Infinera Delivers the Multi-Terabit Infinite Capacity Engine

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Infinite Capacity Engine

Infinera revolutionized optical integration with the introduction of its industry leading 100G Photonic Integrated Circuit (PIC) in 2005.

In 2011 the company followed with the introduction of a 500G PIC and coherent digital signal processing (DSP) technology.

At the OFC Conference in March 2016, Infinera once again pushed the limits of optical integration with the debut of its multi-terabit Infinite Capacity Engine.

The Infinite Capacity Engine is a family of next-generation optical subsystems consisting of fourth-generation photonic integration with advanced coherent signal processing, software defined networking-enabled sliceable photonics architecture and Layer 1 encryption. Compared to prior generations, the Infinite Capacity Engine delivers:

- 4.8x increased capacity
- 4x increased capacity per mm^3 density per PIC
- 70% reduced watts/Gigabit per PIC
- 53% lower total cost of ownership

Key Findings

- Enables the industry's first 2.4 Tb/s super channel.
- Provides industry leading sliceable photonic technology combining massive multi-terabit scale with fine-grained 100G granularity.
- Maximizes fiber utilization with Advanced Coherent Toolkit and FlexCoherent technologies such as Nyquist subcarriers and SD-FEC gain sharing to enhance performance and overcome environmental impairments.
- Secures data transmission with in-flight 256-bit AES encryption, providing a flexible, on-platform engine for adding encryption anywhere at any time and eliminating the need for external security gateways or modules.

Growing Bandwidth Demand

At the 2016 Open Networking Summit, SK Telecom stated that average data usage for its LTE mobile customers will grow by 5x between 2015 and 2020, resulting in 19 Gbytes per user per month. 5G wireless specifications, although incomplete, anticipate increasing over-the-air bandwidth by 10x versus today's LTE networks. John Donovan at ONS posted a graph comparing the 20 Kbytes of a simple text message to the 100+ Mbytes of traffic generated in a one-minute virtual reality video stream. The Internet of Things, big data collection and analytics, 4K ultra high-definition video and virtual reality streaming will all contribute to increasing bandwidth demands between now and 2020.

Three Technologies Converge

The advancement of Infinera's Infinite Capacity Engine brings three disparate but related technological advances together to meet the growing bandwidth demands of service providers and their customers. 1) Advances in optical and electronic component miniaturization, integration and InP wafer technology are enabling higher integration density and lower power than ever before. The 2.4 Tb/s PIC integrates hundreds of optical components on a monolithic substrate, including amplifiers and lasers while achieving a 70% Watts/Gigabit power reduction. Advancements in Infinera's coherent DSP technology are enabling higher speeds, longer distances and better performance over diverse optical networks. With 230 M gates and 1.6 B transistors, Infinera's coherent DSP technology delivers an amazing improvement in density. 2) Software defined networking (SDN) architecture and application interfaces are finally beginning to deliver the network programmability and service agility that providers always wanted from their networks. 3) Layer 1 encryption at multi-terabit scale per super-channel and per ODU0 service levels.

Infinera will tailor the Infinite Capacity Engine for diverse network applications and products that cover long-haul, subsea, data center inter-connect and metropolitan networks.

Optical and Electronic Integration

With delivery of its 4th generation PIC, Infinera is once again pushing the envelope on photonic technology, processes and integration. PIC density (capacity per mm^3) is improved by 4x from the previous generation.

When designing for multi-terabit scale with hundreds of integrated optical components, including modulators, amplifiers and lasers, reducing or eliminating off-PIC components and connections is a major priority for reducing footprint and costs while maximizing reliability.

Infinera's advanced InP processes enable ubiquitous on-wafer component integration with this technology, clocking nearly two billion field hours and a reported FIT rate below one. Integration is now at the multi-terabit scale. The result is a simplified design with zero off-PIC components.

Infinera doubled its baud (or symbol) rate to 33 GBaud adding support for 3-QAM, 8-QAM and also 16-QAM technology, thus enabling the Infinite Capacity Engine to deliver 200Gb/s per wavelength and 2.4 Terabit super channels per PIC.

Infinera's in-house designed FlexCoherent electronics and Advanced Coherent Toolkit (ACT) also delivers a number of programmable performance advances within the Infinite Capacity Engine subsystem: use of Nyquist subcarriers, subsea-specific modulation of Matrix Enhanced Phase Shift Keying (ME-PSK) and soft-decision forward error correction (SD-FEC) gain sharing. By subdividing a single-carrier wavelength into multiple Nyquist subcarriers in the DSP, FlexCoherent technology improves resistance to channel impairments such as cross-phase modulation, which results in increased reach and/or fiber capacity.

SD-FEC gain sharing is an innovative technology that enables the signal integrity of a high-quality carrier to increase the quality of a lower-quality carrier. SD-FEC gain sharing can make a non-usable wavelength usable or enable a poor-quality wavelength with lower order modulation to improve signal quality and utilize higher order modulation, resulting in increased throughput and fiber utilization. By maximizing the quality per carrier, SD-FEC gain

sharing also maximizes throughput per super channel.

Sliceable, SDN Enabled Networks

The second major Infinite Capacity Engine advancement is to combine SDN automation with industry-leading sliceable photonics. Think about SDN as the programmable software layer that enables service providers to maximize the benefit, efficiency and service agility of the Infinite Capacity Engine. With the Infinite Capacity Engine, service providers have a massive, tunable bandwidth pool that can be segmented into slices for individual customers and services. But to fully realize the subsystem's potential, service providers need an easy and efficient way to program and modify these networking slices. That's where SDN comes in. Infinera is delivering application programming interfaces and a software toolkit to enable service providers to utilize their own SDN controller or a third-party controller to dynamically program and manage 100G slices of the Infinite Capacity Engine.

In the wireless industry, service providers had a challenge managing the radio-frequency (RF) communication link between users' devices, such as smartphones and base stations. To successfully optimize RF performance, power, frequency, modulation and a host of other RF parameters had to be adjusted and controlled. To address this challenge, the wireless industry introduced self-organizing network (SON) software, which automated the process, made it near real time and virtually eliminated the manual intensity of continuous RF adjustments.

The introduction of SDN in optical networking is just like SON for RF. With SDN, service providers are empowered to turn on additional bandwidth when and how they need it, adjust baud rates, modulation rates, forward error correction codes and other programmable aspects of the Infinite Capacity Engine.

Sliceable photonics combines multi-terabit super-channel scale with fine-grained 100G granularity to reduce the number of modules in the network, decreasing power and space and ultimately reducing total-cost-of-ownership by 53%. Moreover, these slices can be licensed permanently or temporarily through the Infinera Instant Bandwidth technology. In return, service agility goes up with service providers enabled to deliver just what is needed where it is needed when it is needed and to reallocate that same capacity when it can be better utilized for another purpose.

Encryption & Security

While capacity, scalability and automation are important, so is data security. In prior security models, the application layer was considered responsible for secure communications. For example, when logging into your bank account on-line, HTTPS provides an encrypted communication path between the source, your laptop or smartphone, and the destination, the banking server. However, as multiple public data breeches have come to light in recent years, enterprises and service providers are increasingly adopting a more layered security policy where data integrity is the responsibility of **every** layer of the protocol stack, including the optical transport one.

That's why the Infinite Capacity Engine's in-flight 256-bit AES encryption capability is such an important advancement. In addition to bulk encryption for all traffic, the engine also enables per-flow or per-service encryption. Service providers have a flexible, in-flight, on-platform engine for adding transmission-level encryption anywhere at any time for any service. On-board encryption at multi-terabit scale virtually eliminates the operational complexity and incremental capital and operational costs associated with deploying stand-alone encryption modules or security gateways that can easily double per-gigabit transportation costs.

Conclusion

The introduction of the 2.4 Terabit Infinite Capacity Engine is a significant advancement in photonic integration and transmission. Scalability and performance in diverse optical environments are notably improved while also achieving major reductions in power and cost per gigabit. Combined with sliceable photonics, SDN enablement and advanced in-flight

encryption, service providers can realize a programmable, agile and secure network with increased service velocity and an ability to adapt in near real time to rapidly changing network and business conditions.

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