

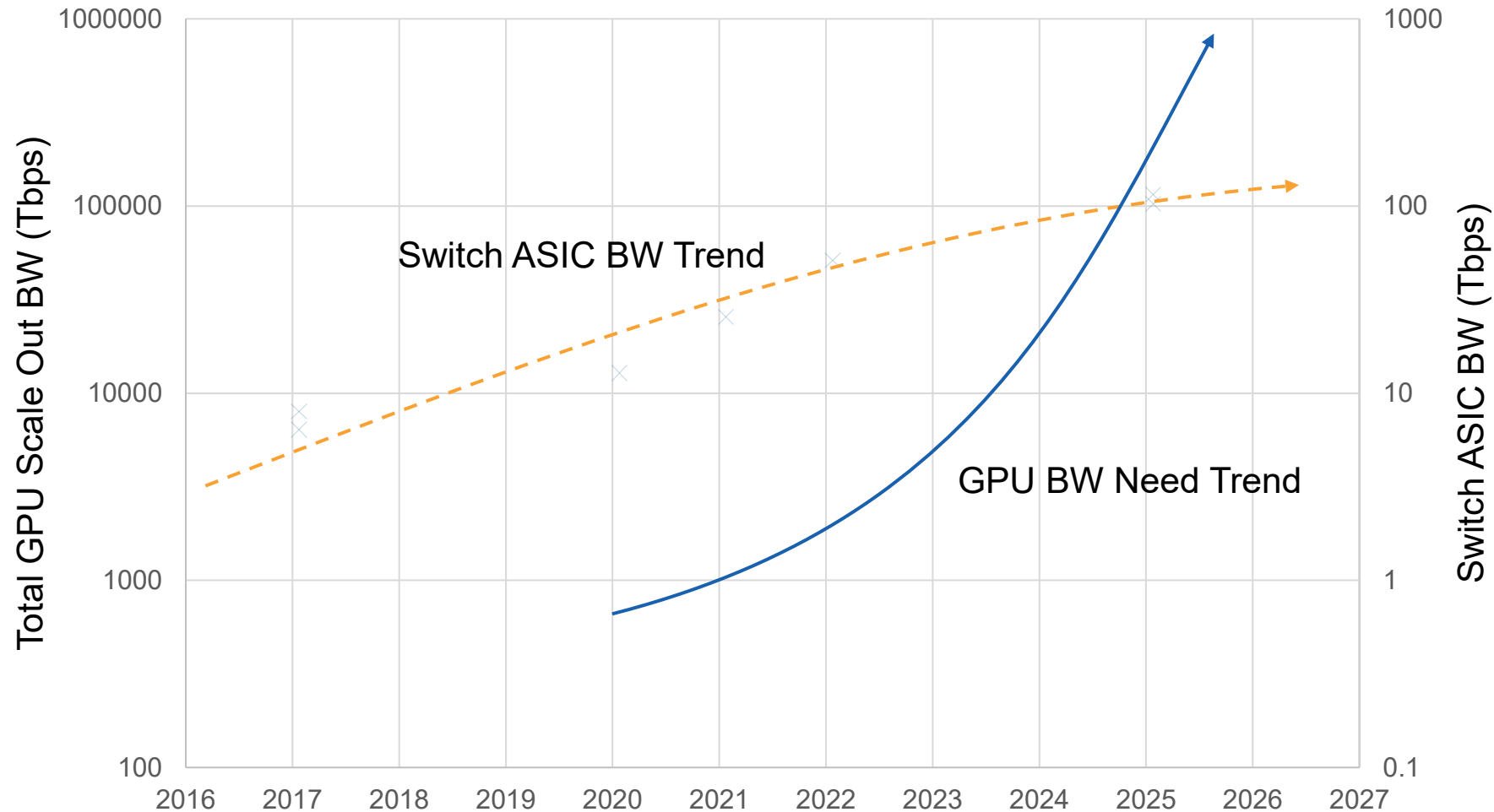
An Overview of OCS Technology and Applications

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Why Do We Have A Scaling Problem?



BW need growing at far higher rate than switch ASIC BW



Number of switches, optics modules and cables is exploding

Image references: <https://www.broadcom.com/company/news/product-releases>

Network Requirements and Challenges for AI

In an AI cluster network performance drives system performance

AI Networks Need



Massive Interconnect

- Challenge: Electrical switch radix is a limitation



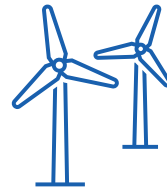
High Reliability / Availability

- Challenge: Huge number of elements drive more potential points of failure



Extreme Bandwidth

- Challenge: Switch ASIC BW is a constraint



Sustainable Power Scaling

- Challenge: Switch ASICs and optics DSPs are power hungry

Optical Circuit Switching

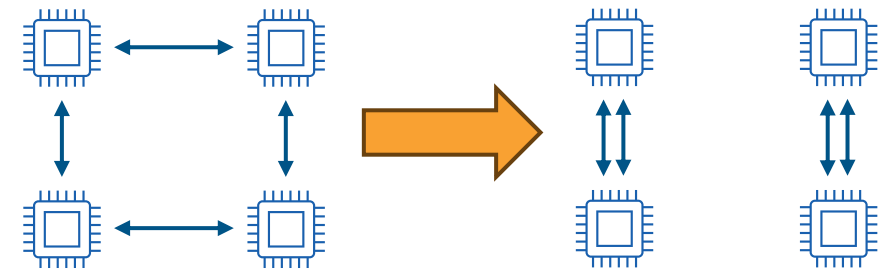
OCS allows dynamic reconfiguration of optical network links

Can happen at chip, box or fabric scale

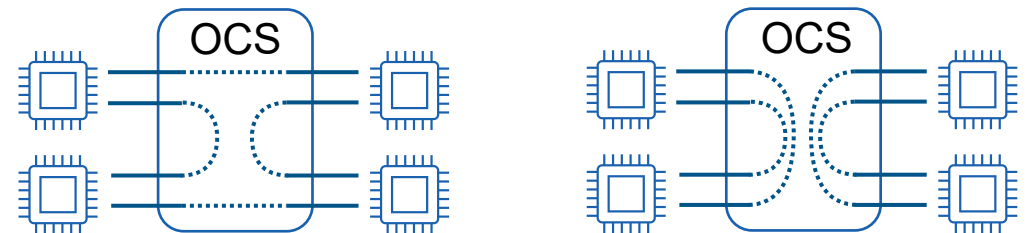
Typical Characteristics (box scale)

- Passive optical device
- No traffic processing is performed
- 1-3dB+ insertion loss
- Usually two-sided; all-to-all also possible
- Often supports bi-directional use
- Usually single fiber, multi-fiber possible

Logical Topology



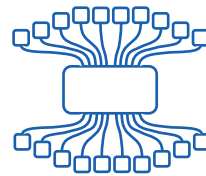
Physical Connections



OCS benefits

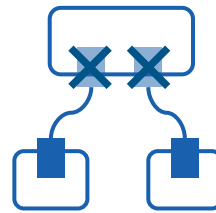
No O-E-O conversions at switch

- ✓ Reduced power consumption
- ✓ Link BW limited only by fiber capacity
- ✓ Highly deterministic, low latency
- ✓ Data rate and protocol agnostic



Natively high radix

- ✓ Enables flatter networks with fewer planes



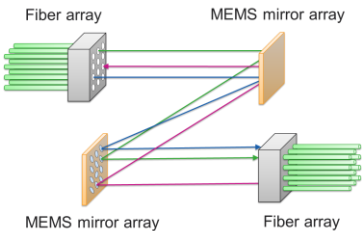
50% fewer optical modules in links

- ✓ Reduced capital cost
- ✓ Improved network reliability

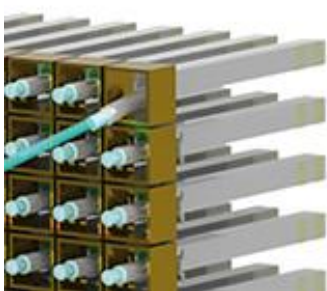
- OCS can bring significant benefits but needs the right applications
- Deterministic traffic patterns of AI workloads are a great fit for OCS

OCS Technology

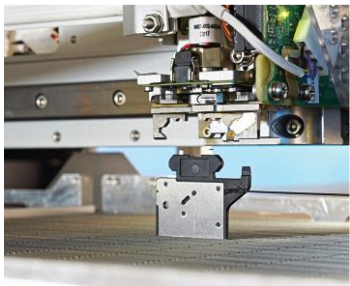
MEMS



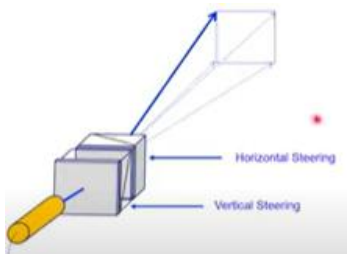
Piezo-electric



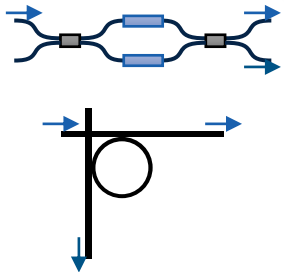
Robotic



Liquid Crystal



Waveguide (SiP)



IL	Low-Med	Low	Low	Low-Med	Med-High
Radix	High	High	Very High	Medium	Low-Med
Speed	Medium	Medium	Slow	Medium	Fast
Maturity in OCS*	>10 yrs	>10 yrs	>10 yrs	<2 yrs	Future
Vendor Support	Many	One	Few	One	Many

* Maturity defined as years that a technology has been used in commercially available OCS devices

Image references: Lumentum [MEMS], Huber+Suhner Polatis [piezo-electric], Eaton [robotic], Coherent [liquid crystal]

Lumentum MEMS technology advantages

▪ Single-crystal silicon MEMS design

- Hinge stress $\ll$ single crystal fatigue strength $\rightarrow$ ie. no 'wear out'
- Similar designs tested to 100s of millions of cycles with no failures

▪ Field-proven reliability

- ~150K MEMS-based wavelength switches deployed in telecom
- >1 trillion mirror operating hours

▪ Performance

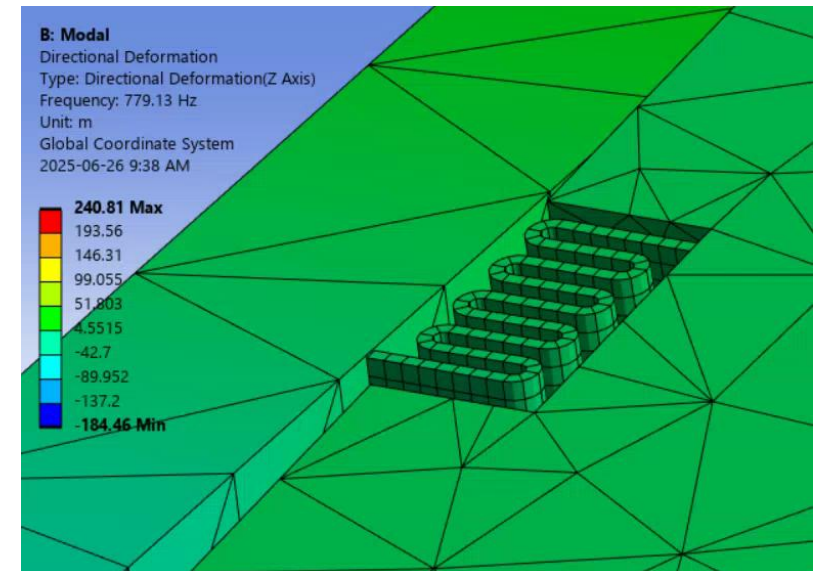
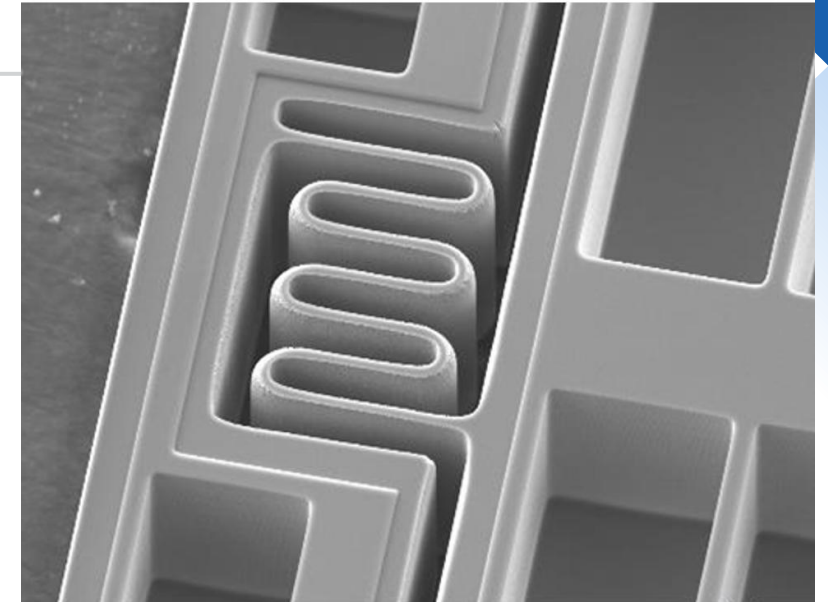
- Low loss
 - typical <1.5 dB
 - Max (all conditions, EOL) <3dB
- No dither (or other) noise

▪ Transparent

- Supports O, C and L band with good performance
- Fully bit-rate transparent

▪ Stability

- No measurable response to 5-100Hz (GR-63 / GR-1360)
- <0.3 dB variation for 3G shock (ETSI EN 300 019)
... but not latching



Lumentum OCS R300

300x300 Radix

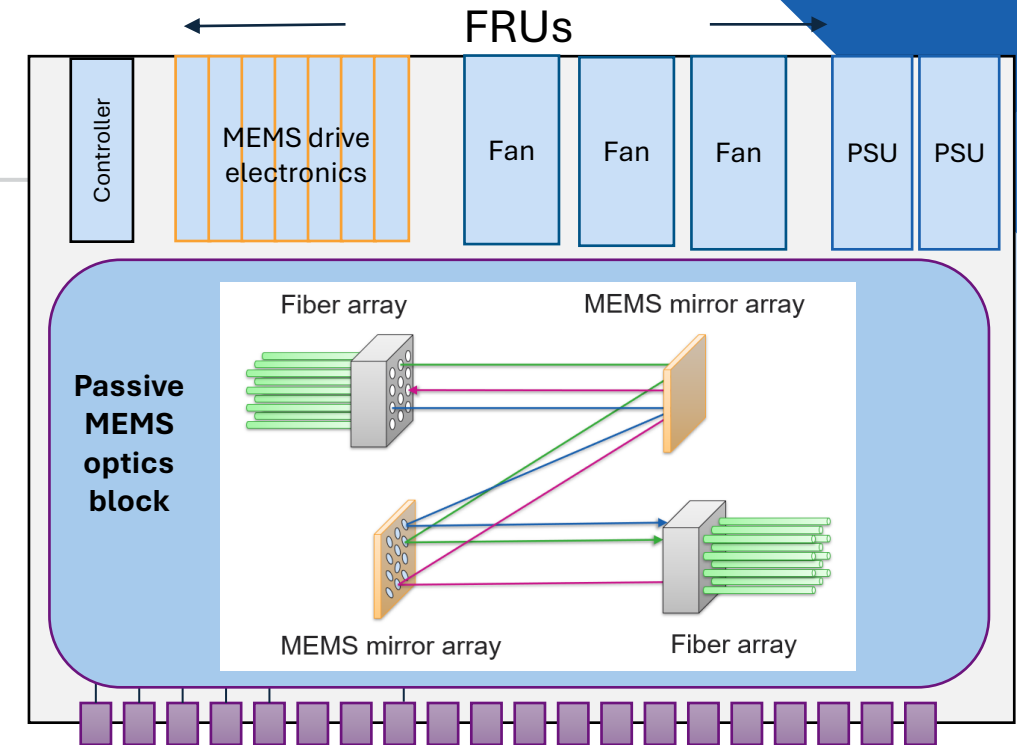
- Supports 300 duplex or 600 bidi links in two side configuration

Key benefits

- Ultra wide band: O + C Bands
- Low IL: typically, <1.5 dB in O band
- Use any data rate/modulation format today or tomorrow
- Field-proven, ultra-stable MEMS technology

Architected for the data center

- High availability with modular electronics, power and cooling
- SONiC-based OS with gNMI connection management



Front View

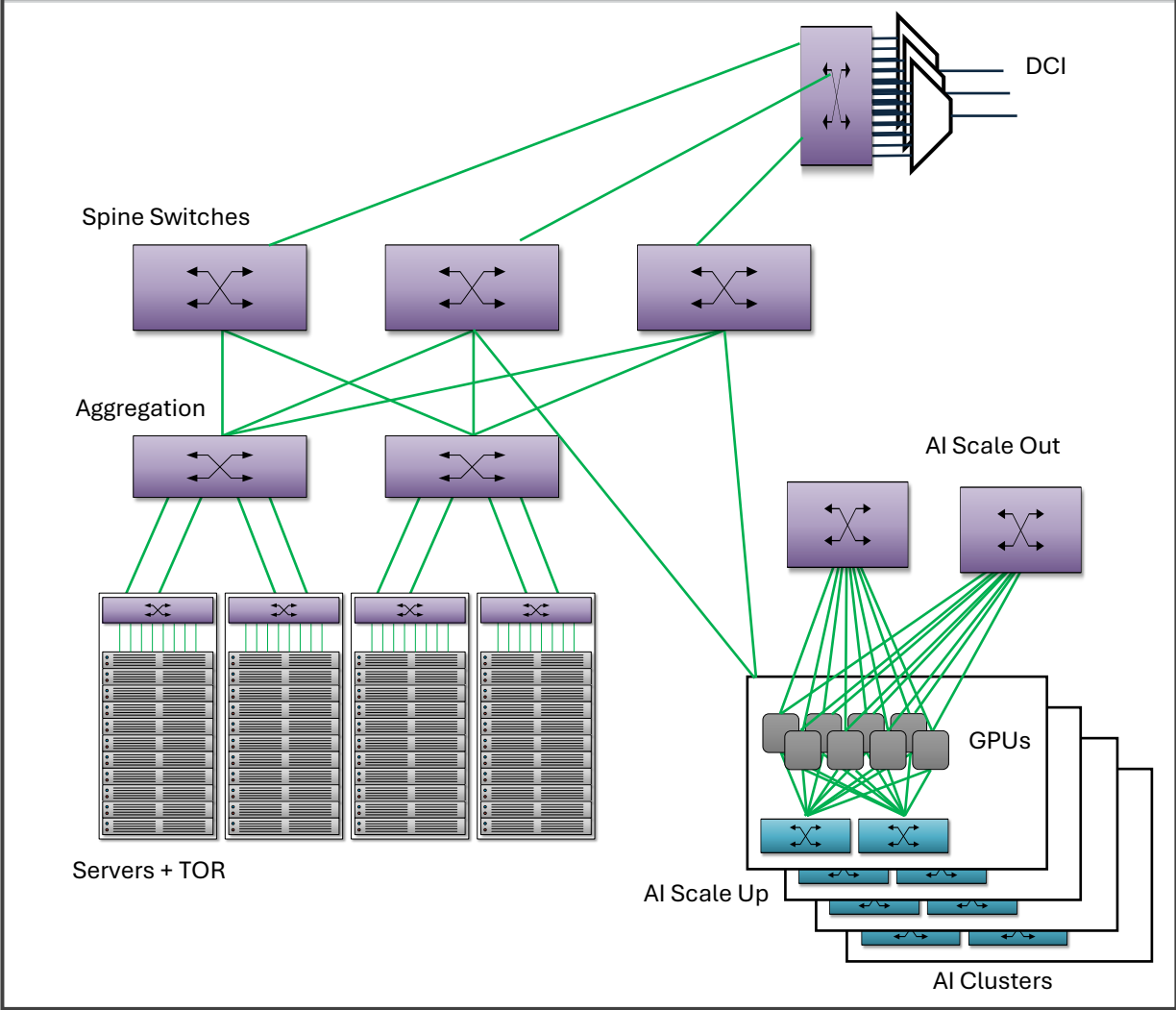


Rear View

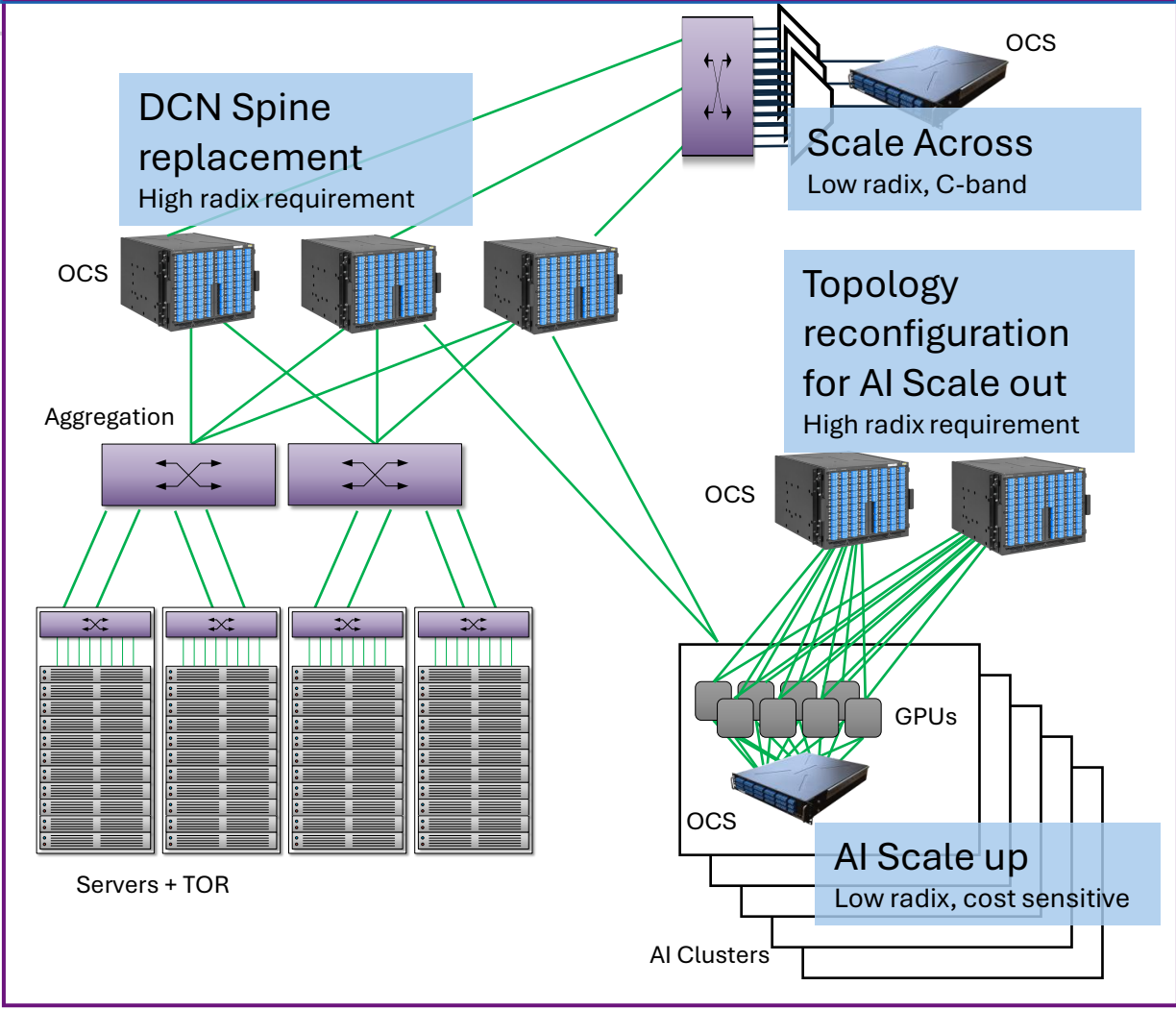


Applications for OCS

Today's Data Center

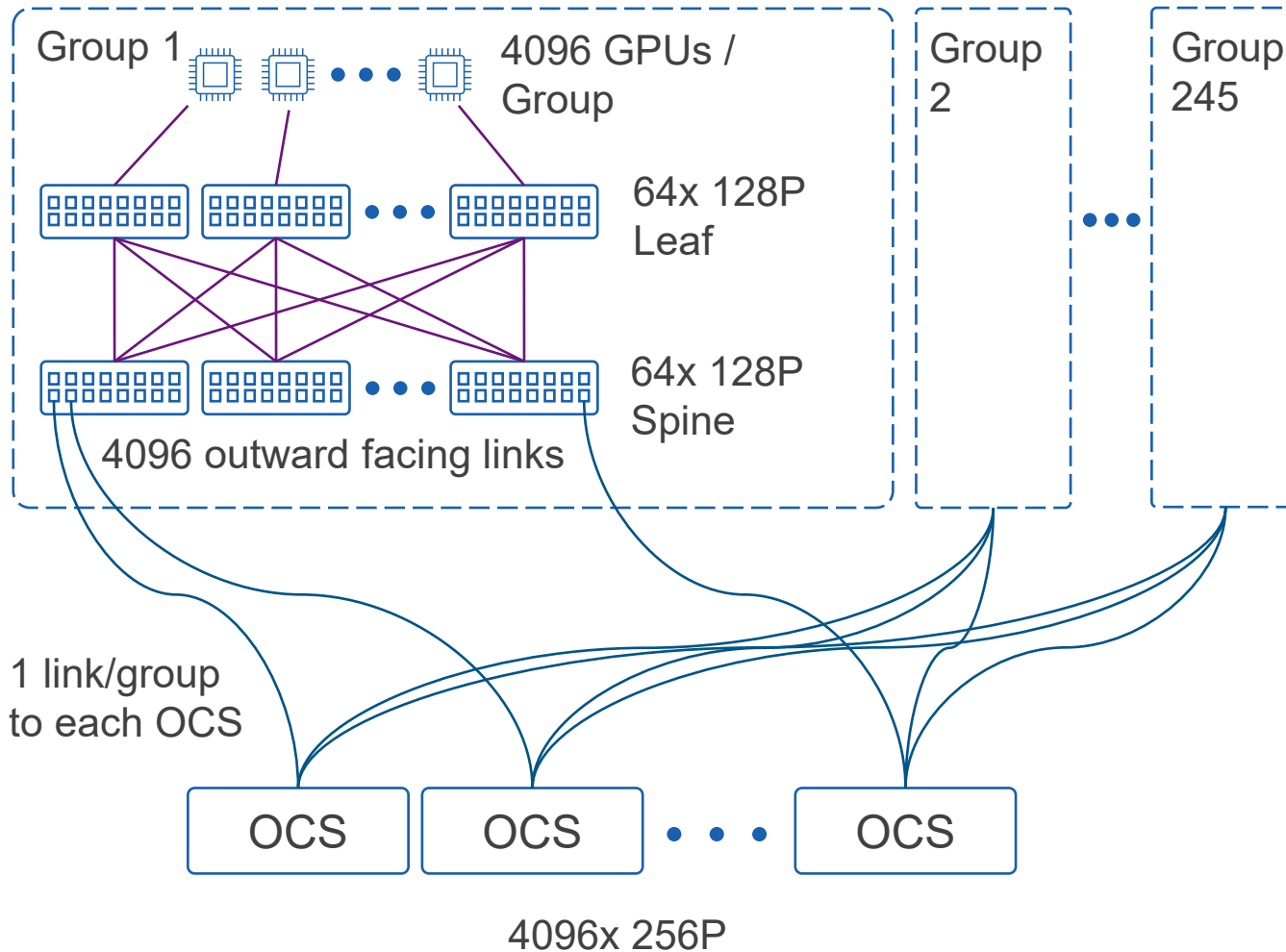


Tomorrow's AI Data Center



Improving Cost, Power, and Reliability

1M GPU Cluster Example



OCS Network Role

- Top layer interconnect in a very large scale AI cluster
- Creates reconfigurable dragonfly+ topology

Solution Benefits

- Massive scale with minimal packet switch layers
- Configurable inter-group BW
- Lower cost and power compared to all EPS
- Easy incremental deployment

Opportunities for OCS Evolution

- Multi-hop optical switching
 - Further strain on link budgets
 - Amplification requirement?
- Faster switching
 - Today: milliseconds for topology reconfiguration and failure restoration
 - Future: microseconds/nanoseconds for optical burst switching?
- Wavelength selective switching
 - Products exist today, but loss and cost challenges in data center applications
- Very high radix OCS (>1000 ports)
 - Opportunity for increased network scale
 - ... but increased blast radius risk

Key Take Aways

- Traditional way of building networks does not scale in the AI era
- Industry must leverage new ideas and new technologies to address new applications
- OCS is one tool that can help with power, cost and reliability
- Future ready and complements technologies like CPO and high radix EPS

Thank You

