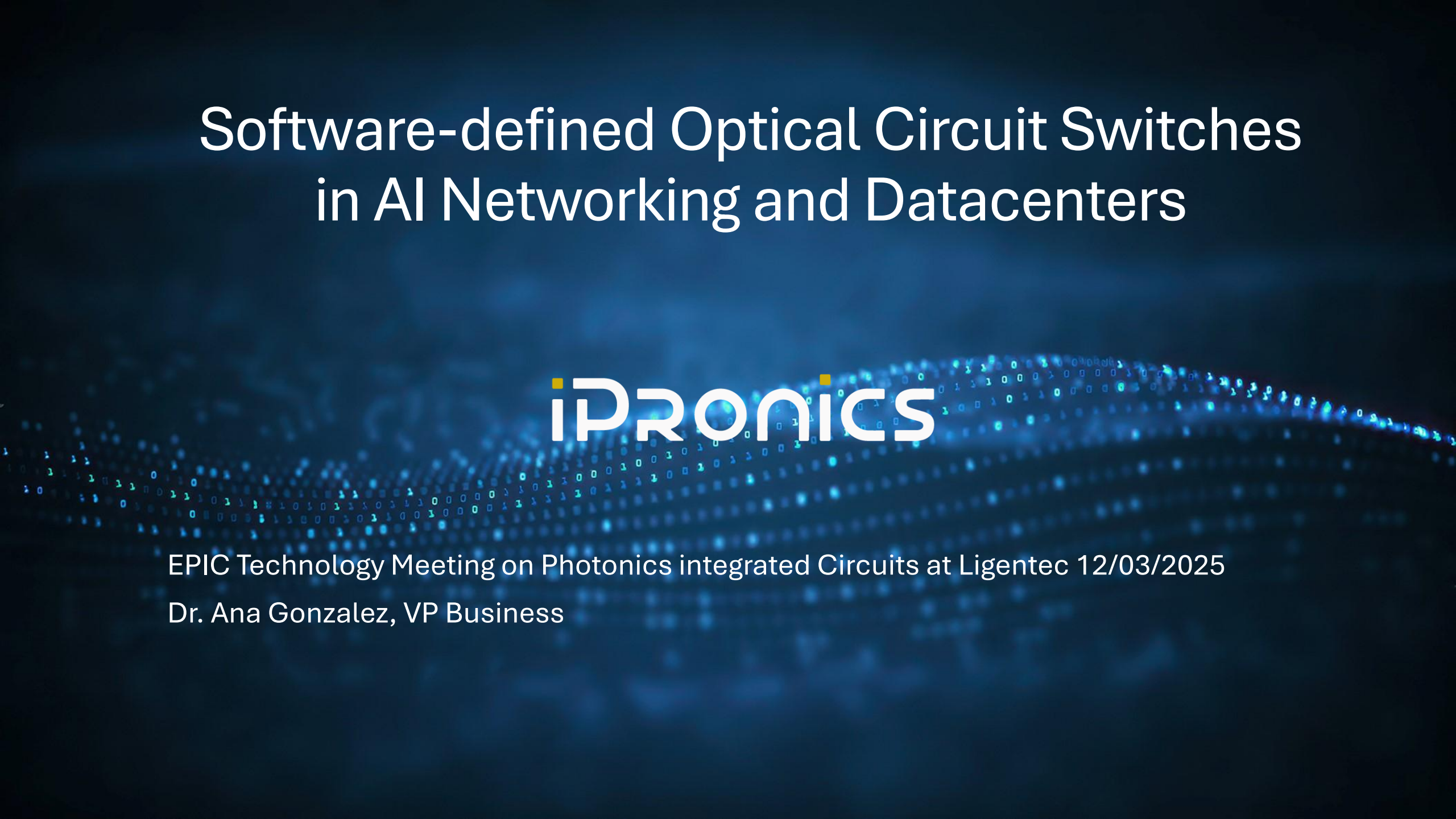
Software-defined Optical Circuit Switches in AI Networking and Datacenters



EPIC Technology Meeting on Photonics integrated Circuits at Ligentec 12/03/2025

Dr. Ana Gonzalez, VP Business

Summary

- Company description
- Problem
- Solution: optical switches
- Other solutions
- Applications and use cases

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

iPronics develops software-define SiPh engines

What is iPronics?

It was founded in 2019 as a UPV spin-off company.

The HQs are located in Valencia, Spain.

50 employees.
13 nationalities.
Mainly PhDs.

100+ years industrial experience.

10-year development of Software-defined photonics.

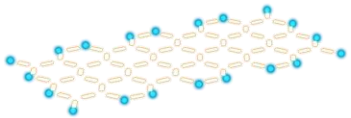
Our first product (general processor, FPPGA) shipped to up to 20 customers.

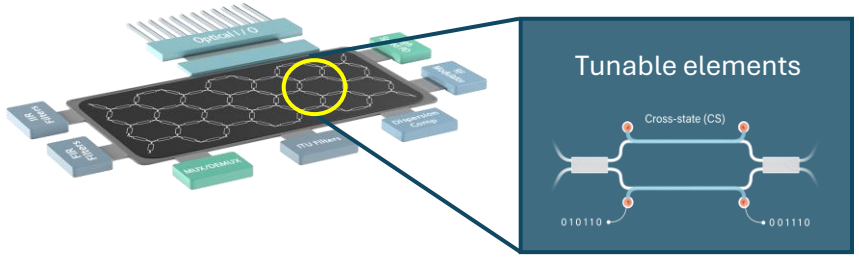
2023 2024 Silicon 100 EE Times 100 startups worth watching

2023 2024 The PHOTONICS 100 The industry's most innovative people

ONE TO WATCH 2020 nature research awards

iPronics Software-defined technology:





Software layer

orchestrates the entire system, provides calibration, automatic optimization functions, telemetry...

Electronic layer

controls thousands of phase shifters, ensuring precise adjustments for smooth data flow and dynamic reconfiguration.

Photonic layer

Mesh of discretize optical tunable elements 2x2 MMIs controlled by thermo-optical phase shifters,

Technology validation through an already deployed product:

NOKIA Bell Labs

Cornell University Founded A.D. 1865

PICadvanced Think outside the box with us!

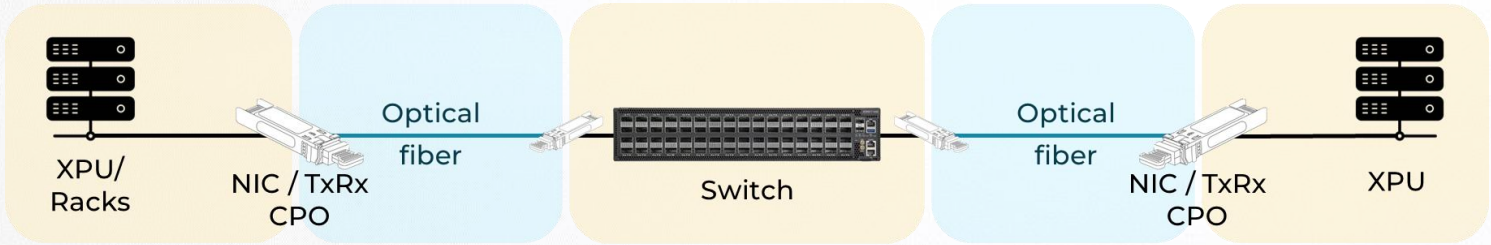
AKHETONICS

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

The Problem:

Data Centers and AI cluster performance is limited by Electrical Packet Switches (EPSs)

- Running AI models requires compute units to grow **x2 every year** reaching thousands GPU clusters
- **EPS doesn't scale in bandwidth**! Incremental deployments using EPS are expensive



Electronic Packet Switch

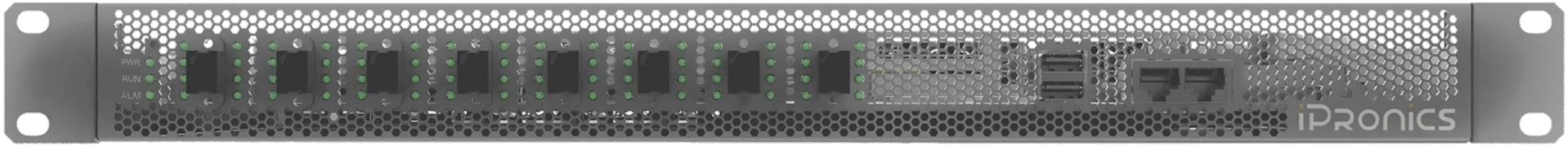
- Fiber optic links are widely used in datacenters with EPS, **optical-electro-optical conversion** necessary to connect such links are power hungry and very inefficient.
- An EPS provides **static links**.

Electronic switching capacity is not keeping up with traffic demands

CONFIDENTIAL. © iPronics

The Solution:

iPronics Optical Networking Engine



Compact 1U form factor.

ROUTING AT THE SPEED OF LIGHT

- **Lossless** routing of **full optical bandwidth** (full O band).
- No latency, no E/O or O/E conversions.
- Radix expansion (32, 64, 128, …).

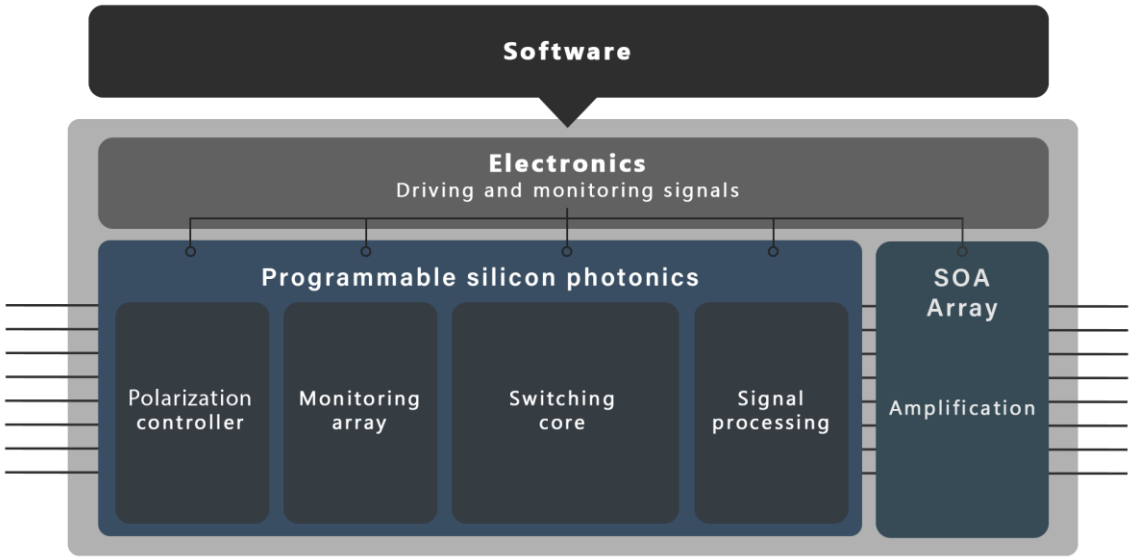
ULTRA FAST AI CLUSTER RECONFIGURATION

- **Reconfiguration**: <100 us.
- Low latency: < 30 ns.
- Compact 1U.

COST EFFICIENT AND PLUG & PLAY

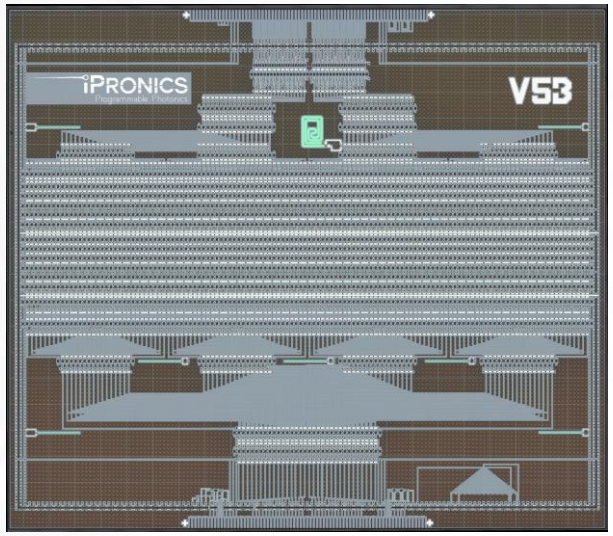
- Based on solid-state CMOs compatible fabrication technologies well-know by drastically reduce cost with volume
- SW API compatible with DC control software.
  - Yang models / Python / SDN protocols (gNMI, Netconf, …)

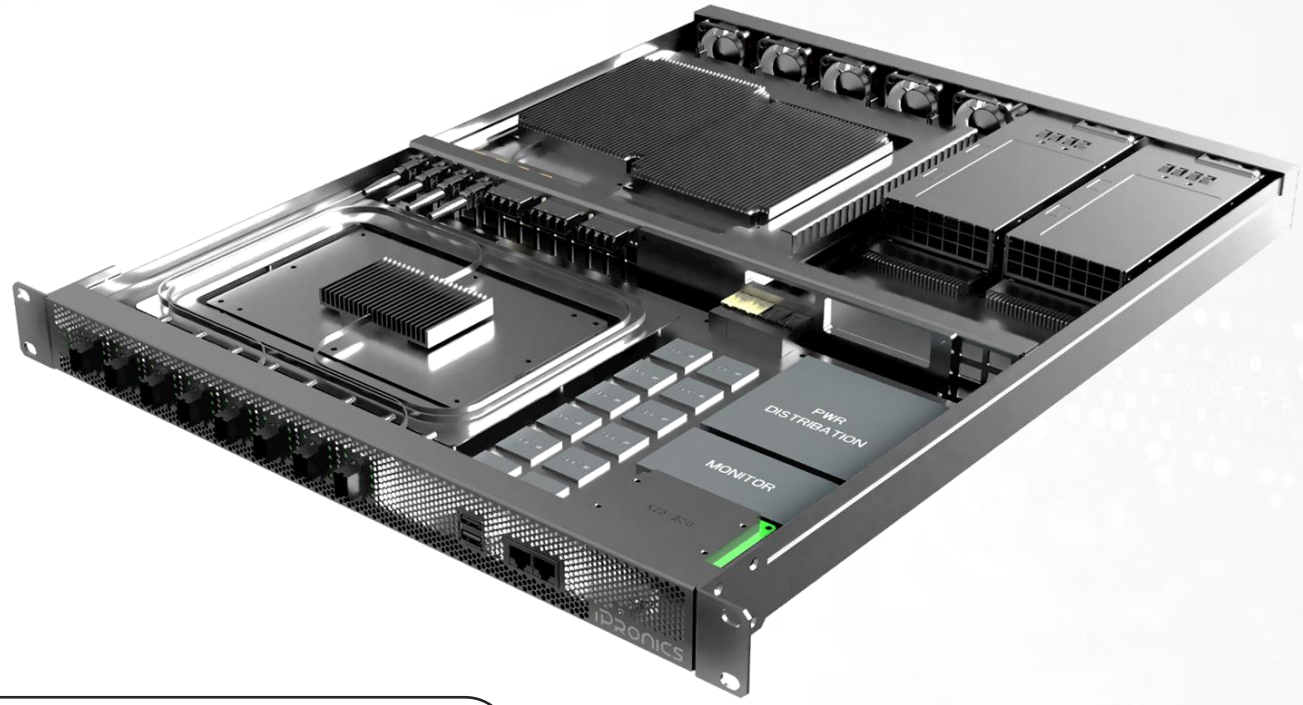
Patent filled



CONFIDENTIAL. © iPronics

ONE32





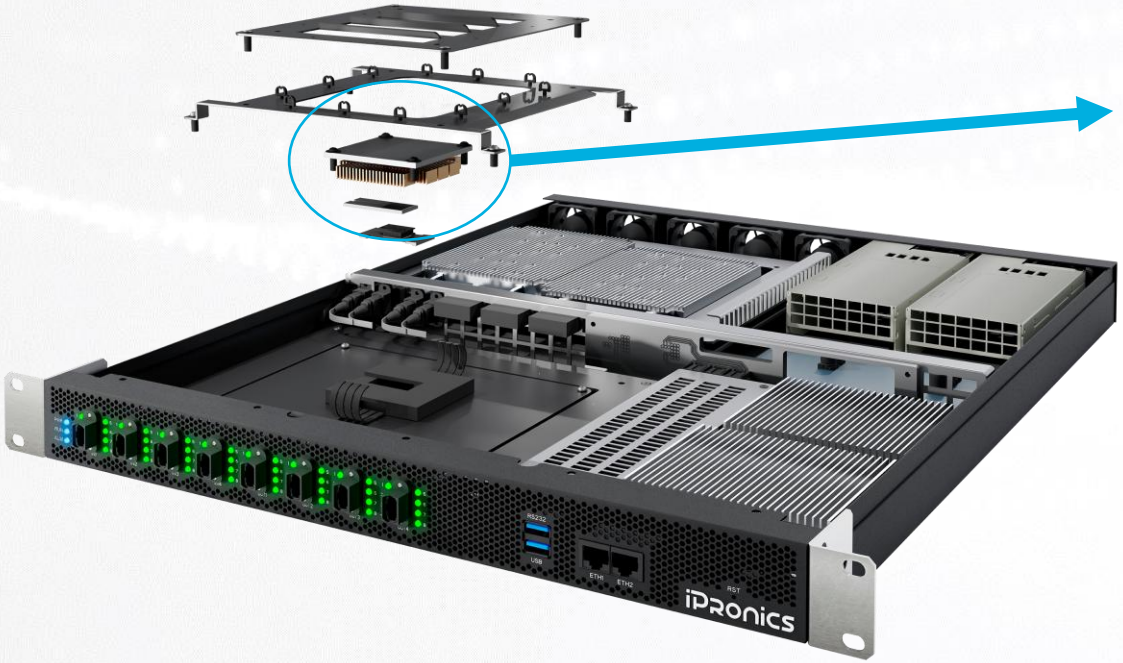
Technological challenges

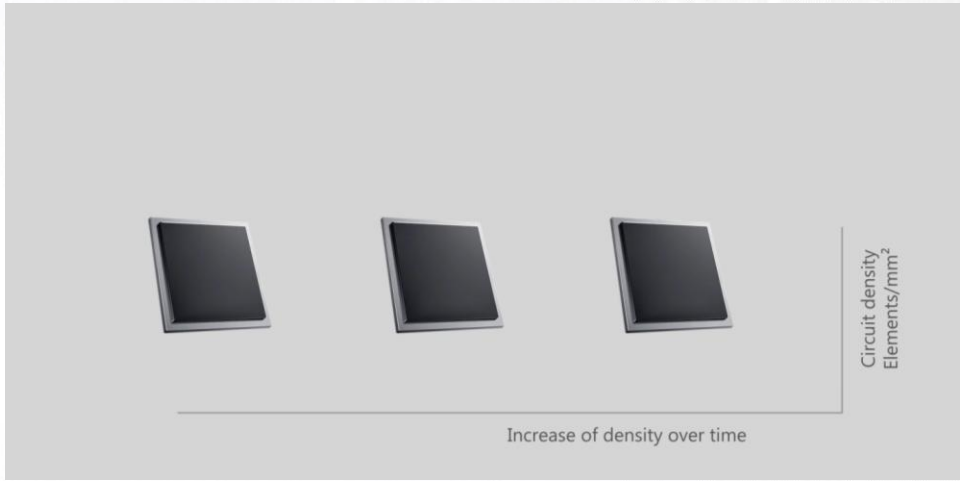
- **Fiber coupling:** edge coupling, losses <2 dB, multiple fiber size 32, 64…
- More **efficient MMI 2x2 designs**, better performance (flatness, low losses…)
- **Assembly:** more efficient way of connecting subsystems to reduce latency
- **Flip-chip bonding** for thousands of connections
- **SOAs**: O-band flat response, reduce BER

CONFIDENTIAL. ©iPronics

The Solution:

OCS: iPronics ONE





- Radix expansion keeping the same chip surface (increase of the integration density)
- Drastically reduction of losses in next fabrication iterations
- Reduced BER, reduced power consumption

Switching in the optical domain, compatible with different optics and datarates, and lossless and with a roadmap focus on efficiency

CONFIDENTIAL. © iPronics

Other Optical Circuit Switch technologies

MEMs based optical switches:

- Very transparent

But:

- Losses (it means it cannot be cascade)
- Bulky (5U)
- High cost/port (500 $)
- Low reliability
- Cross-talk during reconfiguration
- Low reconfiguration time

Companies developing MEMs based OCS have started shipping to hyperscalers in 2025

Coherent's latest optical circuit switch on display at OFC boasts 300 input and 300 output ports – Click to enlarge

CONFIDENTIAL. ©iPronics

The application:

Failure resilience:

- Multi-node AI/HPC applications rely on large networks and are highly susceptible to crashing when network elements fail.
- Resilience using OCS Matrices relies on the addition of OCS between the switching layers which dynamically rewire the network on demand.

“Optical switching for data centers and advanced computing systems” G.Patronas et.al NVIDIA Vol 17, No. 1 / January25/ Journal of Optical Communications and Networking

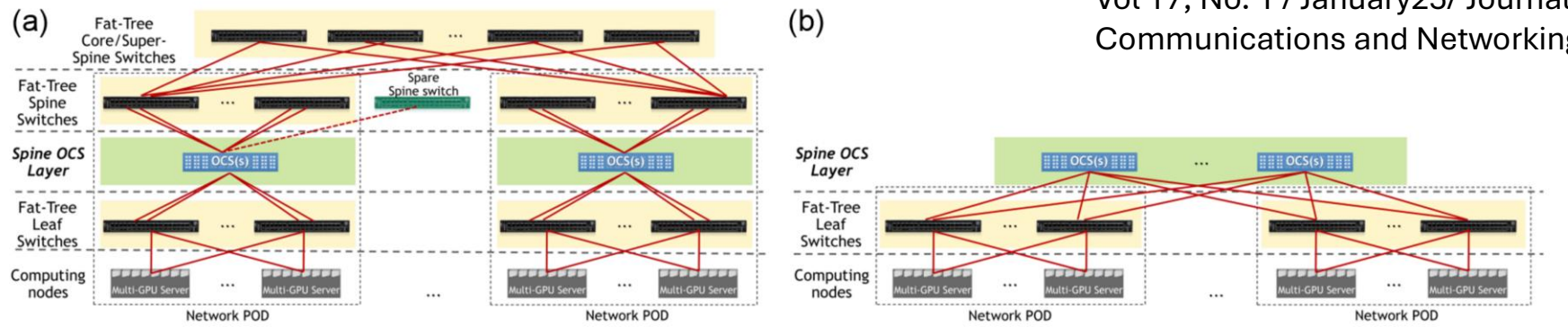


Fig. 2. (a) Introducing an optical switching layer (OCS spines) between the leaf and spine switches, (b) replacing the spine and core switching layers with a layer of optical switches.

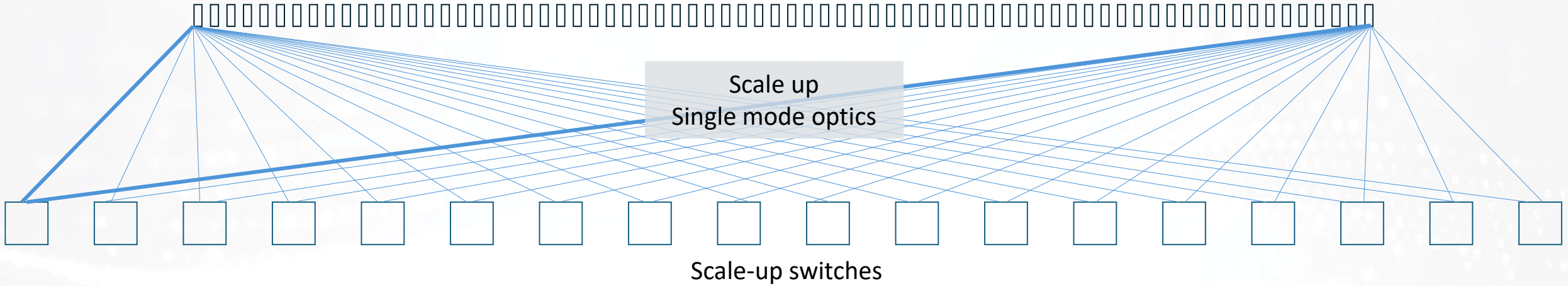
Link failure event is mitigated within 4 s on NICs 100G

OCS can mitigate the crash of large networks when an element fails

CONFIDENTIAL. ©iPronics

The application:

Scale-up networking



- Each GPU is connected to a DR+ transceiver and/or CPO IO solution (OCS doesn't care).
- DR channels define the number of switches and the total bandwidth per GPU.
- OCS must be cost-effective to be introduced in the network.
  - x2 cost reduction, x2 power consumption reduction at endpoints.

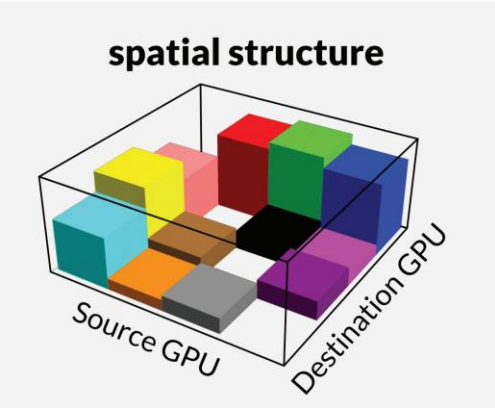
Key OCS KPIs are cost/port < 200$, low form factor 1U, low power consumption < 200W, and radix 32, 64, 128.

CONFIDENTIAL. ©iPronics

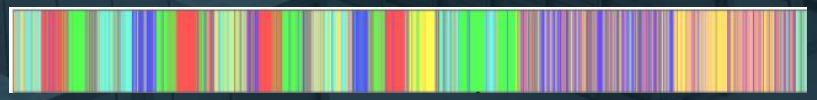
The application:

The applications: reconfigurable topologies
Optical switching technologies allow to quickly change the network topology

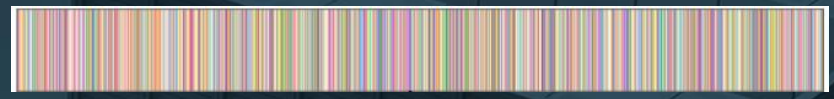
- Current data center technologies are optimized for uniform “all-to-all” traffic (fat-tree topologies)
- However, actual traffic patterns in datacenters feature spatial and temporal structures.
- Benefits of changing the network topology on demand:
  - Adapt topology to traffic demand.
  - Provide topology shortcuts, reducing multi-hop forwarding and saving bandwidth and latency.
  - Optimize the rack-to-rack interconnects towards elephant flows.



Traffic Traces for ML (frequency of links for 4 GPUs)



Uniform



“On the Complexity of Traffic Traces and Implications” Chen Avin et. Al.
“Revolutionizing Datacenter Networks via Reconfigurable Topologies” Chen Avin et. Al.

WE ARE HIRING!

Recent support to accelerate the deployment of ONE:

- **Series A Round**
- **Accelerator**
- **IPCEI**

CONFIDENTIAL. © iPronics

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

iPRONICS

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.

CONFIDENTIAL. ©Property of iPronics Programmable Photonics S.L.