFP2 form factors.

- **ICE-X 400G XR**, a high-performance, intelligent, and fully programmable pluggable solution capable of supporting both point-to-point and point-to-multipoint solutions. ICE-X 400G XR uniquely enables dynamic bandwidth allocation from 25 Gb/s to 400 Gb/s connectivity. ICE-X 400G XR is available in both QSFP-DD and CFP2 form factors.

- **ICE-X 400G ZR+**, a high-performance, point-to-point-optimized, intelligent, programmable pluggable with record-setting performance capable of supporting 400 Gb/s transmission on most industry fiber routes. ICE-X 400G ZR+ can be flexibly configured to support 100/200/300/400 Gb/s-based connectivity. ICE-X 400G ZR+ is available in both QSFP-DD and CFP2 form factors.

- **ICE-X 800G ZR/ZR+**, an advanced pluggable solution that leverages the power and efficiencies of 3-nm-based CMOS technology coupled with advanced multi-vendor interoperability, including open probabilistic constellation shaping. ICE-X 800G ZR/ZR+ will provide long-haul-capable performance in a low-power, pluggable form factor, including 800G transmission over 1,000+ km. ICE-X 800G ZR/ZR+ is planned to be available in both QSFP-DD800 and OSFP form factors.
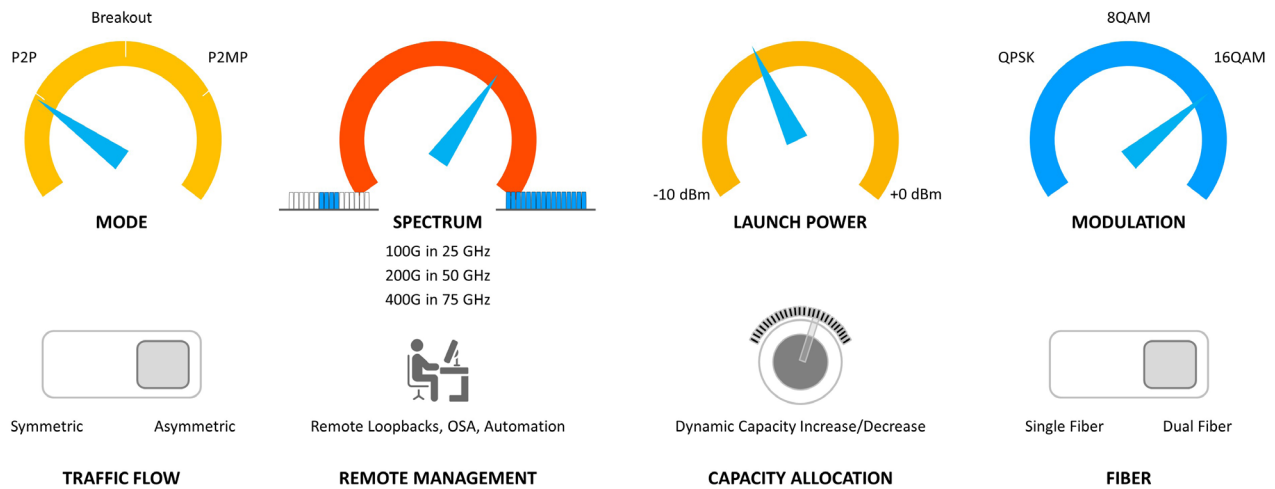
Figure 3: ICE-X optimization through programmability

Intelligent Management/Host Independence

A critical aspect of any pluggable optics deployment, regardless of whether the host devices are DWDM transport platforms or third-party devices, is manageability. As these pluggable optics move to ever-higher coherent line rates and become more sophisticated, manageability becomes an increasingly complex issue. This is especially the case in third-party platforms that typically do not support management of detailed optical parameters or some of the functions necessary to manage the optical layer, such as alarm correlation, automatic power control, and network auto-discovery.

Unlike DWDM transport platforms that are specifically designed to capitalize on the optical layer functionality of pluggable optics or on-board optical engines, third-party devices typically need simpler grey optic-like manageability while maintaining the optical performance of DWDM optics. In other words, the host device is spared from the sophistication and the complexity of optical transport technology.

The ICE-X portfolio is compliant with the Open XR Management Architecture Specification from the Open XR Optics Forum. This dual-management architectural approach enables the host platform to manage the transceiver in the same way as a conventional grey optic via the standard CMIS interface, effectively managing the client side of the virtual transponder. In parallel, a separate management platform, either Infinera's Intelligent Pluggables Manager (IPM) or a third-party manager, manages the optical domain of the transceiver, keeping the challenges of optical domain management separate from the basic operation of the transceiver.

This approach enables quick integration of ICE-X transceivers into third-party devices like routers/switches by hiding the complexity of the optical domain from the host device. It also decouples management domains, enabling the routing/switching and optical networking teams to manage their respective domains independently. Furthermore, this host-independent management approach enables rapid development of new networking features and functionality without dependencies on the host platform's operating system and management software.
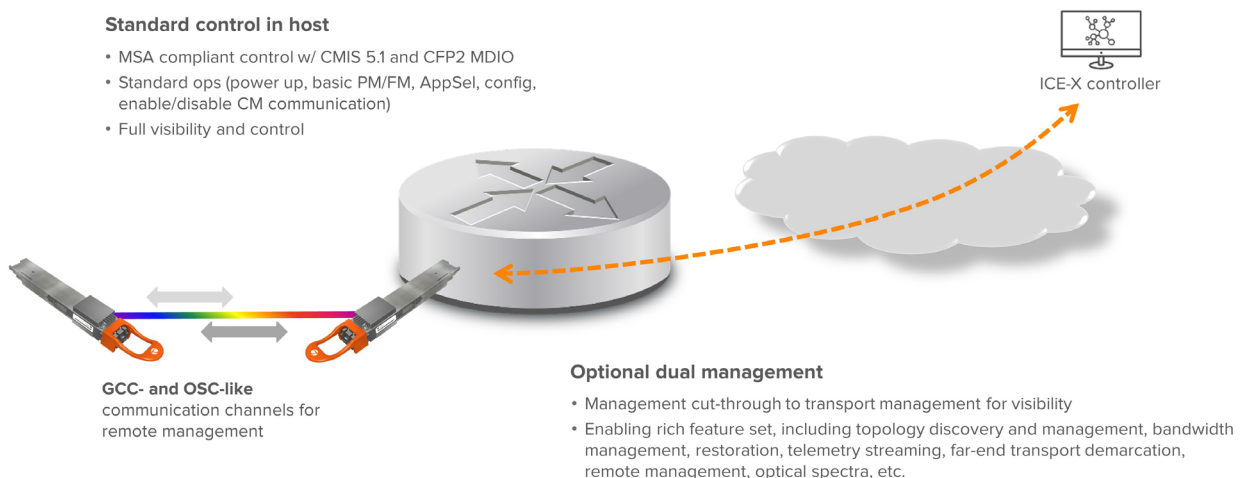

Standard control in host
- MSA compliant control w/ CMIS 5.1 and CFP2 MDIO
- Standard ops (power up, basic PM/FM, AppSel, config, enable/disable CM communication)
- Full visibility and control

ICE-X controller

GCC- and OSC-like
communication channels for remote management

Optional dual management
- Management cut-through to transport management for visibility
- Enabling rich feature set, including topology discovery and management, bandwidth management, restoration, telemetry streaming, far-end transport demarcation, remote management, optical spectra, etc.

Figure 4: ICE-X dual management architecture

ICE-X intelligent coherent pluggables are also feature-optimized to support critical network applications and use DSP processing power to embed many system-level features to support these applications. Examples include an embedded control plane, remote node management, optical power control loops, and an optical spectrum analyzer function.

ICE-X 400G/800G ZR+ Industry-leading Performance

All ICE-X transceivers leverage Infinera's vertical integration and high-performance DSP and TROSA components. This enables the ICE-X 400G ZR+ and ICE-X 800G ZR/ZR+ transceivers to deliver industry-leading high-performance connectivity over point-to-point applications. ICE-X 400G ZR+ QSFP-DD transceivers have broken multiple world records* for 400G optics, including a 2,400-km lab trial with QSFP-DD transceivers in third-party routers and an 1,800-km trial in a live production network.

This industry-leading performance is enabled by:

- The high degree of vertical integration and the holistic design approach enabling optimization of overall performance
- The InP PIC, which enables high (+0 dBm) launch power and low out-of-band noise and in turn removes the need for an additional micro EDFA and a tuneable optical filter (TOF) to remove out-of-band noise, which are both typically found in silicon photonics-based transceivers
- Advanced DSP functionality such as programmable launch power, programmable signal roll-off, and digital subcarriers

This industry-leading optical performance enables network operators to achieve better network economics by spanning longer distances or supporting a higher number of cascaded ROADMs in the network than was previously possible with pluggable coherent optics directly hosted in either third-party platforms or DWDM platforms, rather than using alternative approaches for these applications such as platforms based on embedded optical engines or regenerating the signal at an intermediate node.

ICE-X 100G/400G XR Benefits of Point-to-Multipoint

The XR optics-based variants of ICE-X, specifically the ICE-X 100G XR and ICE-X 400G XR transceivers, leverage digital subcarrier technology to provide highly efficient traffic aggregation in point-to-multipoint applications. Point-to-multipoint ICE-X intelligent coherent pluggables can bring considerable benefits to network operators, including:

- Reduced number of optical transceivers — Point-to-multipoint architectures can reduce the number of optical transceivers in networks by up to 50%
- Reduced number of intermediate aggregation devices — By enabling lower-speed transceivers to communicate directly with higher-speed transceivers, intermediate aggregation devices such as routers, switches, or DWDM muxponders can be removed from network designs
- Support for single-fiber working and asymmetrical traffic flows — Bring high-speed coherent optics to single-fiber networks by assigning individual digital subcarriers to each direction
- Maximized router efficiency, density, and simplicity — By enabling routers to standardize on 400G ports only rather than a mix of 10G, 100G, and 400G ports
- Alignment of CapEx and actual bandwidth requirements — Decouple deployed bandwidth from transceiver speed and dynamically assign subcarriers to network nodes only when needed to match actual bandwidth demands
- Support for multigenerational upgrades — Use ICE-X subcarrier-based transceivers to support multigenerational upgrades so upgrading one transceiver does not force an upgrade to the other end of a link until that location also requires an upgrade

Overall, these benefits reduce overall network total cost of ownership with both lower network CapEx and OpEx, with network operator studies showing possible TCO savings of over 75%. Furthermore, the point-to-multipoint architecture brings considerable benefits in terms of space and power that can positively impact environmental goals for network operators.

Summary

Infinera's ICE-X portfolio of intelligent coherent pluggables brings numerous benefits to network operators in a wide range of networking applications. With industry-leading optical performance and variants that support new point-to-multipoint architectures, ICE-X enables network operators to build the most cost-efficient networks with the lowest CapEx and the lowest space- and power-related OpEx costs. Furthermore, ICE-X's advanced management capabilities enable network operators to quickly and simply integrate ICE-X transceivers into third-party devices and simplify network bandwidth management with dynamic additions or removals to the number of required subcarriers at a network node.

As of February 2023

Further Reading

XR Optics Solution Brief
XR Optics in 5G Transport Networks Application Note
The Advantages of Indium Phosphide Photonic Integration in High-performance Coherent Optics White Paper

BlueAlly.com
Telebroadsales@blueally.com
913-553-5895