



## nfrastructure

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### Agenda

- **Enabling Al Infrastructure:** Charlie Kawwas
  - Scalable Al Networks: Ram Velaga
  - Al Server Interconnect: Jas Tremblay
  - **Optical Interconnects:** Near Margalit
  - Foundational Technology for Al Interconnect: Vijay Janapaty
  - Custom Al Accelerators: Frank Ostojic
  - **Closing Remarks:** Charlie Kawwas

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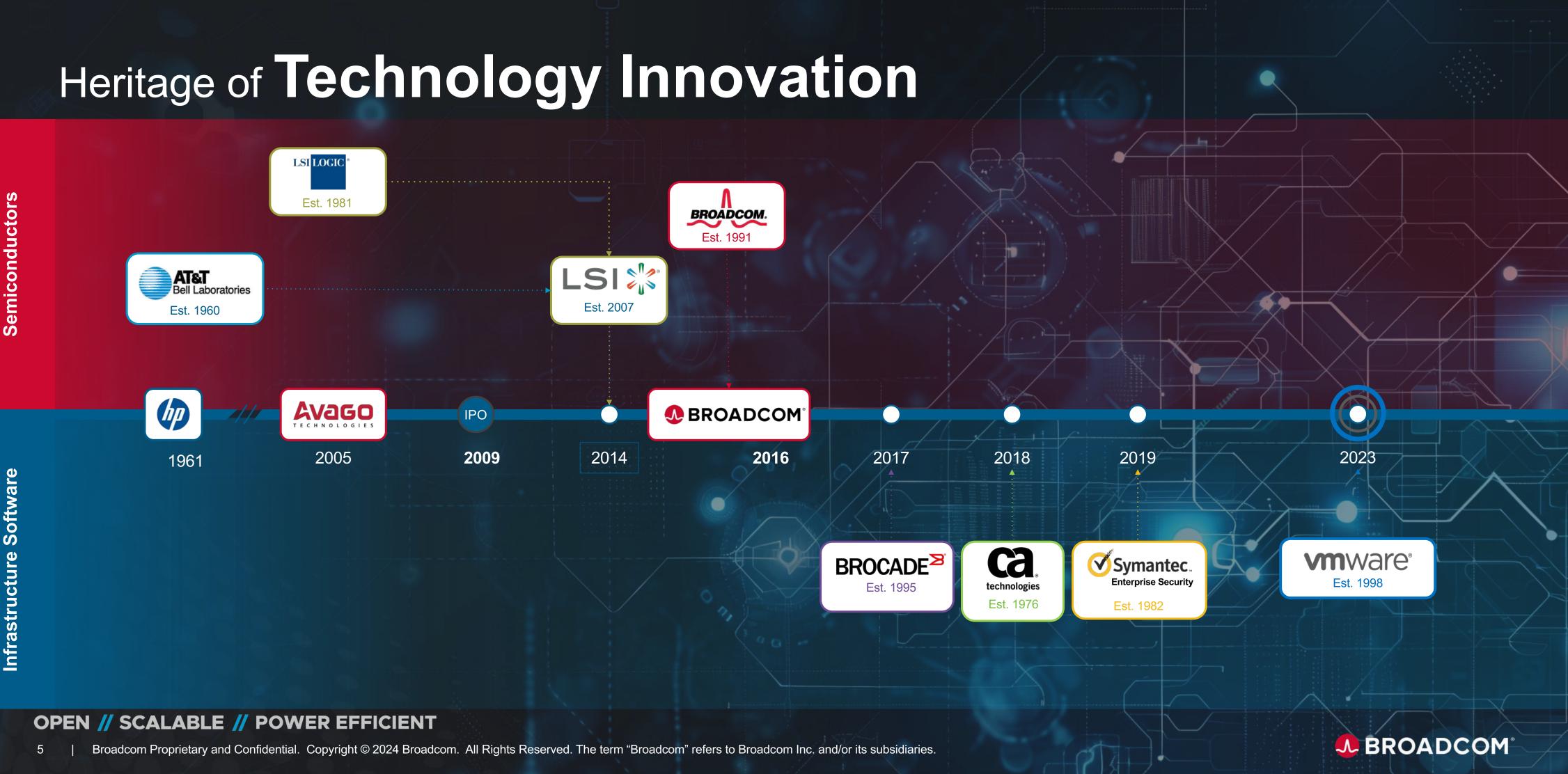




## ENABLINGA nfrastructure

#### Charlie Kawwas, Ph. D. President, Broadcom





### Semiconductors

FY23 Revenue \$28B

2019-2023 CAGR **13%** 

## Annual R&D spend \$3B+

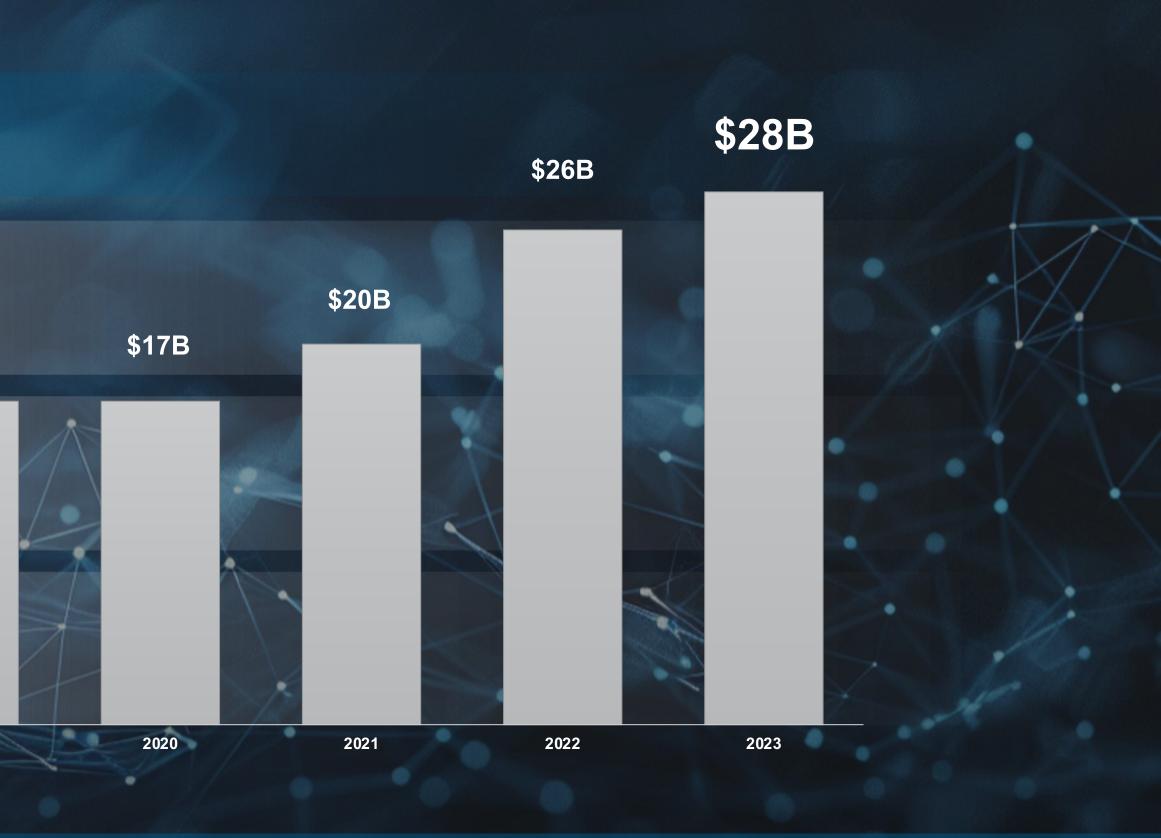
2019

\$17B

## **Technology Leadership** → **Organic Growth**

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### Strategy

### **Market** 10 Year Horizon

Technology Leadership

## **Excellence**

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## Sustainable Franchise

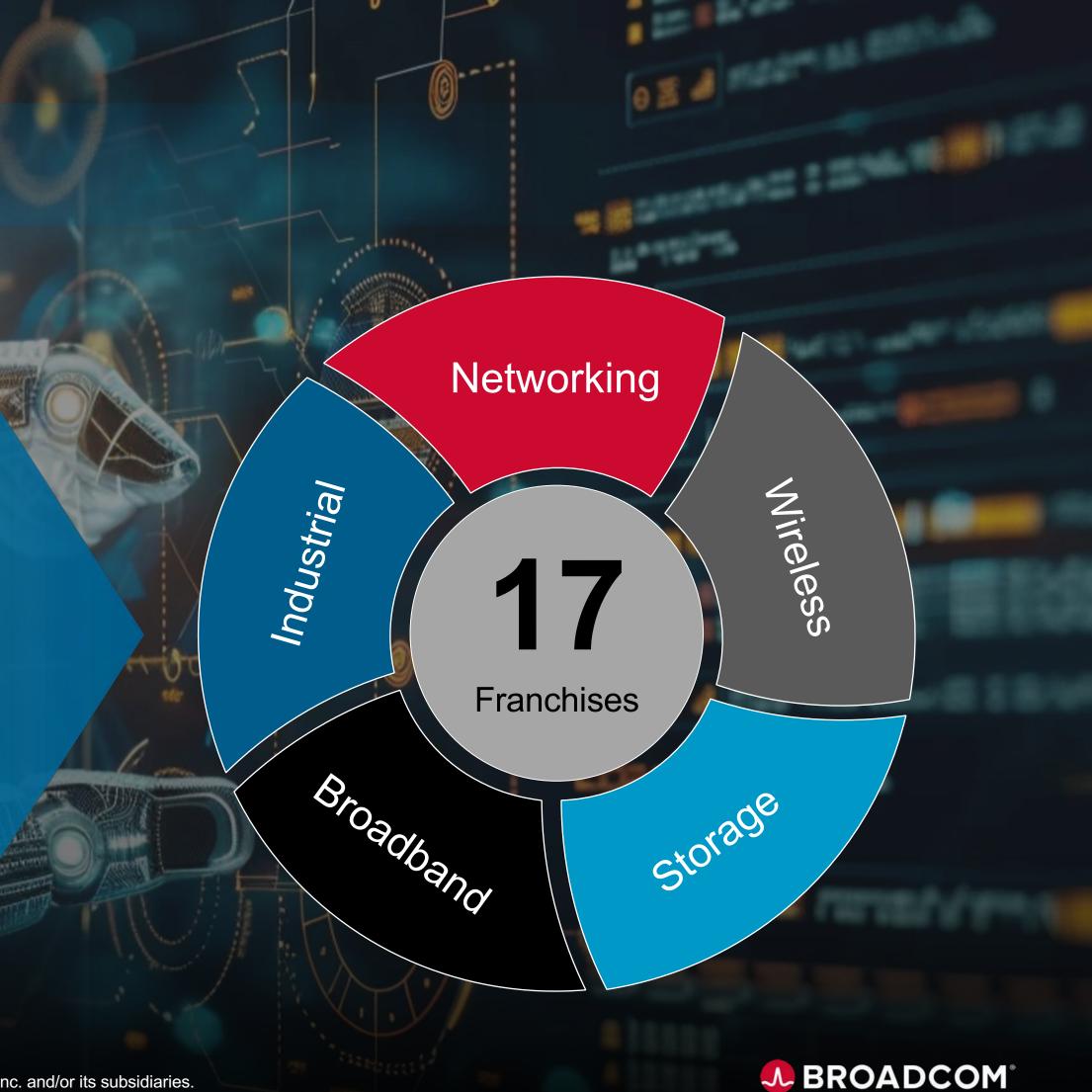
### Strategy

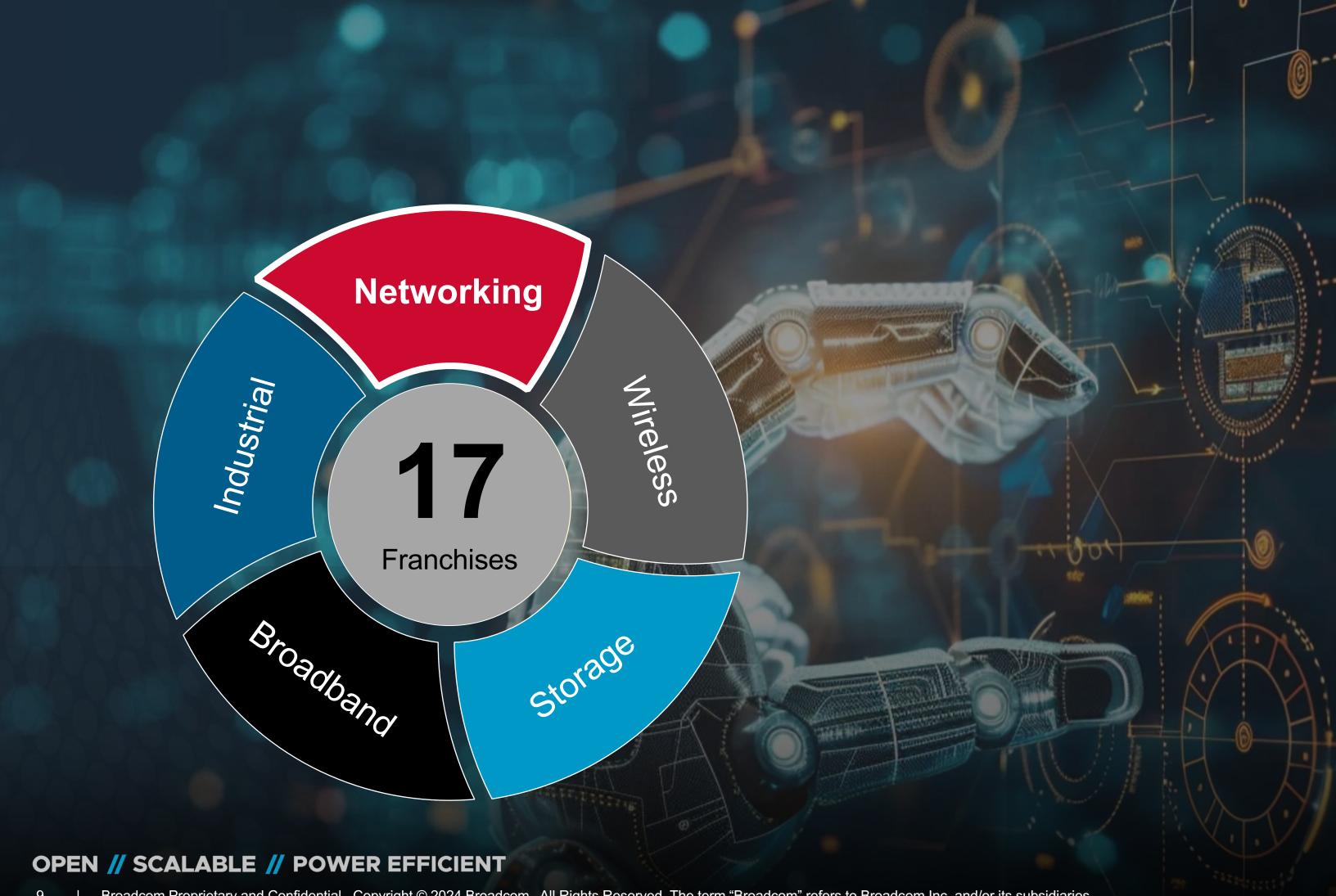
### Market 10 Year Horizon

Technology Leadership

## **Excellence**

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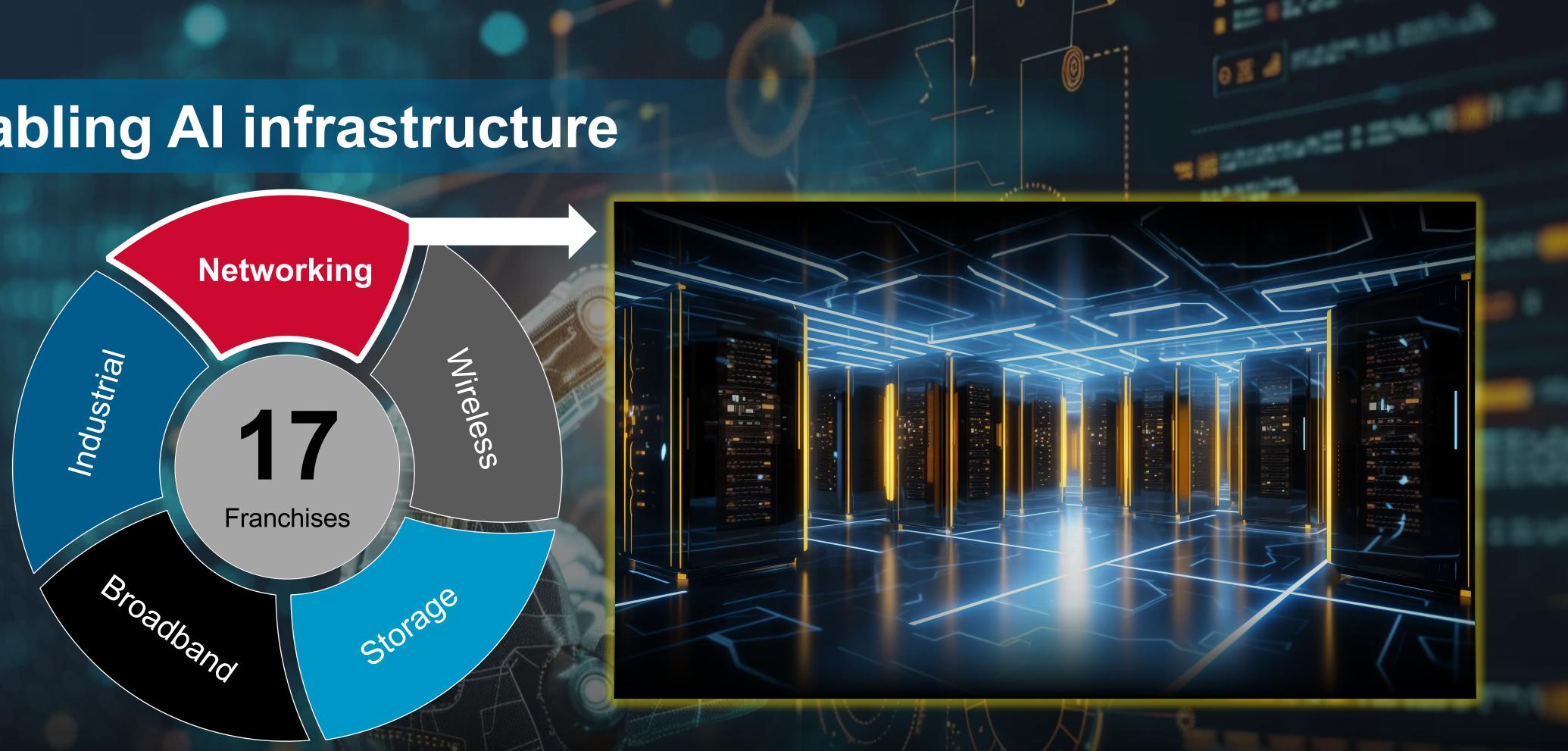


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## **Enabling Al infrastructure**



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## **Two Al Markets**

W ....

100

### **Consumer Al** Search, Social Networking, ...

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## Enterprise Al Public Cloud, On-Prem, ...





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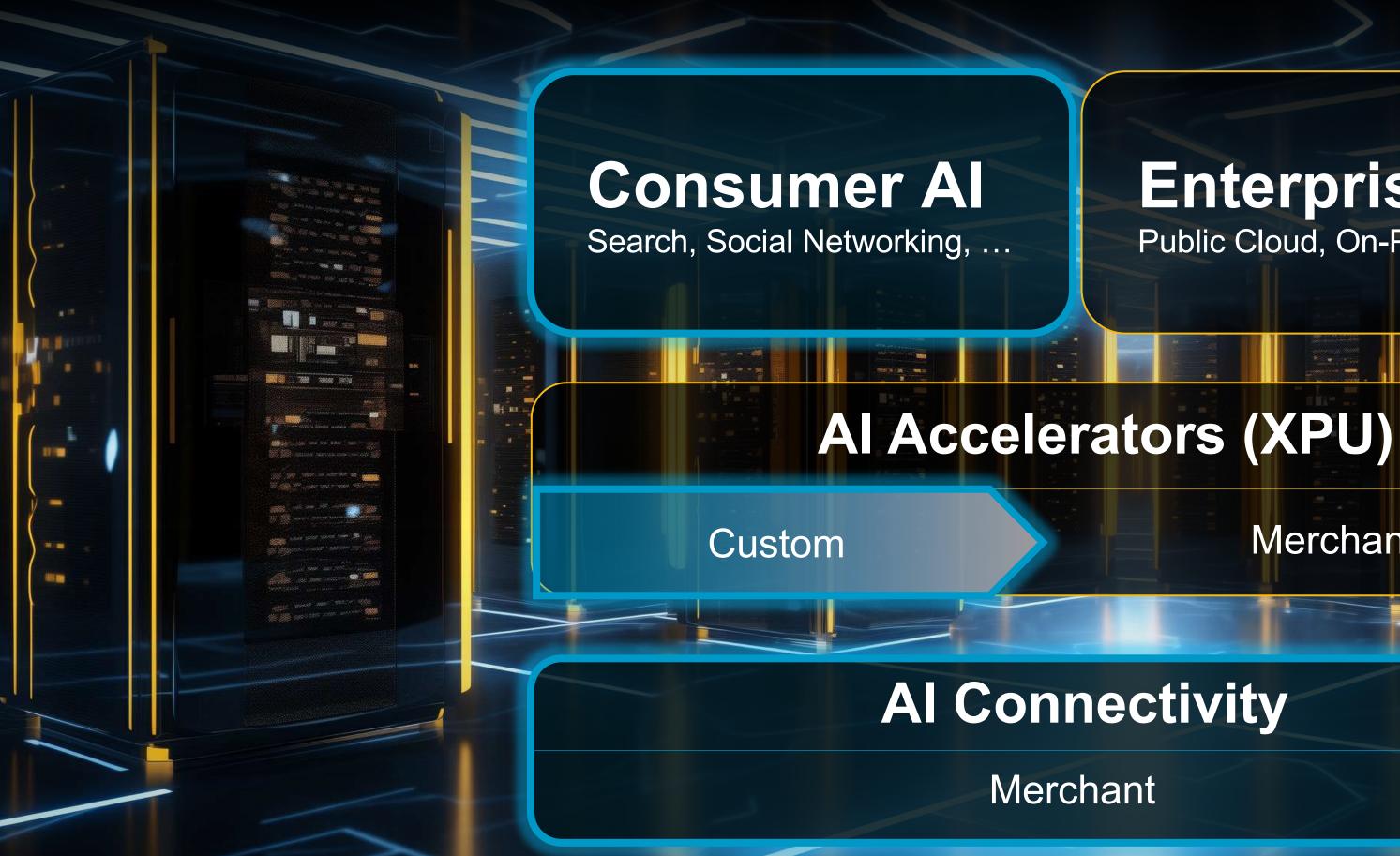
## **Enterprise Al**

Public Cloud, On-Prem, ...

#### Merchant



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## **Enterprise Al**

Public Cloud, On-Prem, ...

#### Merchant



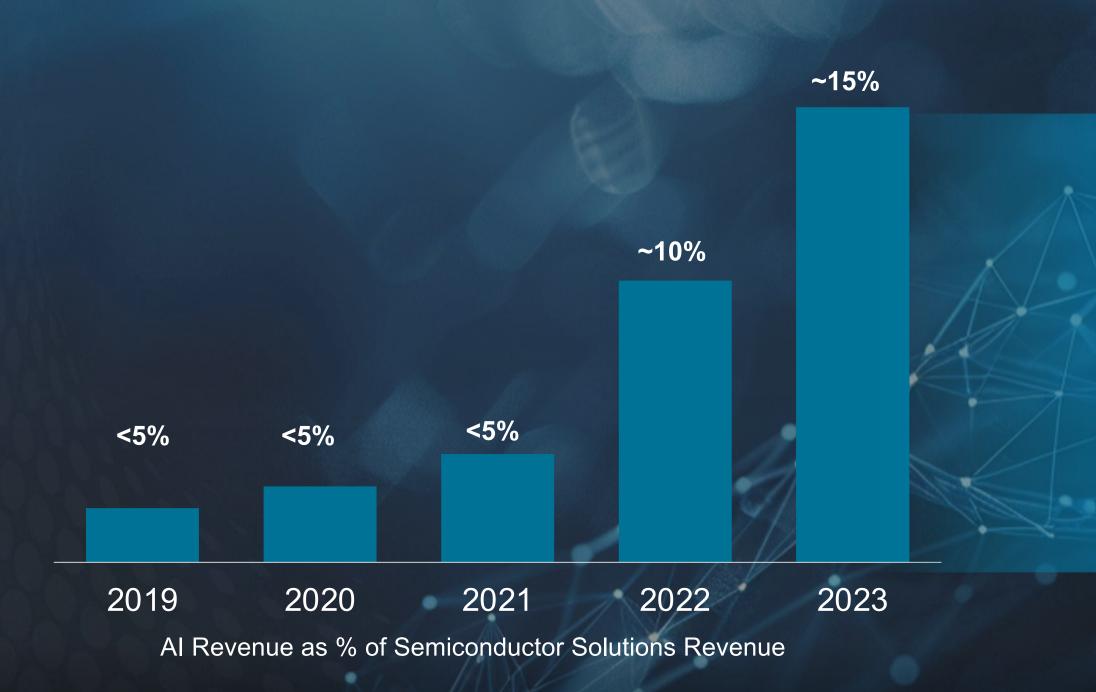






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### Broadcom's Al Journey...



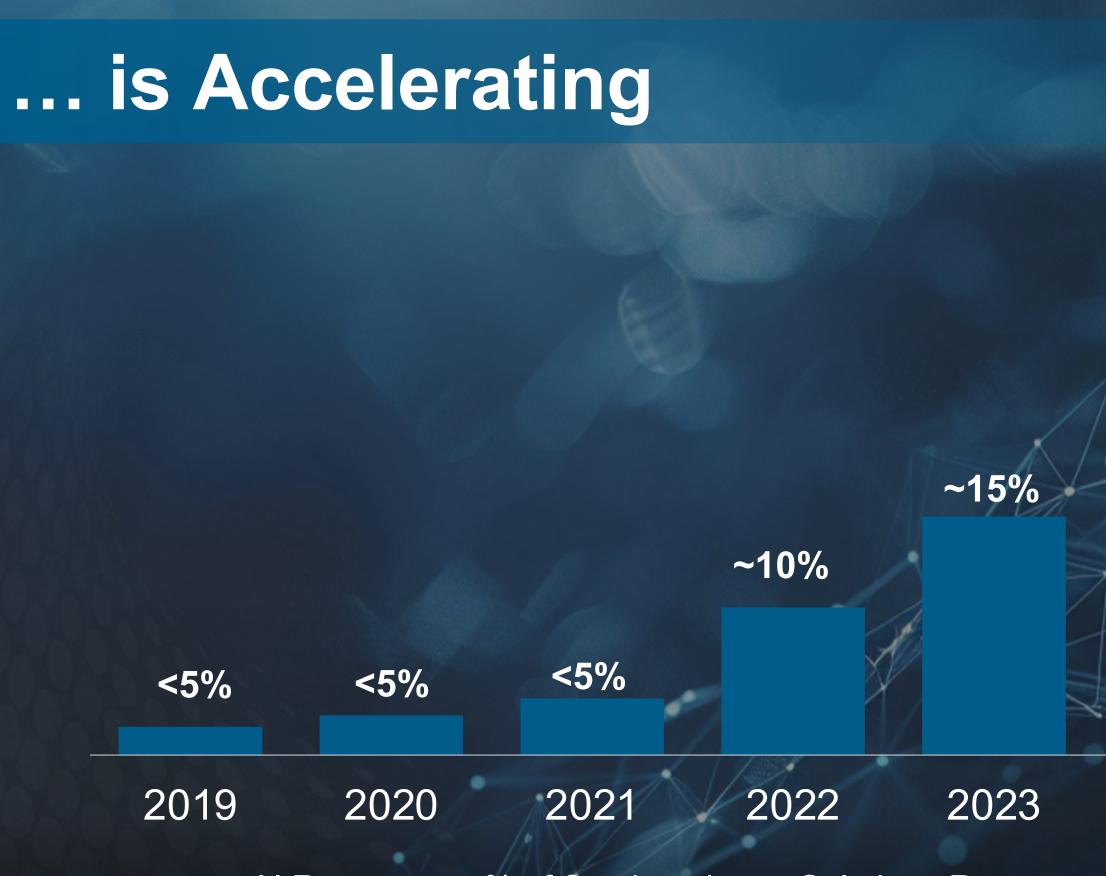
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# 

## FY2024 Target





Al Revenue as % of Semiconductor Solutions Revenue

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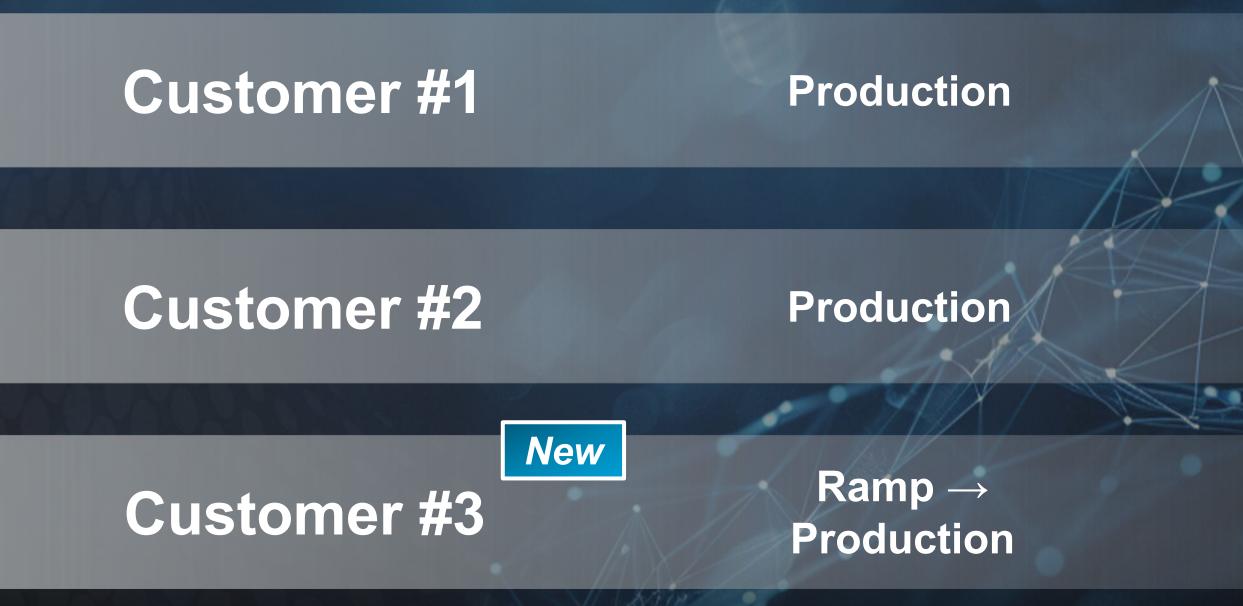


## **SAOBH** Revised FY2024 Target





# XPUs → Multi-Generational strategic engagements 2024 2025 2026



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## The Build-Out is On...

# of XPUs per Cluster

30K+

2024

### 10K+

2023

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4K+

2022

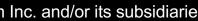
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## 2027+

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## XPU

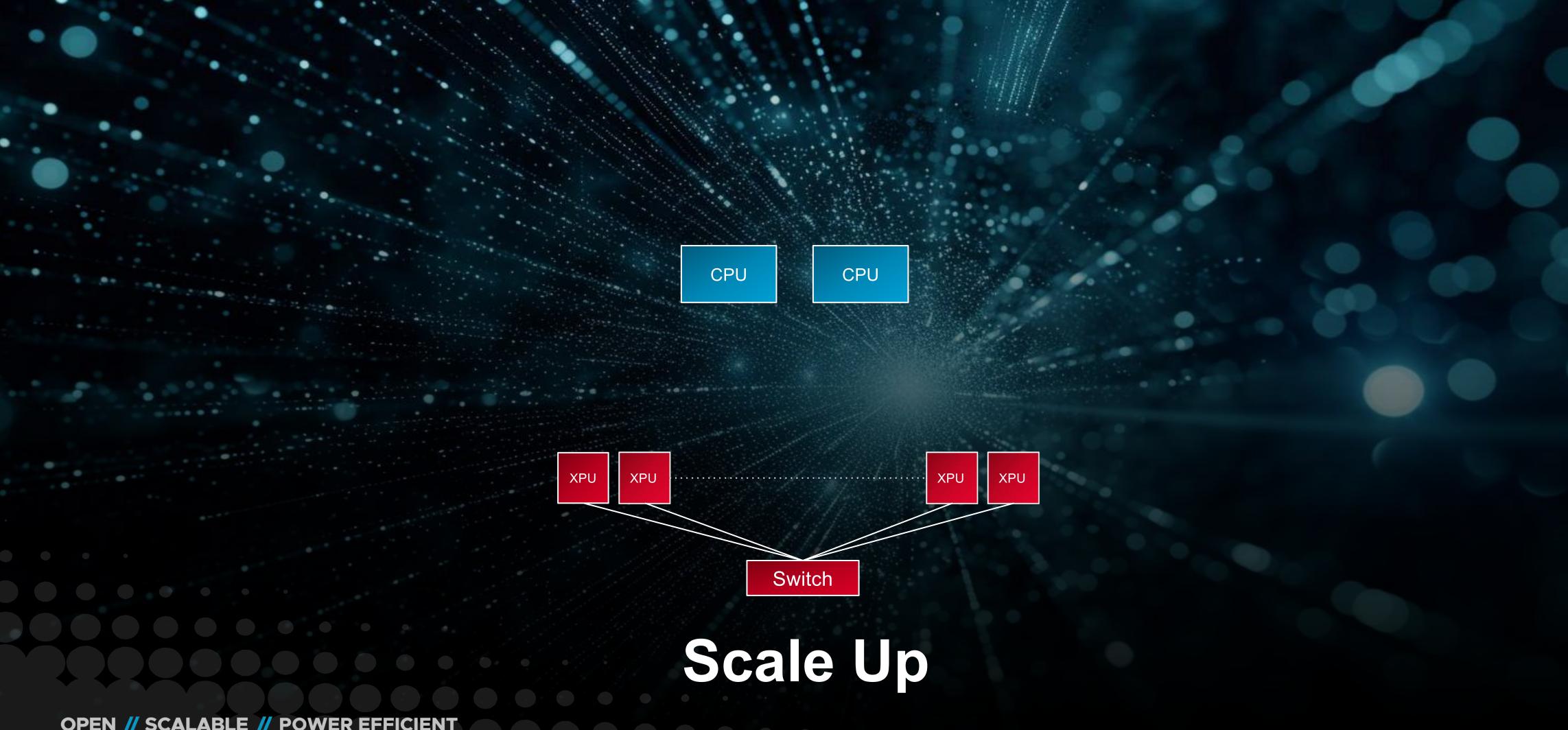
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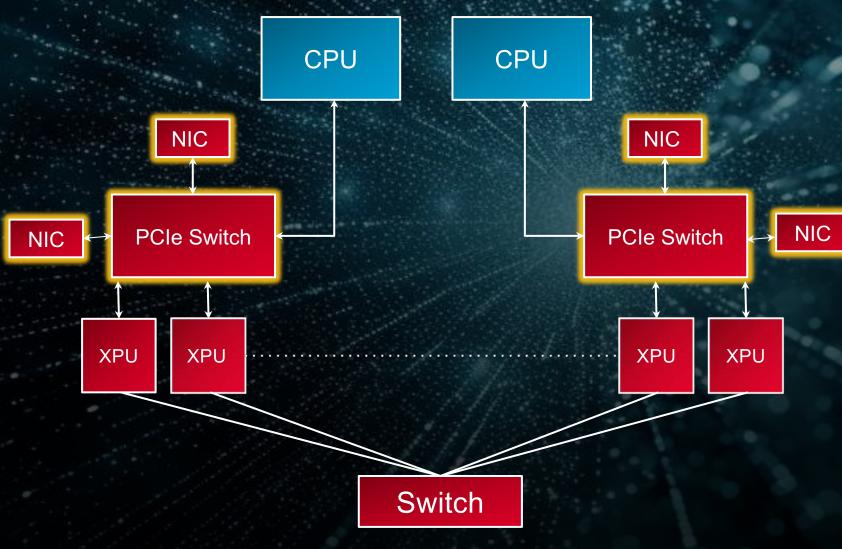










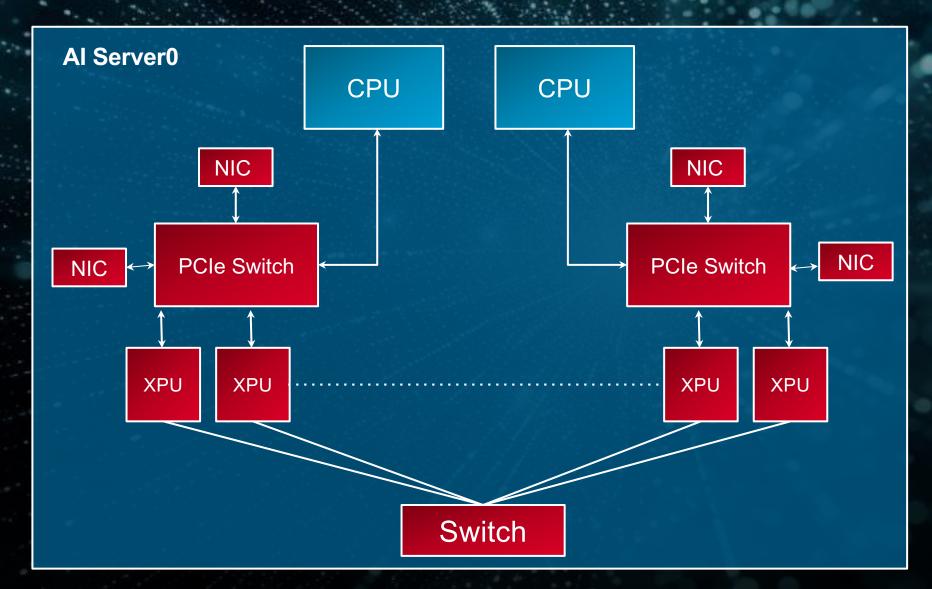








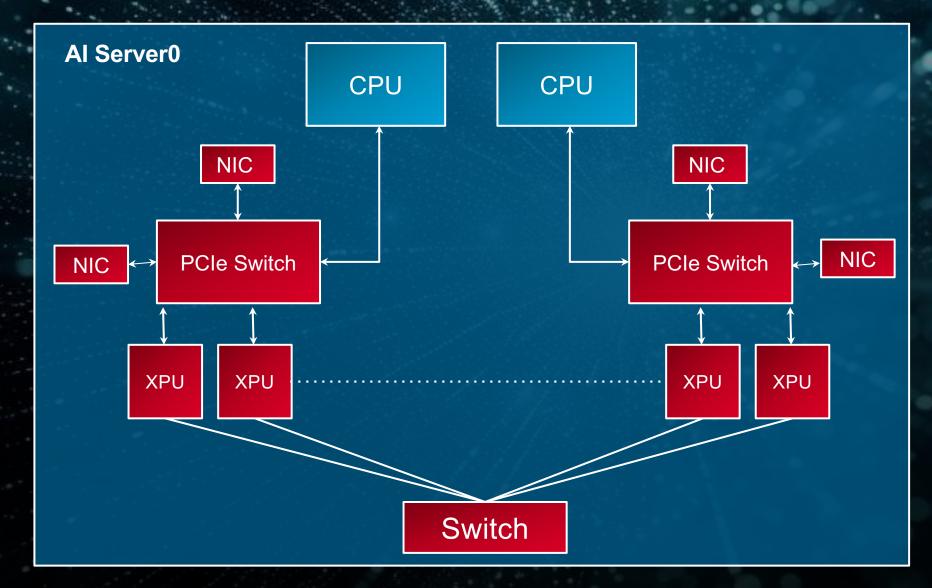
## **hereonneet**



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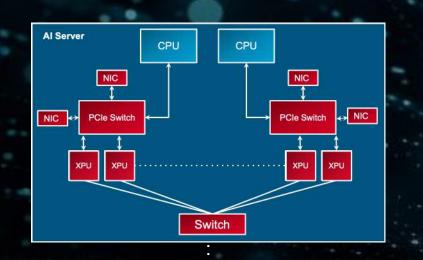
## → Broadcom SAM

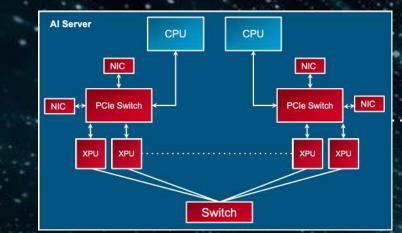


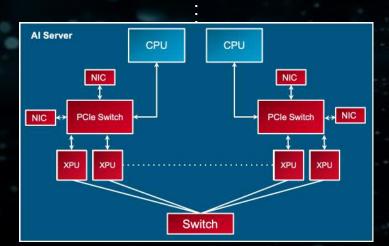
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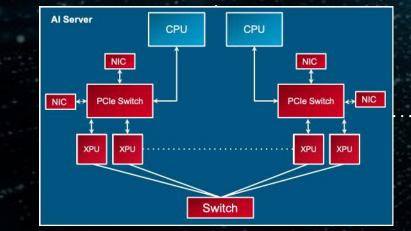


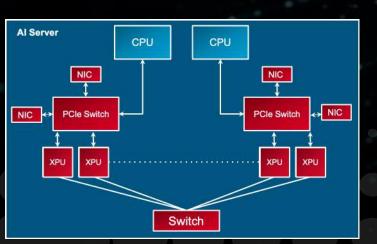


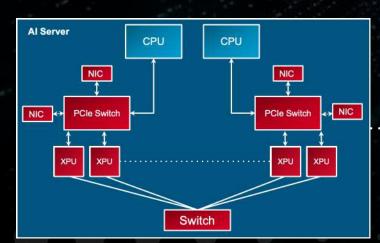






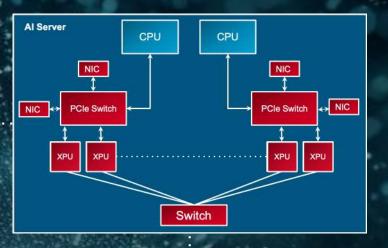


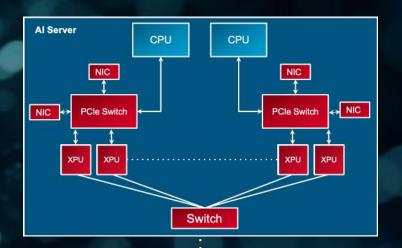


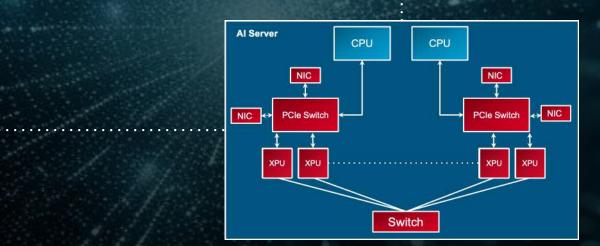


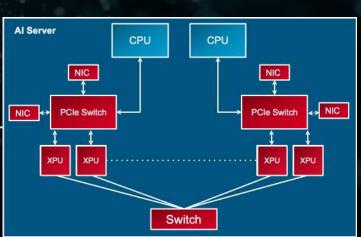
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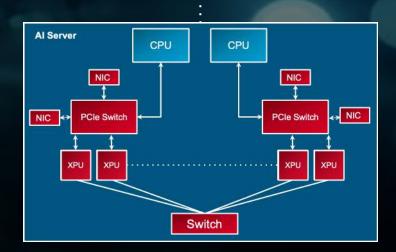


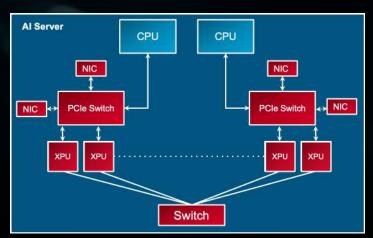






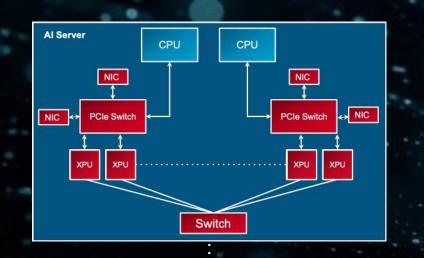


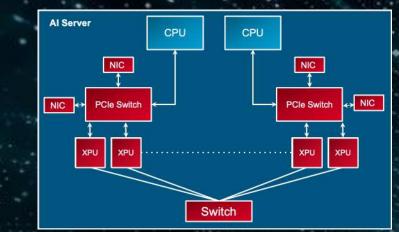


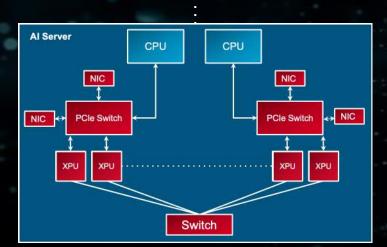


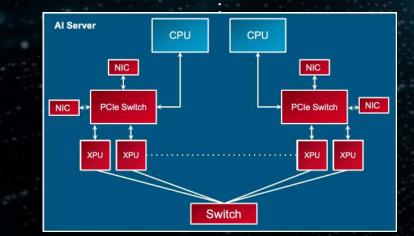


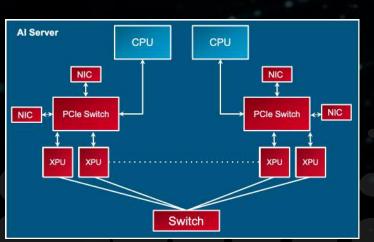


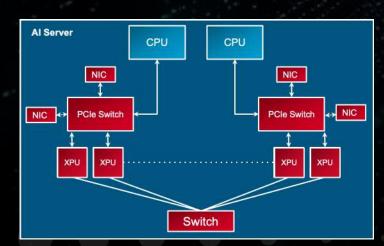






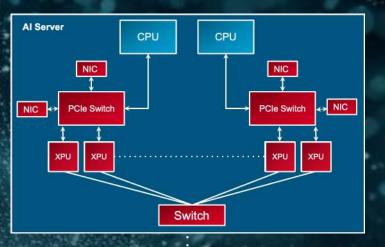


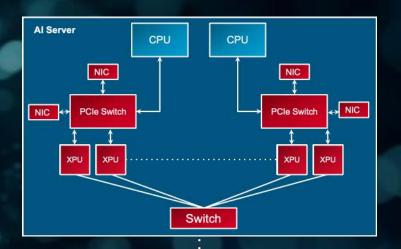


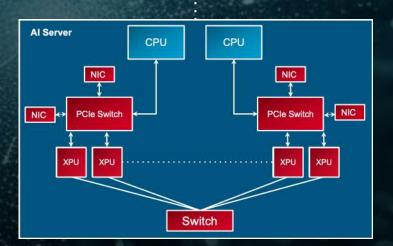


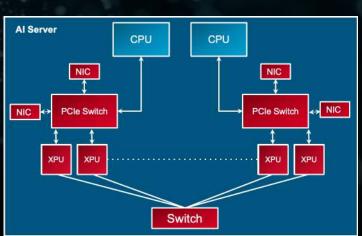
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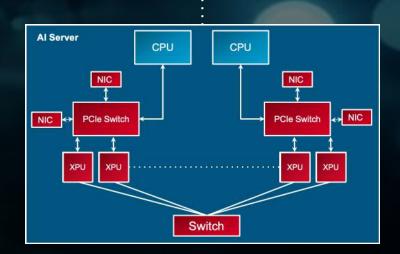


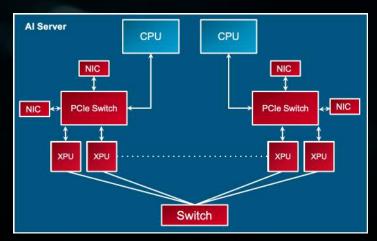






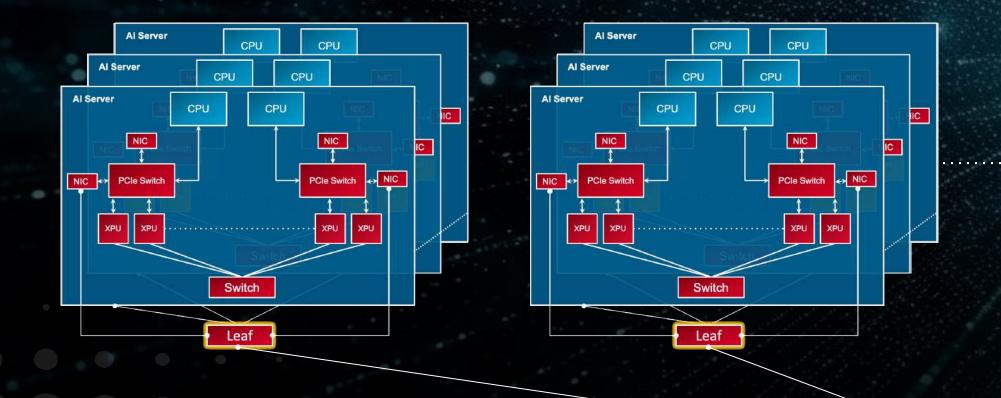








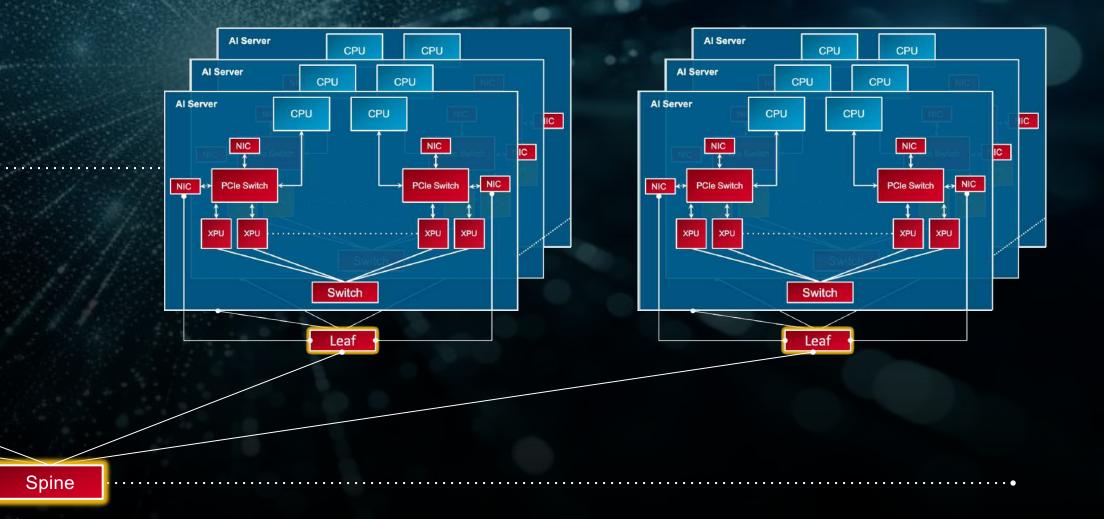
## Scale Up + Scale Out = Back End



Spine

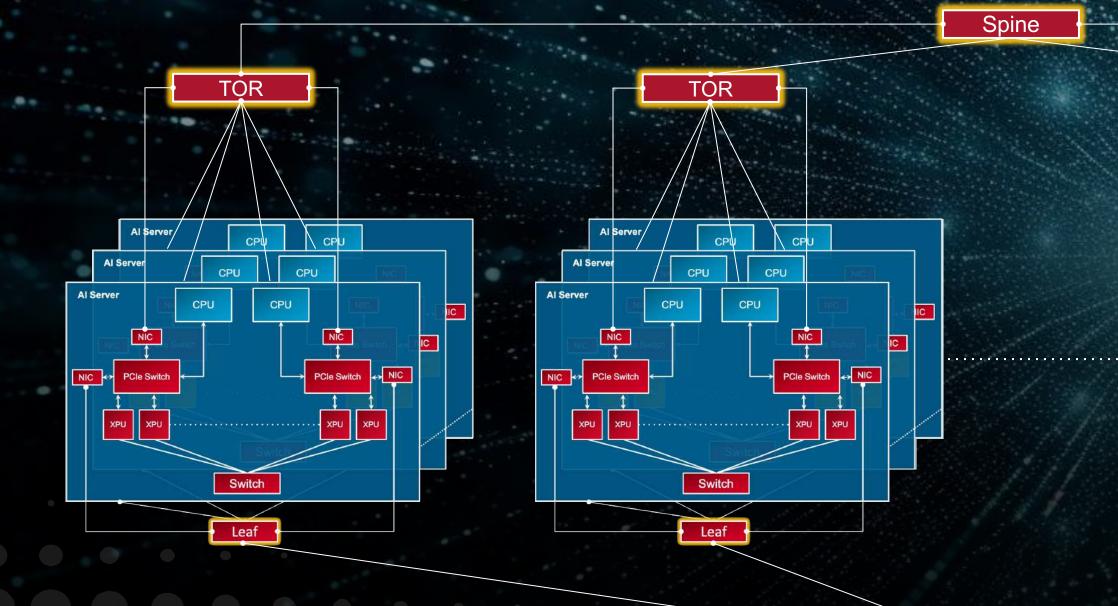
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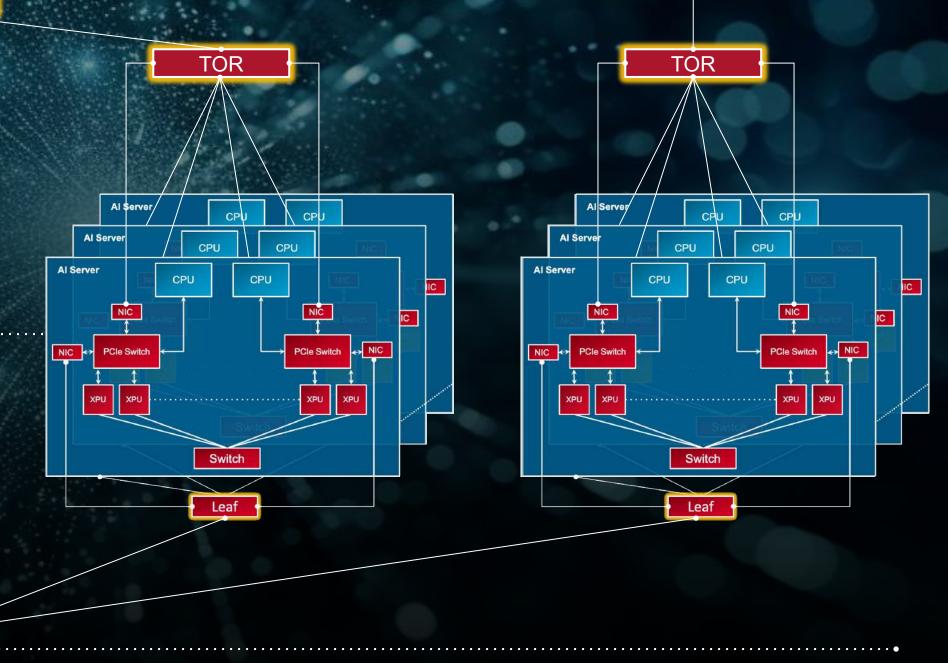


Spine

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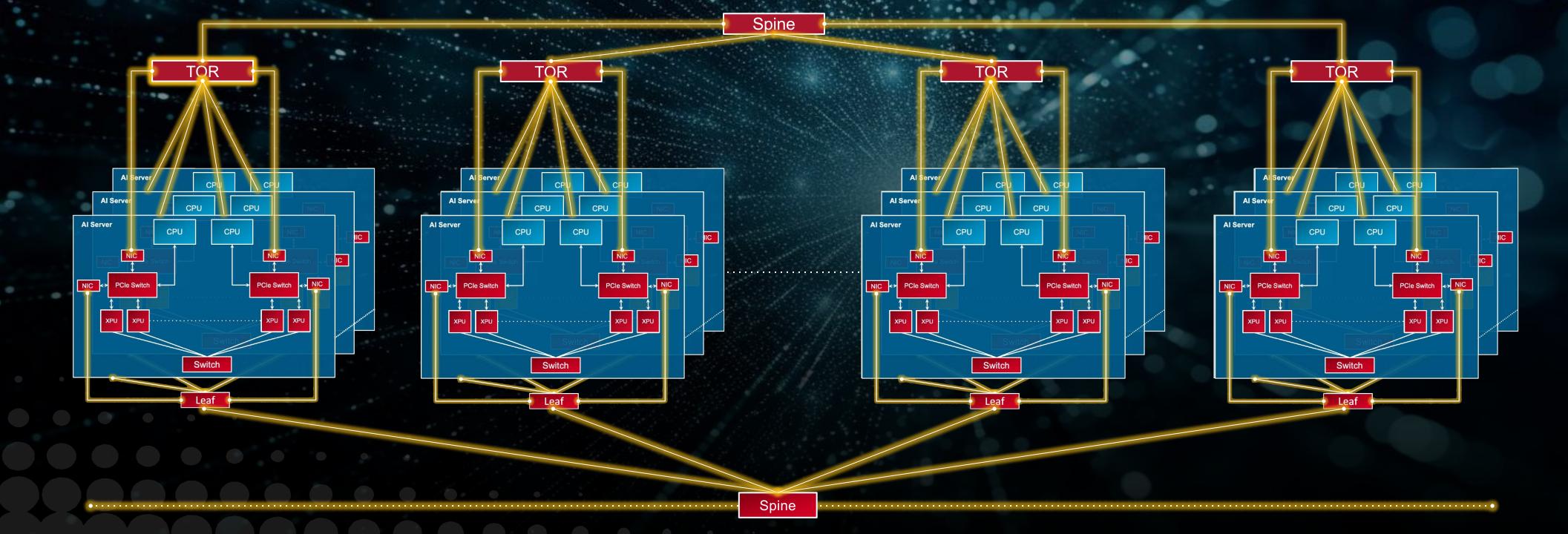
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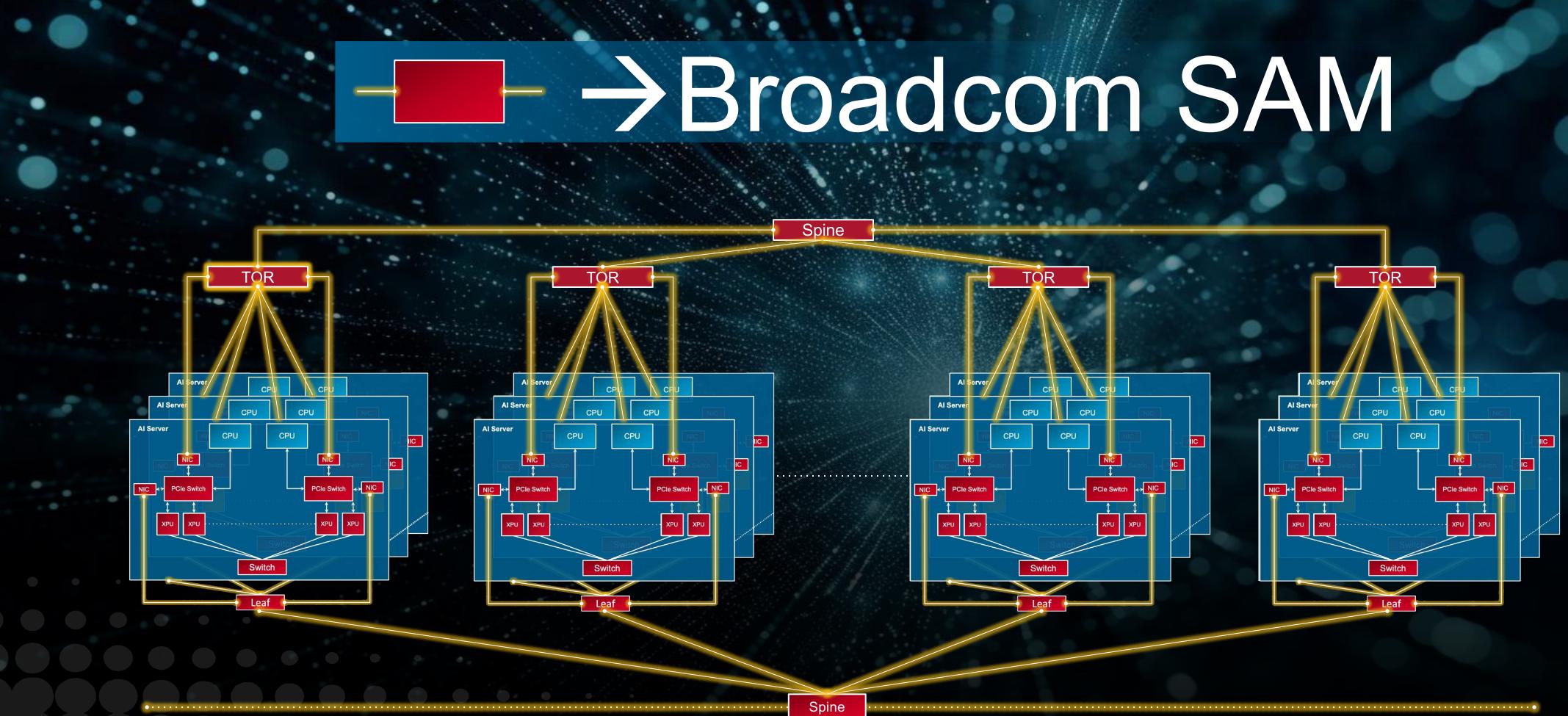
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## **Interconnect**



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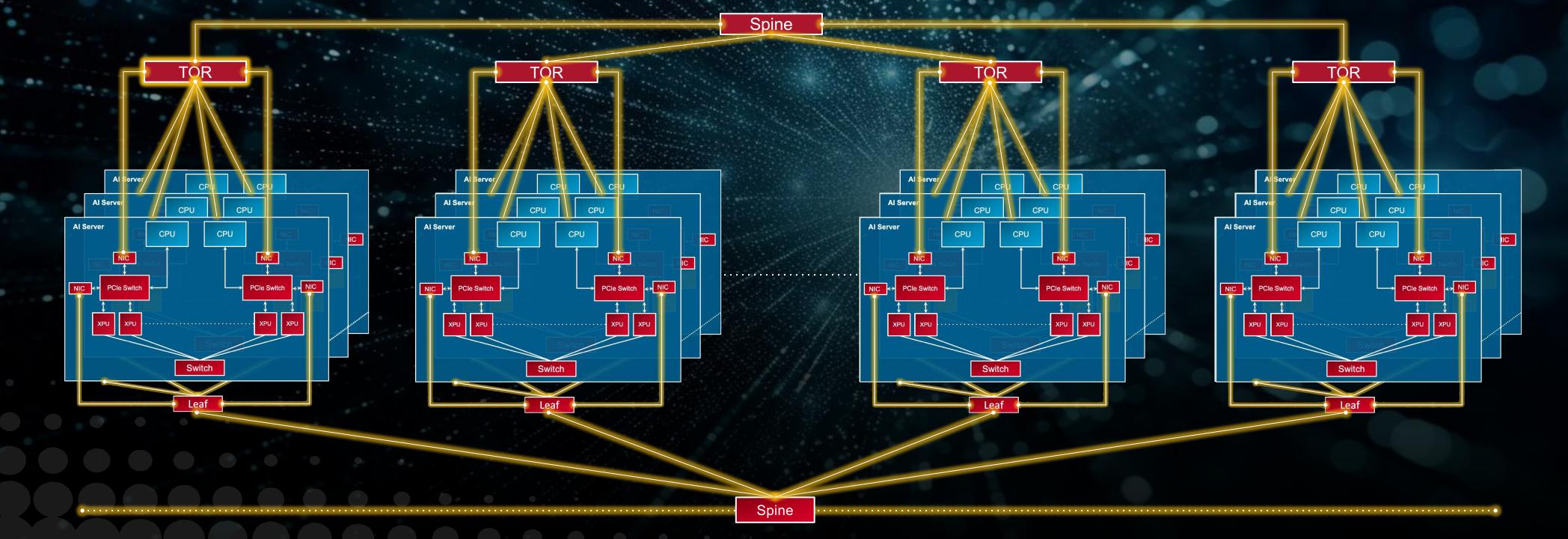




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## 1. Power 2. Complexity 3. Ecosystem



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## **Open Scalable Power Efficient**

## Sustainable Technology Leadership

PCle Ethernet **Optics** 

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## nfrastructure

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## Scalable Al Networks

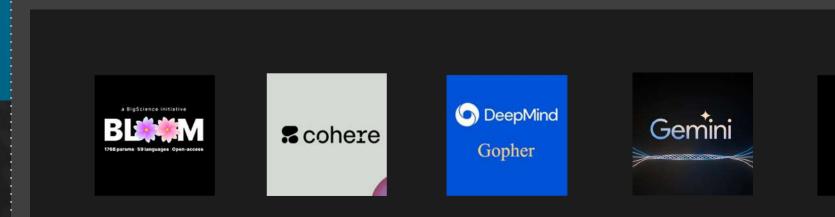
### **Ram Velaga**

General Manager Core Switching Group Broadcom

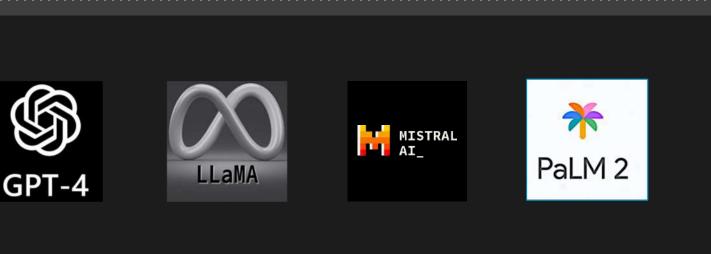


## New Al Models $\rightarrow$ 100X+ Scale $\rightarrow$ Distributed Computing

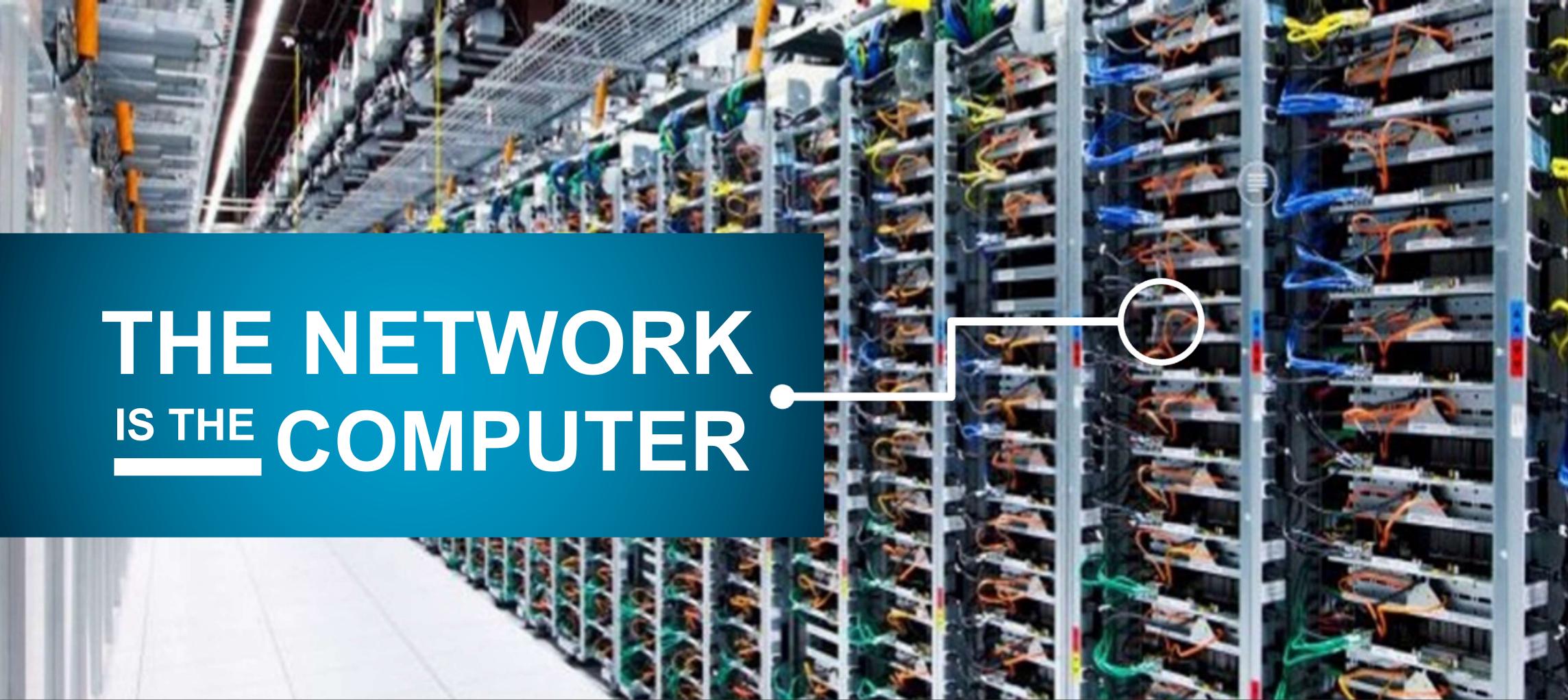
# 1 Million Alaccelerators



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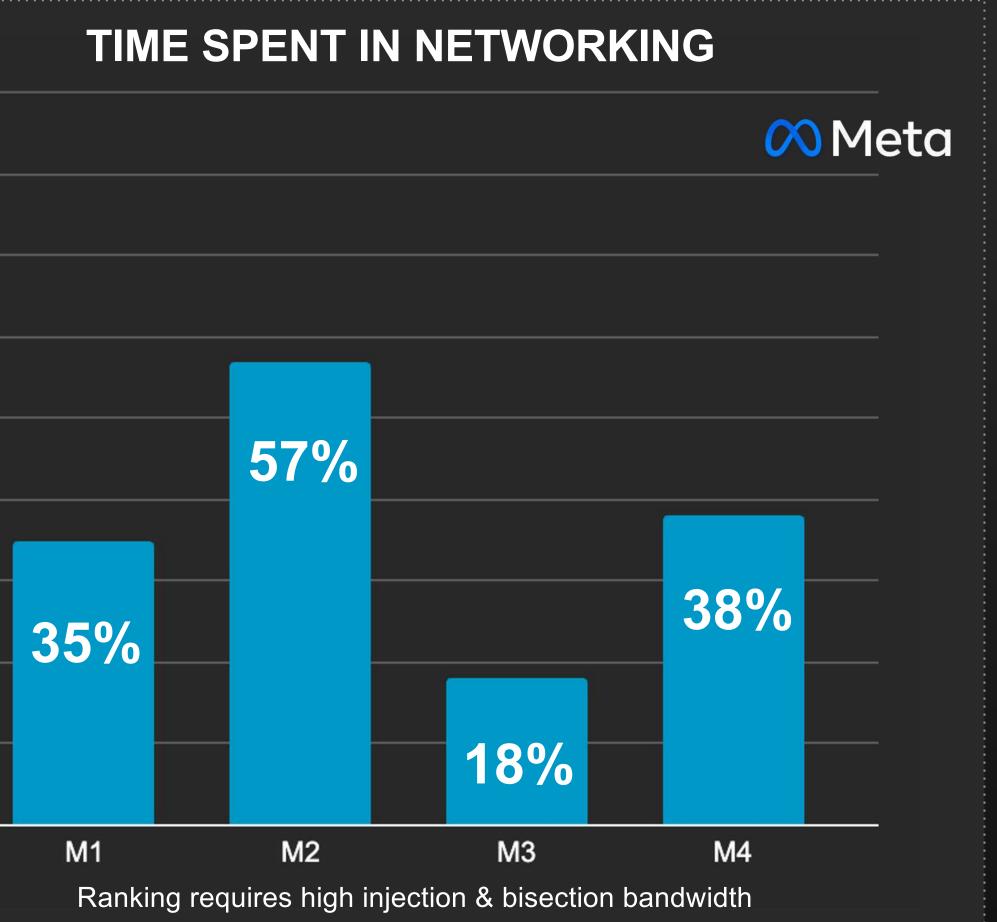


# **Network I/O** is Key for Recommendation Workloads.

Meta, OCP 2022 Global Summit

90% 80% 70% 60% 50% 40% 30% 20% 10% 0% M# = ML model #

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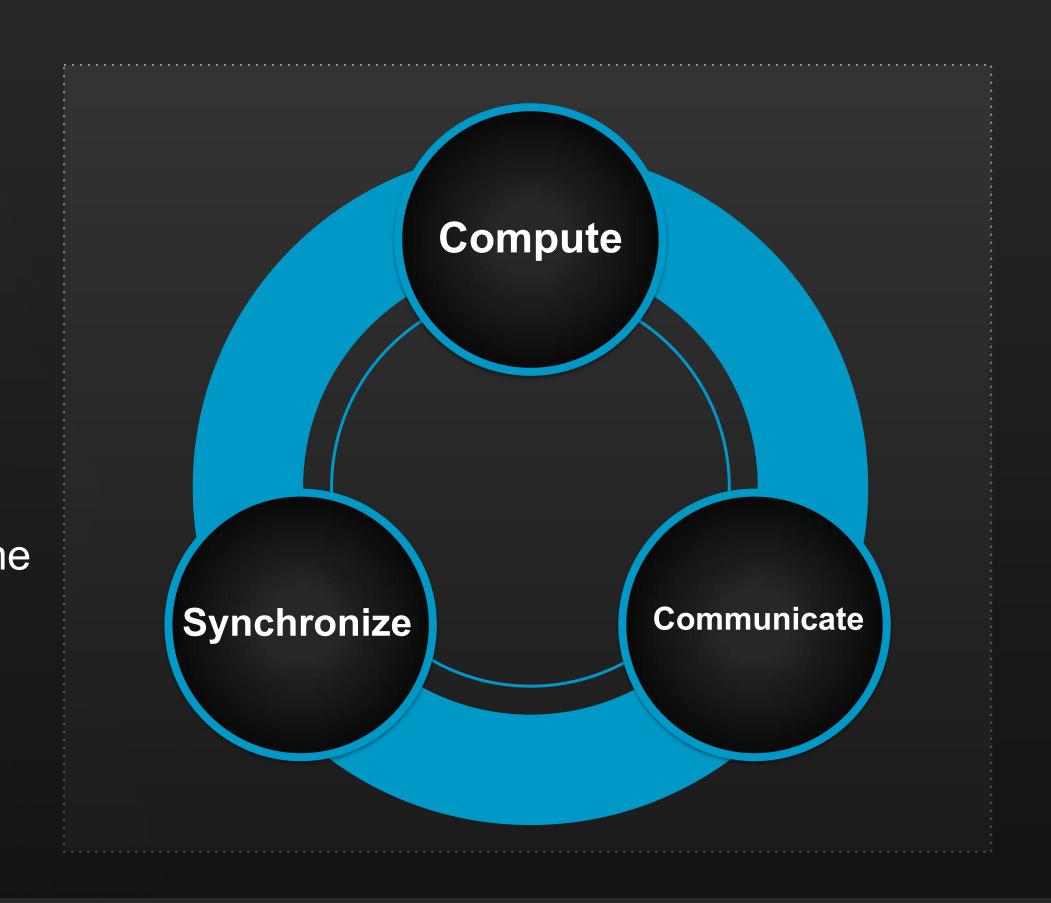




### What Makes Al Networks Unique?

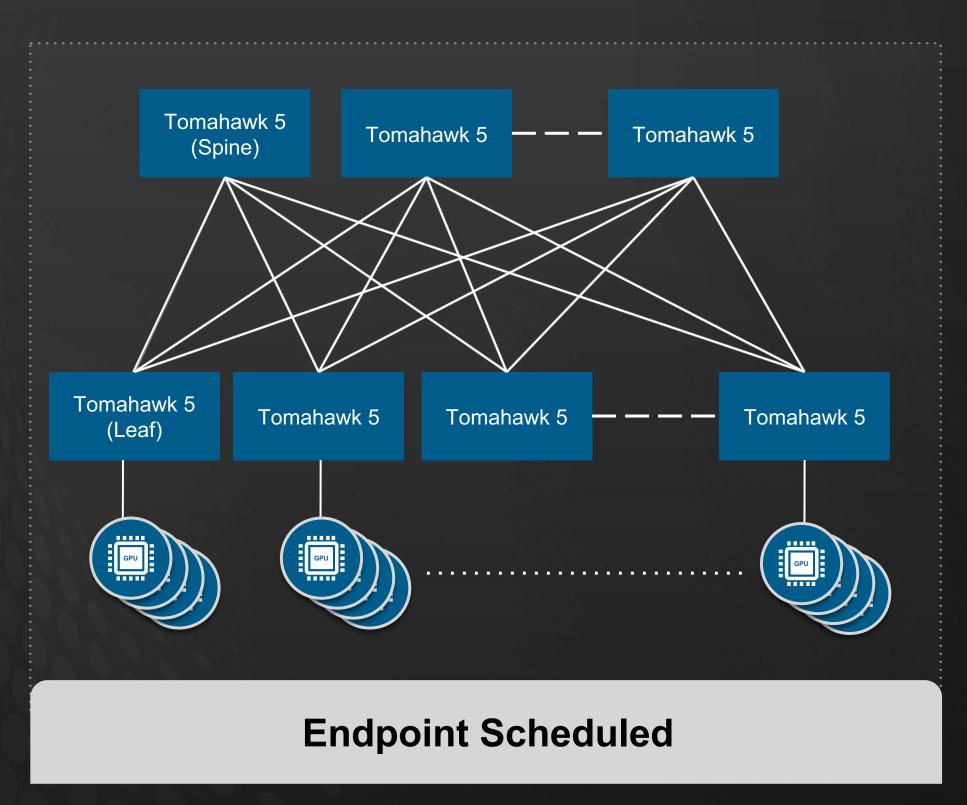
Very high bandwidth RDMA traffic  $\rightarrow$  Bulk data transfers Intermittent data surges Straggler data significantly impacts job completion time Training jobs run over long durations (hours, days)

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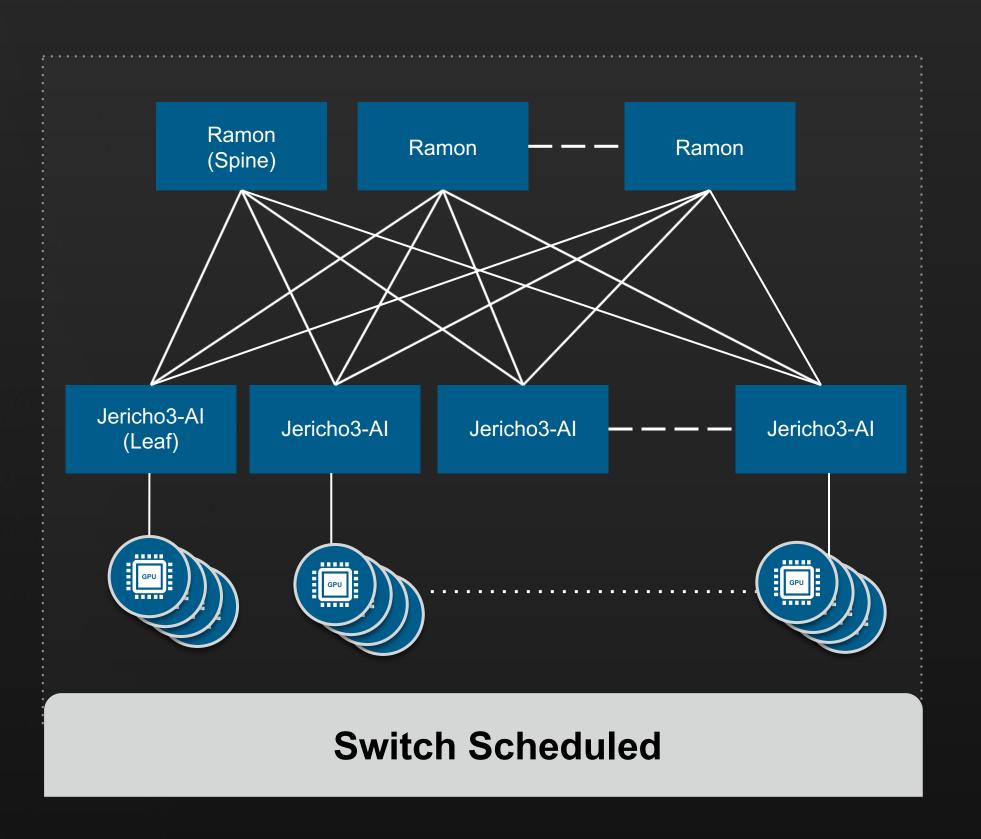




# Broadcom's AI Network Solutions



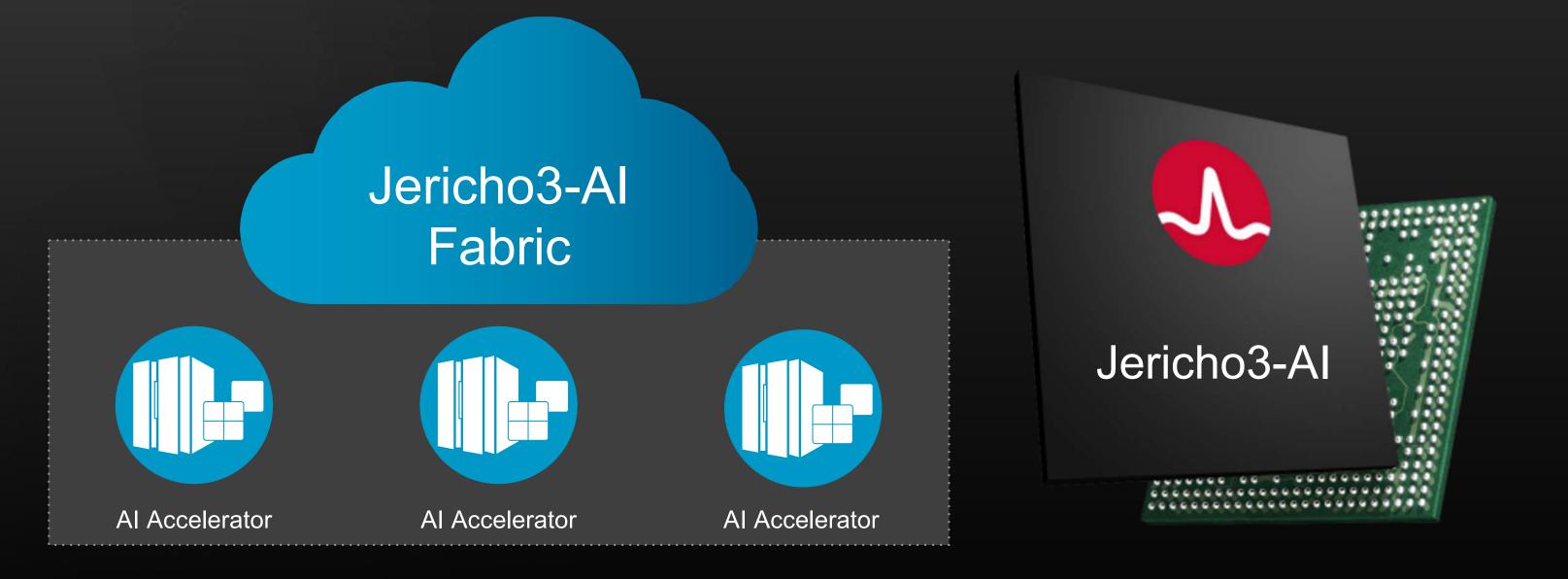
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# Jericho3-AI Fabric: Switch Scheduled Ethernet Network

10% Performance improvement = network more than pays for itself



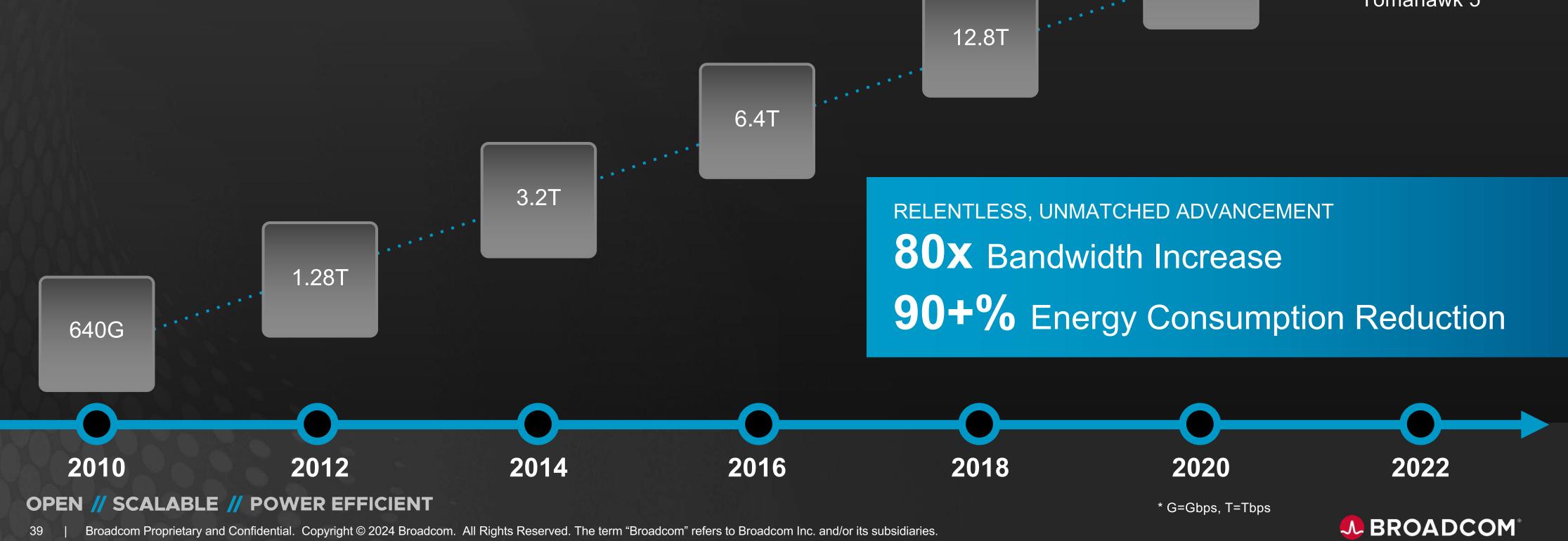


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# Tomahawk: Endpoint Scheduled Ethernet Network



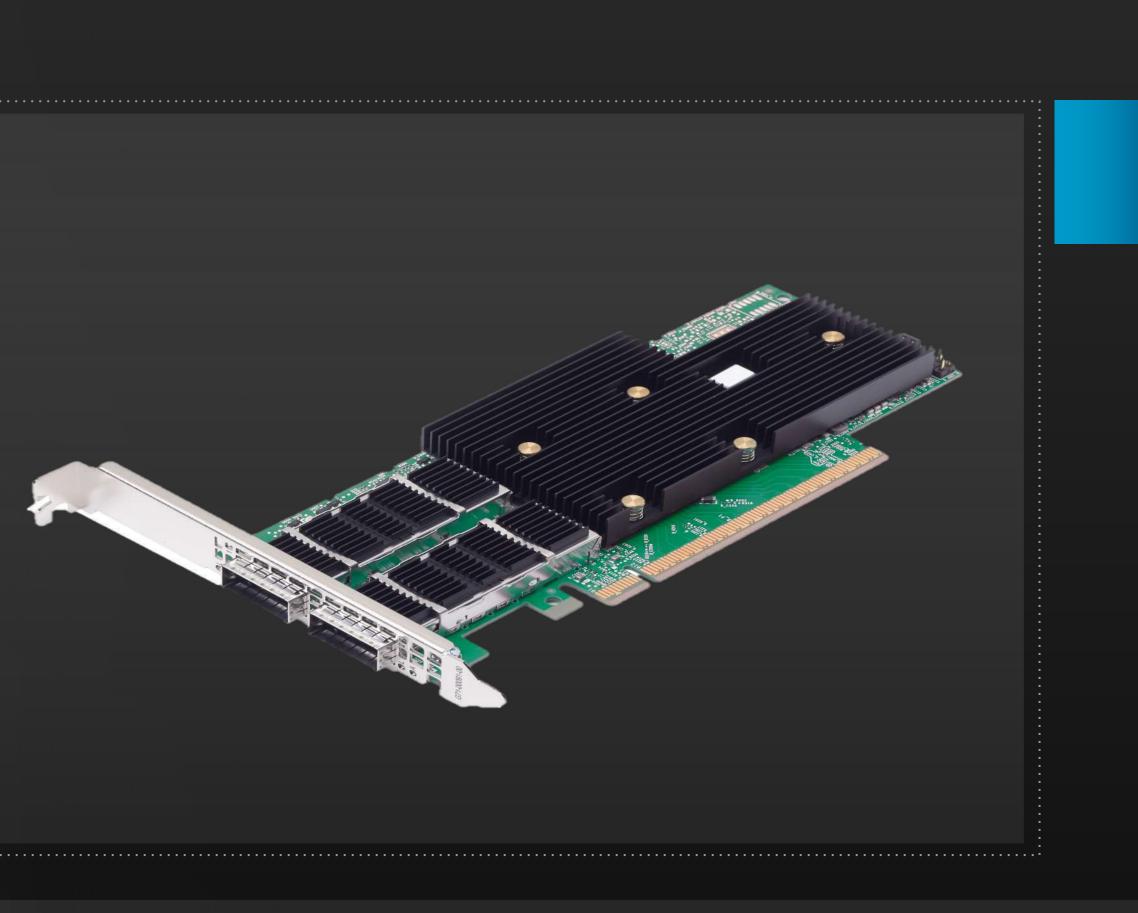


# Introducing Thor2: AI Optimized NIC

# Thor2

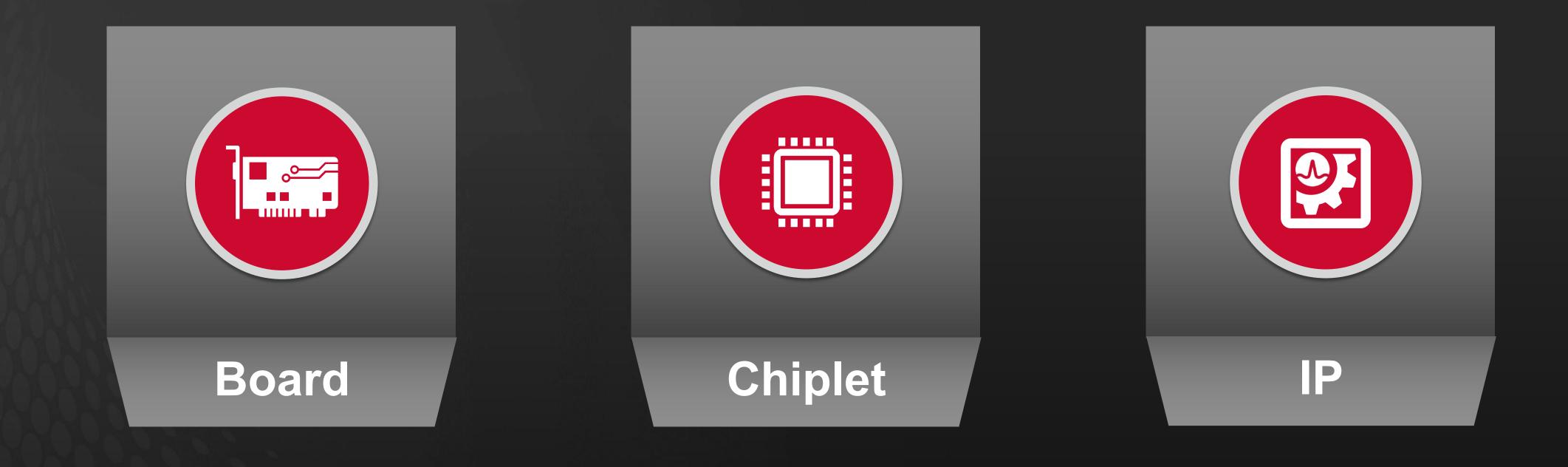


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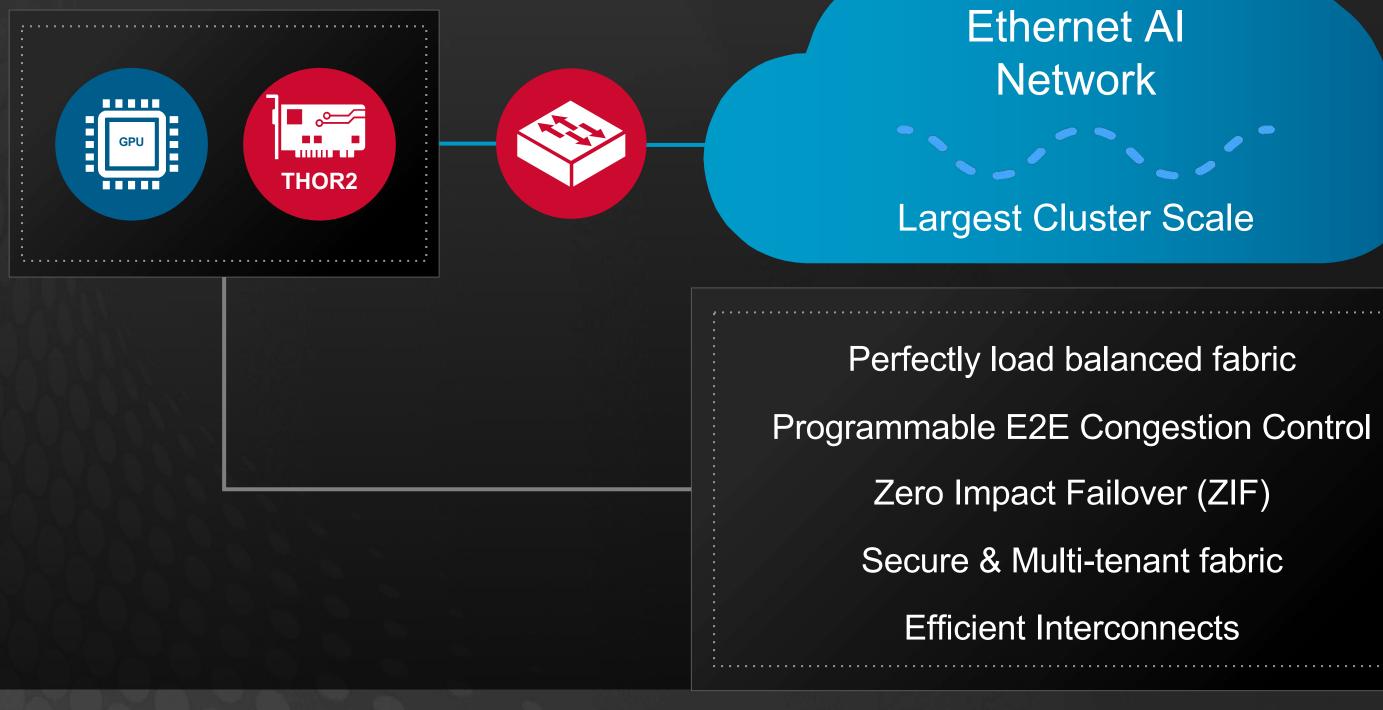
# Thor2 Consumption Models



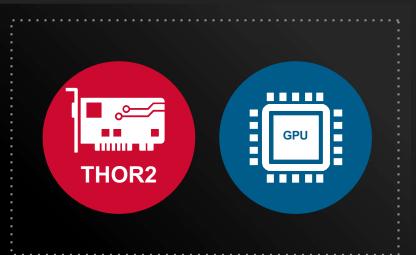
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# End-to-End High Performance Ethernet Al Network

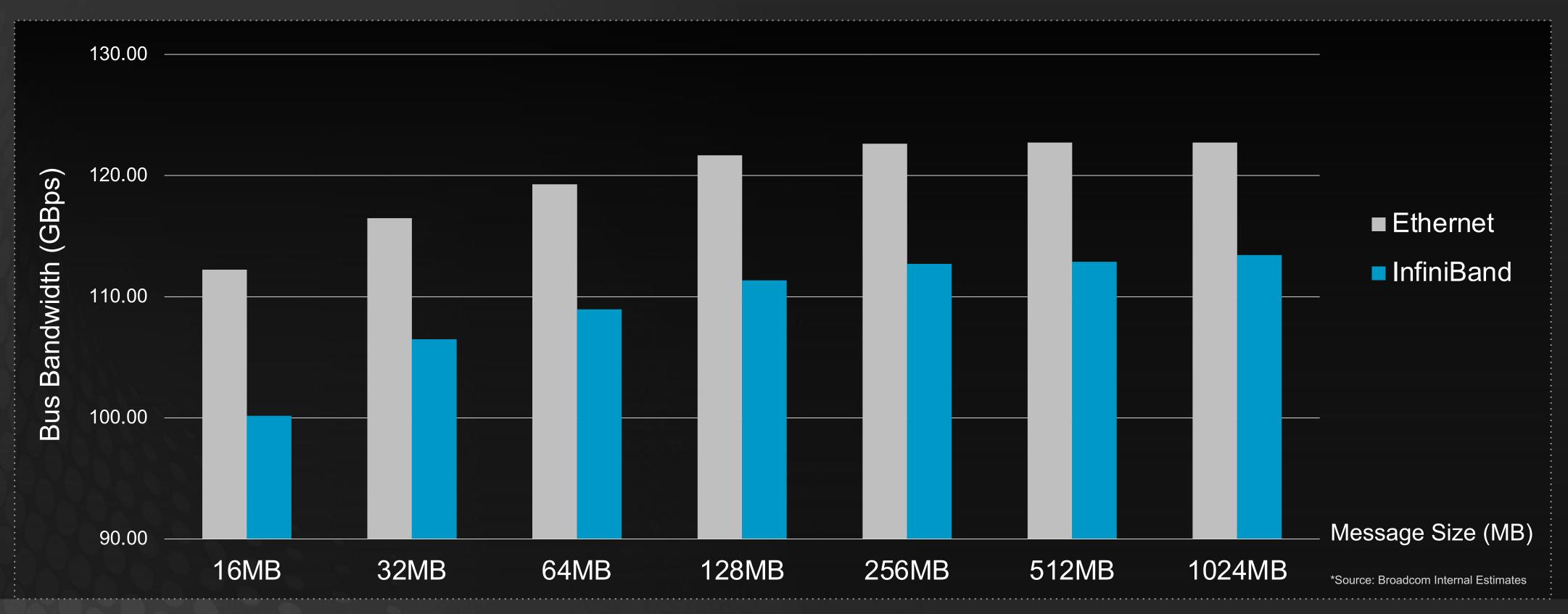


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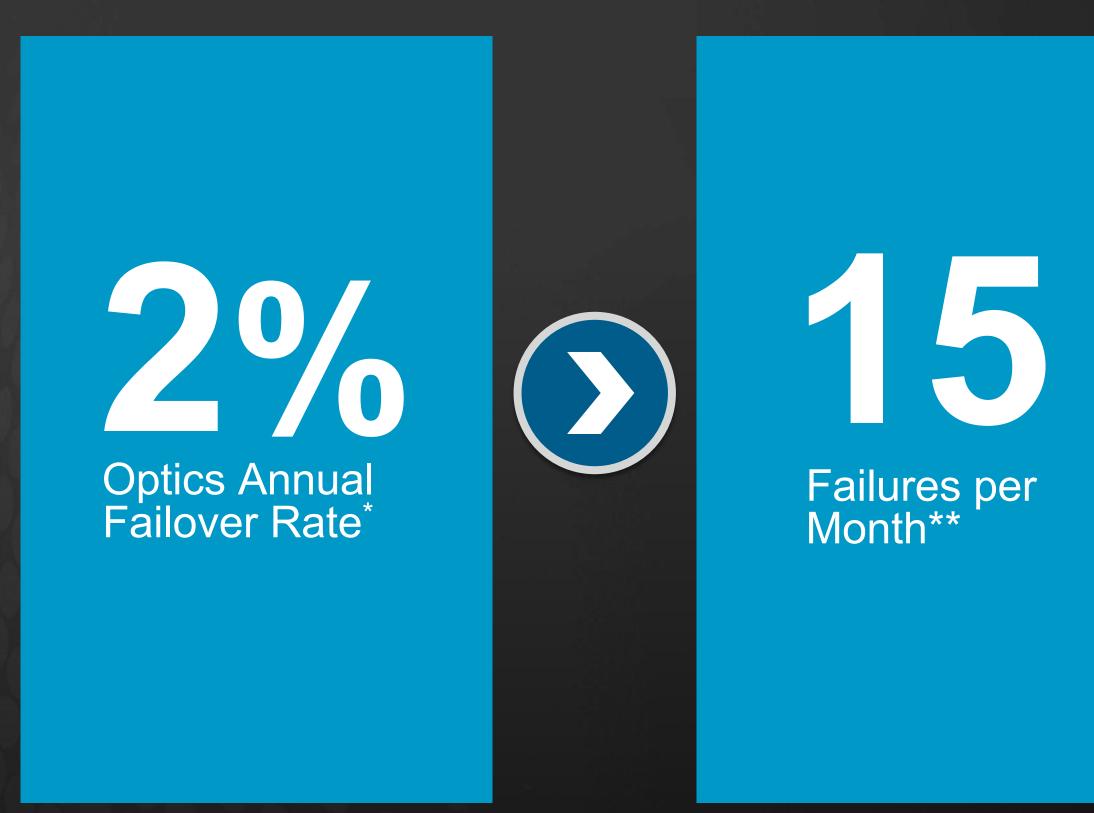
# Ethernet Beats InfiniBand: 10+% Improvement in Job Completion Time



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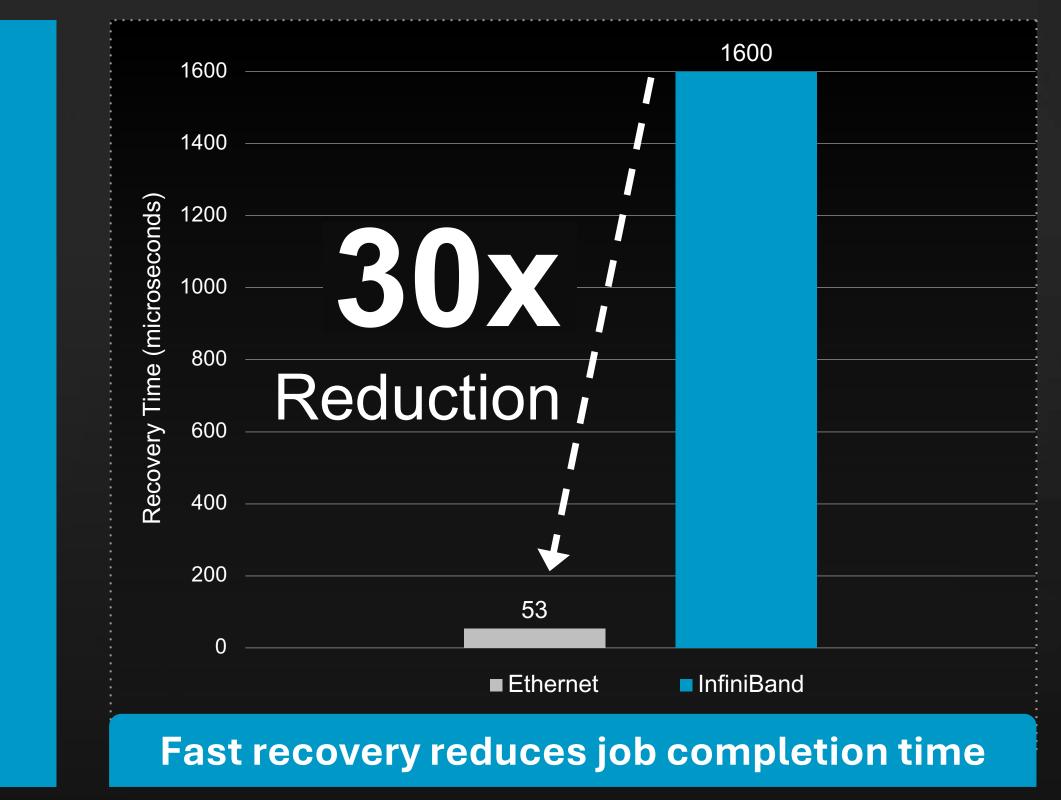
# Ethernet Provides 30x Faster Failover than InfiniBand



\* Typical industry failure rate. \*\* Assuming 4K node cluster using 9.2K optic modules

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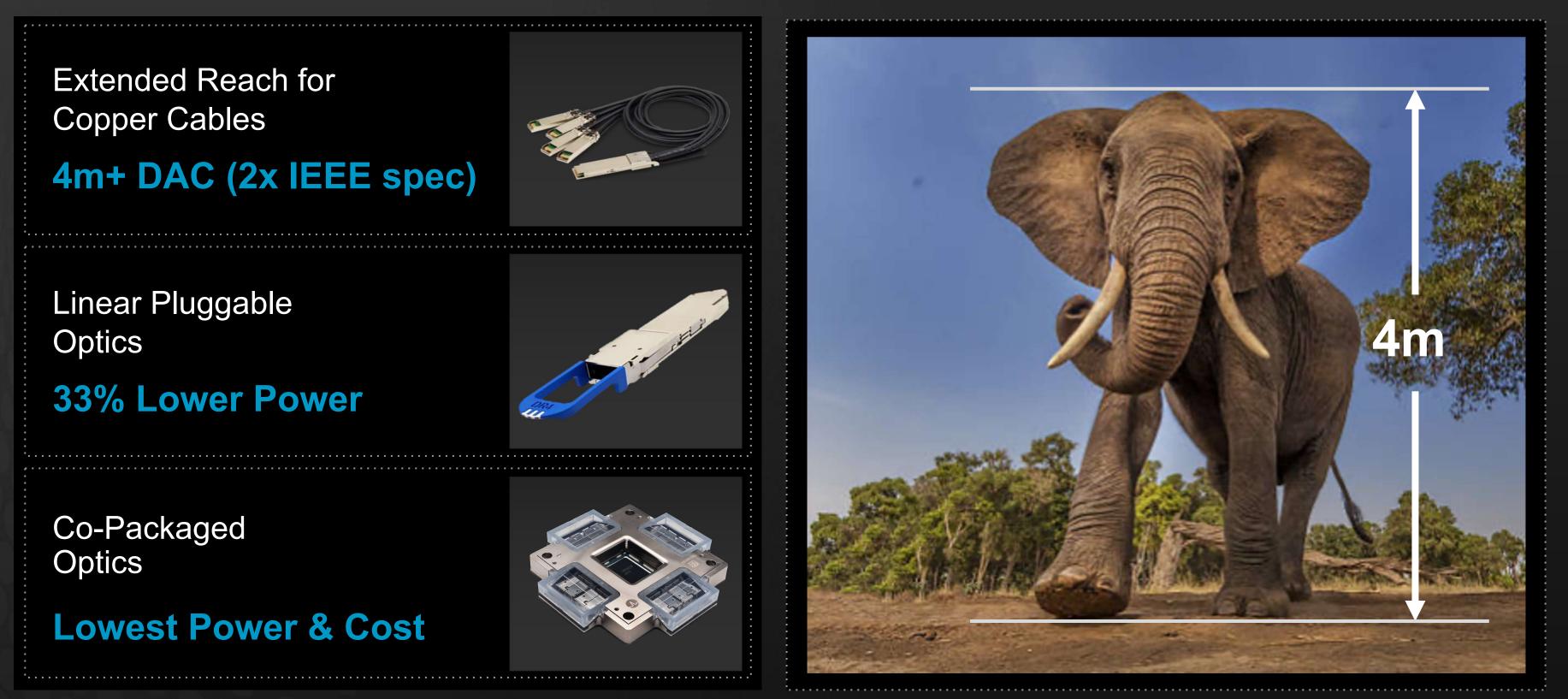
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Source: Broadcom Internal Estimates



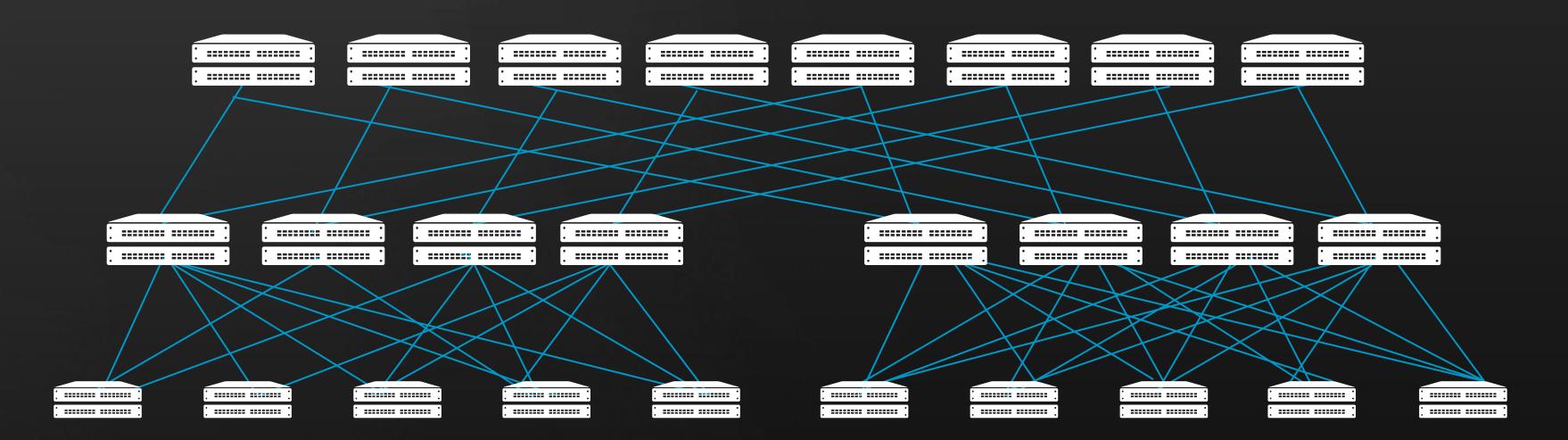
# Reducing AI Interconnect Cost and Power



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# Ethernet is the De-facto AI Network







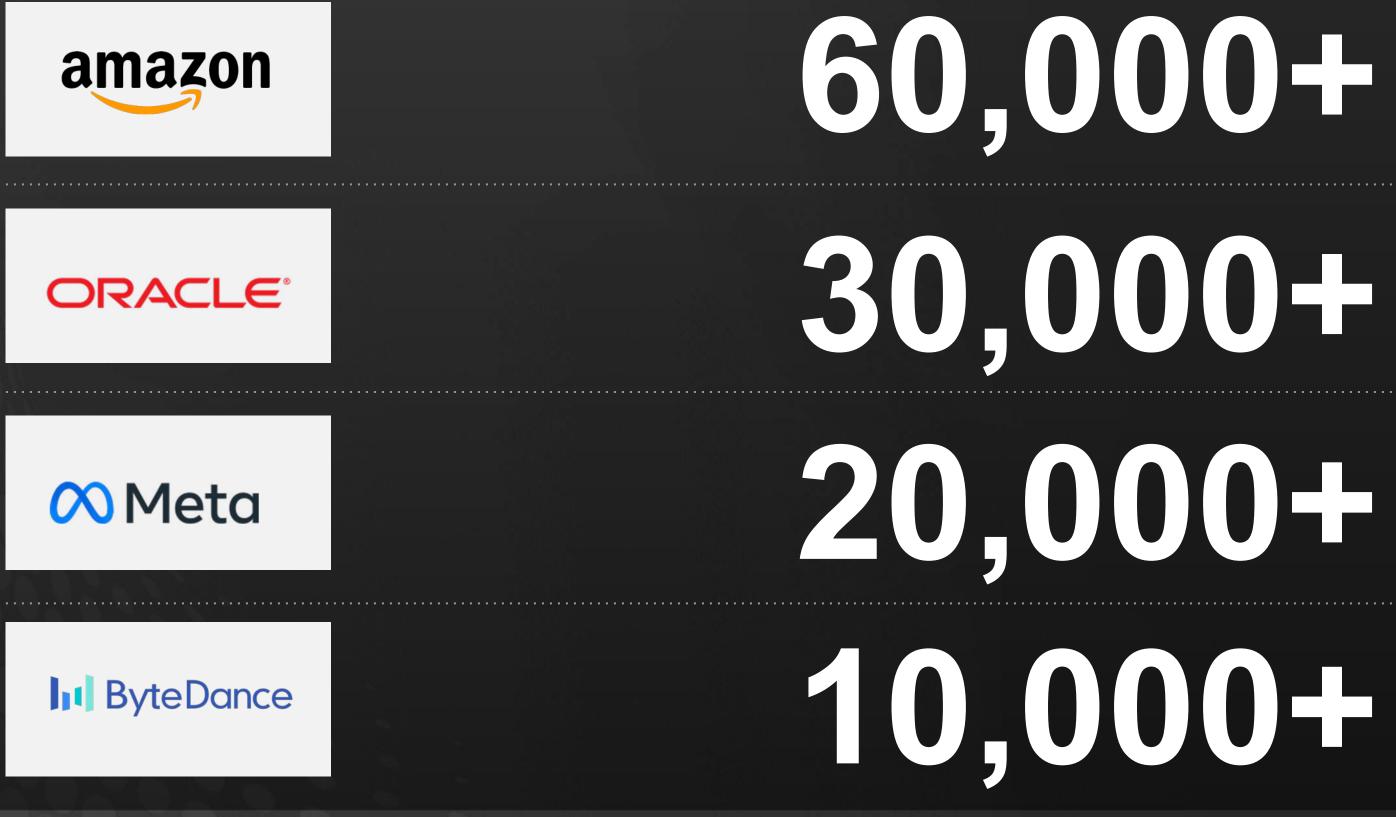
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# amazon In ByteDance Google 公Meta ORACLE Tencent腾讯



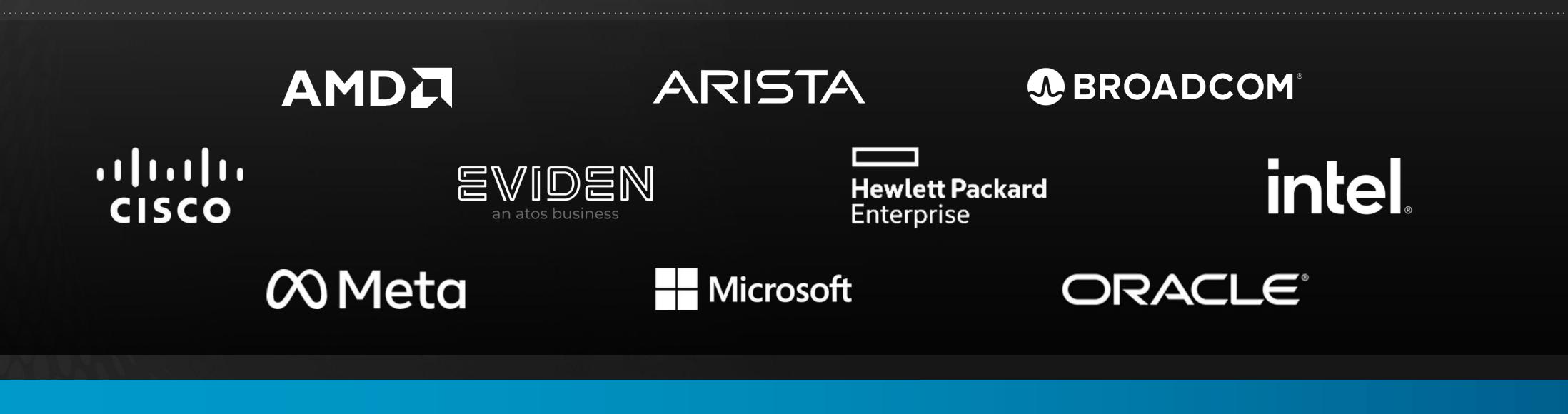
# Large Ethernet AI Clusters



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### Ultra Ethernet: Al at Scale



# Incredibly Strong Industry Reception: 55+ companies

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# Modernizing RDMA...

### **Classic RDMA**

-C

(X)

In-order packet delivery

Go-back-n  $\rightarrow$  inefficient

No multipathing

 $DCQCN \rightarrow hard to tune$ 

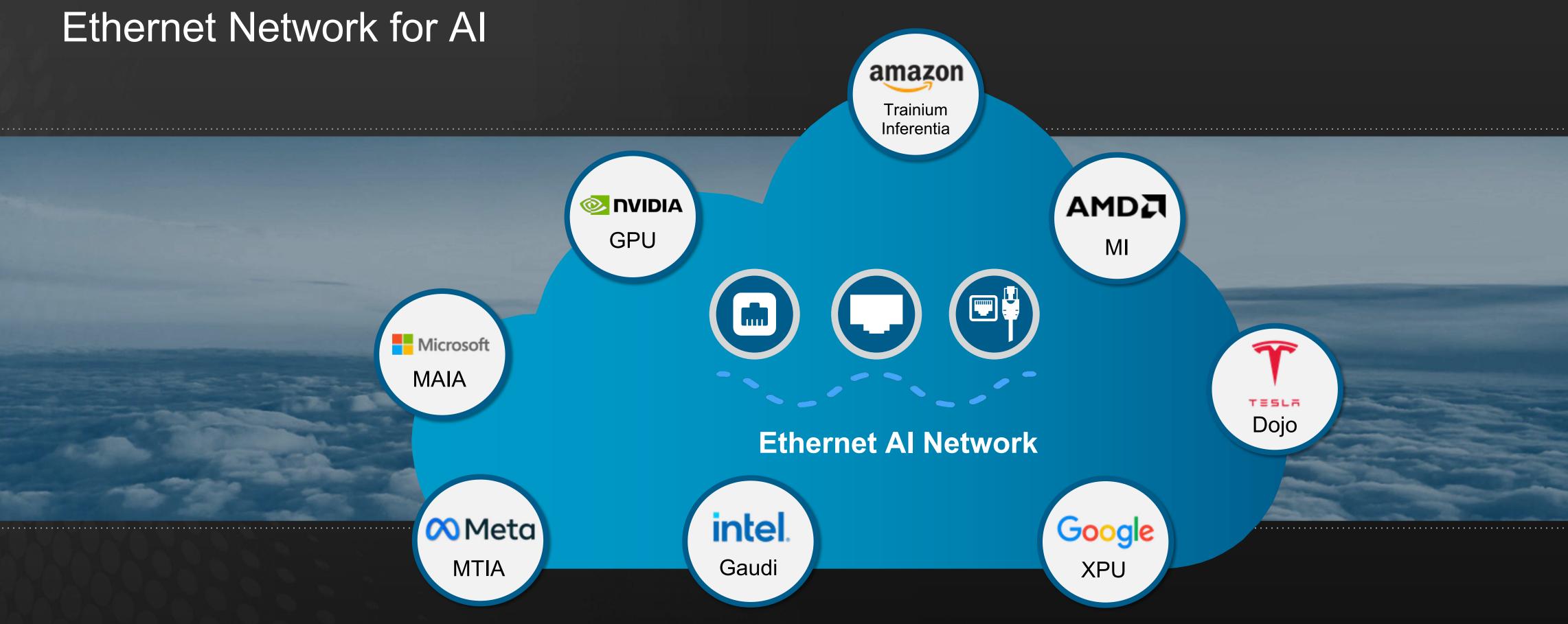
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### Ultra **Ethernet**

- Out-of-order placement, in-order message completion
- Selective Ack and retransmit
- Packet-level multipathing
- Configuration-free congestion control

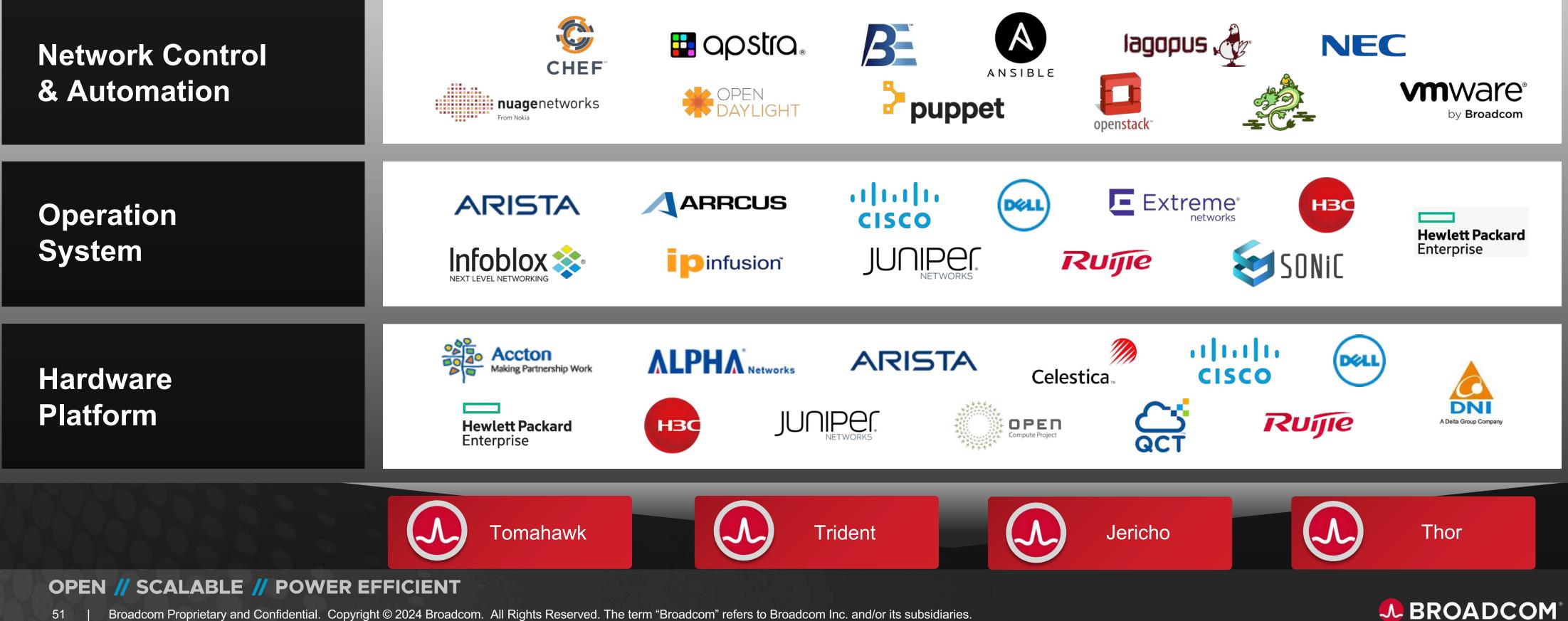




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# **Comprehensive Ethernet Portfolio and Ecosystem**







# Al Server Interconnect

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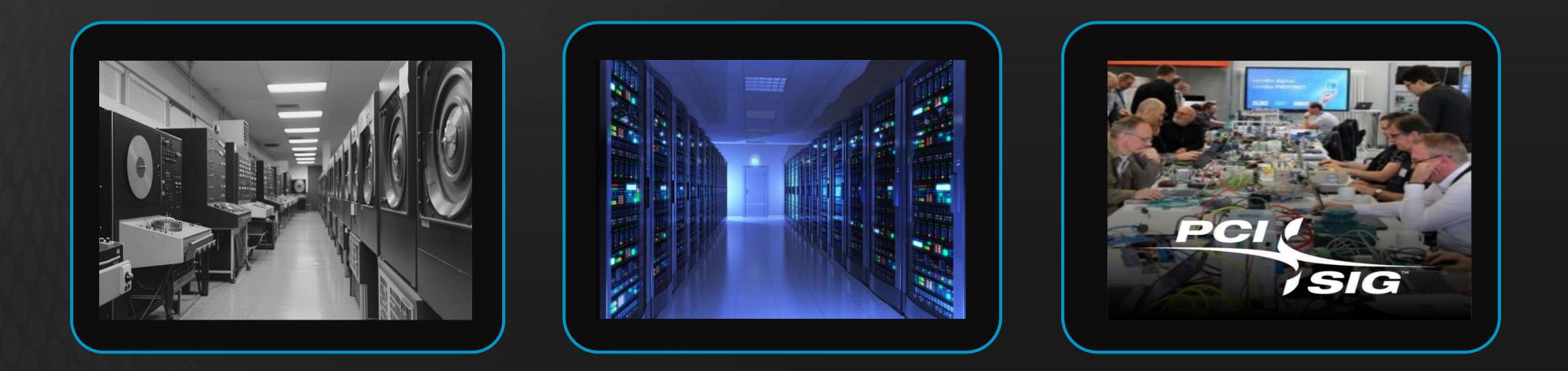
# ENABLINGA nfrastructure

#### **Jas Tremblay**

**General Manager Data Center Solutions Group Broadcom** 



# Server Interconnect History



### PCI Standards Group: Founded in 1992 with 900+ Companies

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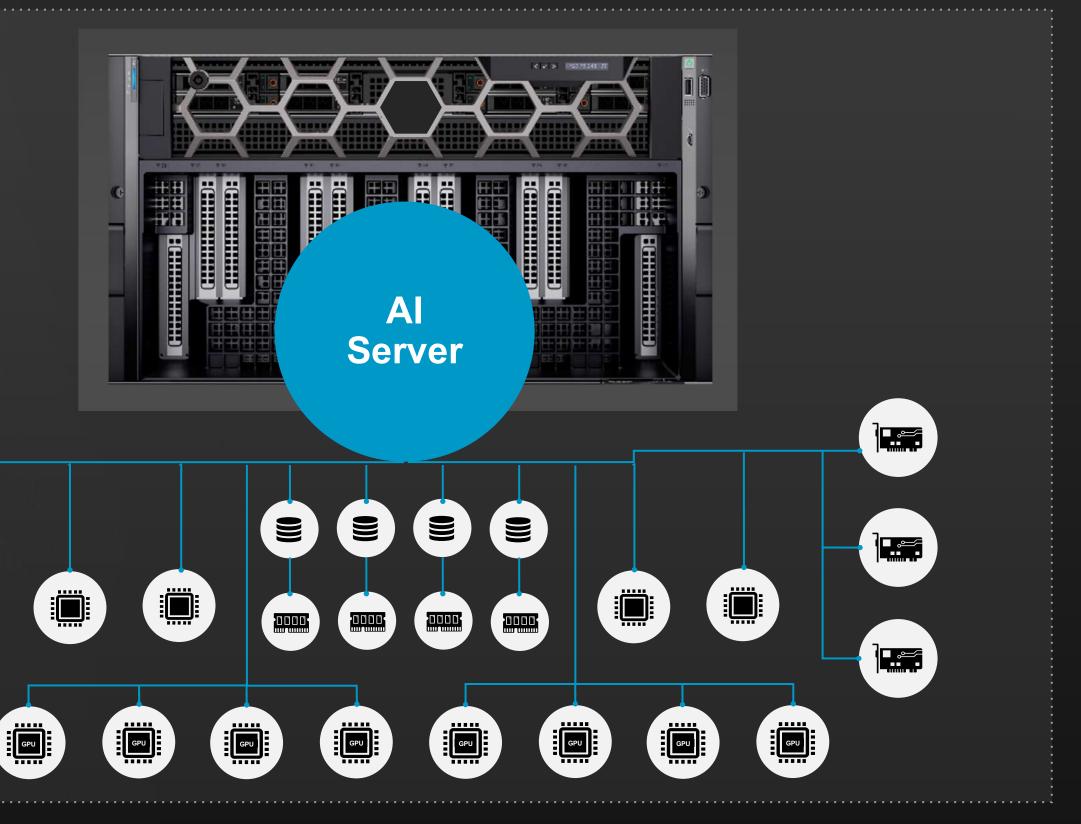


# Server Evolution Compute Server

#### **Compute Centric**

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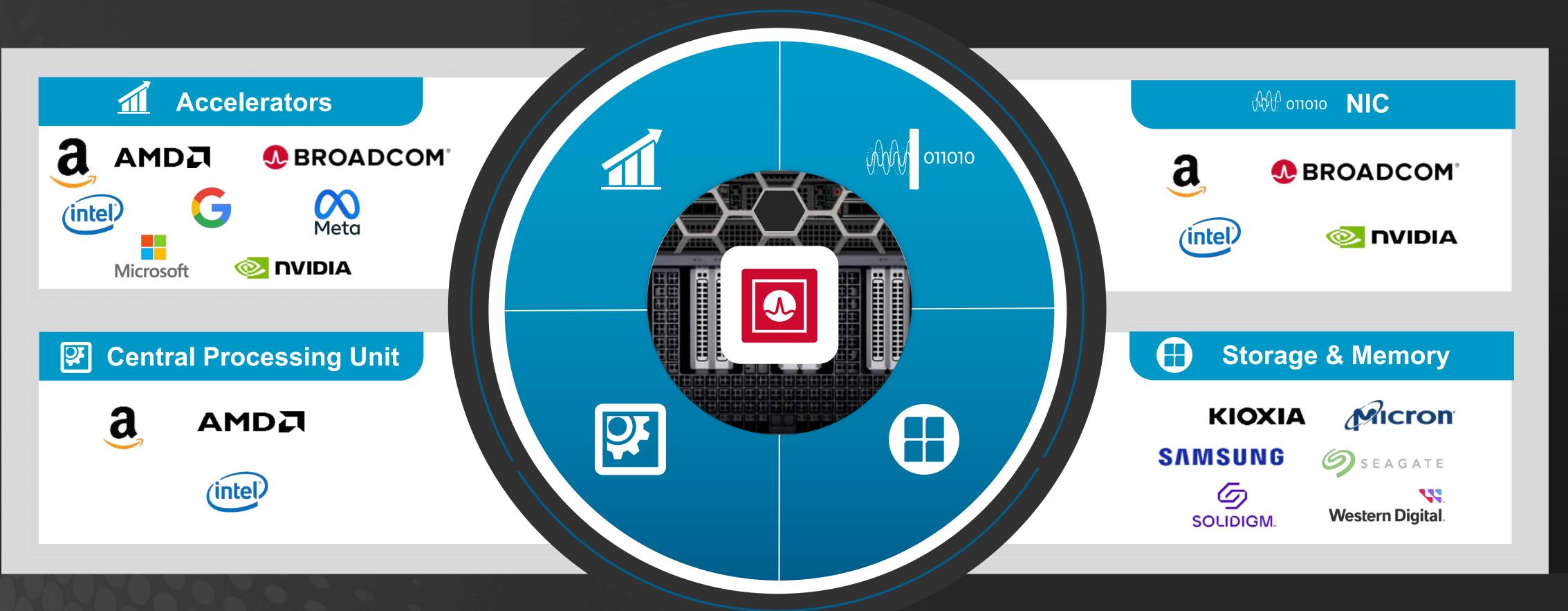
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#### **High-Performance Interconnect**



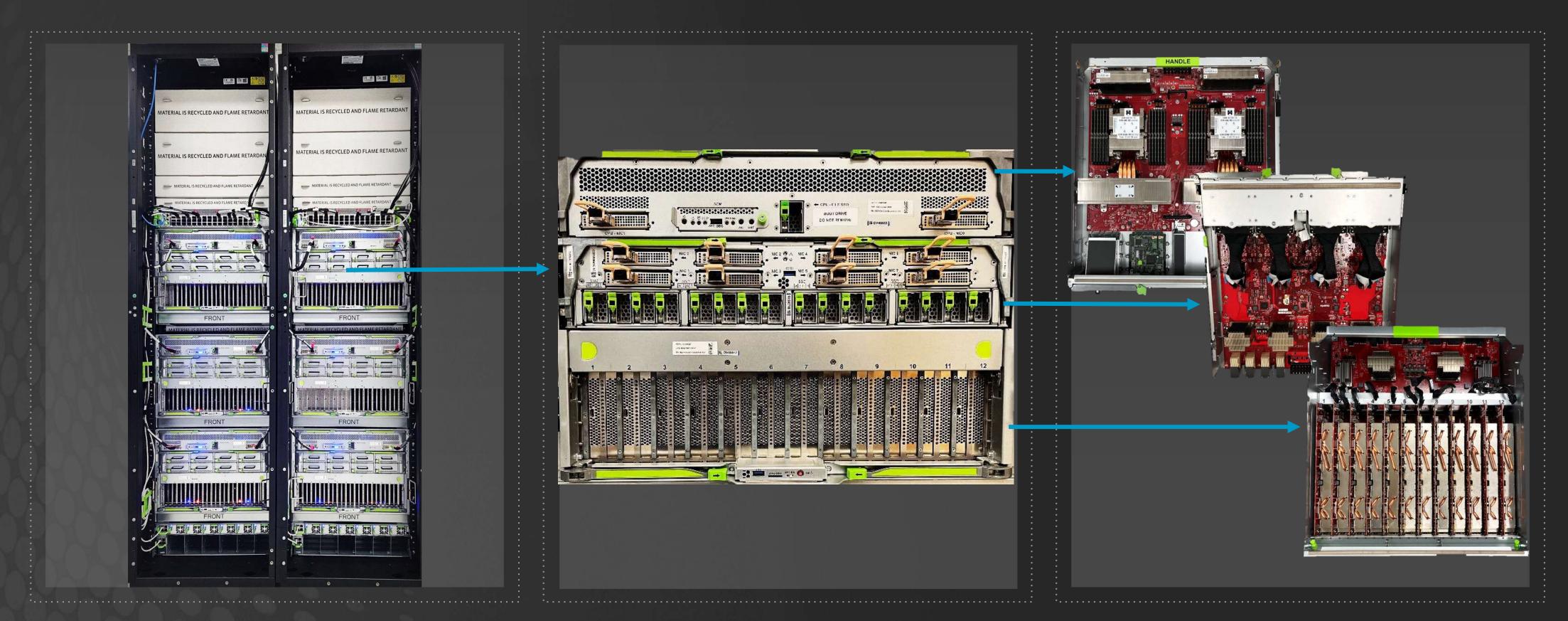
# Al Server: Open $\rightarrow$ Options



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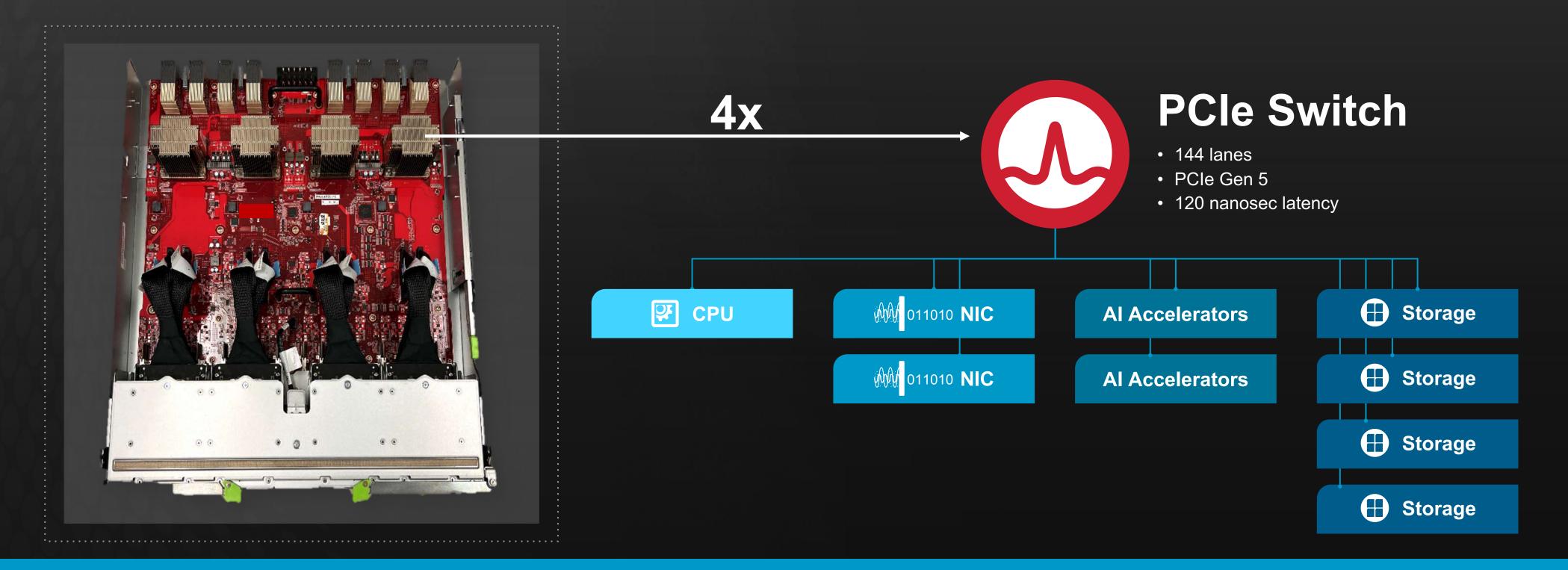
# Al Rack: Interconnect



#### OPEN // SCALABLE // POWER EFFICIENT



# Al Server: Interconnect



### **Most Trusted PCIe Device**

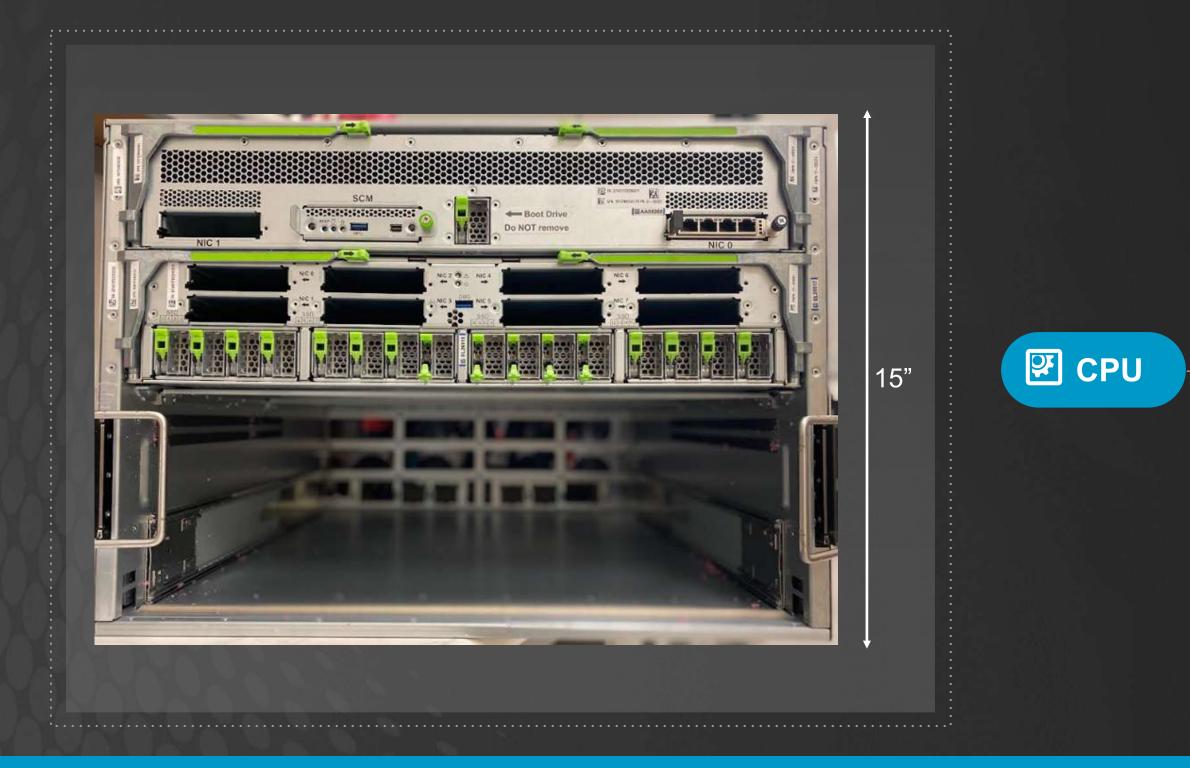
#### OPEN // SCALABLE // POWER EFFICIENT

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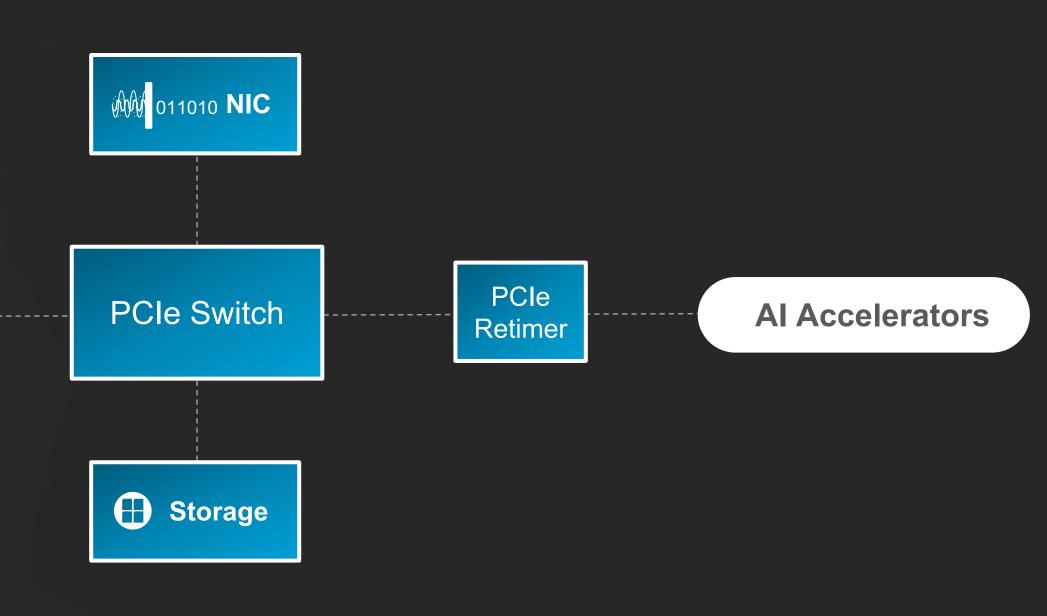


# Al Server: PCIe Interconnect



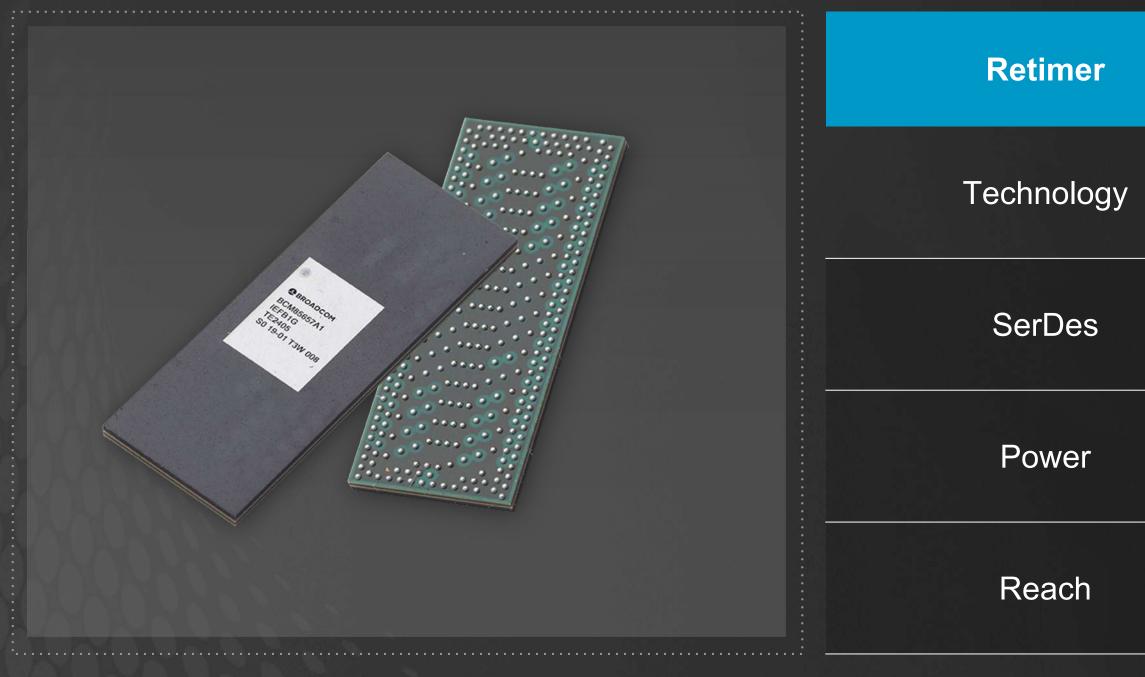
### **End-to-End AI PCIe Connectivity**

#### OPEN // SCALABLE // POWER EFFICIENT





# Al Server: PCle Retimer



Source: Broadcom Internal Estimates

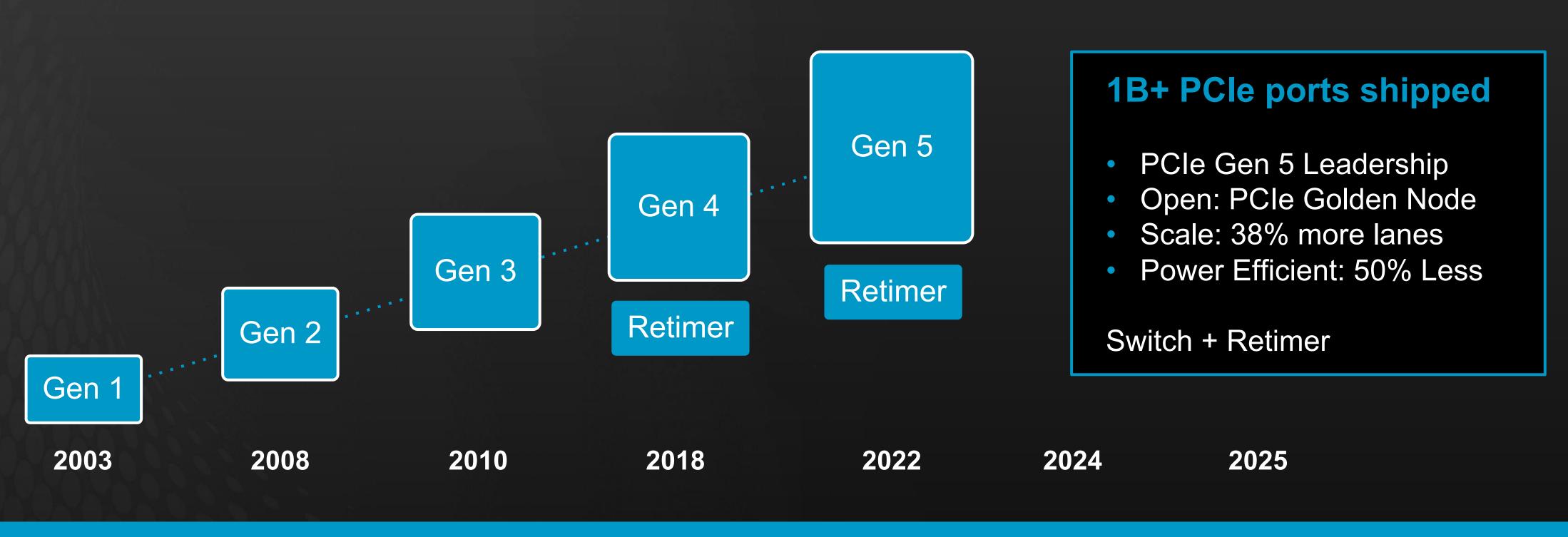
### **End-to-End AI PCIe Connectivity**

#### OPEN // SCALABLE // POWER EFFICIENT

 Competition	Broadcom
7 / 16nm	5nm
Third Party	In House
1x	35% Less
1x	40% More



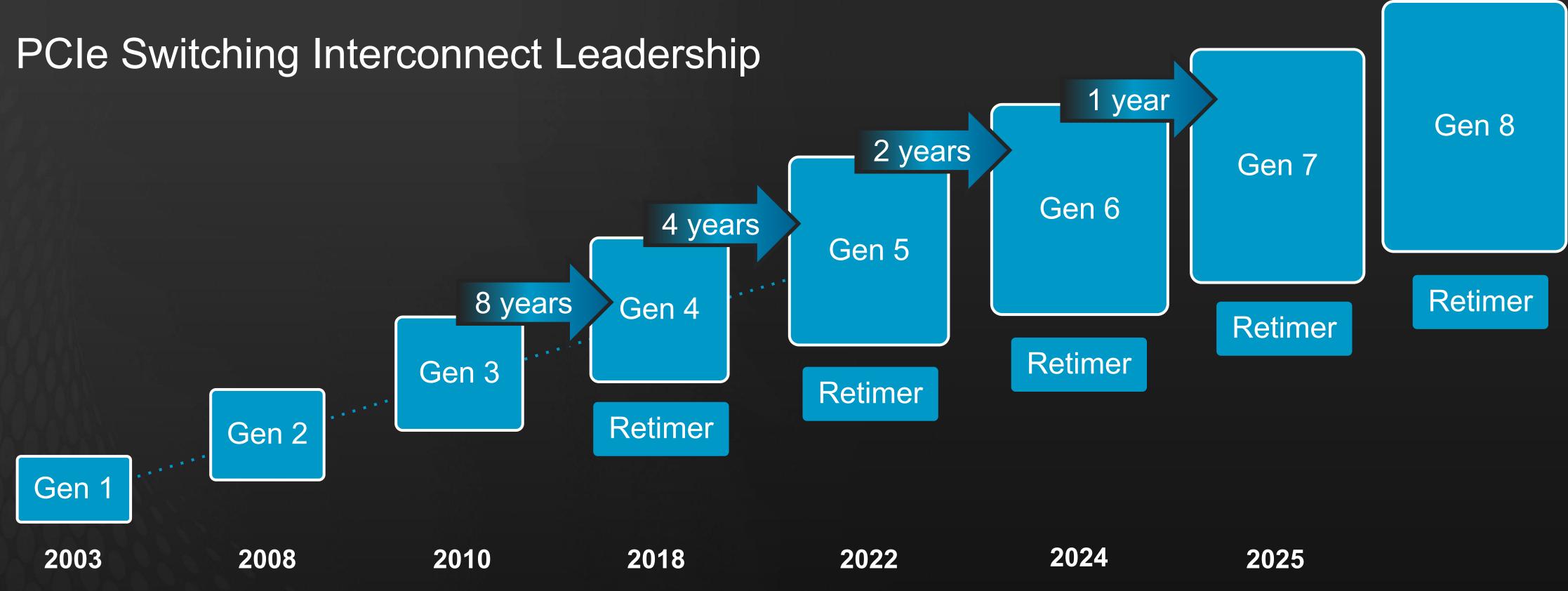
# PCIe Switching Interconnect Leadership



### First to Market for 20 Years ... 5 Successful Generations

#### // SCALABLE // POWER EFFICIENT OPEN



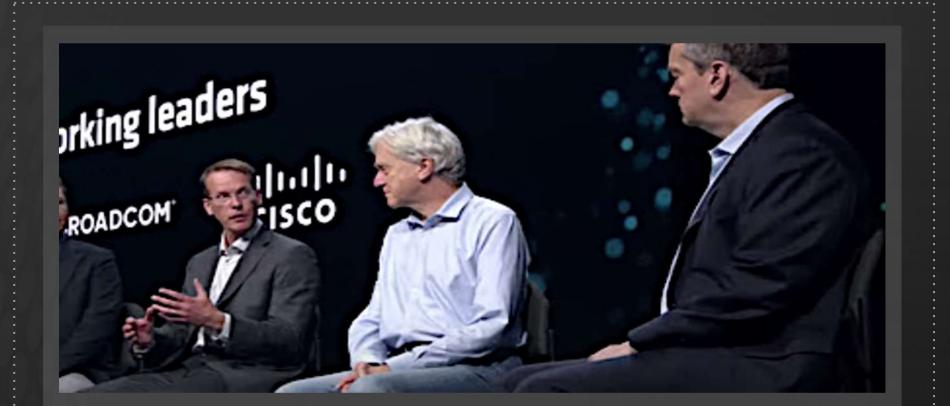


### **Accelerating PCIe Switch + Retimer Introduction**

#### // SCALABLE // POWER EFFICIENT OPEN



# Al Server: Scale Up

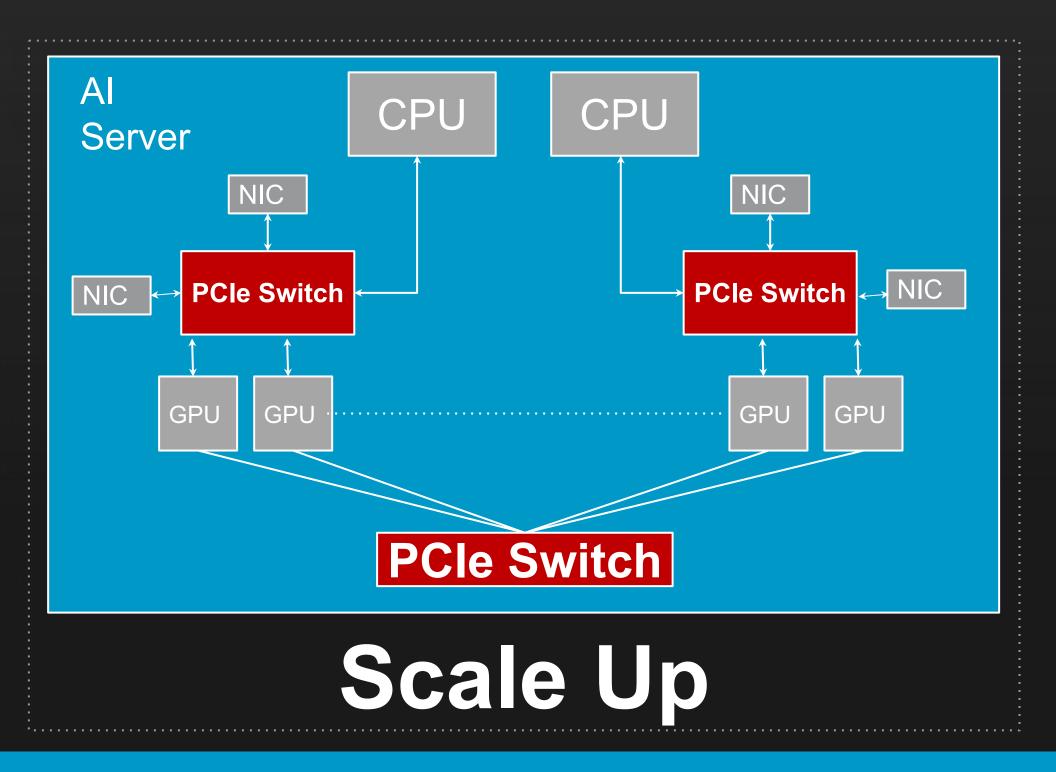


# PCle Gen 7 Switch

Accelerator Fabric Link
 Latency: ~120 nanosecond
 Scale: Hundreds of Nodes

### **AMD/Broadcom Collaborate on Scale Up Fabrics**

#### OPEN // SCALABLE // POWER EFFICIENT





# Al Server Connectivity



PCIe is key to AI Server **OPEN** interconnect





Decades of market leadership in **SCALABLE** PCIe Switches and Retimers

Broadcom end to end PCIe delivers 40% greater reach with 50% lower **POWER** 

**OPEN // SCALABLE // POWER EFFICIENT** 

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Source: Broadcom Internal Estimates





# **hitastructure**

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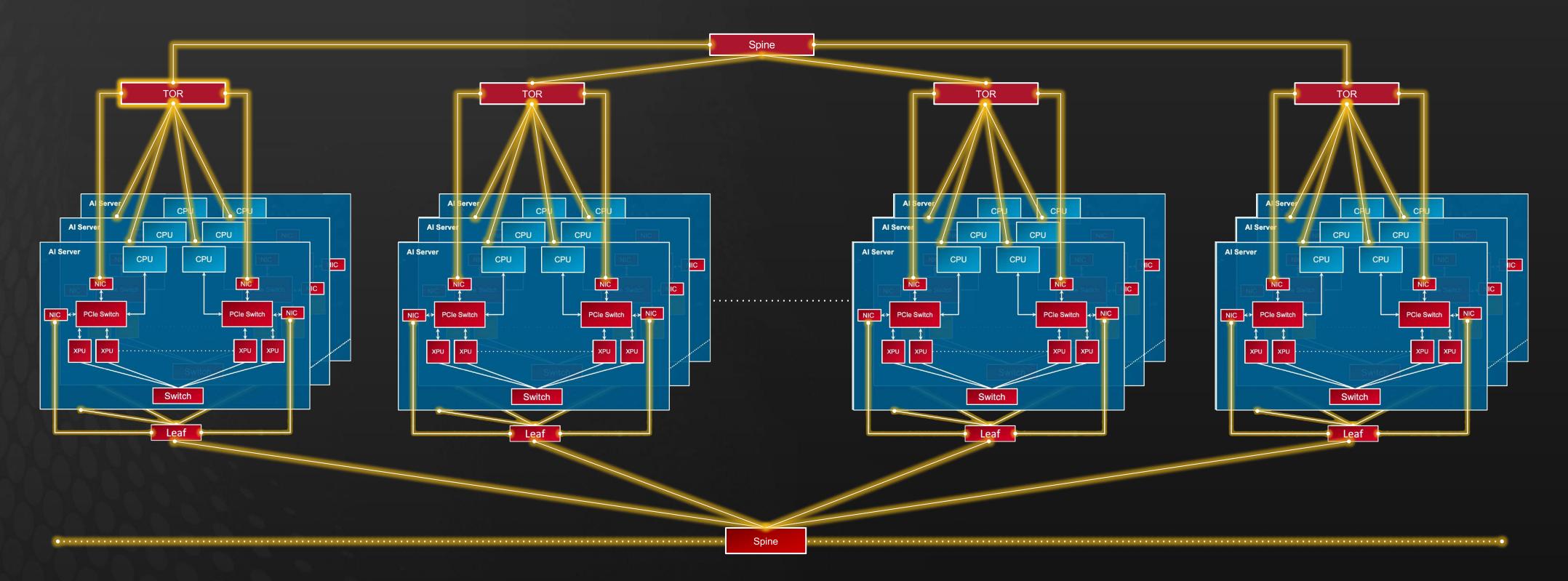
# **Optical Interconnects**

# Near Margalit, Ph. D.

General Manager **Optical Systems Division** Broadcom



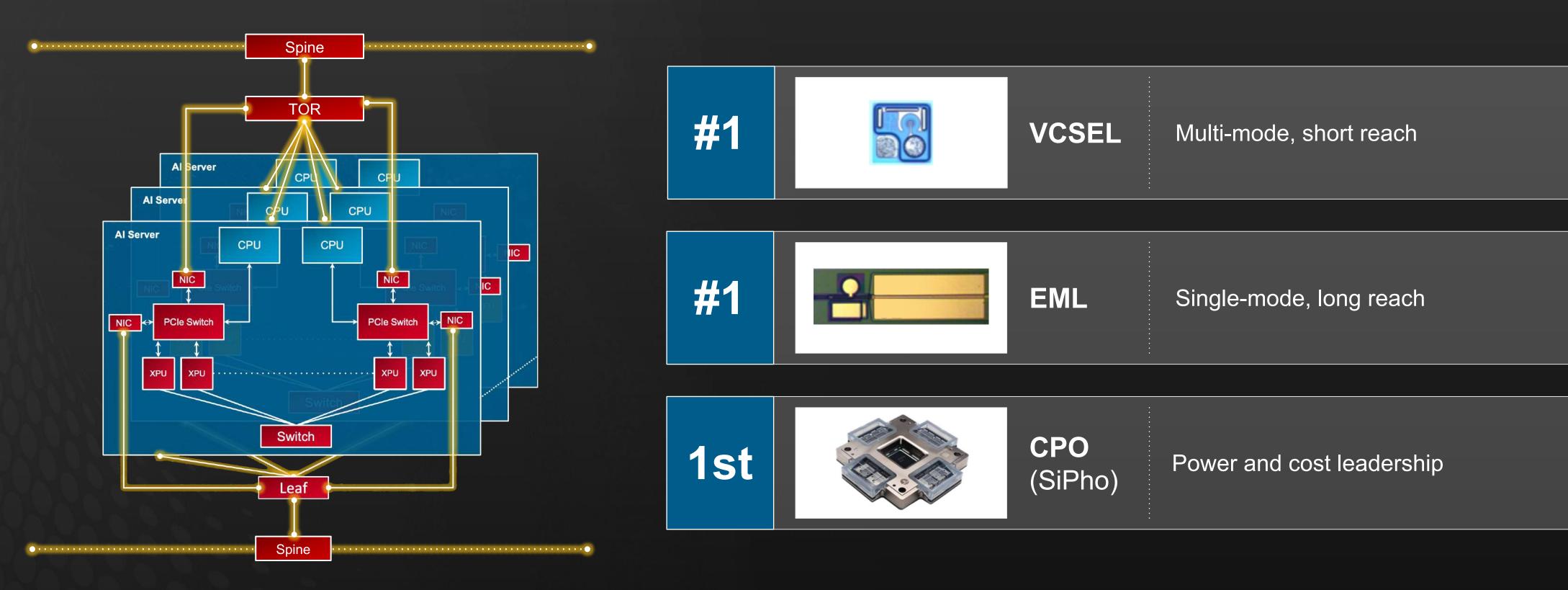
# The Optical Interconnect for AI



#### OPEN // SCALABLE // POWER EFFICIENT



# Optical Interconnect for AI



#### OPEN // SCALABLE // POWER EFFICIENT



# **Broadcom Optics Leadership**

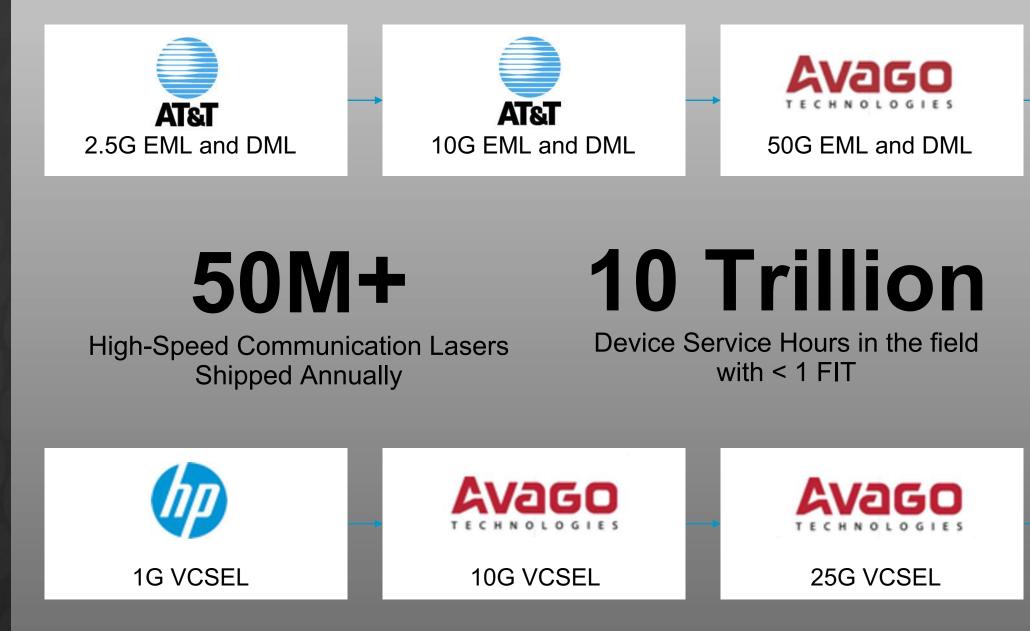
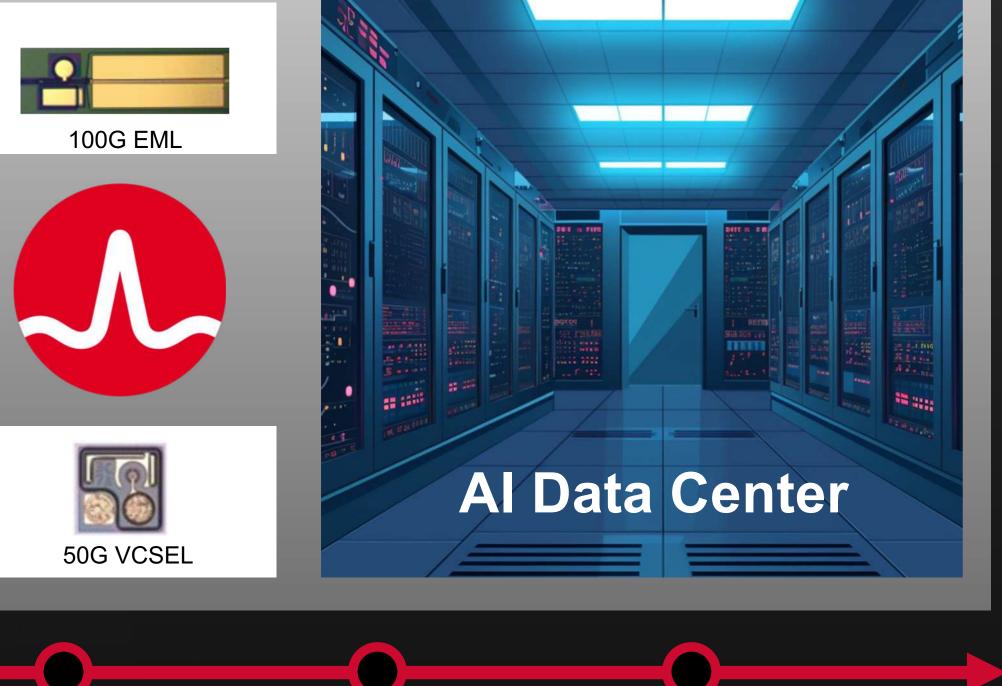


 Image: 1998
 Image: 2004
 Image: 2013
 Image: 2019

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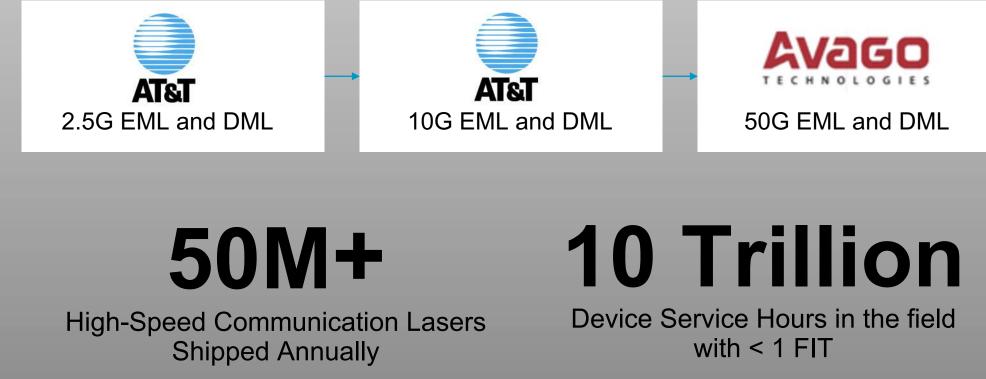


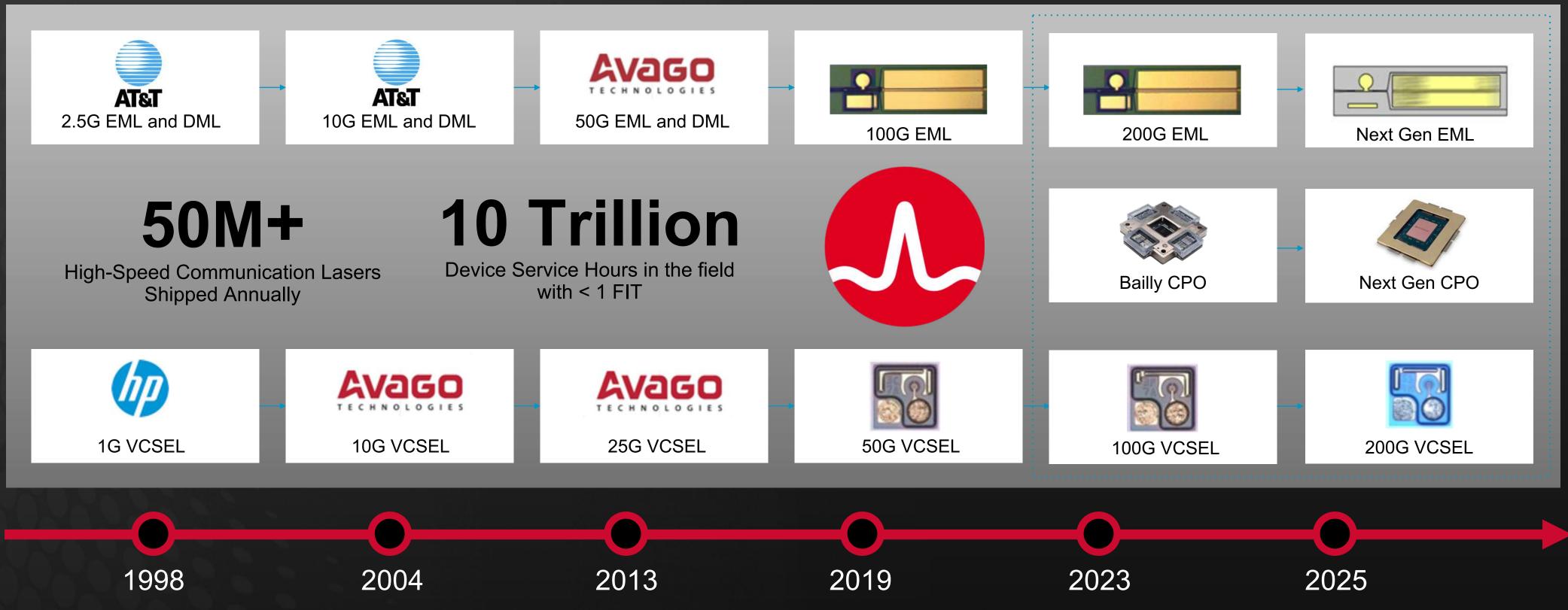
2023

BROADCOM°

2025

# **Broadcom Optics Leadership**





#### OPEN // SCALABLE // POWER EFFICIENT



# Why Co-Packaged Optics (CPO)?



#### Lowest Cost/Bit

Massive reduction in components and interconnects



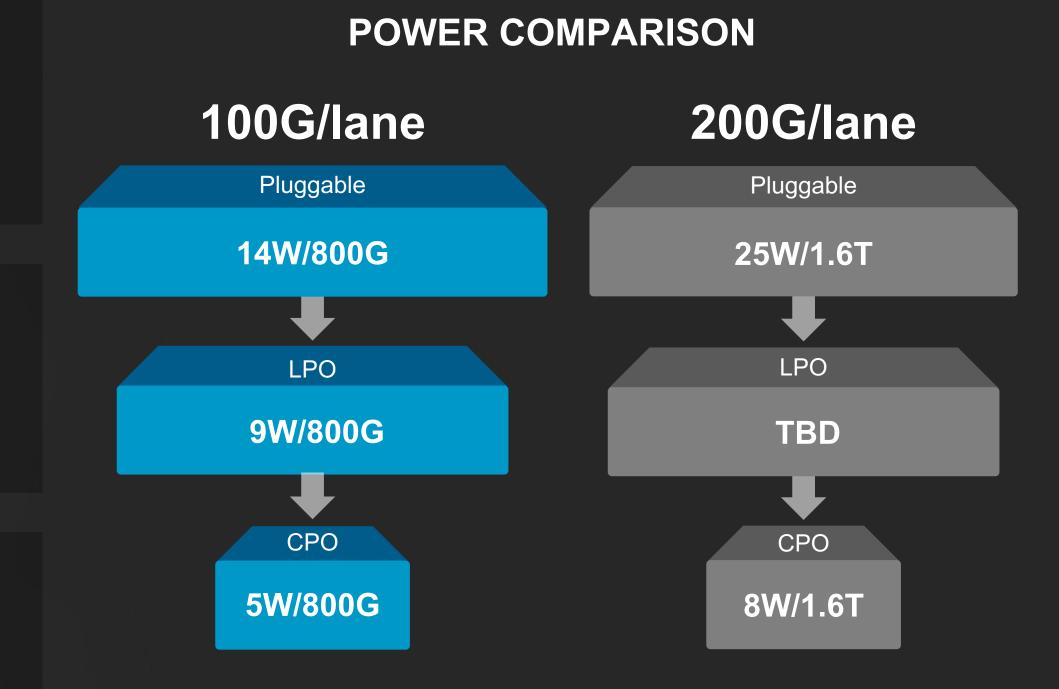
#### **Power/Performance Leadership** Eliminate electrical interconnect power



#### **Increased Reliability**

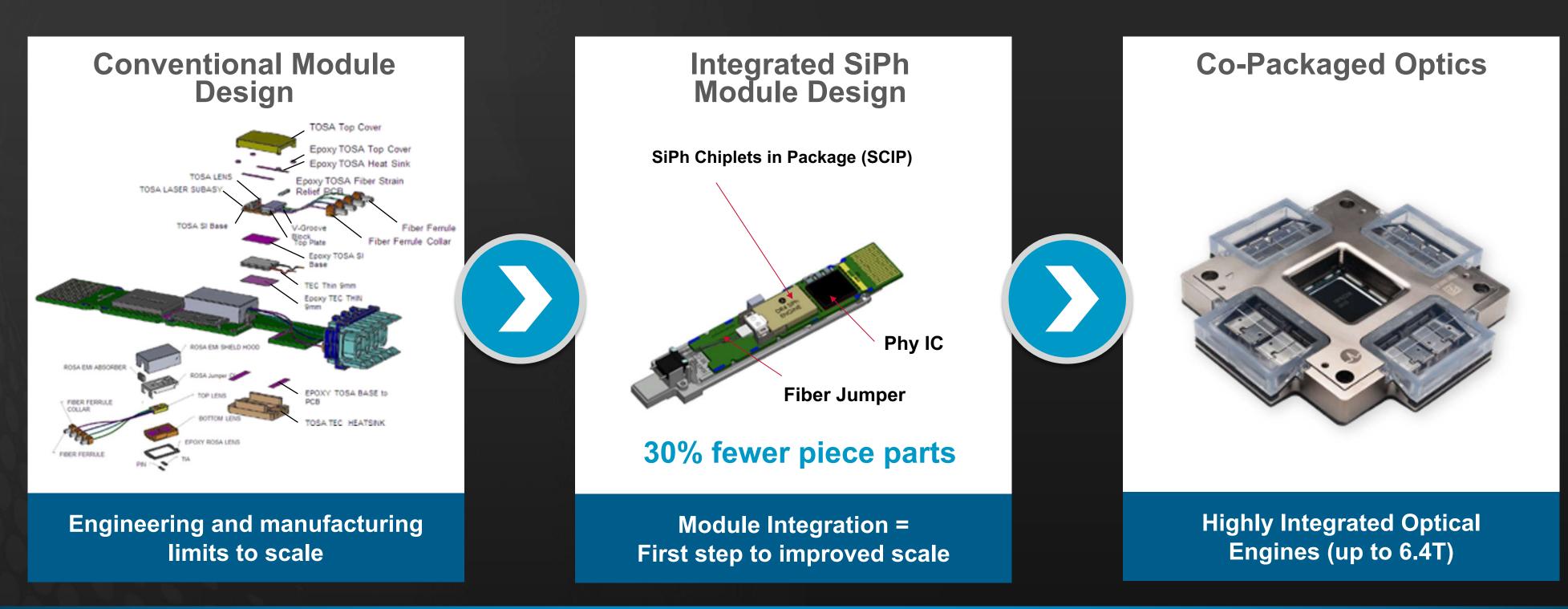
Silicon integration with pluggable Laser

#### OPEN // SCALABLE // POWER EFFICIENT





# The Journey to Integration at Scale



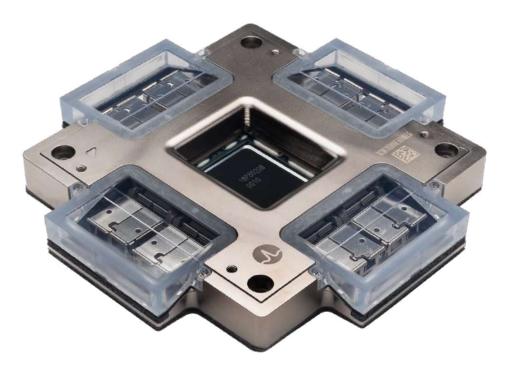
#### FIRST to Productize High-Density Photonic Integration

#### OPEN // SCALABLE // POWER EFFICIENT



# CPO Applications: Ethernet Switch, XPU Interconnect

#### **Ethernet Switch**

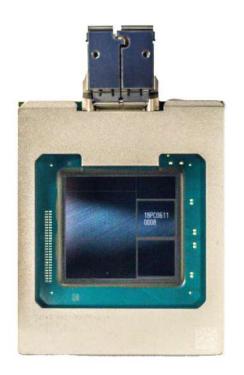


More than 50Tbps optical connectivity co-packaged with an Ethernet Switch

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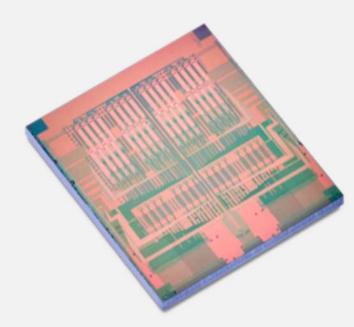
#### **XPU Interconnect**



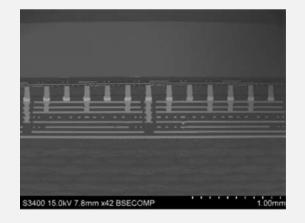
Up to 50Tbps optical connectivity co-packaged with a XPU



# 51.2T TH5-Bailly CPO available today



64 Channel FR4 PIC with Integrated Mux/Demux

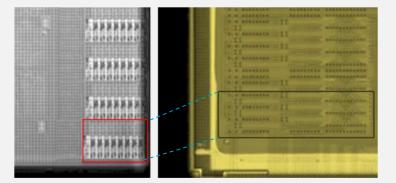


Advanced Packaging

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64 Channel EIC with CMOS Driver and TIA



ODM System Integration





## Optical Interconnects



## Key Points





\*Source: Broadcom Internal Estimates

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### Industry leadership on $100G \rightarrow 200G$ VCSEL and EML

First commercial **CPO** with pluggable lasers

Unmatched >70% power reduction<sup>\*</sup> and >30% cost savings





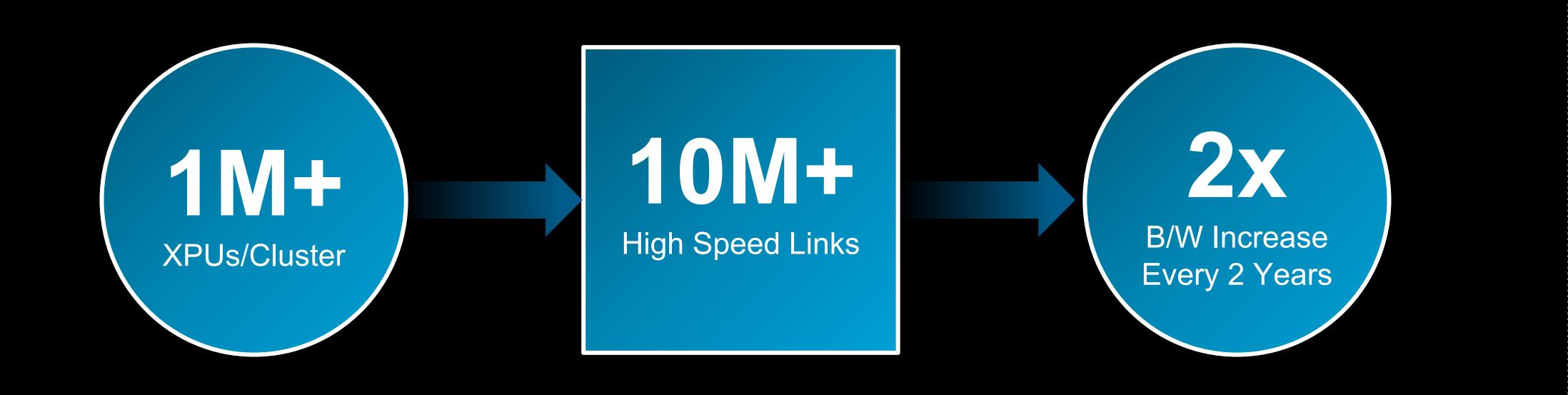
# ENABLING AI Infrastructure

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## Vijay Janapaty

General Manager Physical Layer Products Broadcom

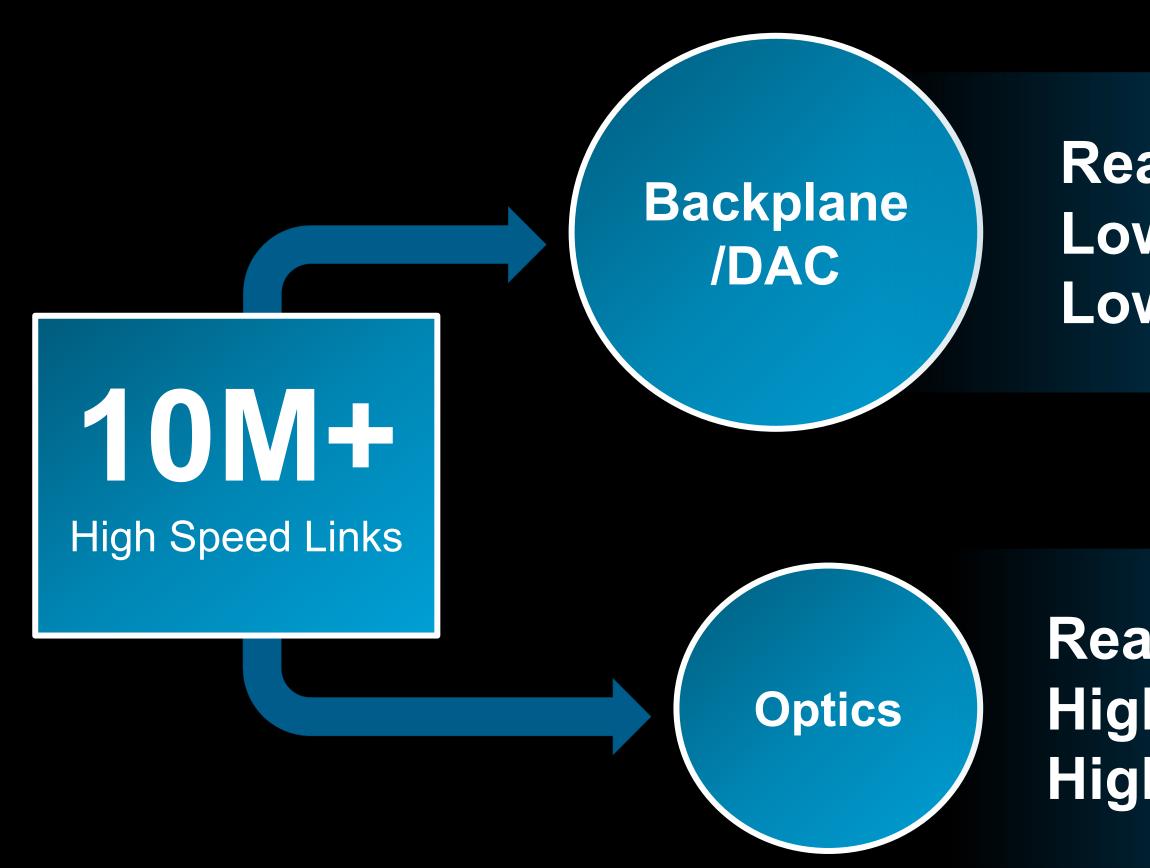




## High Speed Links : 2<sup>nd</sup> Highest Power & Cost in Al Cluster

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Reach: < 5m Lowest Power Lowest Cost

## SerDes

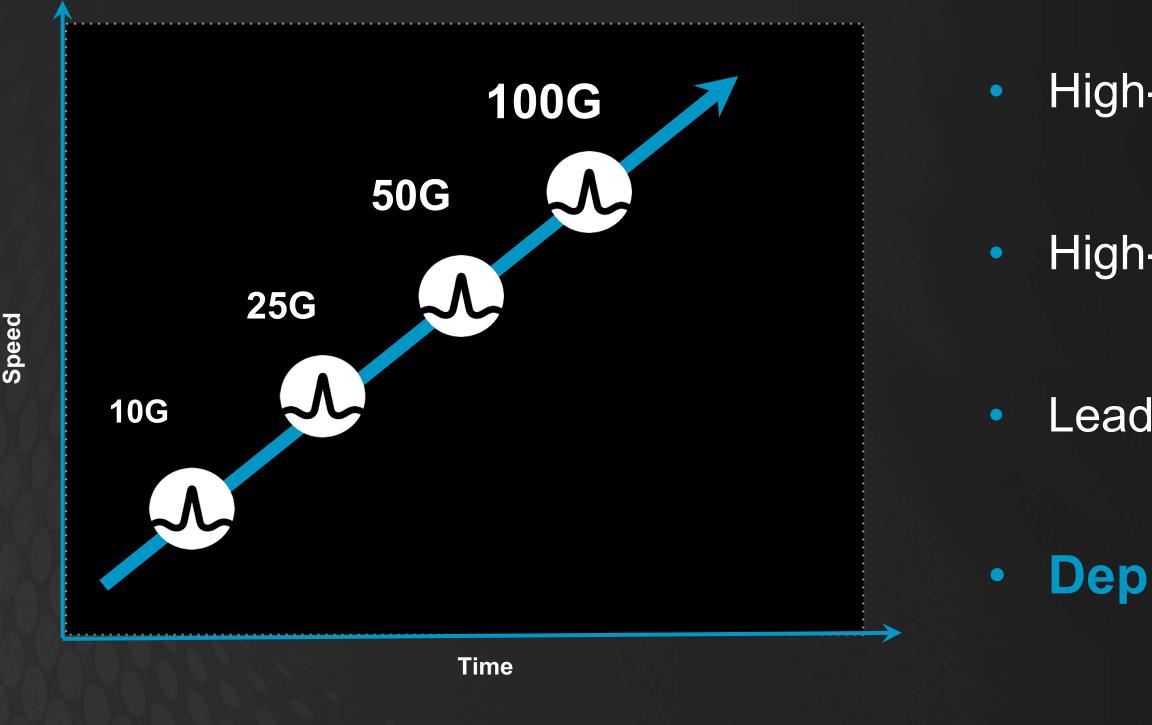
Reach: 10m–10 Km Highest Power Highest Cost

## SerDes

DSPs

Source: Broadcom Internal Estimates





## **#1 SerDes for 4+ Generations**

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## High-Speed Analog-to-Digital Conversions

- High-Speed Custom Digital-Signal Processing
- Leading-Edge Process Technology Nodes
- **Deployment** in 100s of Systems



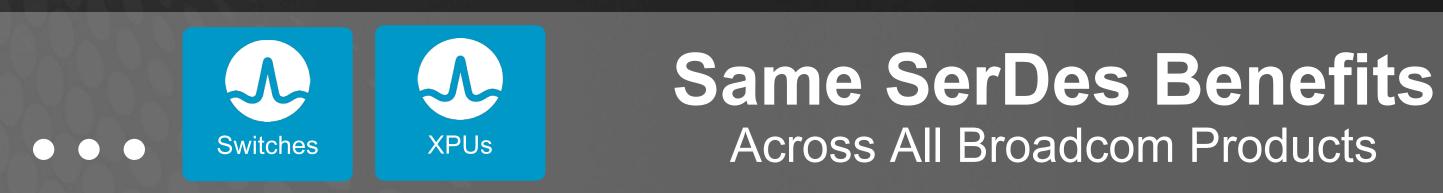
## Industry-Leading 5 nm 112 Gb/s SerDes: Peregrine



45+ dB Backplanes Higher Fanout



### **Drives CPO Natively** 50+% Power Reduction



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New

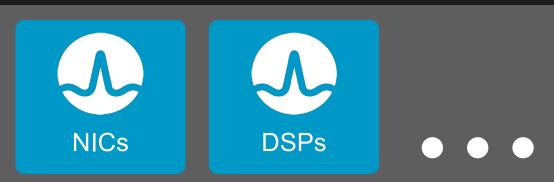


## 4+m DAC Cables

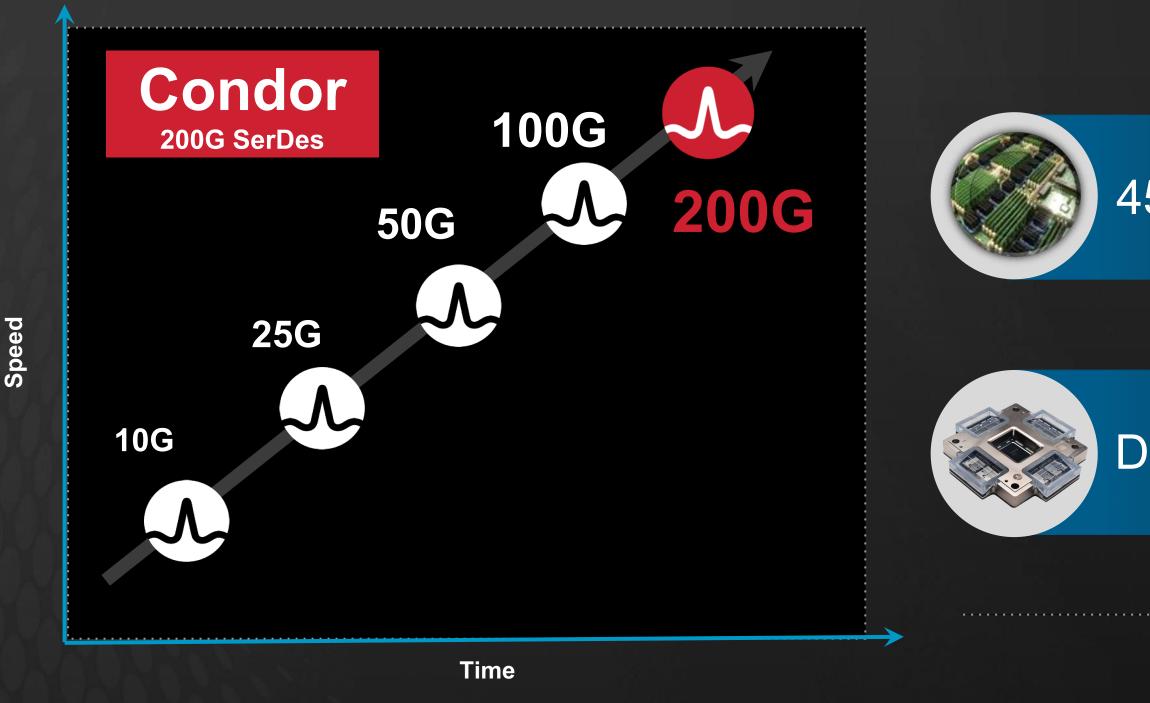
Lowest Power and Cost for Intra-Rack & Inter-Rack



New





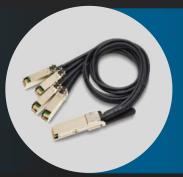


## Industry's Best 200 Gb/s SerDes in 3 nm

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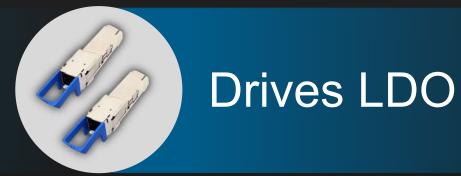
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## 45+ dB Backplanes



### 2+m DAC Cables

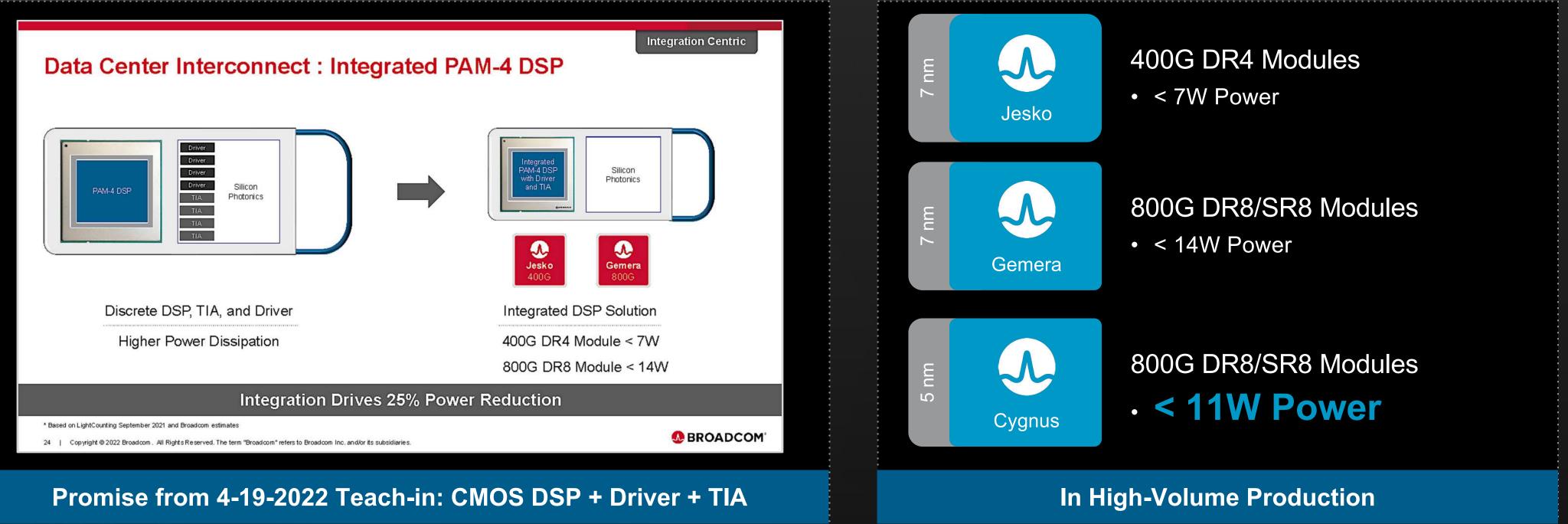
## **Drives** CPO



## **Available Now**



## Industry's First: CMOS DSP + Driver + TIA for 100 G/λ PAM4 Optics



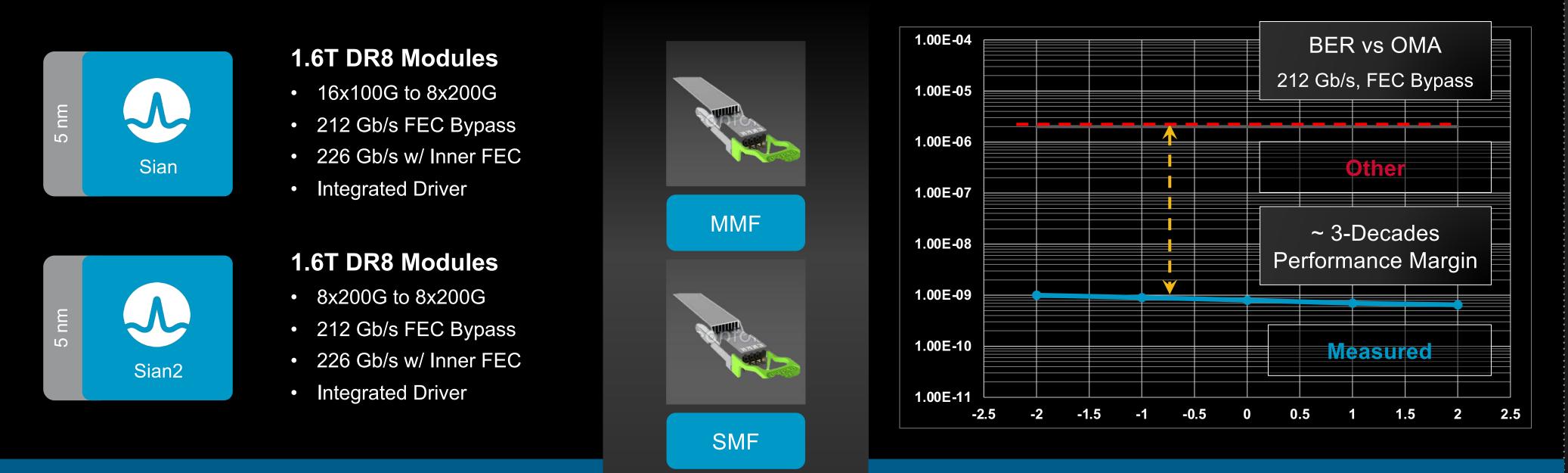
## Broadcom iDSPs ⇒ Lowest Power/Cost MM/SM Pluggable Modules

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## Best-Performing 200 G/λ DSPs in the Industry



#### **Integrated DSPs for 1.6T Generation**

## 200G iDSPs ⇒ Performance, Power and Latency Leadership

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**Performance Result from Partner 1.6T Module** 



## Foundation Technology



### **100 Gb/s BEST-IN-CLASS Innovative Connectivity**

## Key Points



## 200 Gb/s LEADS Open Ecosystem



## **DIFFERENTIATION** from Analog + DSP Expertise, R&D Scale

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## ENABLING A Infrastructure Custom Accelerators

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## Accelerators (XPUs)

## Frank Ostojic

General Manager Custom AI Product Division Broadcom



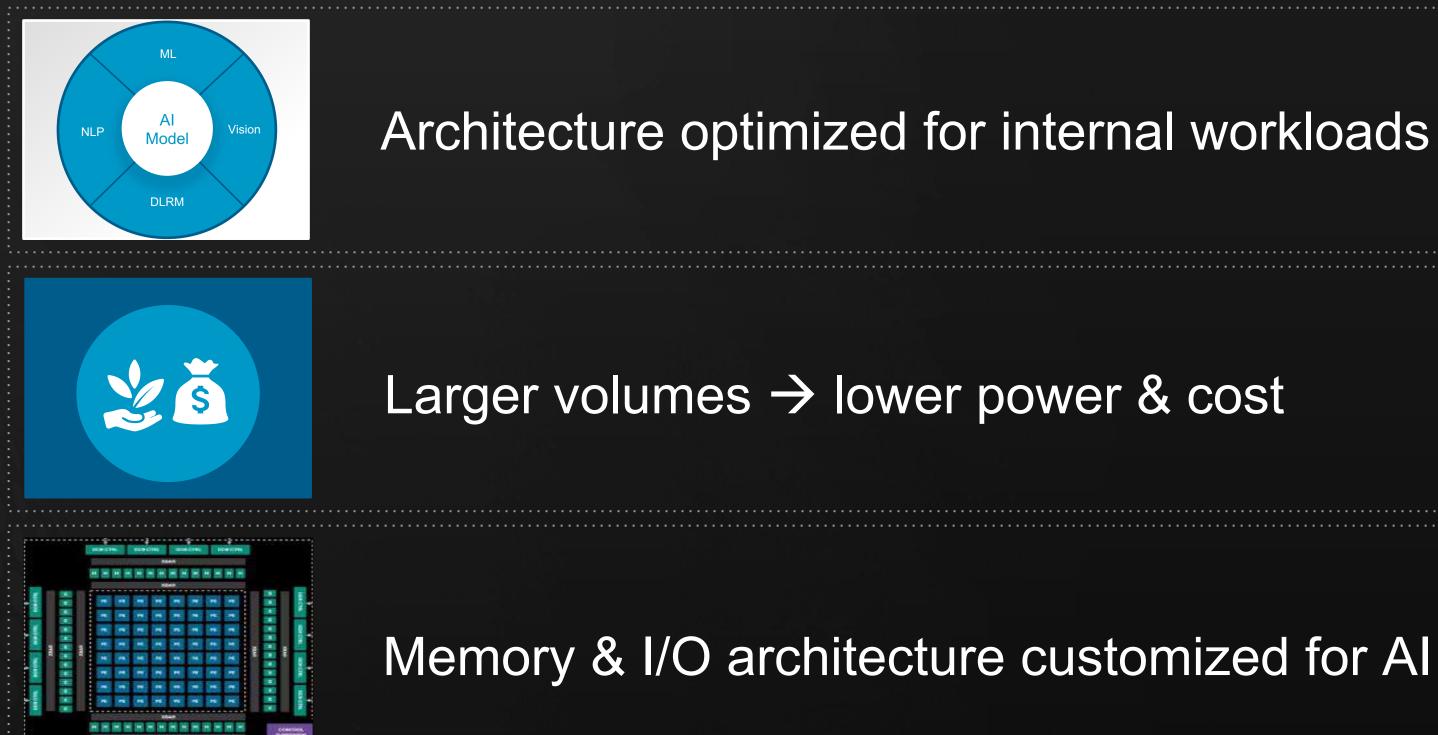


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## custom silicon

10 years

## Consumer AI Requires Custom Accelerators (XPUs)



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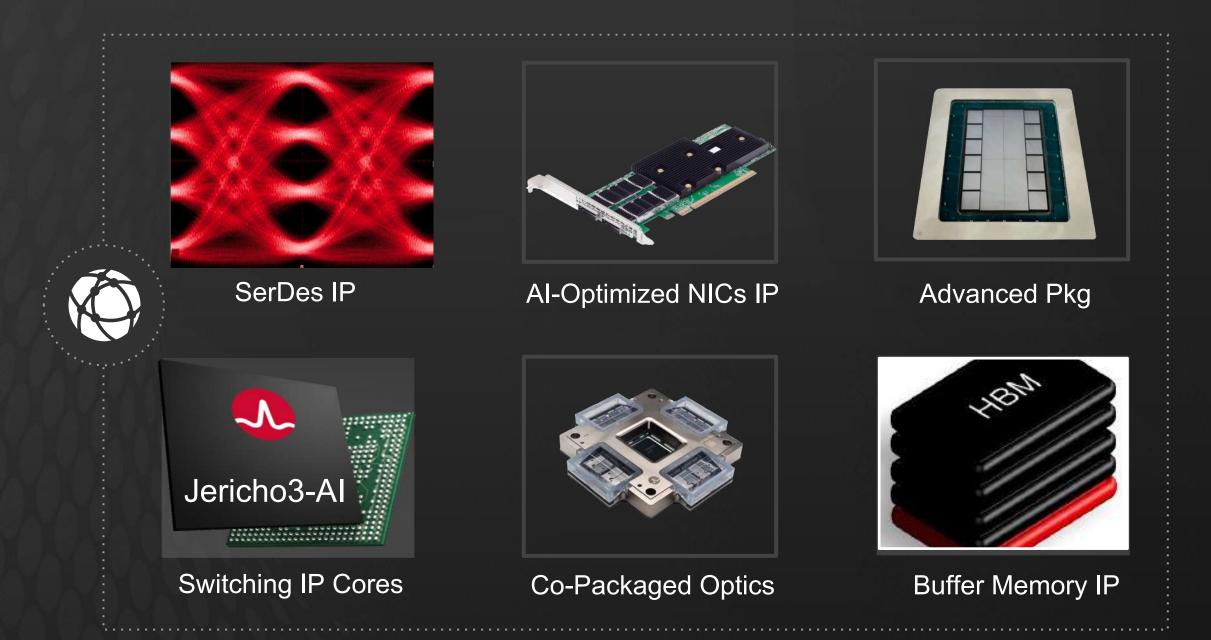
86



## Memory & I/O architecture customized for AI workloads



## Industry-Leading IP Portfolio for Differentiated XPUs



## Optimized Architecture + Lowest Power → Best Performance/TCO

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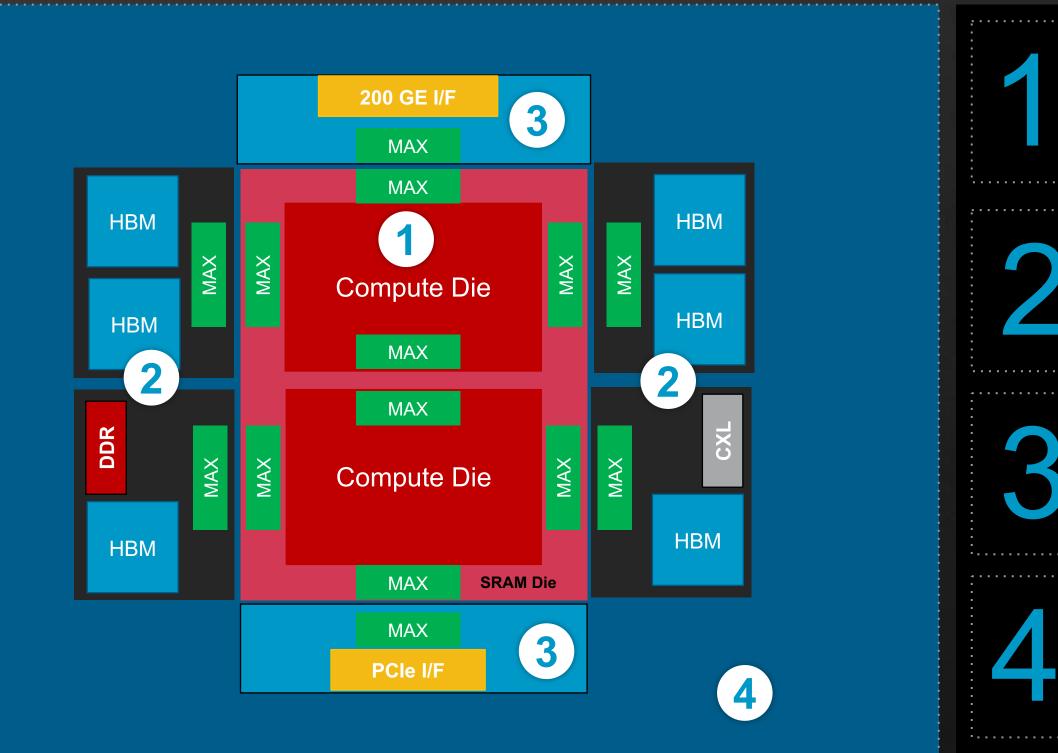








## Broadcom IP Enables XPU Critical Components



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#### Compute

Processing Unit Architecture (Customer Owned) Design Flow & Performance Optimization (Broadcom Owned)



#### Memory

HBM PHY, Integration & Performance (Broadcom Owned)

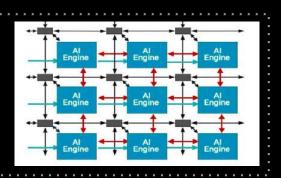


#### Network IO

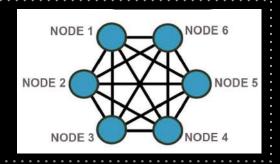
Architecture & Implementation (Broadcom Owned) Full Solution Chiplets (Hardware, Firmware, & Software)

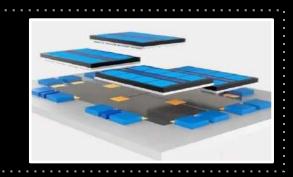
#### Package

2.5D, 3D, & Silicon Photonics Architecture & Implementation (Broadcom Owned); Vertical Integration Advantage









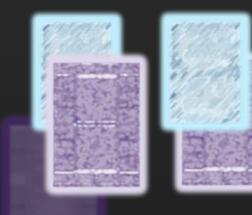


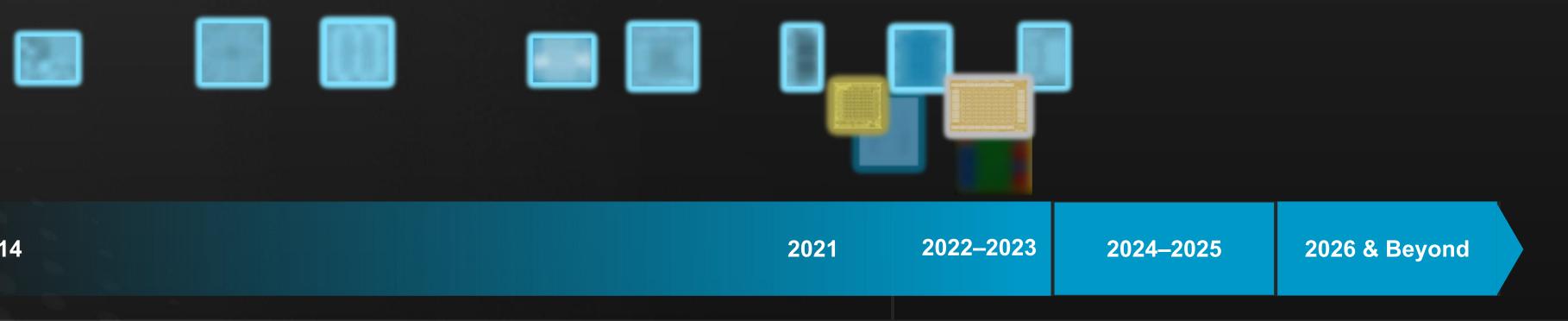
## Delivering Multi-Generational Custom Al Accelerators over the Past Decade



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## Deep, Strategic, Multi-Year Partnership with Consumer AI Customers

## 10 Years & 10 XPUs

Production

**Co-Development** 

2014–2023

## 4 Years & 4 XPUs Co-Development

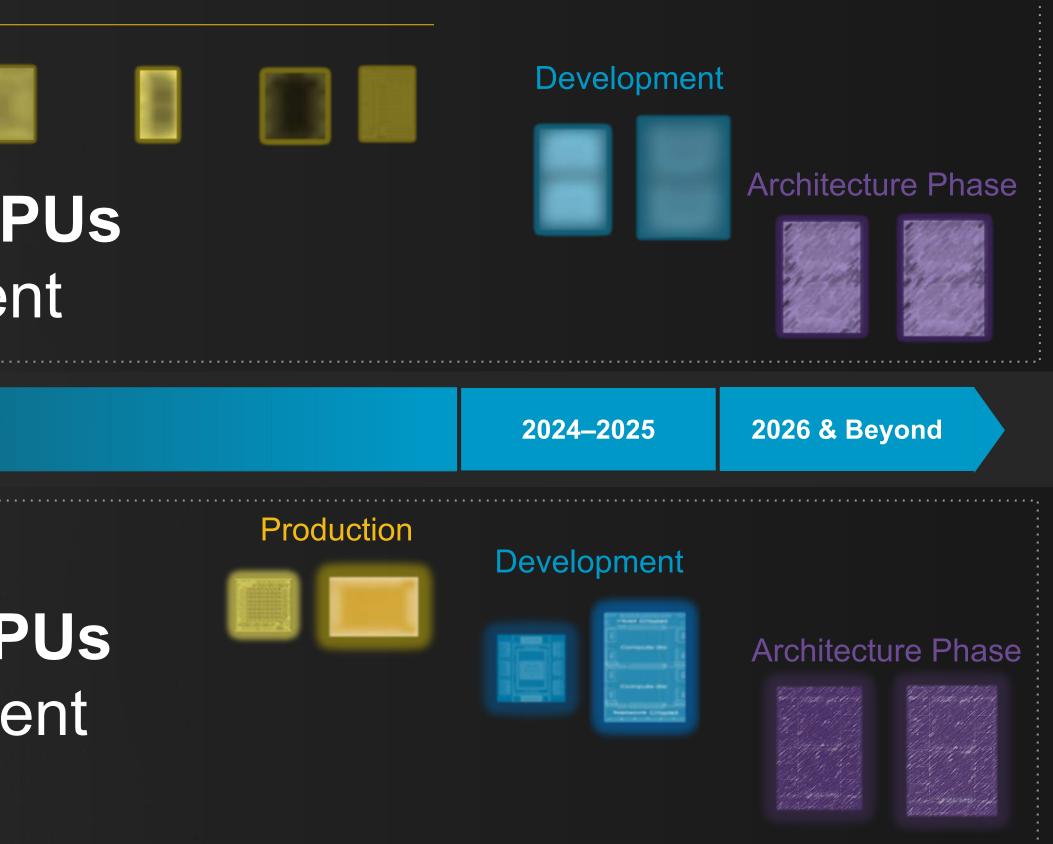
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CUSTOMER #2

#

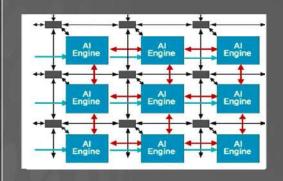
CUSTOMER





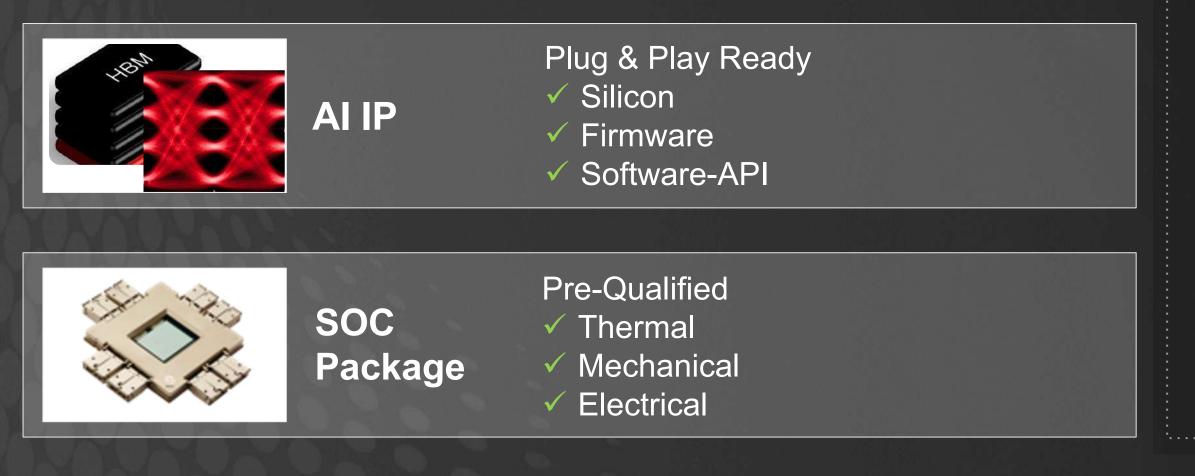
## Industry's Fastest Time-to-Production with Annual Cadence

XPU Platform Engineering Years prior to Design Start



Automated Design Flow

AI Design Flow Optimized over 10 Years of XPU experience



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3-Month 7–9 Month FAB **Production Development** Ramp  $\mathcal{C}$ **Co-Development** with Consumer **Al Customer** 

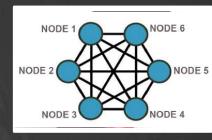


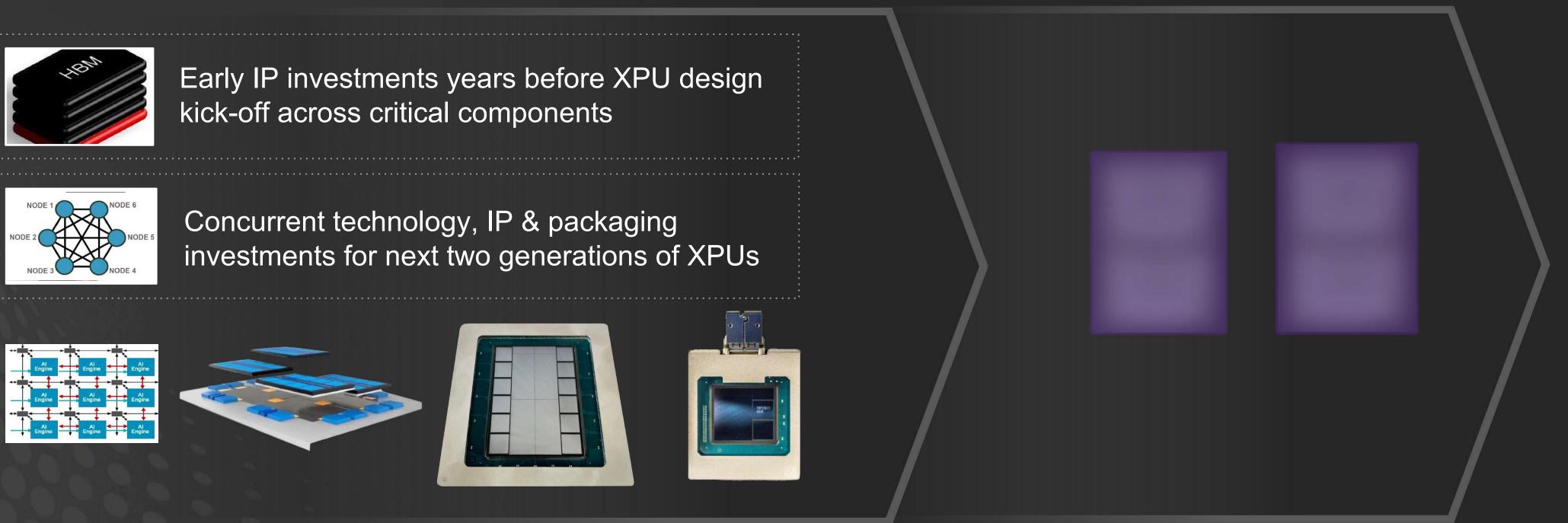
## Deep & Strategic Collaboration During Architectural Phase

#### **INVESTMENT PERIOD** 2023-2025



kick-off across critical components





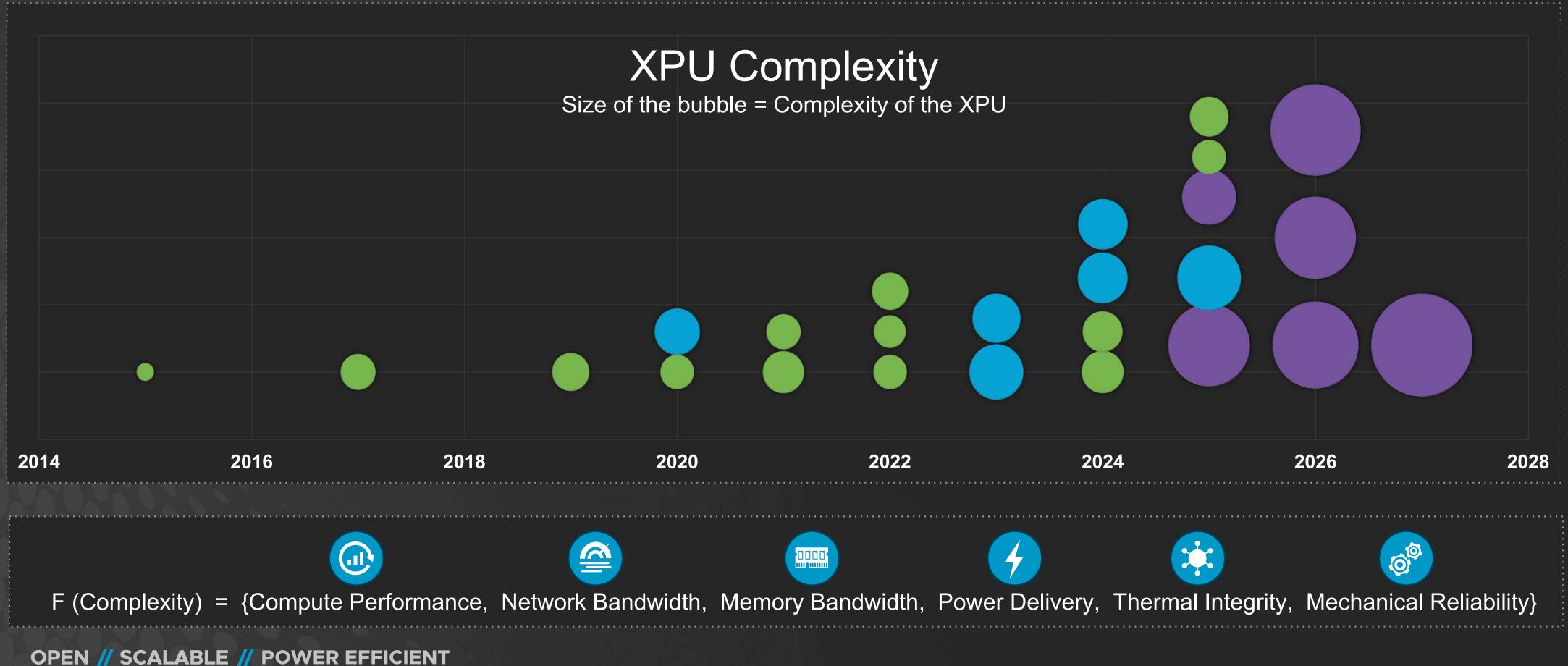
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## Execution Excellence in Delivering to Consumer-AI Requirements



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## **Custom Al** Accelerators



**\$3B+** Investment Scale in Differentiation XPU IP

## **Key Points**



10-year Engineering Excellence in High-Complexity XPUs

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Focused on Consumer-AI Custom Accelerators

3-year Deep Architectural Advantage in Co-Development



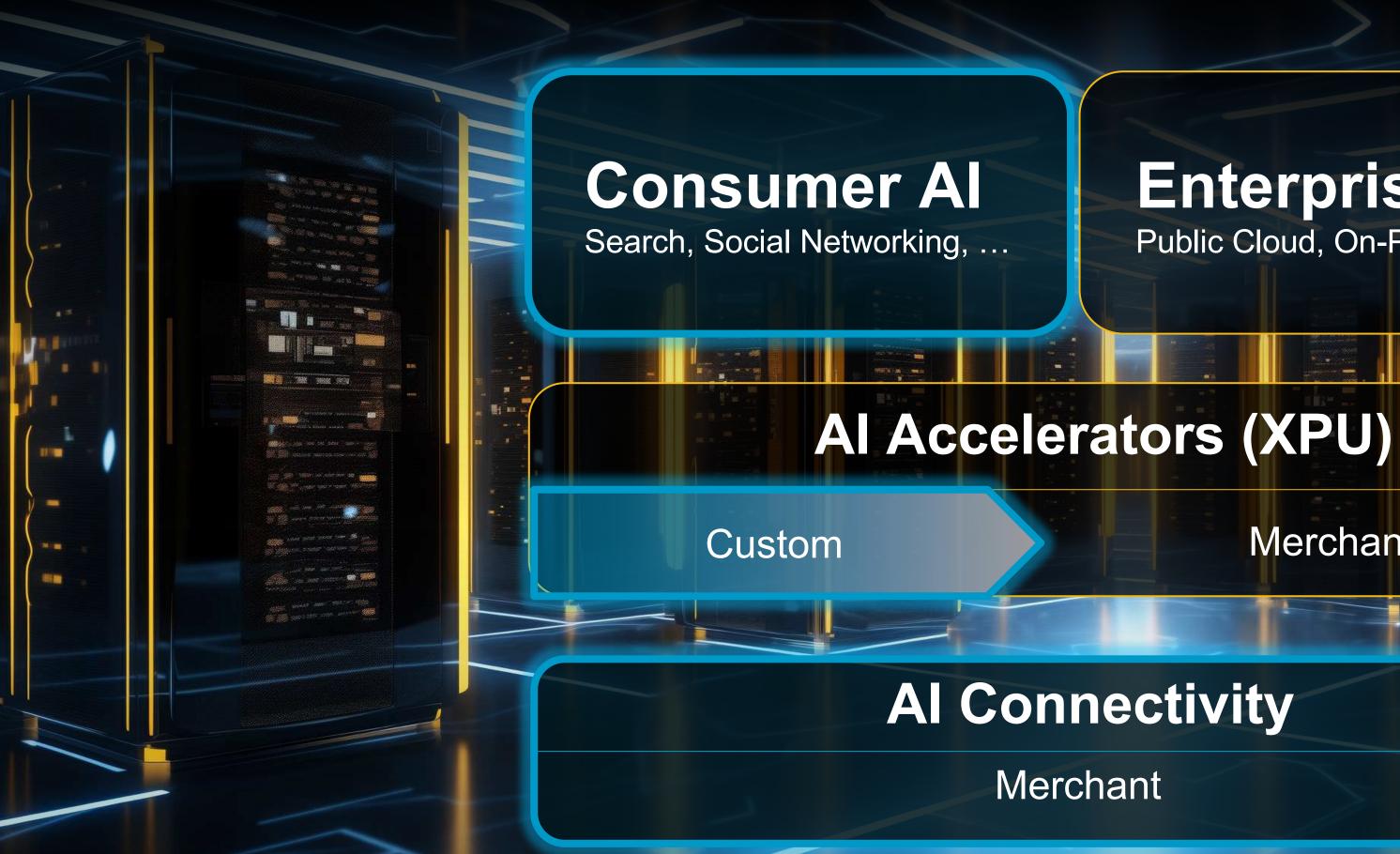




## ENABLINGA nfrastructure

### Charlie Kawwas, Ph. D. President, Broadcom





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## **Enterprise Al**

Public Cloud, On-Prem, ...

### Merchant



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## **XPUs** $\rightarrow$ **Multi-Generational Strategic Engagements** 2026

## 2024

2025

## **Customer #1**

### Production

## Customer #2

**Production** 

**Customer #3** 

 $Ramp \rightarrow$ Production

New



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## **Broadest & Industry-Leading AI Networking Portfolio**

## Ethernet

Broadcom (AVGO) to Deploy World's First 51.2 Tbps Switches

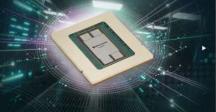


Broadcom Qumran3D 5nm





New Chip on the Block:



source: Interesting Engineerin

Broadcom Adds AI Features to Speed New Trident Networking Chip





**PCle** 



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## **Optics**

Broadcom Upgrades Co-Packaged Optics Switch to 51.2Tb/s



Source: Electronic Design

World Leader in Al Infrastructure Optics



## Foundational Technology

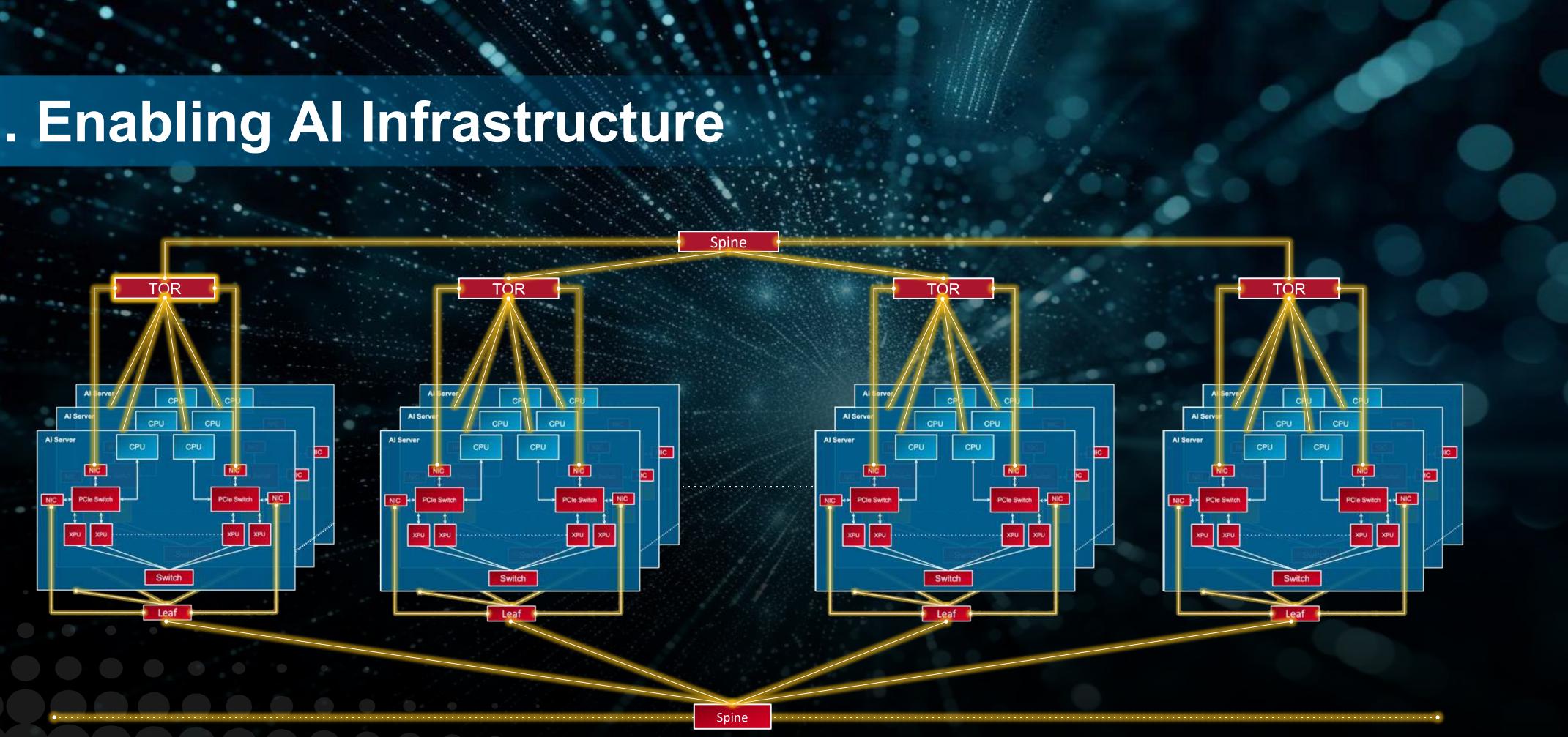
Broadcom Delivers 200G/lane PAM-4 DSP PHY for Next-Gen Switches and Al Networks

Source: Yahoo Finance





## ... Enabling Al Infrastructure



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## **Open Scalable Power Efficient**

#### Sustainable Technology Leadership SerDes DSP Custom PCle Optics Ethernet

#### **Execution Excellence Investment Scale Innovation Leadership**

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## nfrastructure