Institute for Energy Efficiency: Low Power Hybrid Silicon Sources for Optical Interconnects

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May 2013 IEE Roundtable Report: Core Networks: Toward a Scalable, Energy Efficient Future
Establishing the Zettabyte Era

Global IP Traffic Will Increase 4X From 2011 - 2016

Reduction in energy to transport a bit across the ocean

How?

After Tucker (2012)
Data Center Networks Architecture Changes
Core and Aggregation

Past

3 Tier Architecture
Oversubscription between Access Aggregation and Core

CY2010+

Non-blocking Data Center Fabric
Oversubscription only in Access

Consequence: Higher port count, higher density, higher power

Nowell (Cisco)
Power Savings with New Optical Architectures: Circuit Switches

Low Power: $320 \times 10 \text{Tb/s} = 3200 \text{Tbit/s}$

$320 \text{Tbit/s/W}$

Source: IEE Industrial Partner: Calient Networks
HIGH-CAPACITY WDM SYSTEMS
COMMERCIAL CAPACITY SATURATION AT ~ 50 TB/S

- WDM systems available up to ~10 to 20 Tb/s
- WDM capacity scaling has slowed from ~100%/year to ~20%/year in 2000

Integration Essential to Implement High Capacity and Low Power

- Polarization
- Frequency
- Physical dimensions
- Time
- Quadrature

Space

Serial interface rates [Gb/s]

- Serial interfaces (Research)
- Serial interfaces (Products)
- Router interfaces

Dual-carrier 400G:

[F. Buchali et al, OFC (2012)]

Deploying $M$ parallel paths is better than using multiple regenerators.

But: $M$ systems cost $M$ times as much & consume $M$ times the energy

→ Cost/bit (or energy/bit) remains constant

→ Integration is key to scale capacity in parallel systems

After Winzer (2013)
Hybrid Silicon: Heterogeneous Integration of 6 Photonic Platforms

GaAs

Silicon

LiNbO$_3$

InP

SiN/SiON/SiO$_2$

Ce:YIG

Ce:YIG Isolator

Top view

Input

UCSB MOTOR
Hybrid Silicon PIC Integration

Number of components / PIC

- Indium Phosphide
- Hybrid Silicon

Year

1985
1995
2005
2015

DQPSK receiver

2D Optical Phased Array

Optical Buffer

AWG Digital Tunable Laser

4 integrated optical buffers

Pre-amplifier

Channel amplifiers

Grating array

Delay Interferometer

Phase Shifter

Balanced Photodetector

Laser

1x8 splitter

Phase modulators