ALPHAWAVE SEMI

Optical Connectivity in The Datacentre

Tony Chan Carusone, Chief Technology Officer

July 6, 2023

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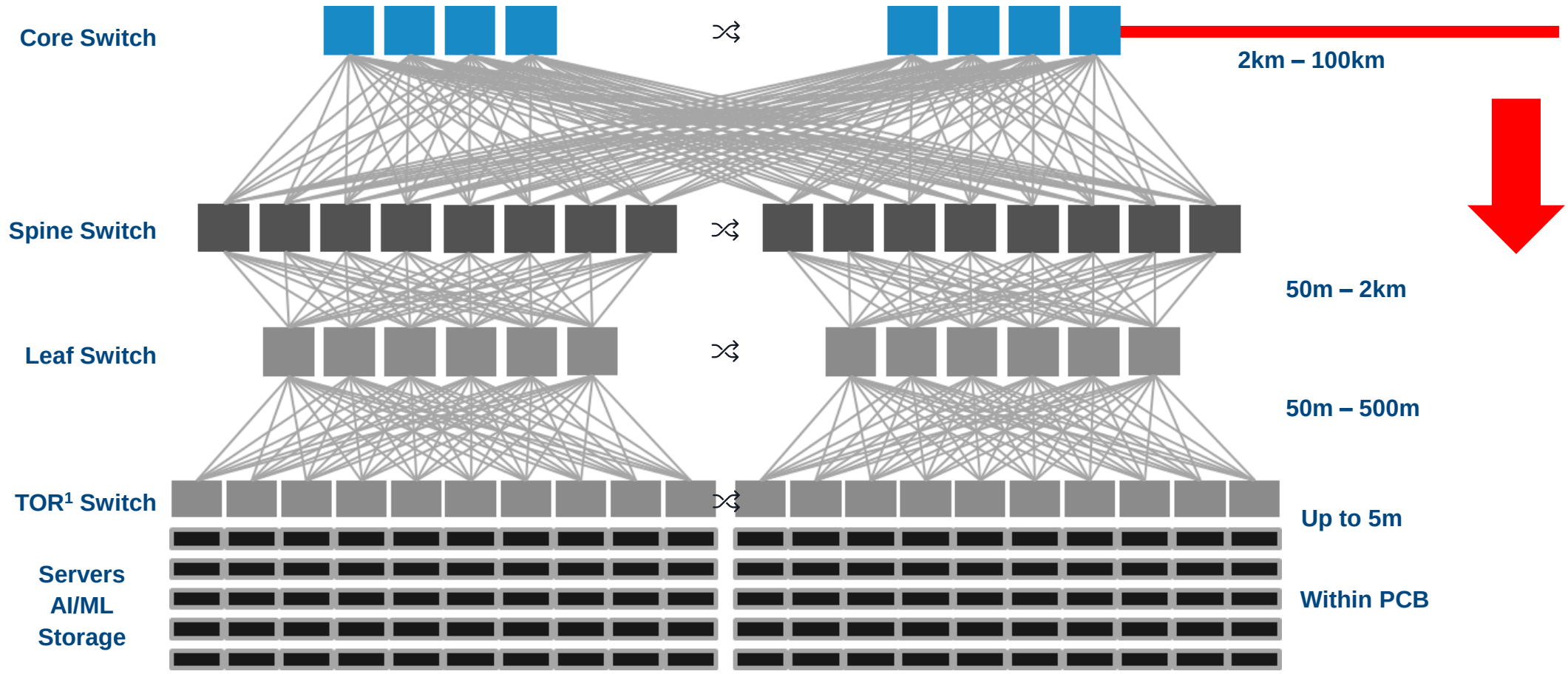
Agenda

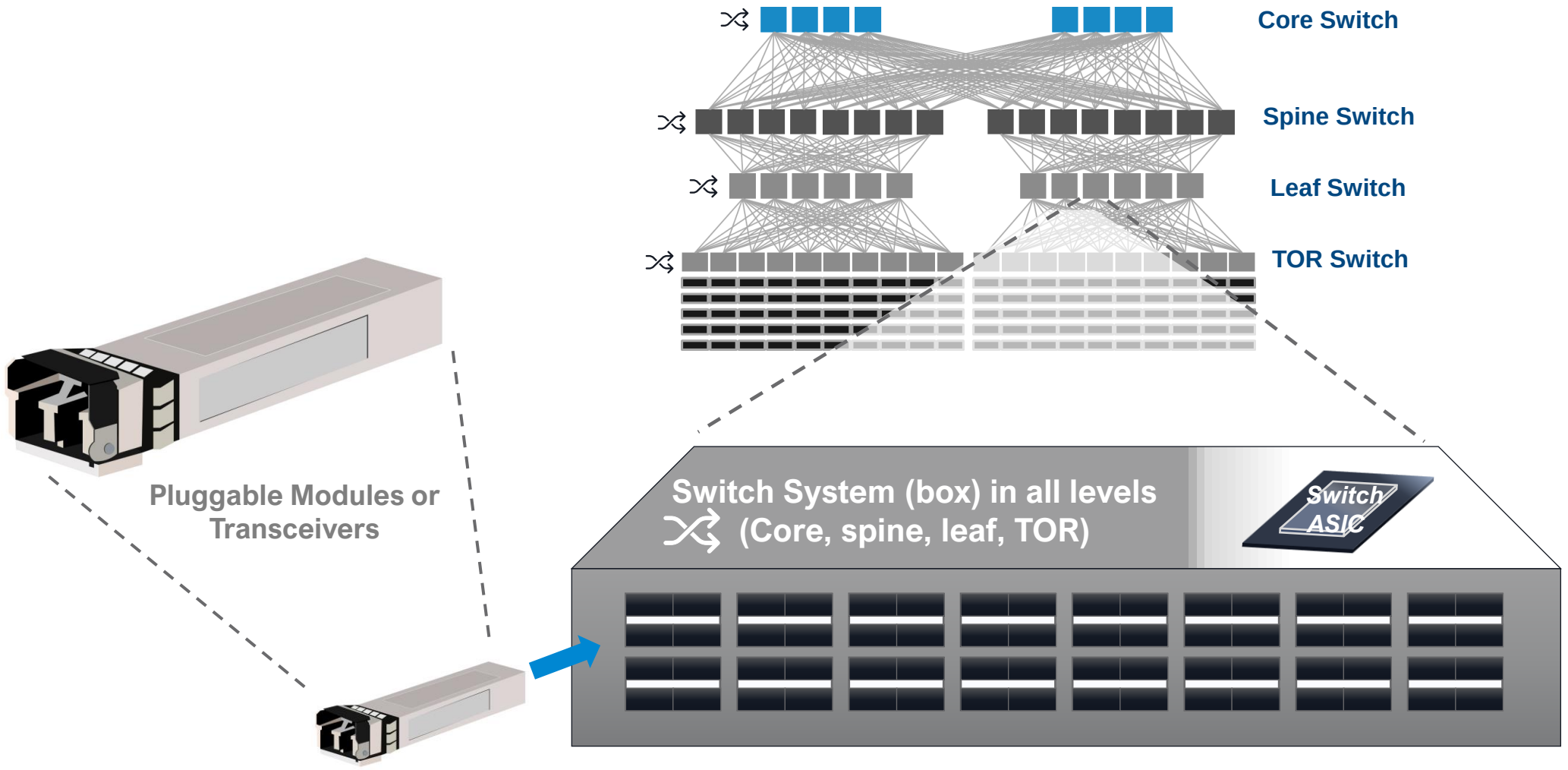
- The role of optical connectivity in the datacentre
- Key optical transceiver technologies
- Q & A

Proliferation of Optics in The Datacentre

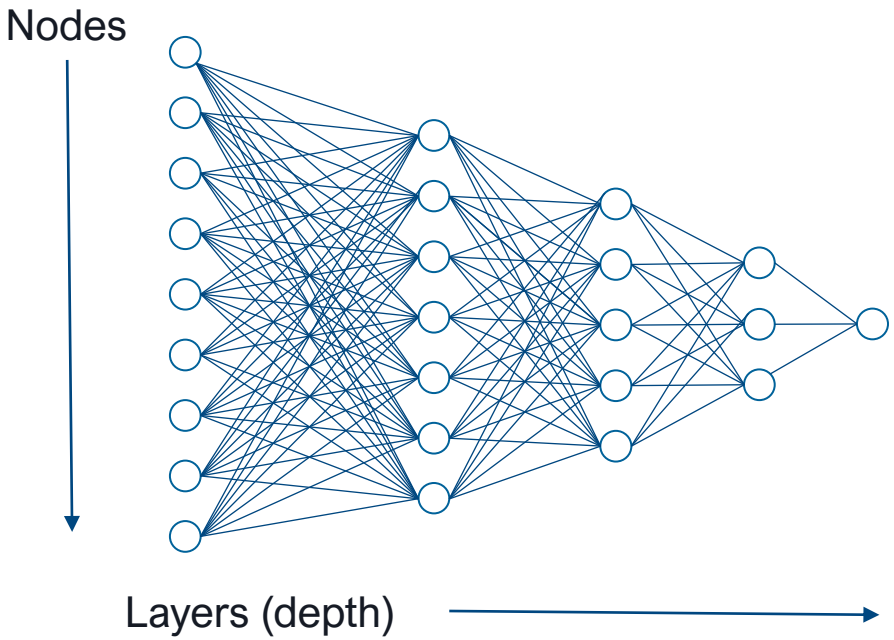


1. Top of Rack

Optical Modules in The Datacentre



Deeper Neural Networks - New Hardware Requirements



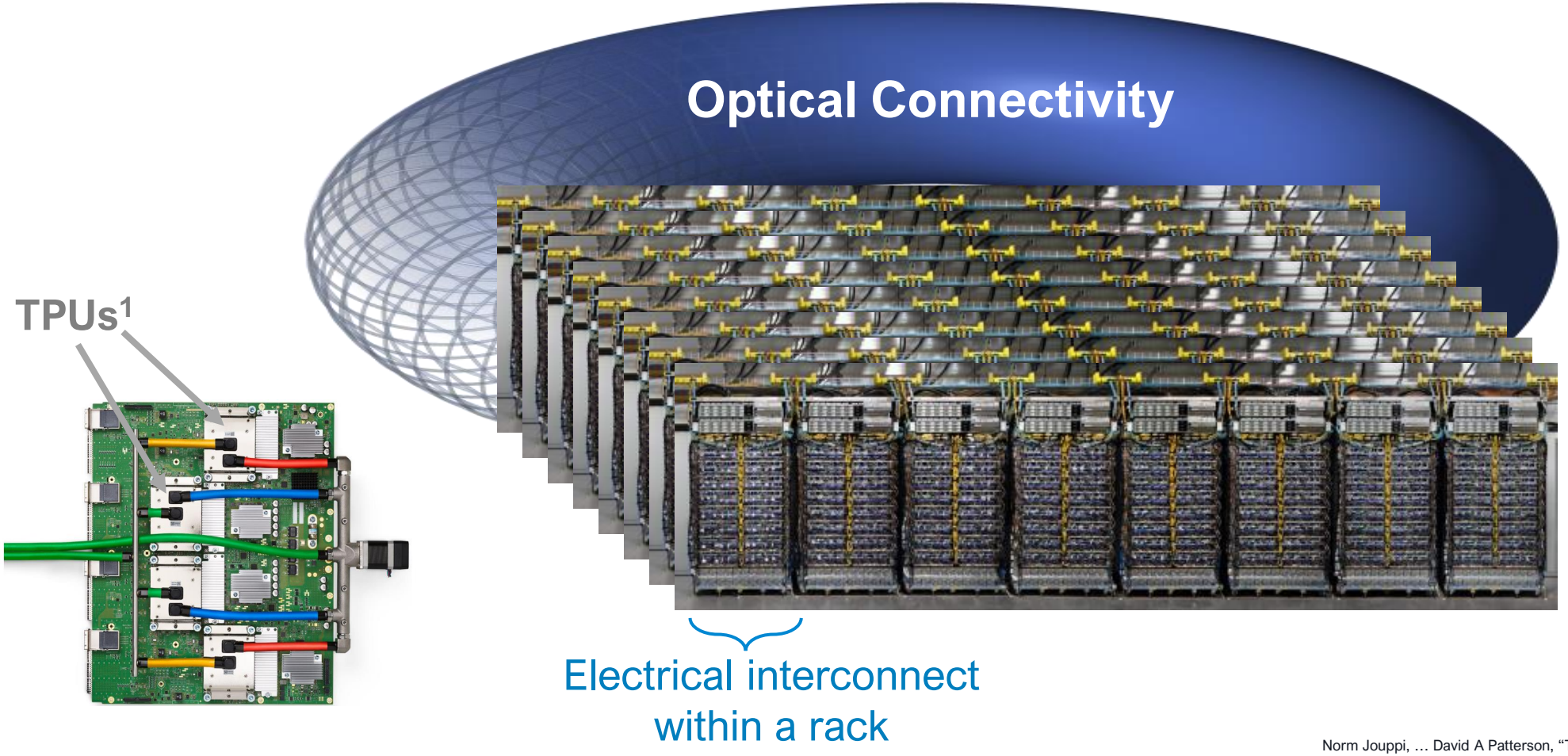
The "deep" in deep learning refers to the depth of layers in a neural network

ChatGPT2.0
1.5B parameters
40GB data

ChatGPT3.0
175B parameters
45TB data (one million feet of bookshelf space)

ChatGPT4.0
100 trillion parameters
Text + Images

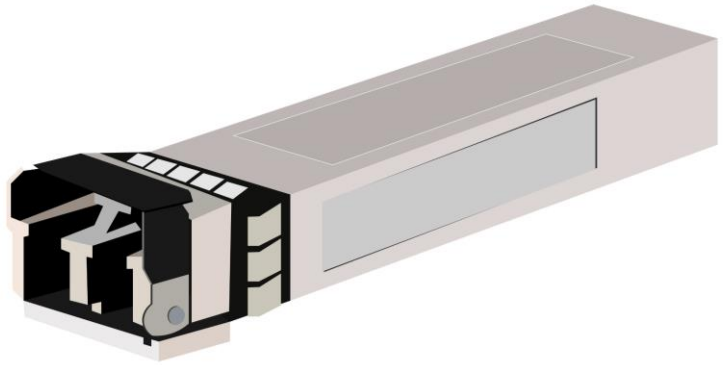
Google TPU v4: 4096-Chip AI Supercomputer

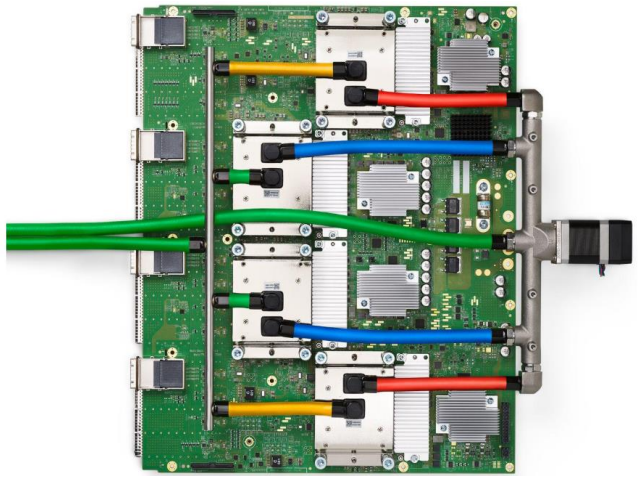


Norm Jouppi, … David A Patterson, "TPU v4: An Optically Reconfigurable Supercomputer for Machine Learning with Hardware Support for Embedding," *ISCA*, June 21, 2023

1 Tensor Processing Unit – is a purpose-built processing IC for neuronal networks

Optical Modules

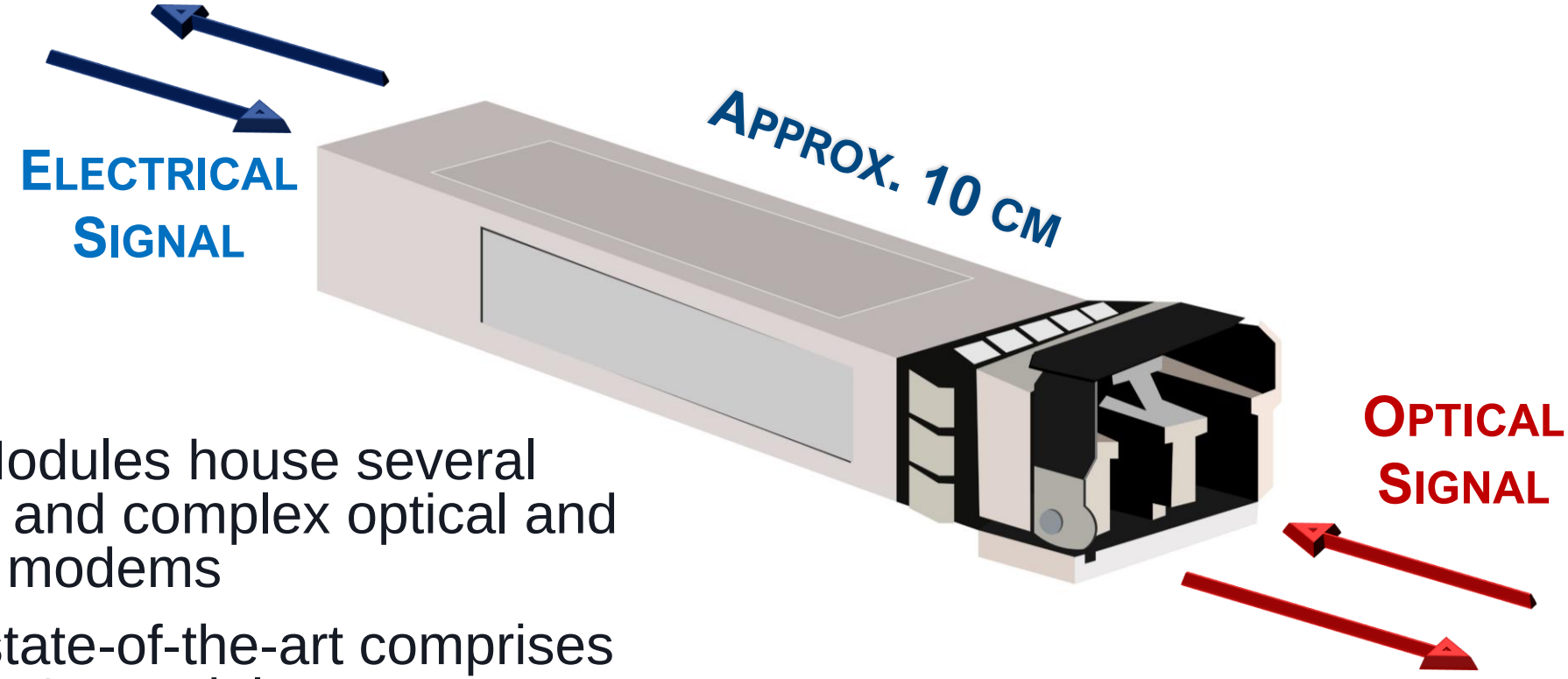




Optical modules / transceivers on the back side of the circuit board

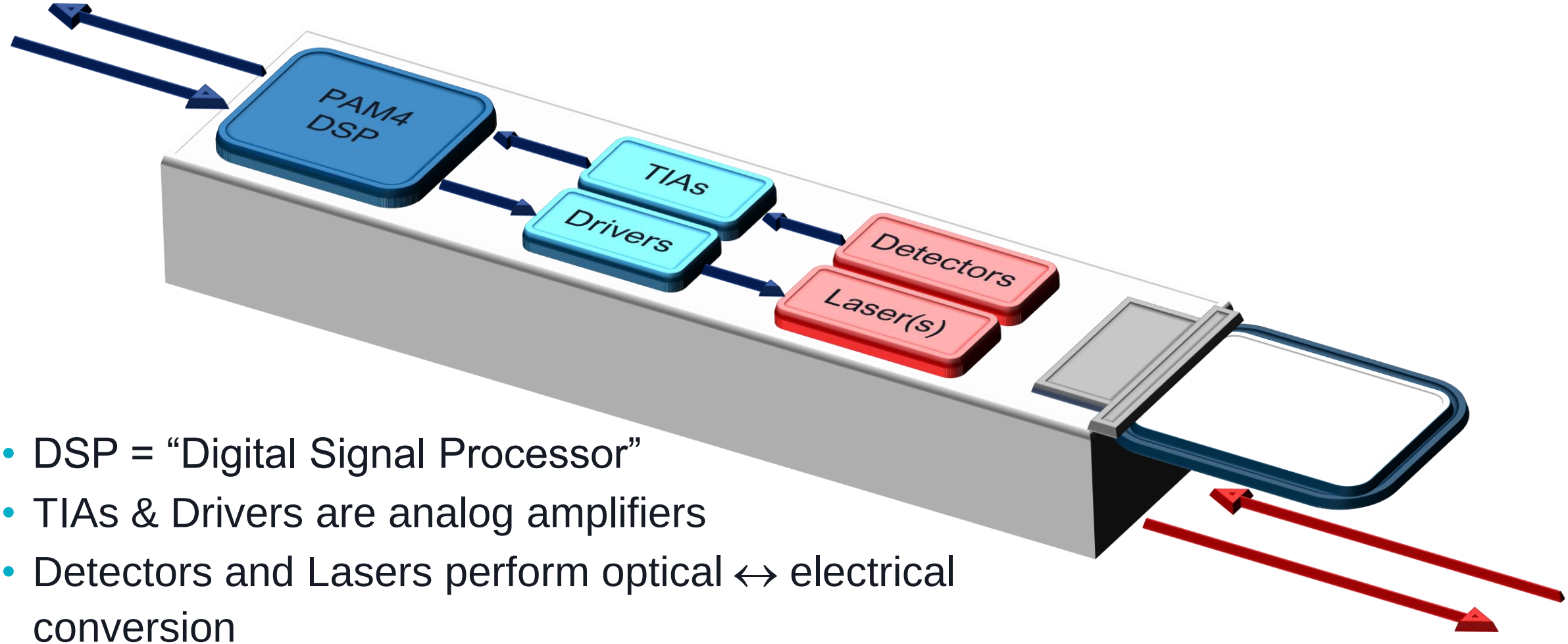
Norm Jouppi, … David A Patterson, “TPU v4: An Optically Reconfigurable Supercomputer for Machine Learning with Hardware Support for Embedding,” *ISCA*, June 21, 2023

Optical Modules



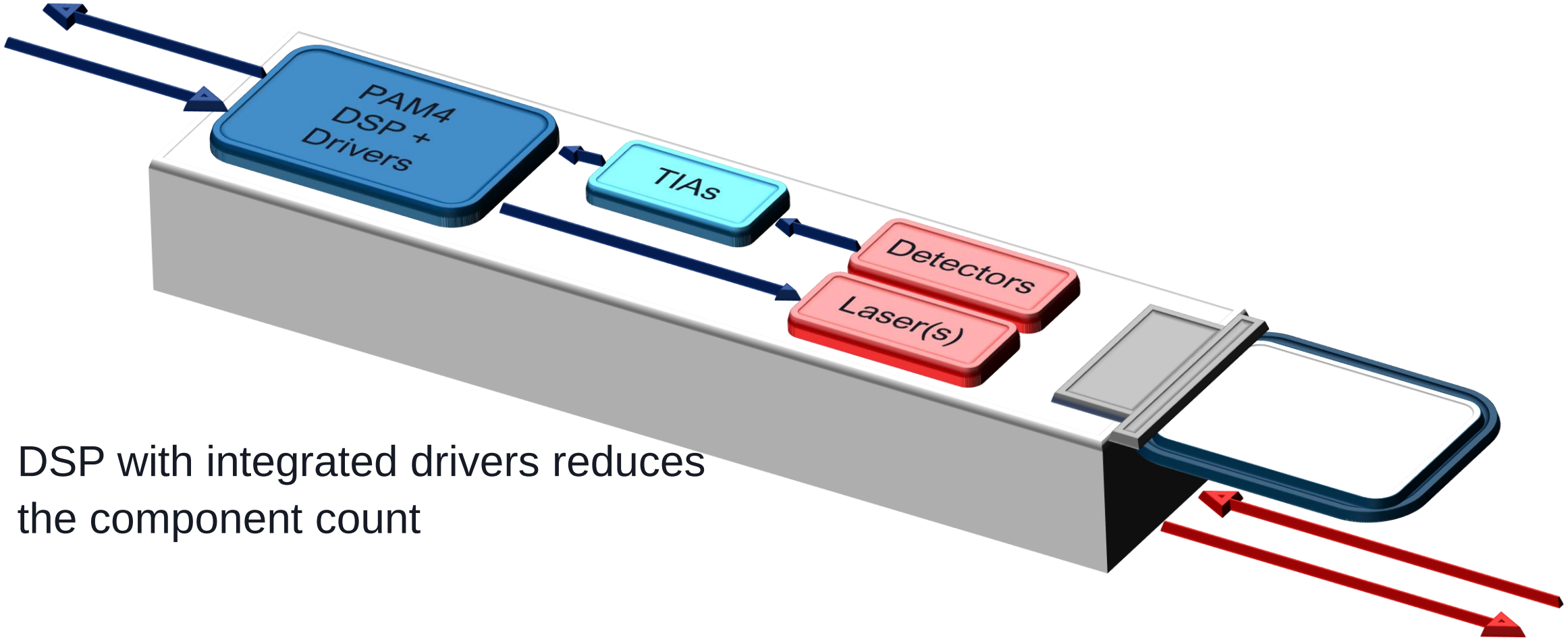
- Optical Modules house several complete and complex optical and electrical modems
- Modern state-of-the-art comprises 400G to 1.6T modules

Optical Module Anatomy



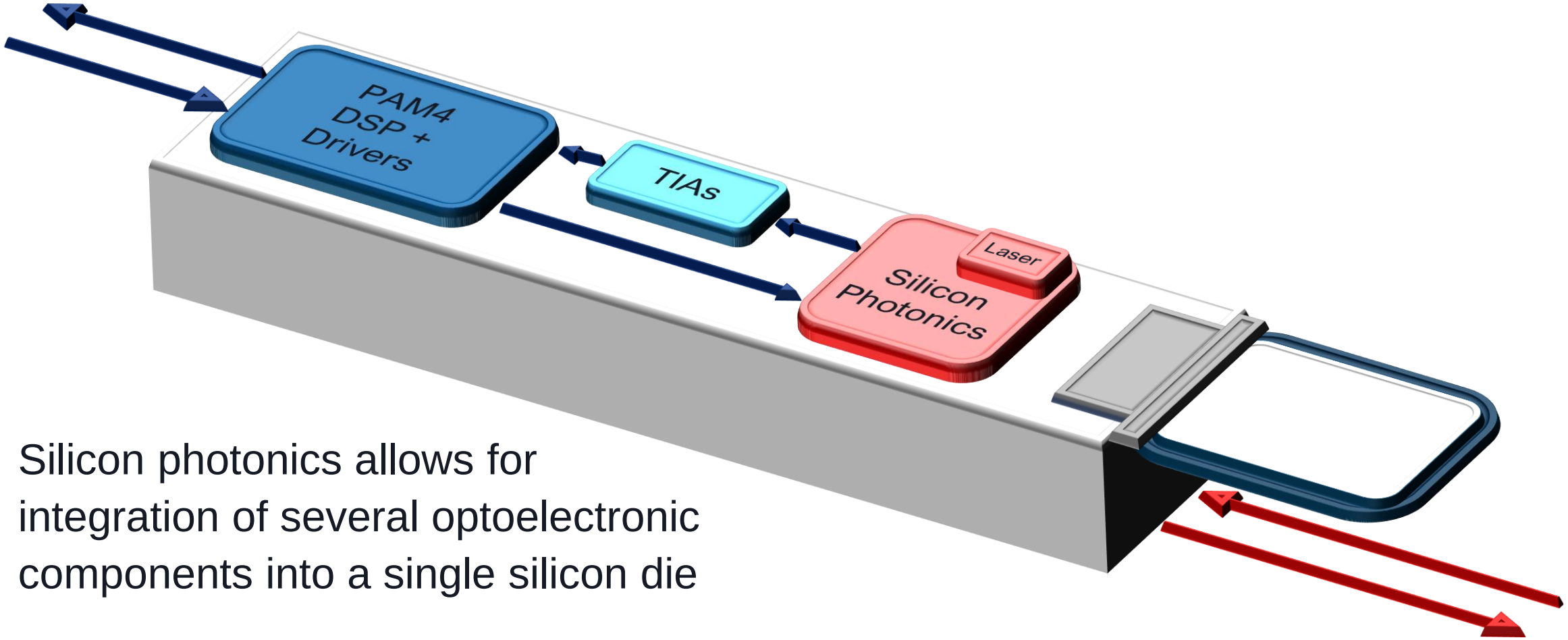
- DSP = “Digital Signal Processor”
- TIAs & Drivers are analog amplifiers
- Detectors and Lasers perform optical ↔ electrical conversion

Optical Module Anatomy



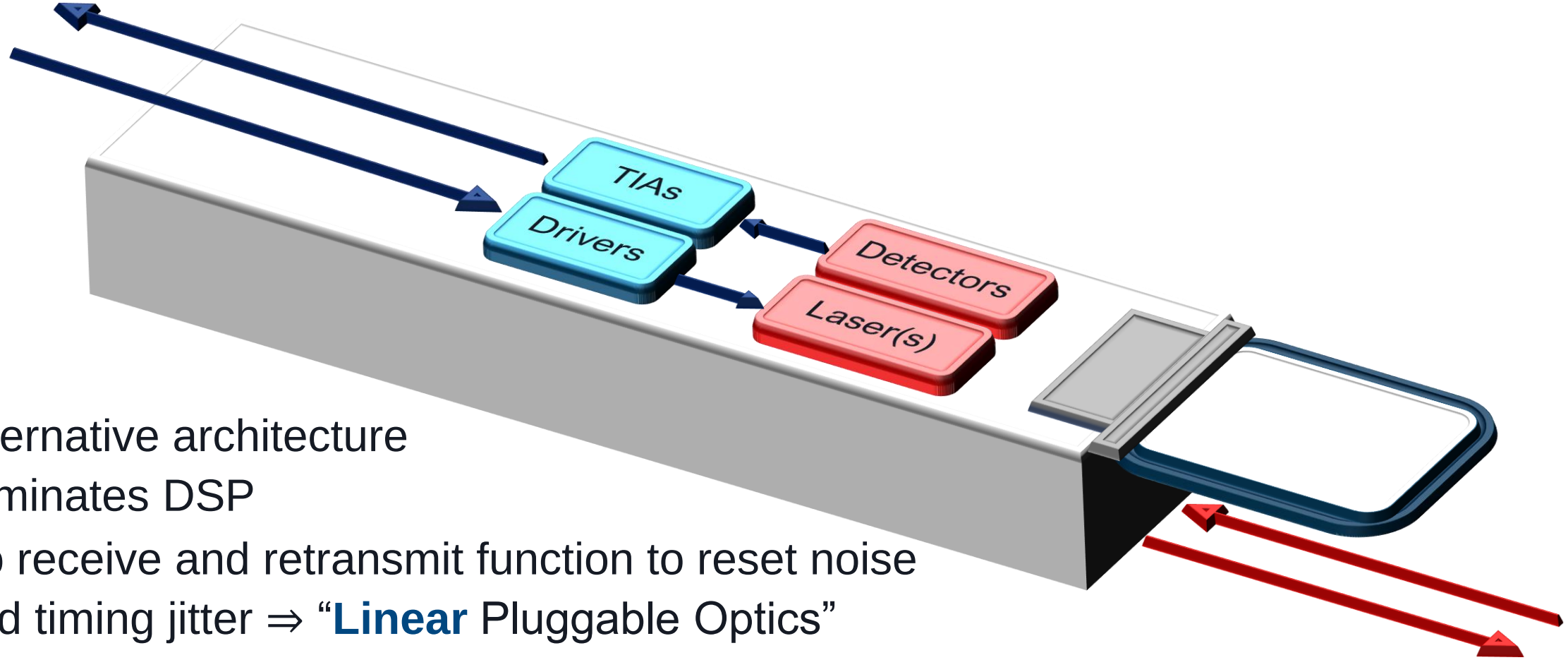
- DSP with integrated drivers reduces the component count

Optical Module Anatomy



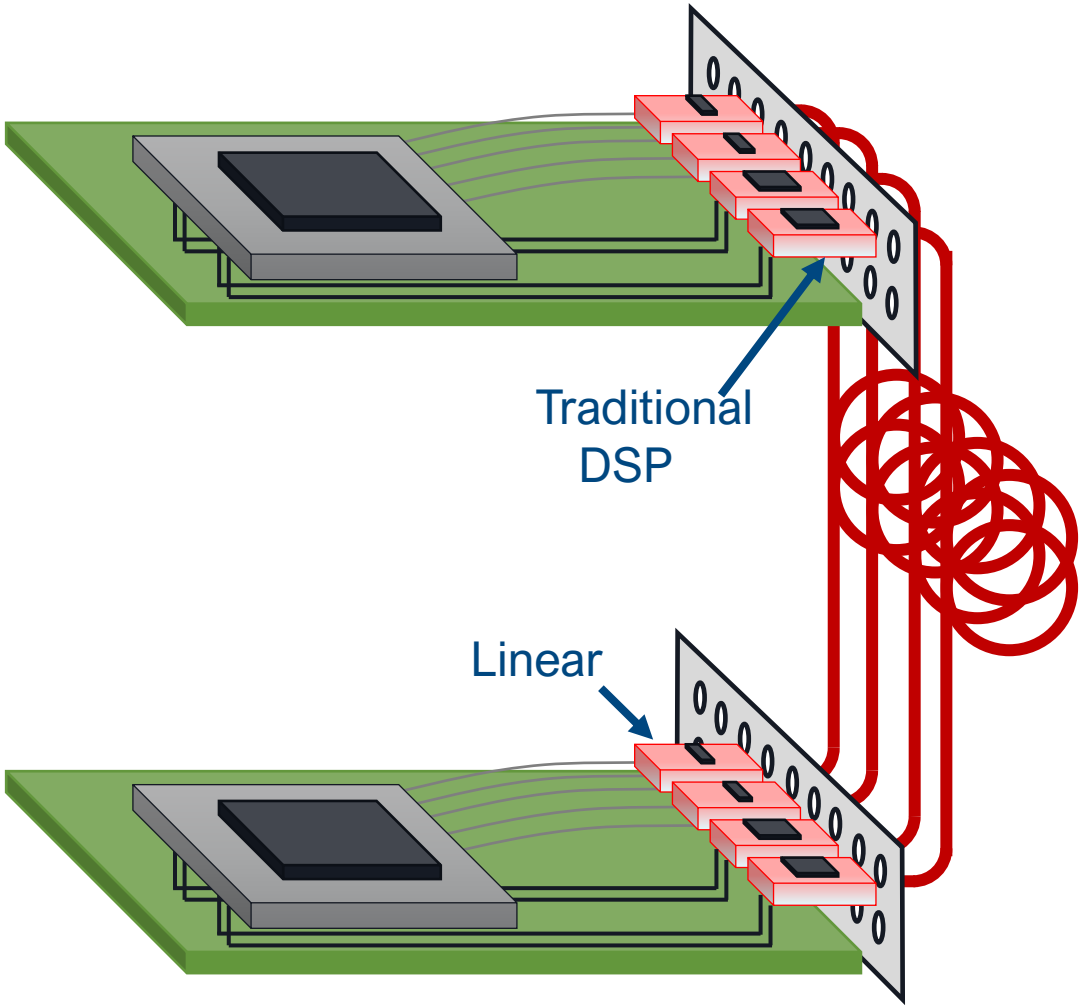
- Silicon photonics allows for integration of several optoelectronic components into a single silicon die

Optical Module Anatomy



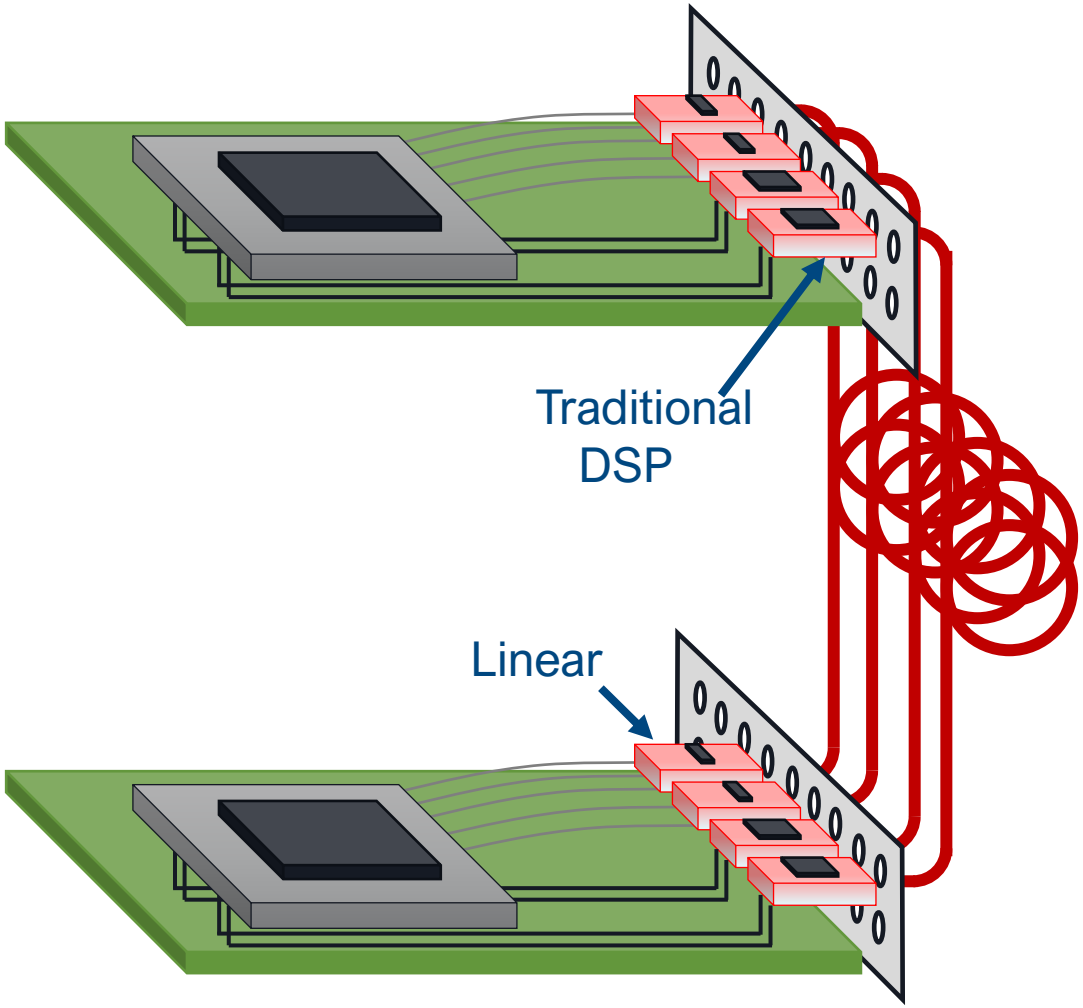
- Alternative architecture eliminates DSP
- No receive and retransmit function to reset noise and timing jitter ⇒ “**Linear** Pluggable Optics”

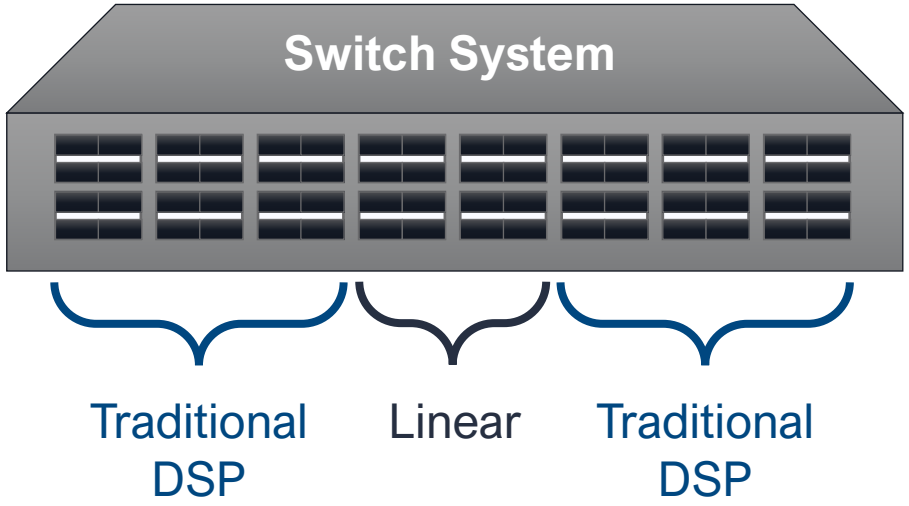
Traditional DSP vs. Linear Pluggable Optics



- Traditional DSP optical modules are a workhorse of optical connectivity
  - Robust and reliable
  - Backward & forward compatible
  - Robust ecosystem
  - Flexible deployment
- Linear pluggable modules create an end-to-end link where every intervening connection and component is interdependent
  - Potential for power and latency savings

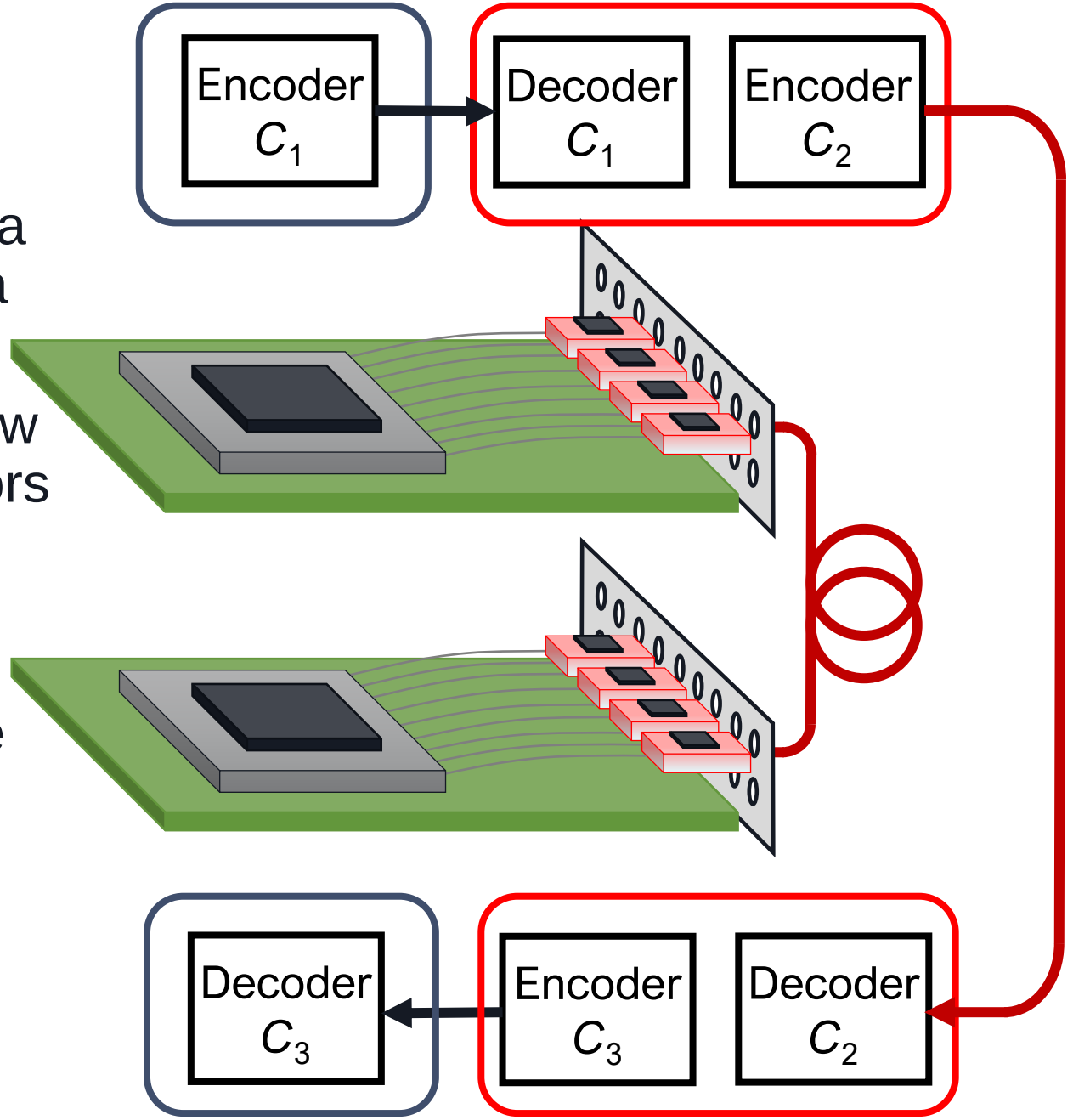
Traditional DSP vs. Linear Pluggable Optics





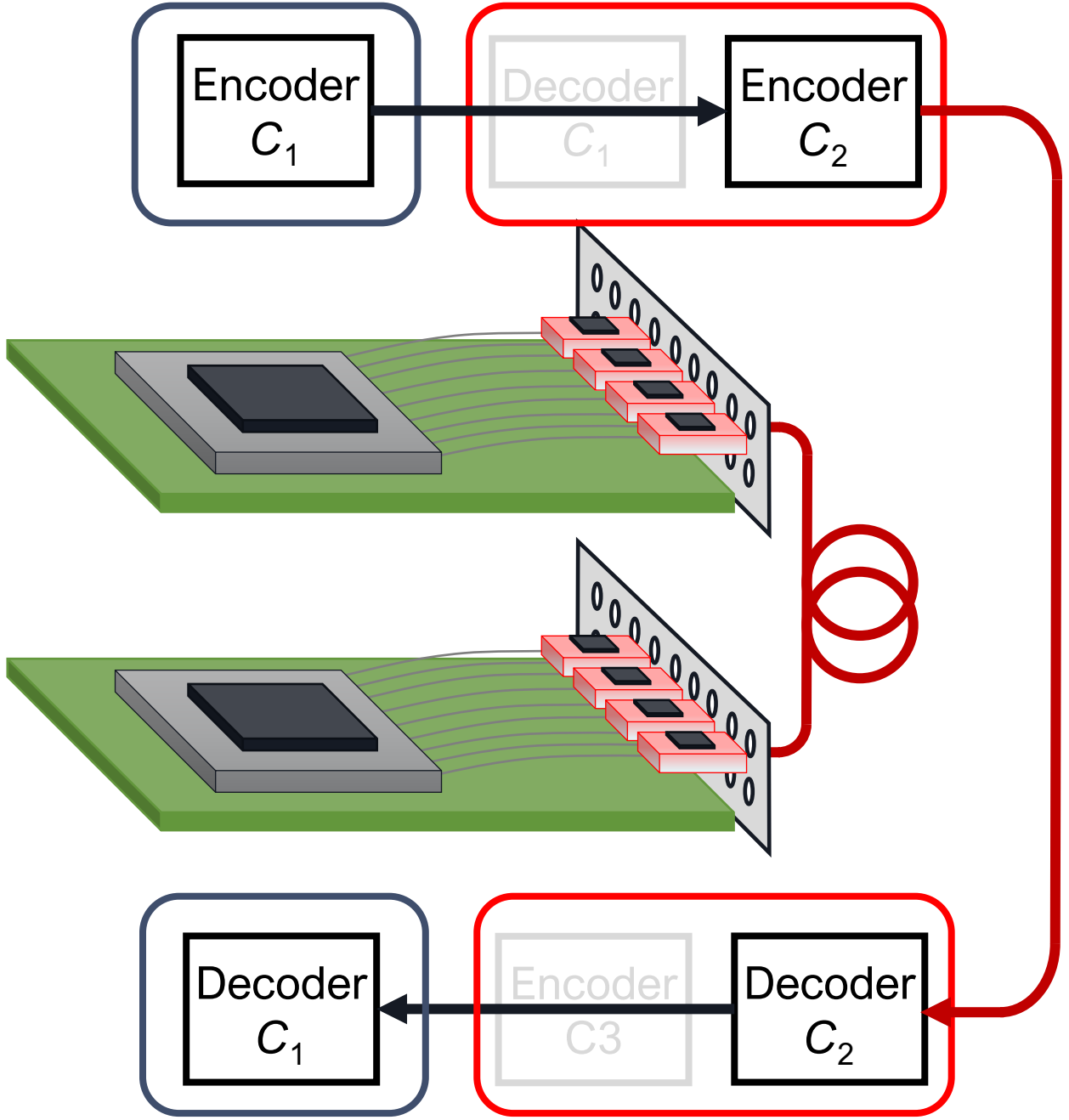
FEC Backgrounder

- Forward error correction has been a key component of optical links for a long time
- Encoders add redundancy that allow decoders to detect and correct errors in transmission
  - No retransmission required
    ⇒ “Forward” Error Correction
- Higer data rates are requiring more powerful FEC
  - More complex decoding
  - More power consumption
  - More latency



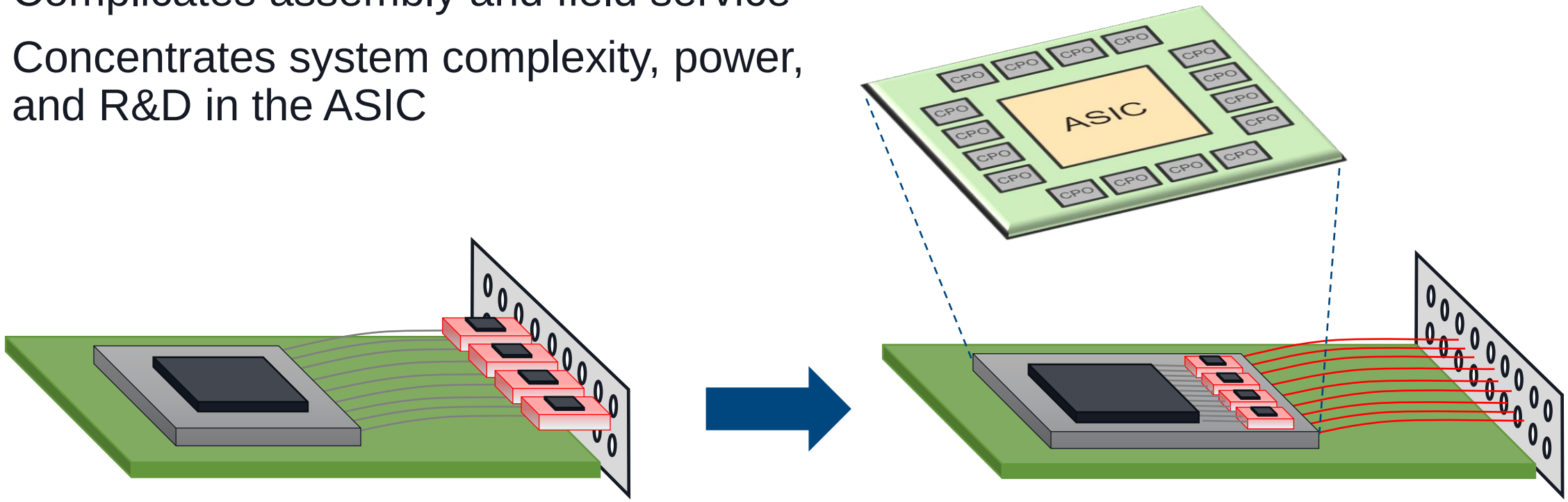
200G Concatenated FEC

- Concatenating codes provides double-protection to the optical link
- Allows for relatively simple constituent codes

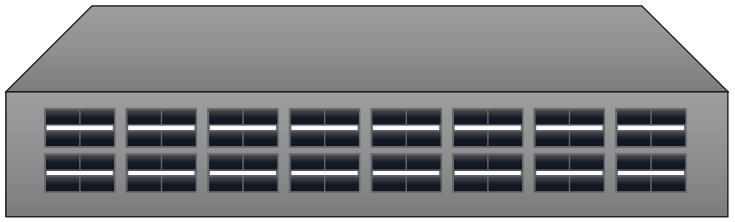


Co-Packaged Optics

- Shortens/eliminates the electrical link
- Complicates assembly and field service
- Concentrates system complexity, power, and R&D in the ASIC

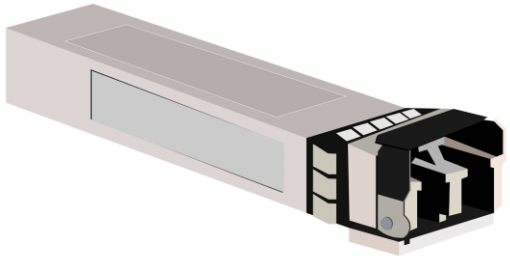


Evolution of Datacentre Rates



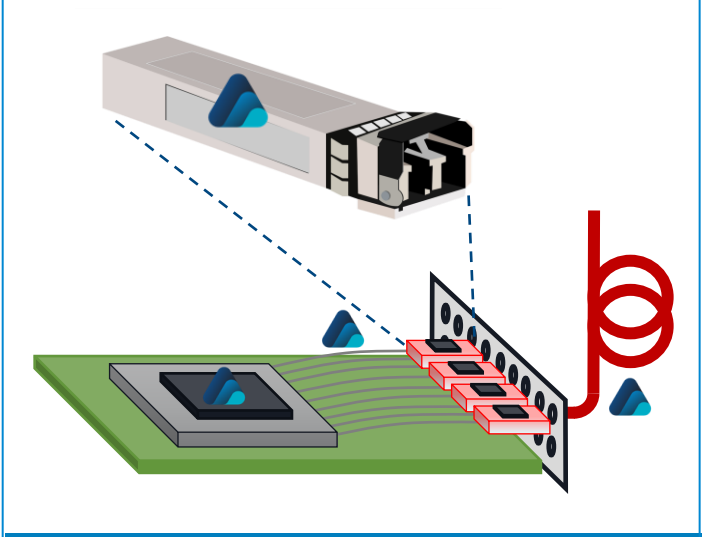
Switch Data Rates

Transceiver Data Rates



2017		2020		2022		2025
5Tbps	x2	12.8Tbps	x2	25.6Tbps	x2	51.2Tbps
100Gbps 4x25Gbps	x2	200Gbps 4x50Gbps 4PAM	x2	400Gbps 4x100Gbps 4PAM / 400G Coherent	x2	800Gbps 4x200Gbps 8x100Gbps 4PAM / 800G Coherent

Alphawave Solutions



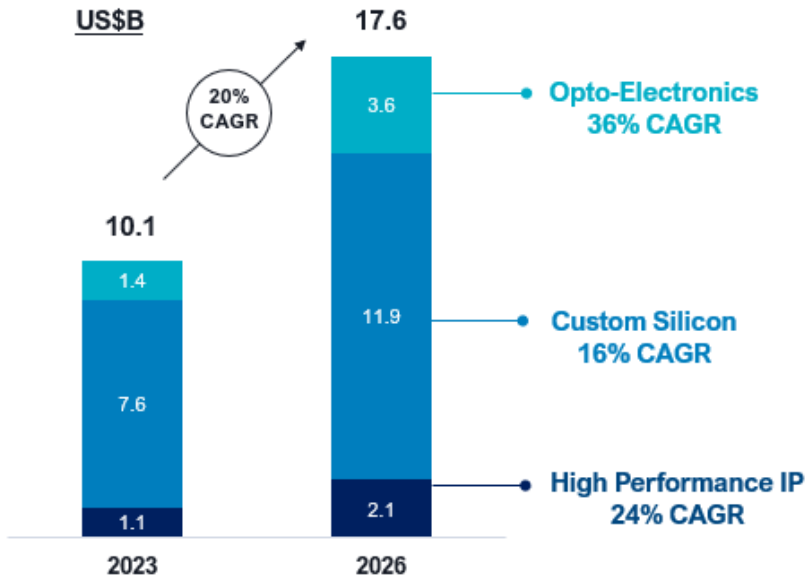
- Electrical and optical links
- Centimetres to kilometres
- Communication and compute

Connectivity Silicon IP

Custom Silicon

Connectivity Products

Addressable Market Expanding to $18B by 2026



Semico Research Corporation, December 2022, IPNest and Lightcounting

Summary

- Optical connectivity is playing a growing role in data centres
  - Higher data rates limit the reach of copper cables
  - High-bandwidth low-latency connectivity over longer distances is being required by scale-out of more compute and new network architectures
- Pluggable optical modules are a workhorse of data centre optical connectivity
- The DSP is the key component in pluggables, making them robust, reliable, backward & forward compatible
- The proliferation of optical connectivity in datacentres is making room for new technologies tailored to emergent demands