



Executive Summary

Consistent with Infinera’s commitment to accelerate the pace of new product introductions, Infinera today announced ICE5, incorporating its fifth-generation photonic integrated circuit (PIC) and coherent digital signal processor (DSP).

Infinera continues to build upon its strong heritage and deep experience in photonic integration. In 2017, the company delivered the 1.2 Tb/s Infinite Capacity Engine (ICE4) with the fourth-generation PIC and FlexCoherent DSP. ICE4 supports up to six, 200Gb/s per wavelengths with super-channel support for up to 1.2 Tb/s. ICE4 technology is broadly deployed across the Infinera product portfolio, including the Cloud Xpress 2, XT/XTS-3300 meshponder and the flagship DTN-X XTC series.

The 2.4 Tb/s ICE5 triples per-wavelength capacity, supporting up to four 600 Gb/s wavelengths and doubles the capacity of the ICE4 engine. Each wavelength may be independently provisioned for operation as a single carrier or as part of a super-channel. By adjusting modulation, symbol rate and forward-error correction settings, each wavelength can be provisioned to support between 100 Gb/s and 600 Gb/s.

In parallel, Infinera has demonstrated initial advances for ICE6 where 100 GBaud and constellation shaped 1024QAM have achieve industry-leading throughput and optical reach.

Infinera is demonstrating a commitment to accelerating its product development cadence. ICE4 is shipping, ICE5 is maturing and the advances of ICE6 are coming into view.

Key Findings

- Infinera is accelerating the pace of new optical engine development with focus on 24-month delivery cycles
- ICE4-based platforms are deployed across multiple applications: subsea, long-haul and DCI with customers like Netflix with Cloud Xpress 2
- ICE5 delivers 600 Gbs per wavelength in industry-leading 2.4 Tb/s engine, tripling ICE4 capacity/wave and doubling engine capacity
- Early ICE6 technology advances including 100GBaud symbol rate and CS-1,024QAM modulation have publicly demonstrated a path to 1Tb/s per single wavelength

ICE4 RAMPING

In the Q4-2017 earnings call, Infinera announced that the ICE4 technology was responsible for 20% of the company's revenue. ICE4 is deployed with over 17 customers, up from 10 customers in Q3-2017. With the debut of the 2.4 Tb/s XT/XTS-3600 meshponder for trials in Q1-2018, Infinera's ICE4 product refresh for data center interconnect, long-haul and subsea applications will be complete.

As the company that was first to market in the optical small form factor appliance segment for data center interconnect (DCI), it is not surprising that initial deployments of ICE4s occurred in the DCI application space. One of Infinera's most notable deployments was the announcement in November 2017 that Netflix, the world's leading Internet television network, had selected the Cloud Xpress 2 to expand its delivery capacity for video streaming. Infinera also notes that Cloud Xpress 2 is deployed in hyperscale Internet content provider networks.

RETN, an international network service provider, announced deployment of the ICE4 with the Infinera XT-3300 and FlexILS in March 2018. The long-haul deployment triples the operator's fiber capacity as part of an upgrade to its backbone network that spans 34 countries across Europe, Asia and North America.

In the subsea market, Hetzner Online, a leading web hosting and data center operator in Germany, announced deployment of the XTS-3300 in February 2018. The subsea application enables Hetzner to expand its network into Finland. This announcement followed a 2017 subsea announcement in which Seaborn deployed the XTS-3300 on its Seabras-1 cable where the solution achieved a record capacity of 18.2 Tb/s over 10,000km.

ICE5 REACHING FURTHER

With the ICE4 product refresh complete and with ramping customer adoption and revenue, Infinera is announcing ICE5, its 5th generation optical engine. The 2.4 Tb/s optical engine includes the PIC and market-optimized DSP for advanced coherent optical transmission. ICE5 supports 100Gb/s to 600 Gb/s single wavelength transmissions with flexible modulation up to 64QAM and symbol rates up to 66 GBaud. The four

wavelengths of the ICE4 may be provisioned independently or as part of a combined 2.4 Tb/s super channel. A fully-loaded ICE5 transmission network enables over 40Tb/s on a single fiber pair.



Figure 1: Infinera ICE5 5th Gen. PIC and FlexCoherent DSP

Infinera expects ICE5 to debut in its Intelligent Transport Networking Platforms in early 2019.

INFINERA INSTANT NETWORK CONTINUES

One of the unique hallmarks of Infinera is that customers only pay for the capacity they need when and where they need it. This is embodied in Infinera Instant Network where customers may purchase optical capacity in 100G increments of movable bandwidth licenses. That means that service providers can deploy 2.4 Tb/s of optical capacity with ICE5 throughout their network and then enable and pay for portions of that capacity only when they need it, creating a flexible pool of bandwidth. As a testament to the success of Infinera Instant Network and the value that service providers place on the ability to instantiate incremental capacity and services rapidly, over 70 of Infinera's existing customers utilize Infinera Instant Network today, including the top three subsea customers and 60% of all DCI customers.

MORE ICE PLEASE

In parallel with the ICE5 announcement, Infinera has also begun demonstrating advances for its 6th generation optical engine, ICE6.

Infinera had two industry-leading demonstrations at the September 2017 ECOC conference. The company demonstrated how increasing the symbol rate to 100GBaud could be used in combination with 16QAM modulation to extend the optical reach for high-speed transmissions and drove a 600Gb/s wavelength 1,400 km. With 32QAM, Infinera also demonstrated 800 Gb/s transmission with a path to 1 Tb/s. In a second demonstration focused on maximizing throughput

(versus reach), Infinera demonstrated how advanced constellation shaped 1024QAM could be used to deliver the highest coded bit rate ever reported in optical communications at 1.32 Tb/s.

Although advances in symbol rates and modulation algorithms will continue, we are edging ever closer to the Shannon limit for maximum transmission in a communication channel.

CONCLUSION

Infinera continues to utilize its experience and deep understanding of optical networking to drive industry-leading photonic integration and transmission. ICE4 is driving increasing deployments and revenue. ICE5 will double ICE4 capacity, and platforms featuring ICE5 are expected to be available in 2019. In parallel, preliminary ICE6 advances in high-speed optical reach and maximum throughput are being realized with 100GBaud symbol rates and 1024QAM with constellation shaping. Look for Infinera to continue to focus on accelerating the pace of its new product introductions.



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