

Ultra-Stable Integrated Lasers and Low-Cost, Low-Energy Coherent Data Center Interconnect

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Abstract: As data center ethernet switches scale towards 100Tbps, fiber links that keep pace with interconnecting exploding DCI capacity will face significant cost, power and engineering barriers. In this talk, we describe FRESCO, an approach to bring highly coherent WDM Terabit links inside the data center without the need for DSPs and other power consuming technologies. FRESCO is based on photonic integrated ultra-stable, ultra-low linewidth shared laser, optical frequency comb and silicon photonic transceiver technologies. © 2019 The Author(s)
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1. Introduction

Hyperscale data centers will drive internet traffic to an astounding 20 Zettabytes by 2021 and number world-wide from 338 in 2016 to 628 by 2021 at which point representing 53 percent of all installed data centers [1]. Hyperscale data centers are pushing switch ASICs, the ethernet engines of the data center interconnect (DCI), to scale from today's 12.8 Tbps to next generation 25.6 Tbps. As these switch chips scale to 100 Tbps, the limits of today's fiber optic interconnect solutions will be reached in terms of power envelope, energy consumption and heat dissipation engineering limits and new low-energy, highly integrated, high-capacity fiber link technologies and DCI architectures will be needed. Scaling the switch ASIC to 100 Tbps is equivalent to integrating the electronic functions of architectures like the 92 Tbps Cisco CRS-1, consisting of 8 racks of switches and 72 racks of buffers and other electrical functions [2] to the scale of a single switch package as illustrated in Fig. 1.

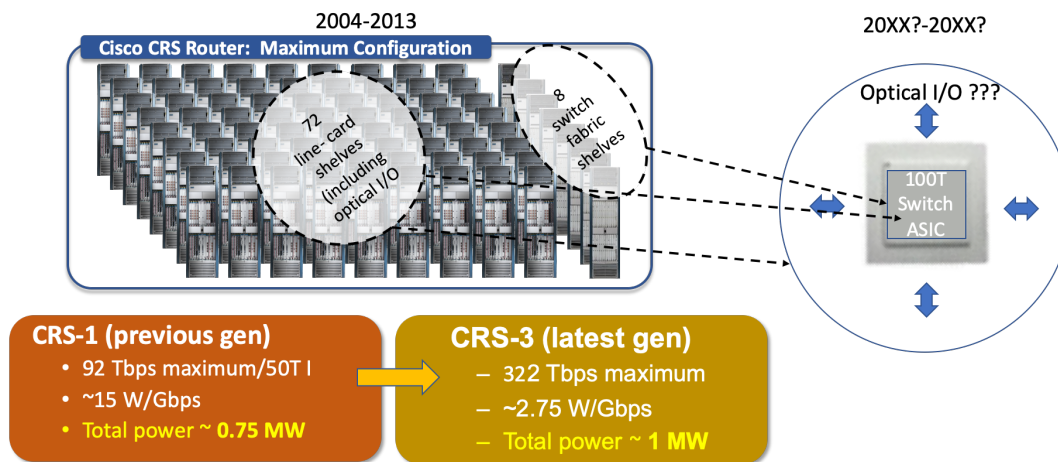


Fig. 1. Future integration of prior generation multi-rack 92 Tbps switches to a single switch chip package will face challenges using today's optical I/O solutions to scale with the switch ASIC.

Integrating racks of switching, buffering and other electronic functions into a single chip package will push the limits of Moore's law and at the same time there is no clear path to integrate the equivalent of 72 racks of fiber optical I/O using today's optical interface technology. Historically, the optical I/O capacity and power envelope lags behind the switch technology, and with switch ASIC scaling to 100 Tbps there will be a divergence of optical I/O capacity to track switch capacity. An illustration of number of modules and fiber count for 50 G NRZ, next generation 50G PAM-4 and possible 100G PAM-4 is shown in Fig. 2, also illustrating the power and engineering limited regimes.

2. FRESCO Architecture

FRESCO (FREquency Stabilized Coherent Optical) is a WDM coherent link architecture for the DCI, based on highly-integrated, ultra-stable, narrow-linewidth laser and transceiver technology. The FRESCO coherent WDM link supports Tbps transmission per wavelength to connect 100 Tbps switch ASICs with pJ per bit efficiency. FRESCO

brings narrow linewidth and laser stabilization technology developed for frequency standards [3] and atomic clocks [4] to the coherent fiber DCI by employing a shared ultra-stable, spectrally-pure laser, that drives a ultra-stable, spectrally pure, shared optical comb (Tx and LO), modulated with a highly-integrated silicon photonic coherent transceiver (see Fig. 3). The shared WDM optical source consists of a silicon photonic tunable laser [5], a micro-scale ultra-stable optical reference cavity, a silicon nitride Brillouin laser [6] and a nonlinear optical frequency comb (OFC) source [7]. The ultra-stable, spectrally pure, shared WDM source serves as the Tx and LO carriers for a silicon photonic integrated coherent modulator and receiver [8]. All chip sets are implemented using foundry compatible silicon photonic and silicon nitride processes. Coherent QAM modulation will operate at 64 and 72 GBd and 64- and 256-QAM, and support out to 1.6 Tbps per wavelength on a frequency stabilized link.

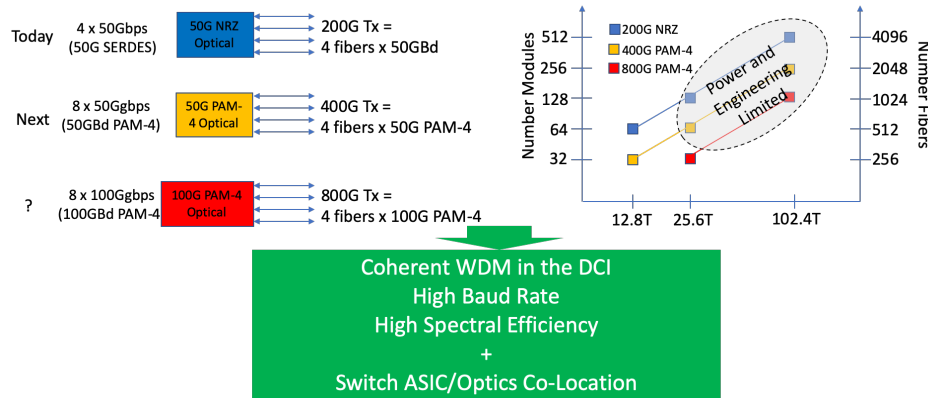


Fig. 2. Module count and fiber count for various switch ASIC capacities using today's and emerging optical I/O technology, will be power and engineerable solution limited. New coherent WDM solutions that are DSP-free and free of high power, high speed electronics, will be needed.

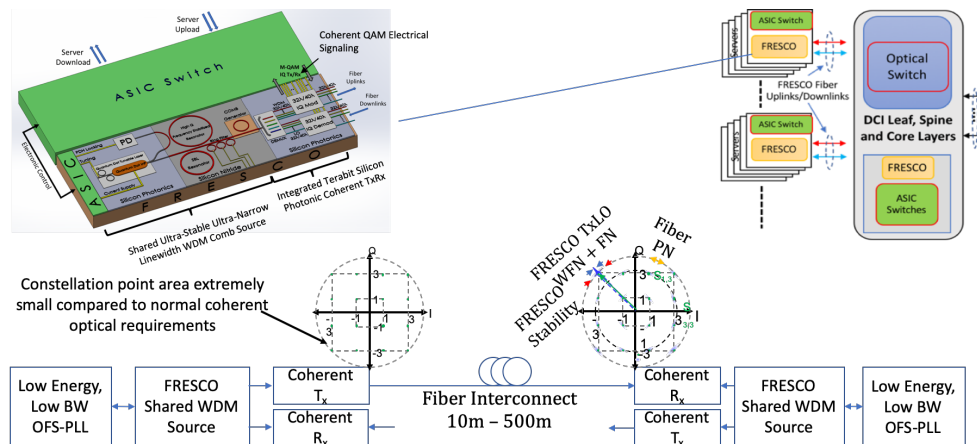


Fig. 3. FRESKO integrated transceiver based on a shared sub-Hz ultra-stable frequency WDM comb source and integrated Terabit per wavelength coherent WDM modulators and receiver with DSP-free coherent QAM modulation and low energy, low speed PLL for fiber WDM.

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4. References

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