



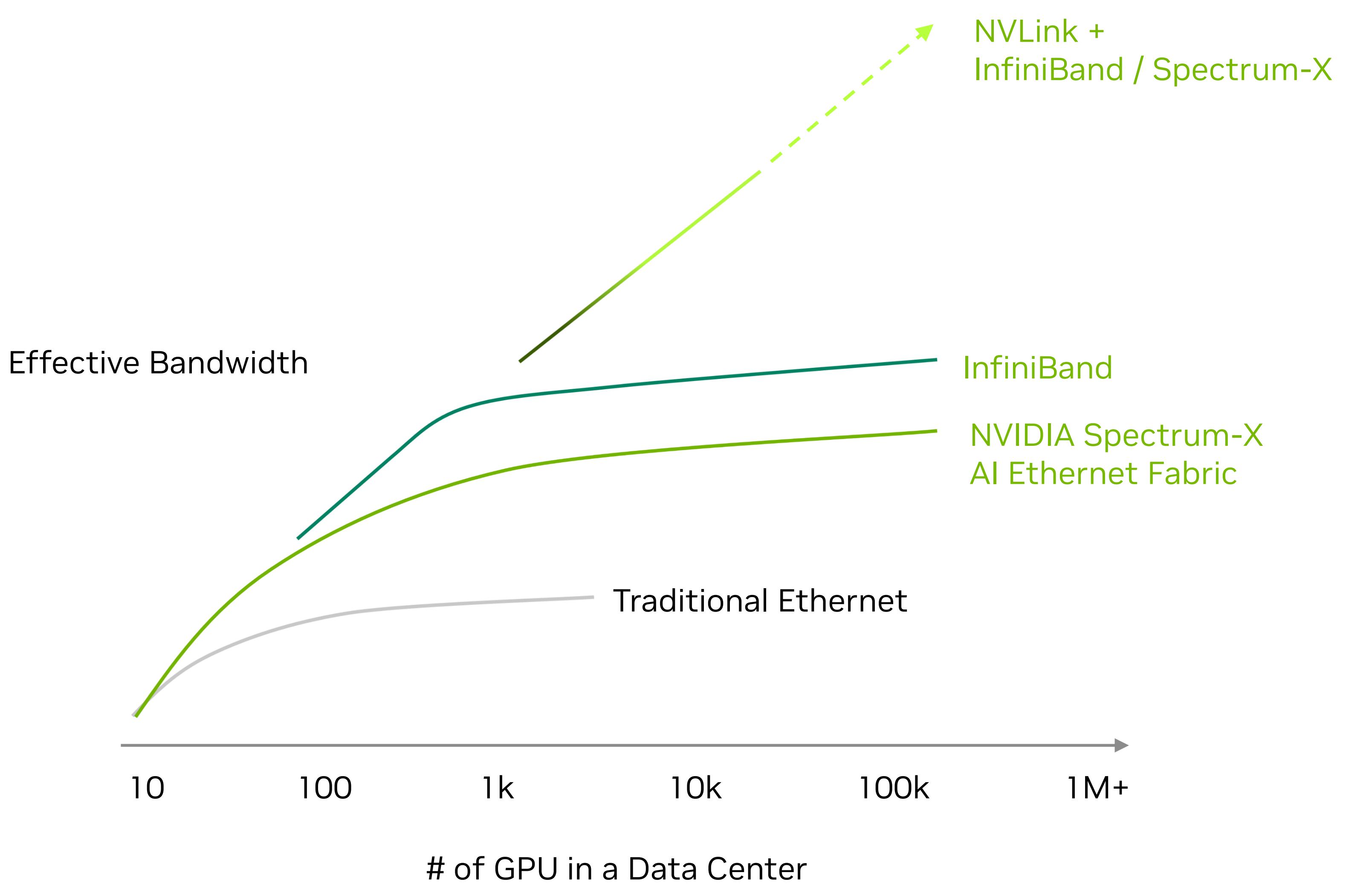
# NVIDIA Spectrum-X Networking Platform

February 2025

# Generative AI is a Data Center Scale Computing Problem

AI factories emerge as a new class of generative AI data centers

*Purpose-built high performance networking is necessary to effectively scale AI*



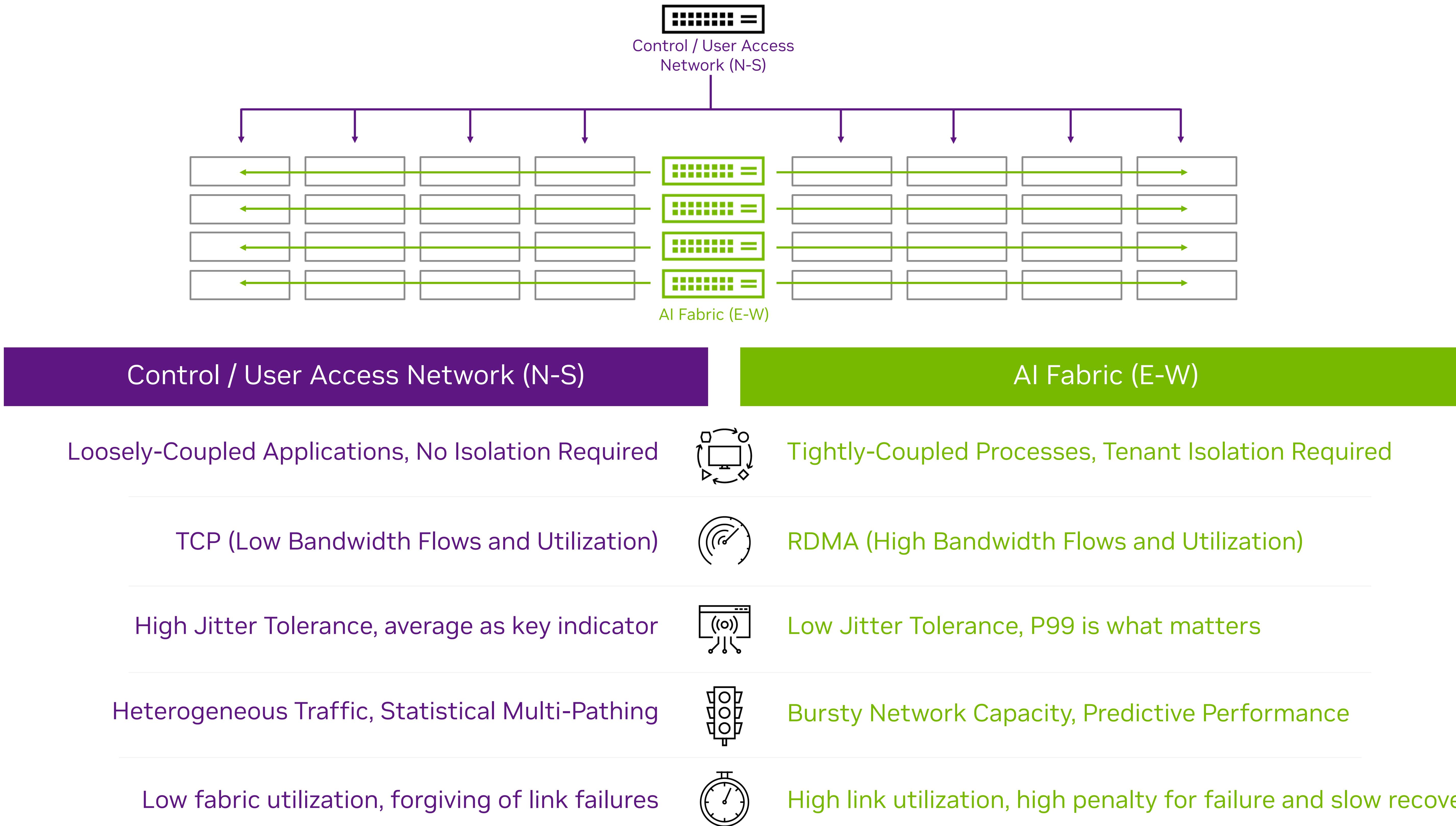
**NVIDIA NVLink**  
Fastest Compute Fabric Connectivity

**NVIDIA InfiniBand**  
Gold Standard for Scale-Out AI Fabrics

**NVIDIA Spectrum-X**  
Ethernet Optimized for Multi-Tenant AI Factories

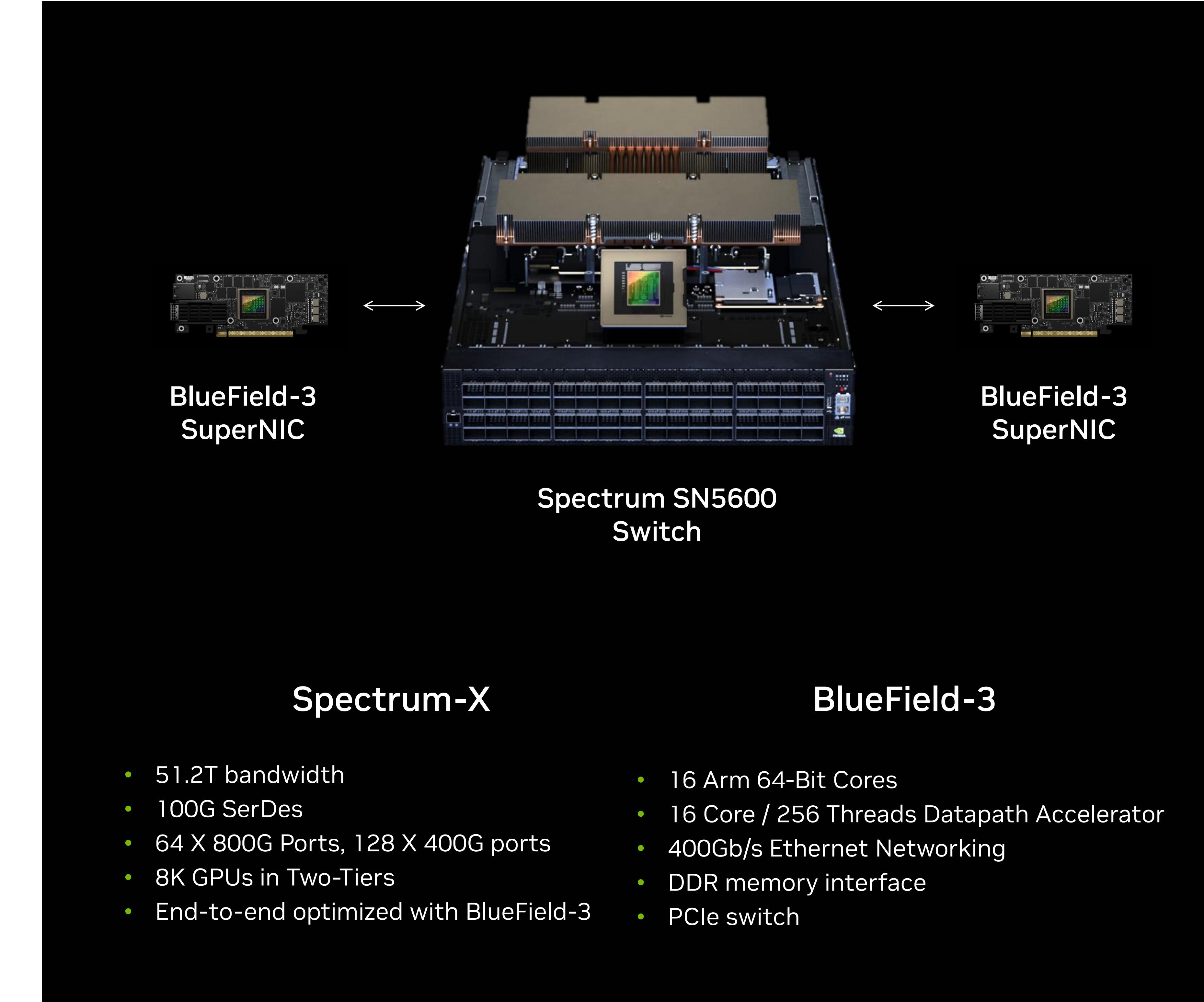
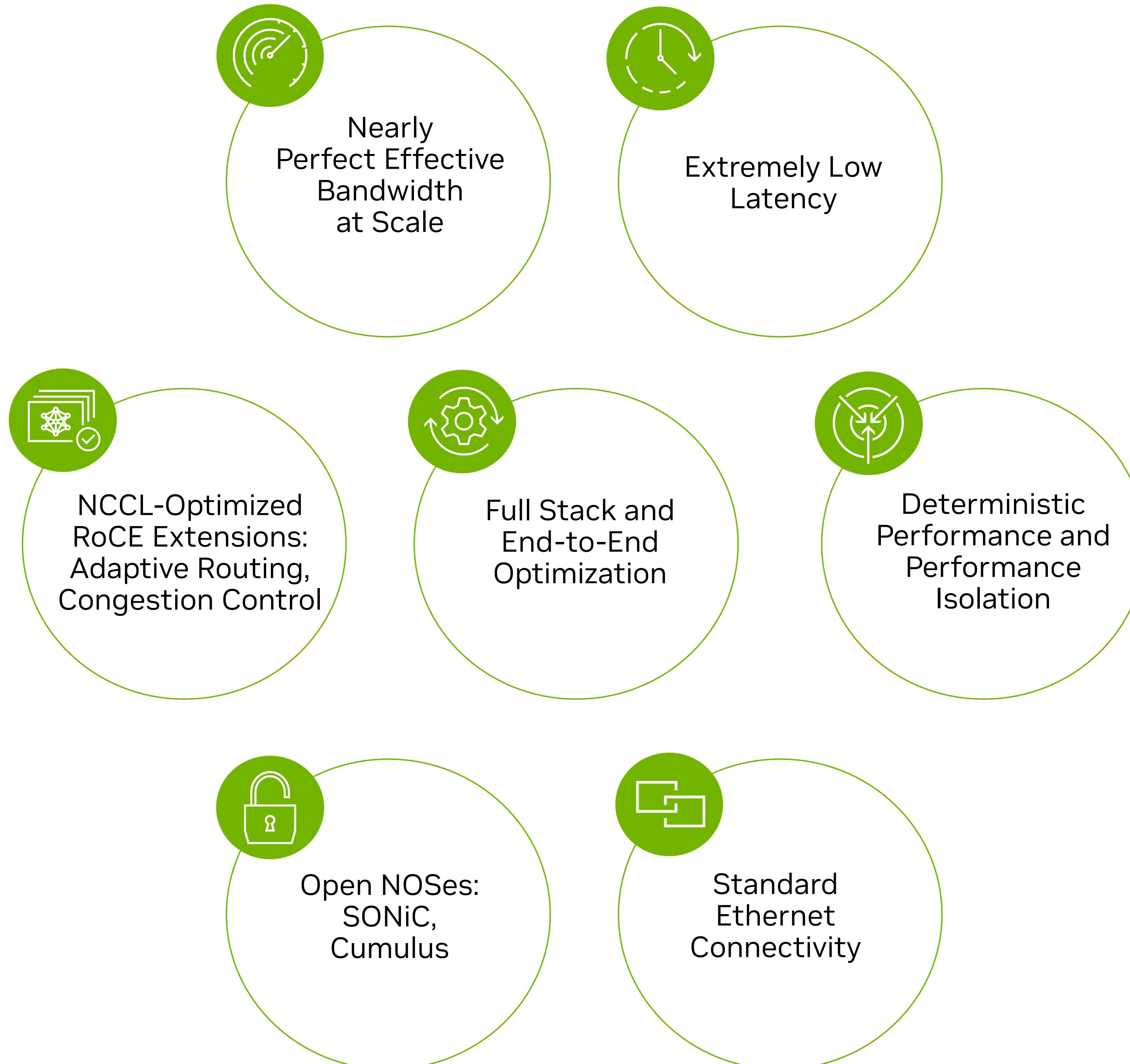
# AI Workloads Require an AI Fabric

## Full Stack Optimized



# NVIDIA Spectrum-X: World's First Ethernet Platform for AI

Combining Specialized High-Performance Architecture with Standard Ethernet Connectivity



# Spectrum-X Ethernet is Purpose-Built For 100K+ GPU Connectivity

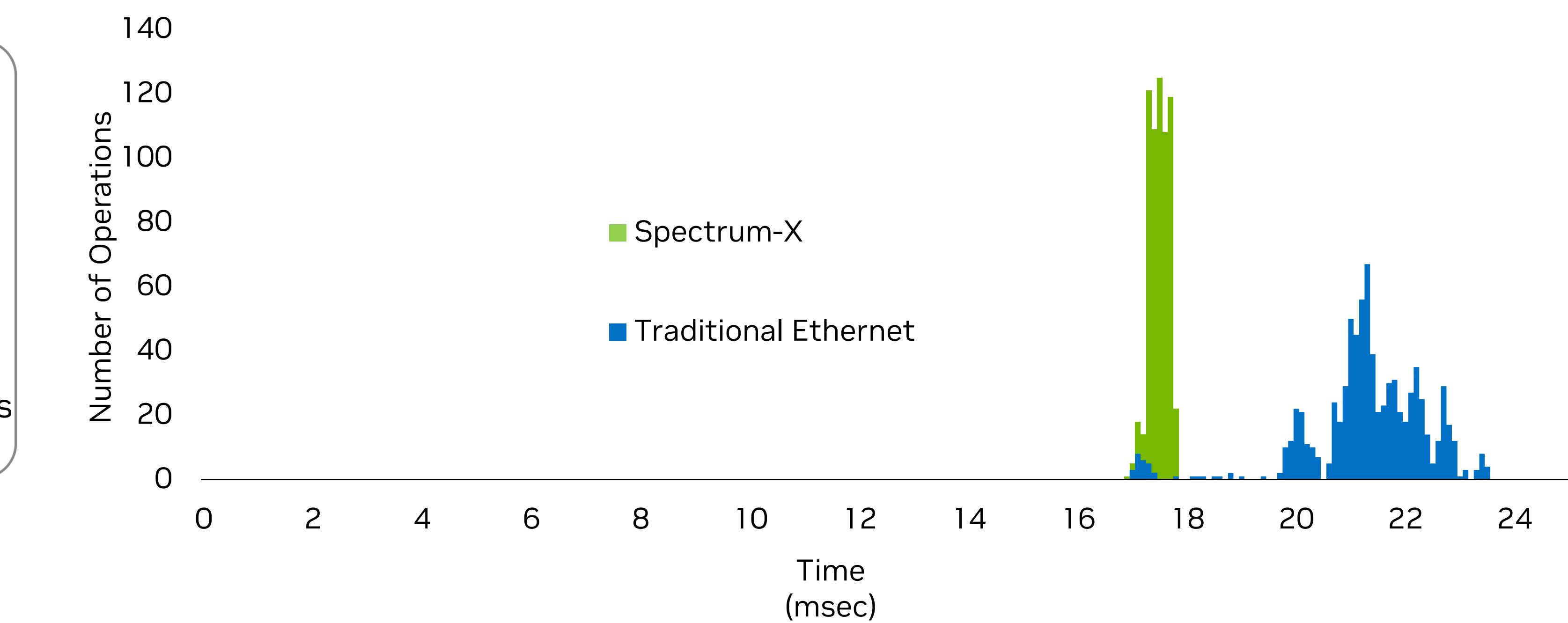
Switch-to-SuperNIC, End-to-End Network Processing Delivering Ultra Ethernet Performance

LOAD BALANCING  
**1.6X**  
Higher Effective Bandwidth  
Optimal Usage of All Network Connections

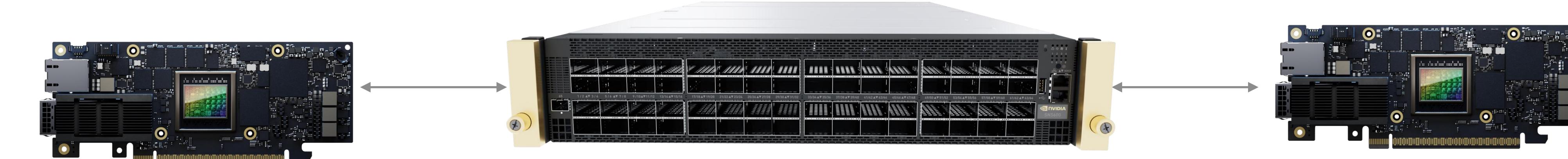
TAIL LATENCY  
**1.3X**  
Higher Collective Bandwidth  
Reducing Collectives Tail Latency

NOISE ISOLATION  
**2.2X**  
Higher All-Reduce Bandwidth  
Eliminating Network Hot Spots

RESILIENT PERFORMANCE  
**1.3X**  
Higher All-to-All Bandwidth  
Rebalances Data Flows Avoiding Failed Links



Collectives Performance — Reducing Tail Latency



Schedule Data Transmission to Avoid Congestion

Ultra-High-Speed Traffic Monitoring Distribute Data Across All Switch Ports Ignoring Data Ordering

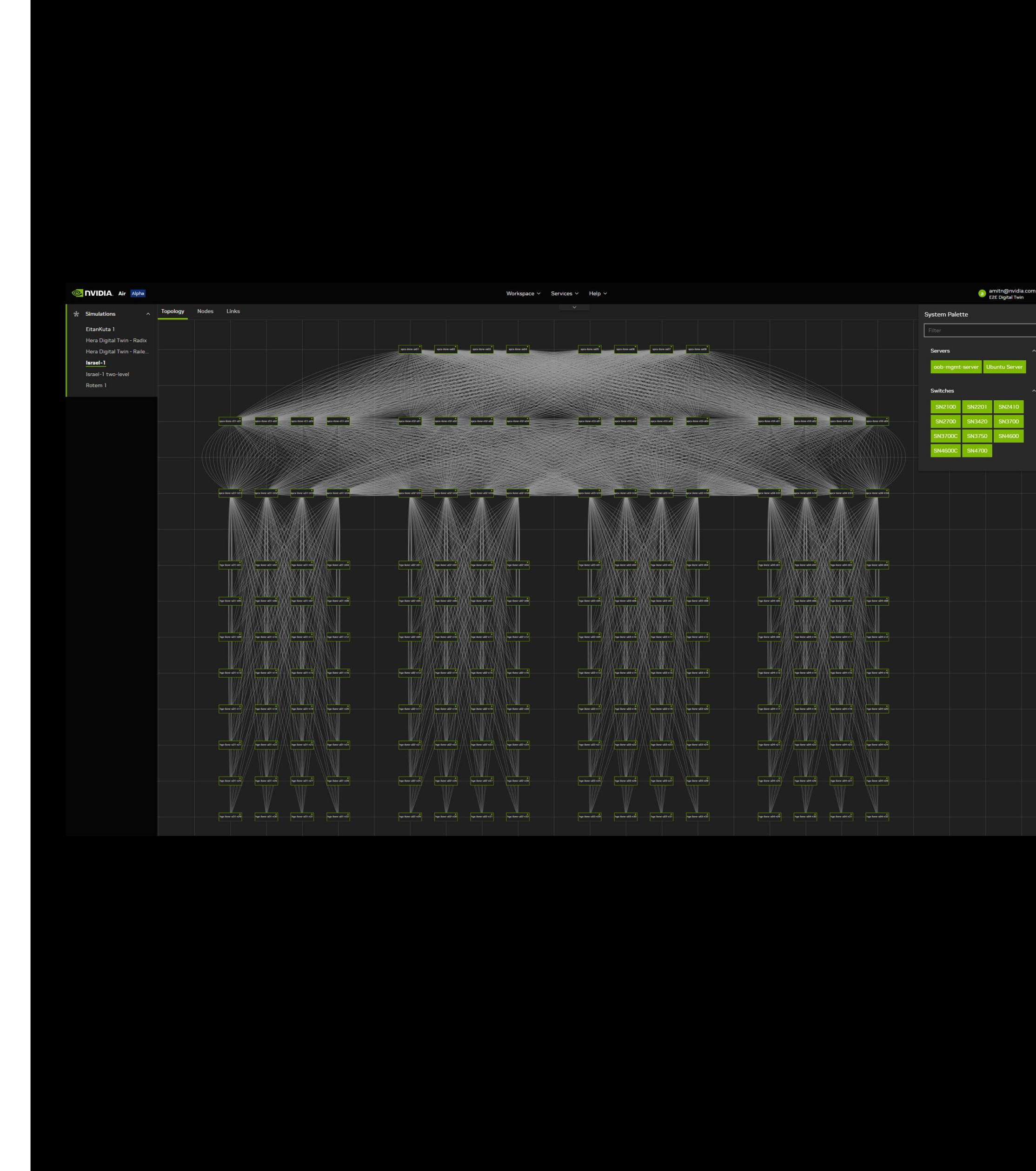
Reordering - Receive Data and Place it Back in Order

# Reducing Time To Train

Faster Deployment, Faster Troubleshooting



**Israel-1**  
Validated, Optimized RA



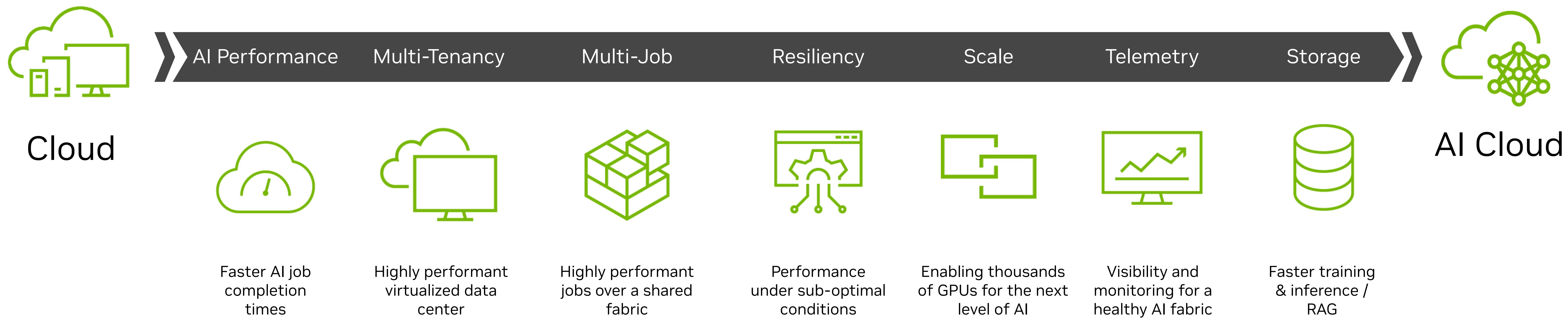
**NVIDIA Air**  
Check Physical vs. Digital Twin



**Enhanced Profiling Tools**  
Full Stack Telemetry

# Spectrum-X Paves the Way to Build Large Scale AI Clouds

NVIDIA's Recipe, Tested, Verified & Benchmarked on Israel-1



# NVIDIA Air for Spectrum-X

Data Center Digital Twins of AI Factories



## Infrastructure Simulation – Reduce Time To AI

Full-size virtual data centers with compute and network  
Topology + cabling modeling  
Full data path connectivity, OOB config and ZTP test



## Solution Validation – Deploy / Upgrade With Confidence

Compute and network automation  
Host to switch traffic connectivity  
Routing, failover, upgrade, telemetry, security protocols



## Simplify Network Operations – With No Infrastructure Investment

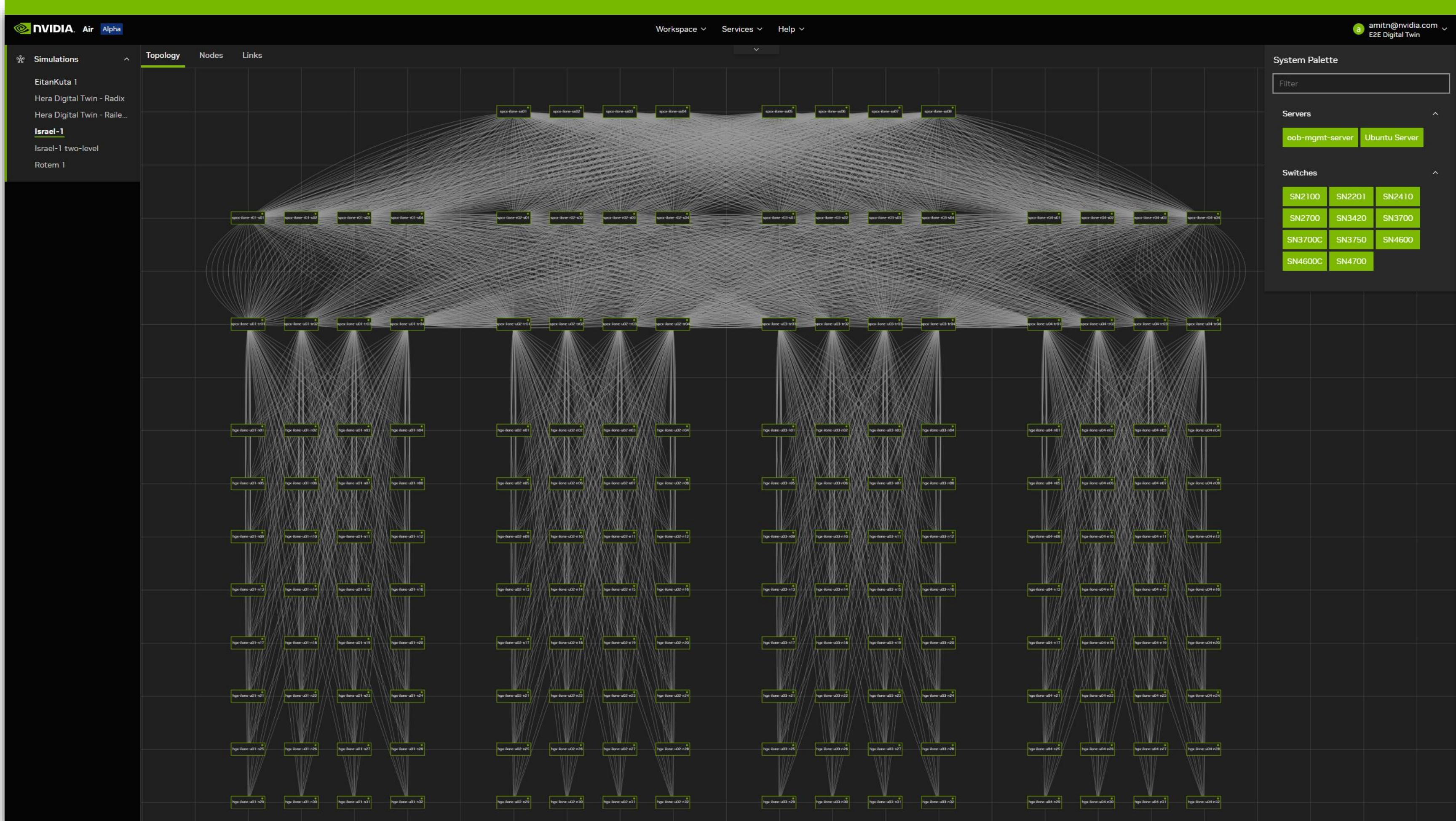
Create multiple digital twins for parallel testing (CI/CD)  
Share simulations, enhance training, skills transfer

**“Over 80% of network problems** are due to improper configuration and issues with change management.”

— Gartner



## Israel-1 (Spectrum-X) Data Center Digital Twin



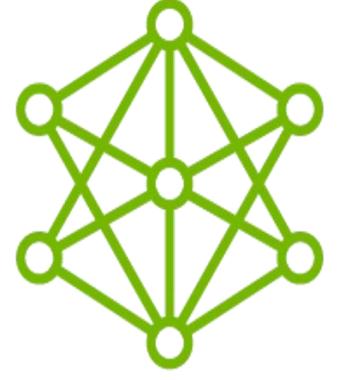
Try It Now

[SDK](#)

[API](#)

[User Guide](#)

# NetQ for Spectrum-X



## Topology Validations – Reduce Time To AI

Detect cabling issues using LLDP data



## AI Performance – Maximize GPU Utilization

For AI compute fabric, monitor and validate status of ASIC, BGP, EVPN, VXLAN, Adaptive Routing, RoCE etc.



## Actionable Visibility – Reduce Time To Identify Issues

Get an aggregated view of fabric wide events and packet drop data using What Just Happened™



## Link Health Monitoring – Detect Links Causing Issues

Ensure optimal AI fabric utilization and proactively minimize AI performance impact by monitoring link health



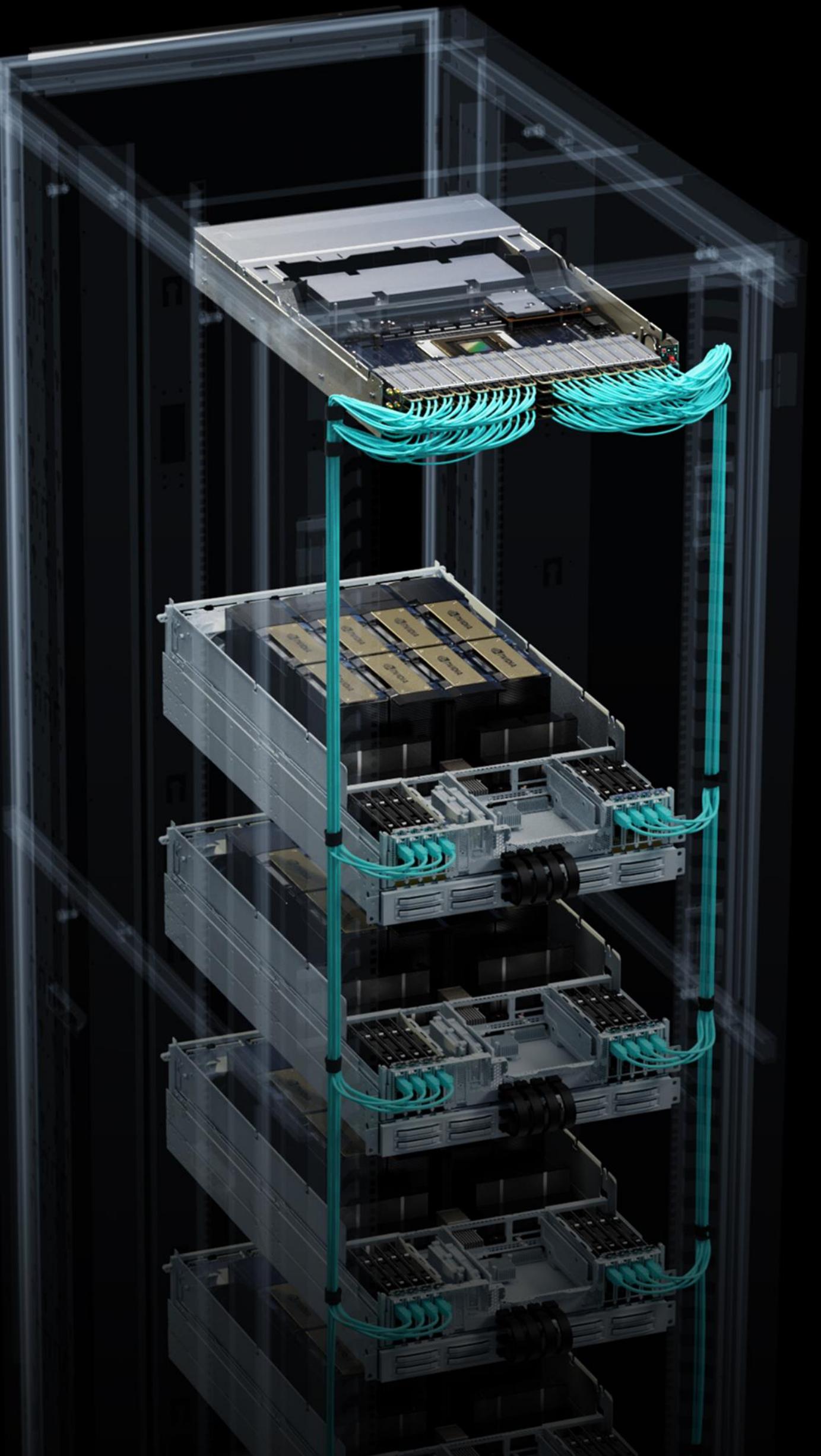
## Hardware Monitoring – Identify Faulty Hardware

Validate basic system hardware components (sensors, fans, PSUs etc.) as healthy and operational



# Leading OEMs and Ecosystem Partners Adopt Spectrum-X

- Dell, HPE, Lenovo, and Supermicro are integrating Spectrum-X into their data center offerings
- Spectrum-X will be available with HGX systems
- Systems featuring the complete NVIDIA AI stack are available now



**DELL** Technologies



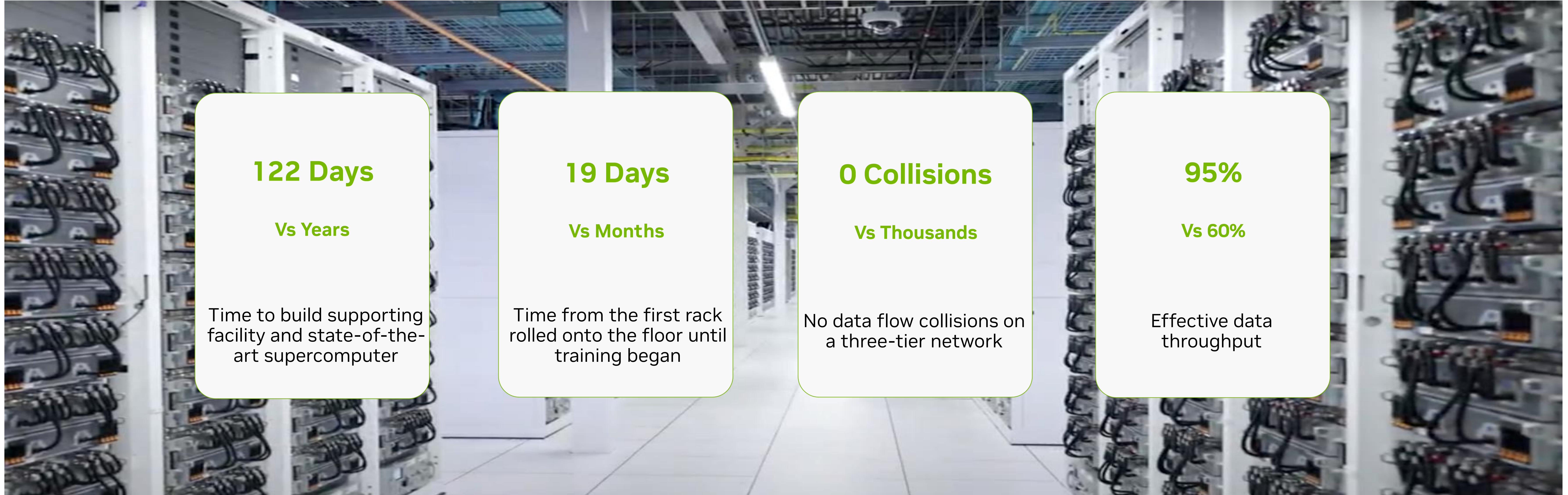
**Hewlett Packard  
Enterprise**

**Lenovo**

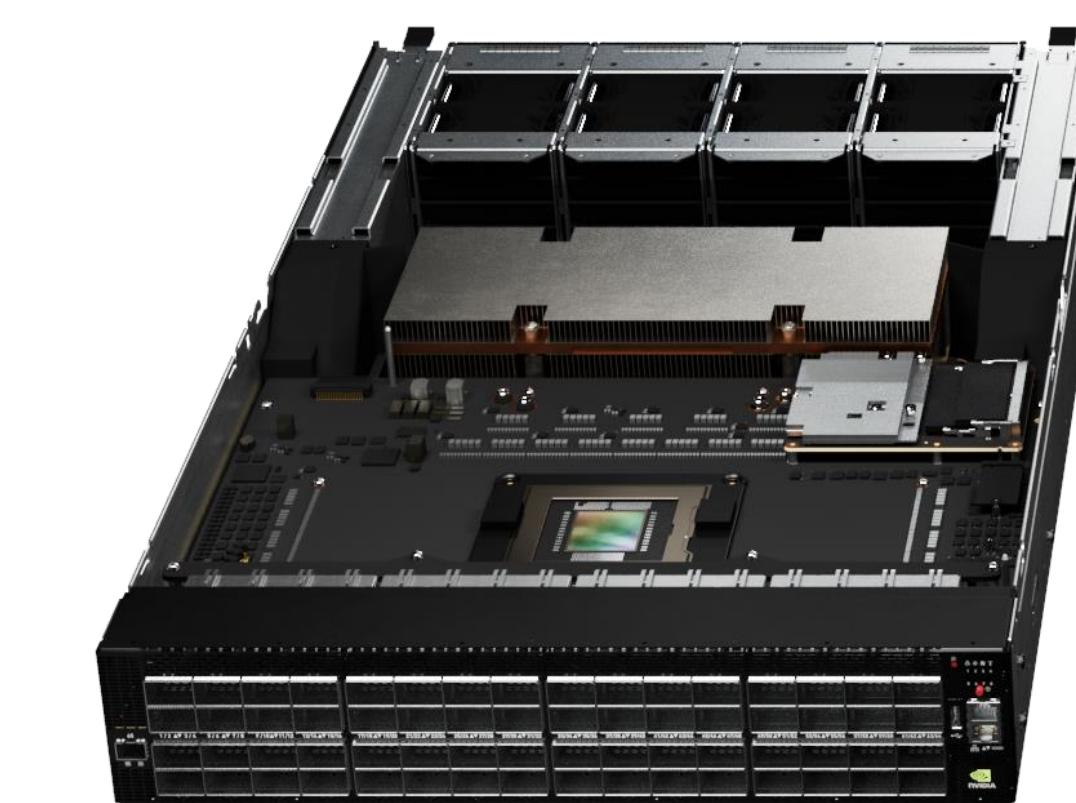
**SUPERMICRO**

# Spectrum-X Ethernet Accelerates World's Largest AI Supercomputer

Built by X



BlueField-3 SuperNIC



Spectrum-X800 Switch



BlueField-3 SuperNIC

Press Release

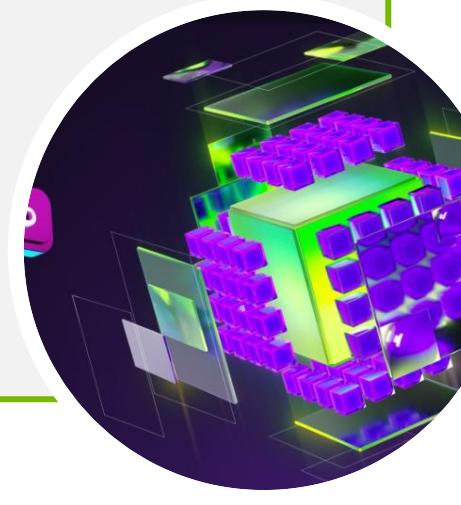
# Spectrum-X AI Factory Successes

## GPU Cloud Deployments at Scale Across the World



- **Use Case:** Regional AI Cloud (Europe)
- **NVIDIA Networking:** Spectrum-X E-W, Spectrum and BlueField N-S
- **NVIDIA Compute:** HGX H100
- **OEM Partner:** HPE

[View PR Here](#)



- **Use Case:** Massive Scale AI Factory (US)
- **NVIDIA Networking:** Spectrum-X E-W, BlueField N-S
- **NVIDIA Compute:** HGX H200
- **OEM Partner:** Multiple

[View PR Here](#)



- **Use Case:** Regional AI Cloud (Japan)
- **NVIDIA Networking:** Spectrum-X E-W, Spectrum and BlueField N-S
- **NVIDIA Compute:** HGX H200
- **OEM Partner:** Dell

[View PR Here](#)



- **Use Case:** Spectrum-X R&D (Israel)
- **NVIDIA Networking:** Spectrum-X E-W, Spectrum and BlueField N-S
- **NVIDIA Compute:** HGX H100
- **OEM Partner:** Dell

[View PR Here](#)



### Learnings

- Close collaboration with networking team is essential
- Full alignment with the Spectrum-X RA is key for GTM
- NVIDIA Air is an instrumental part of the sales cycle
- NVIS is crucial for smooth deployments
- Tight integration with OEM/GSI is required

*“ We can be sure that everything was tested end-to-end and was going to just work, and we would not have to add our own engineering on top of that... We can empower our customers, who are mostly data scientists, to move quickly and not have to care what is going on underneath the AI frameworks in the switching stack.”*

— Yann-Guirec Manac'h, Head of Hardware R&D, Scaleway



# NVIDIA Infrastructure Specialists (NVIS)

## Deploying Spectrum-X Networking at World's Largest AI Facilities

### Challenges

- Multi-vendor coordination & integration
- Power & cooling, on-site bring-up sequence
- Managing equipment logistics
- Security
- Ensure fiber installation & networking integration
- Regulatory Compliance
- Detailed issues visibility and monitoring

### Solutions

- World-class NVIDIA Professional Services
- 24x7 coverage on-site integration teams
- Cross-platform verification
- Advanced telemetry tools
- NVIDIA Air, ClusterMinder, ClusterMod, CVT, and more
- Verified performance, network bandwidth and isolation for multi-tenant AI training

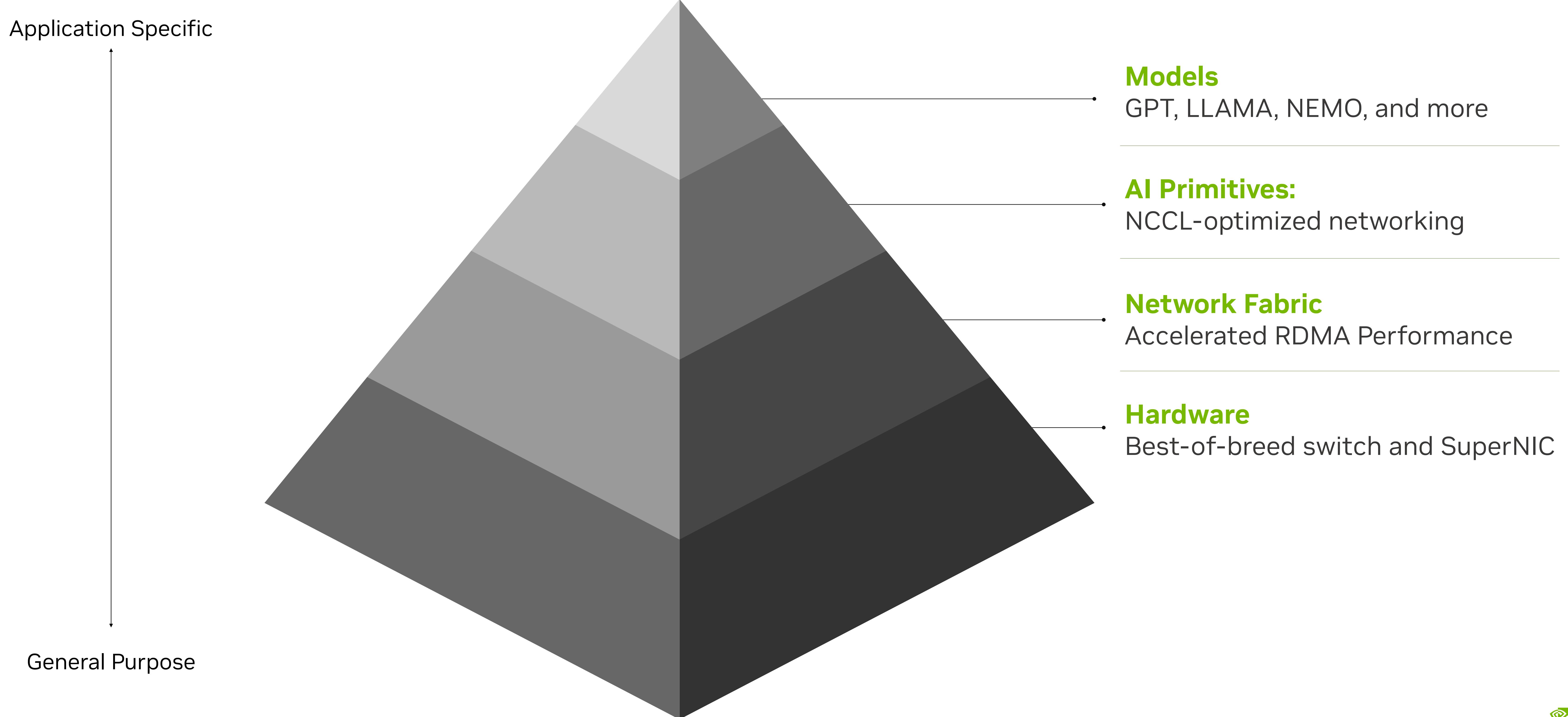
### Deploying Spectrum-X:

- At 100K+ GPU scale
- Without headache or risk
- With cutting-edge tools
- Across the world

# Performance Results

# Spectrum-X Optimizes Each Level of the Application Stack

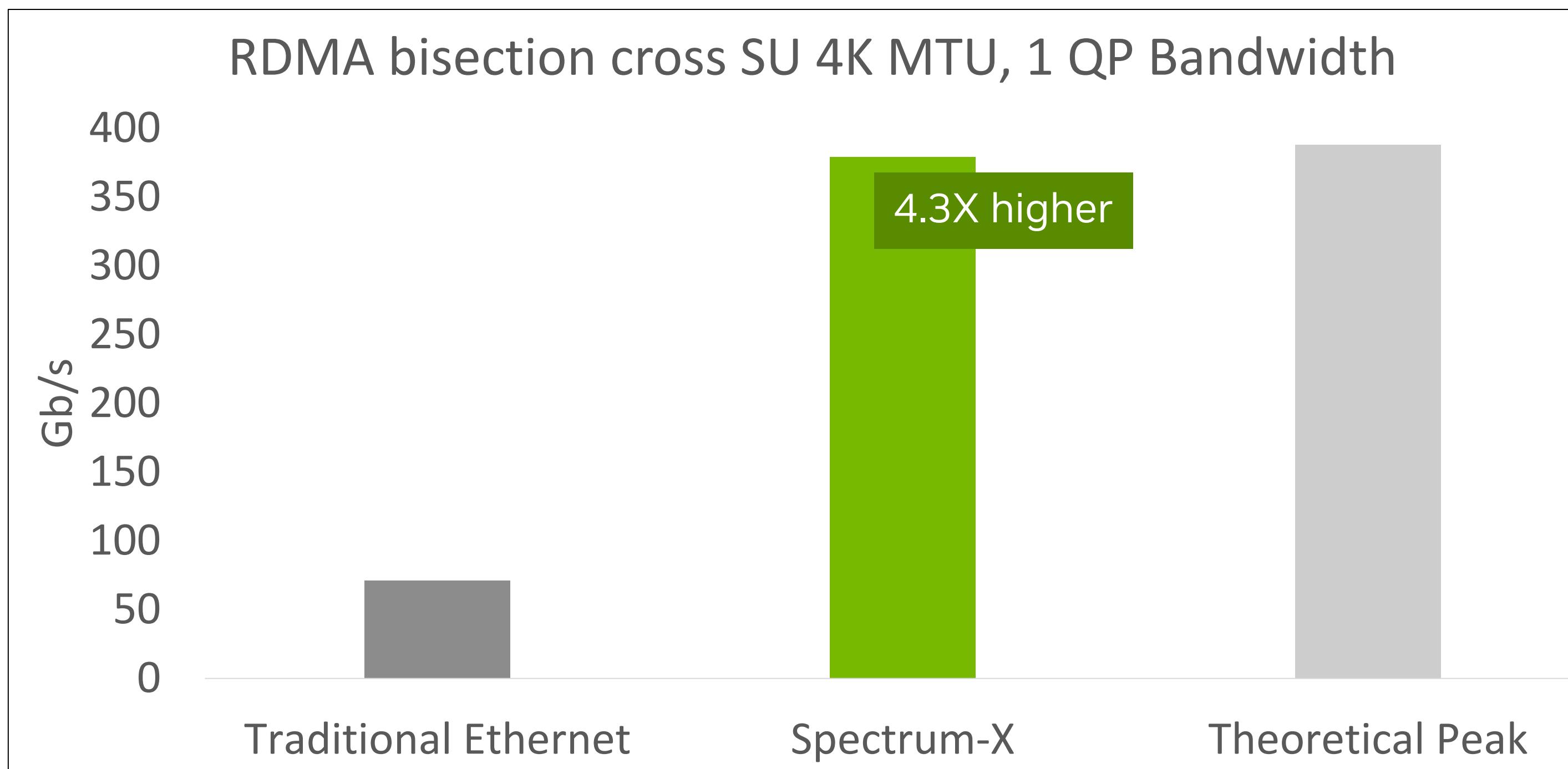
Performance Tuning From the Hardware to the AI Model



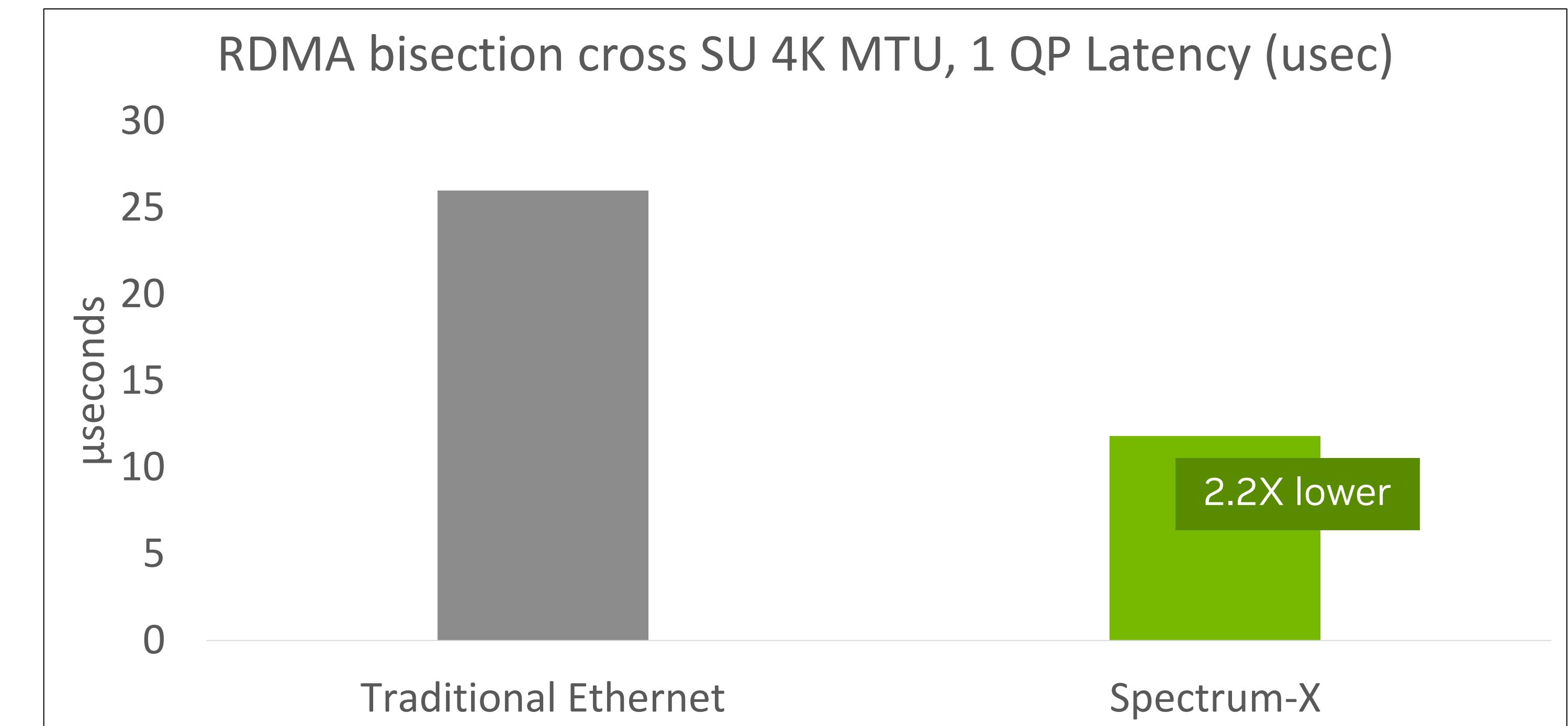
# Spectrum-X Performance Update

RDMA Bisection Cross Scalable Units

Higher is Better



Lower is Better



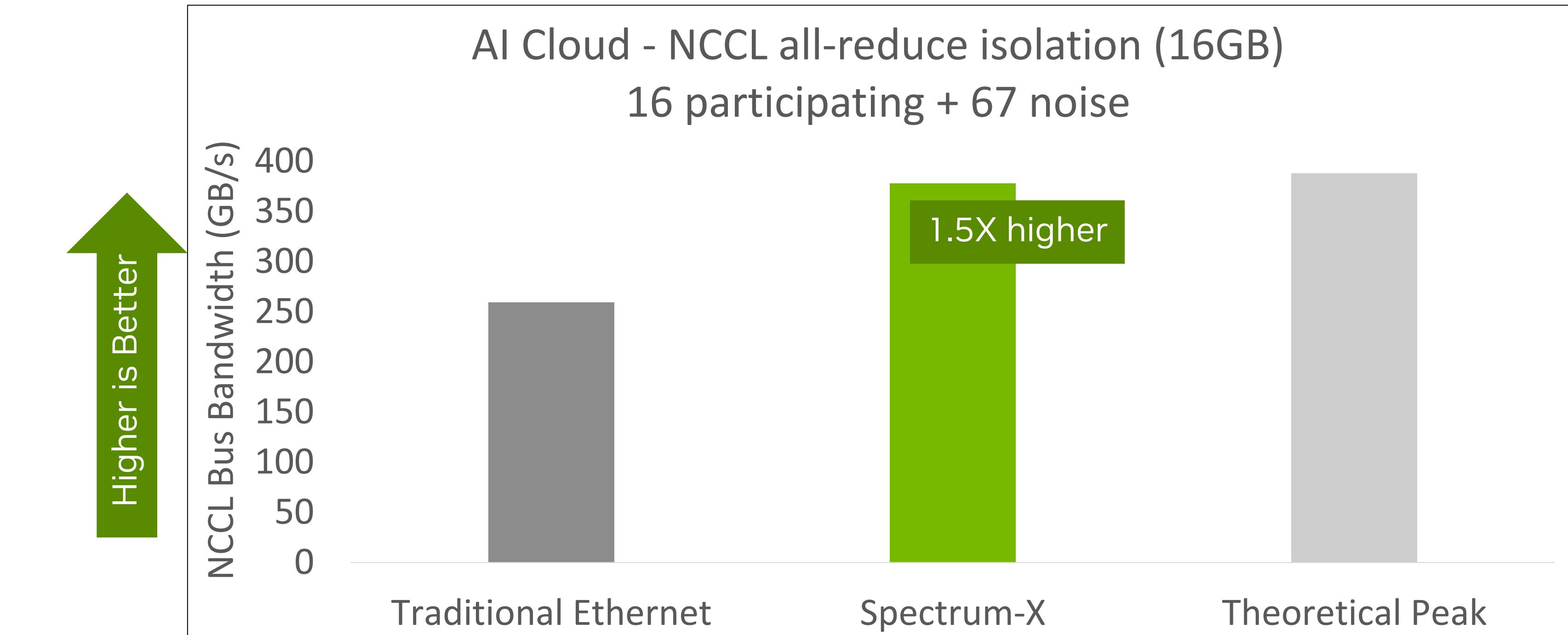
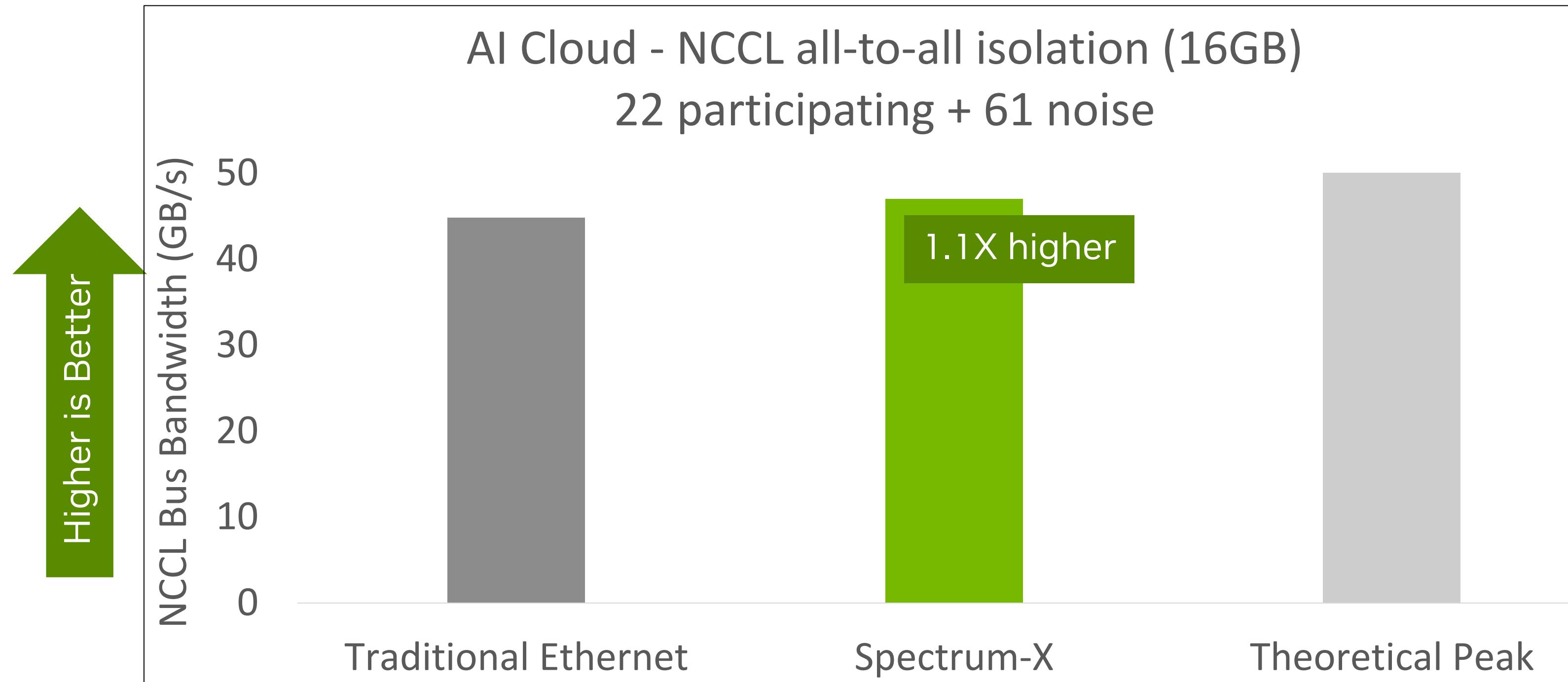
Allocated resources may not always be contained within a single SU.

For AI Clouds, Cross-SU performance is a critical metric.

Spectrum-X increases performance for RDMA offloads

# Spectrum-X Performance Update

AI Cloud Performance for NCCL All-to-All/All-Reduce Isolation



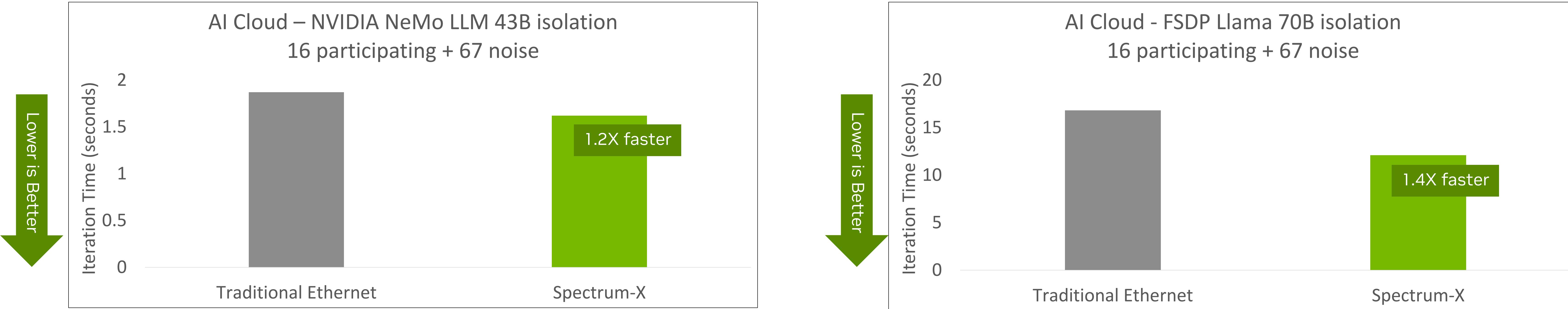
Spectrum-X provides noise isolation ensuring almost identical performance to non-noisy scenarios.

Spectrum-X performance is consistent and predictable.

Spectrum-X provides highest performance for NCCL in noisy AI Cloud environments

# Spectrum-X Performance Update

## AI Cloud Workload Performance Isolation



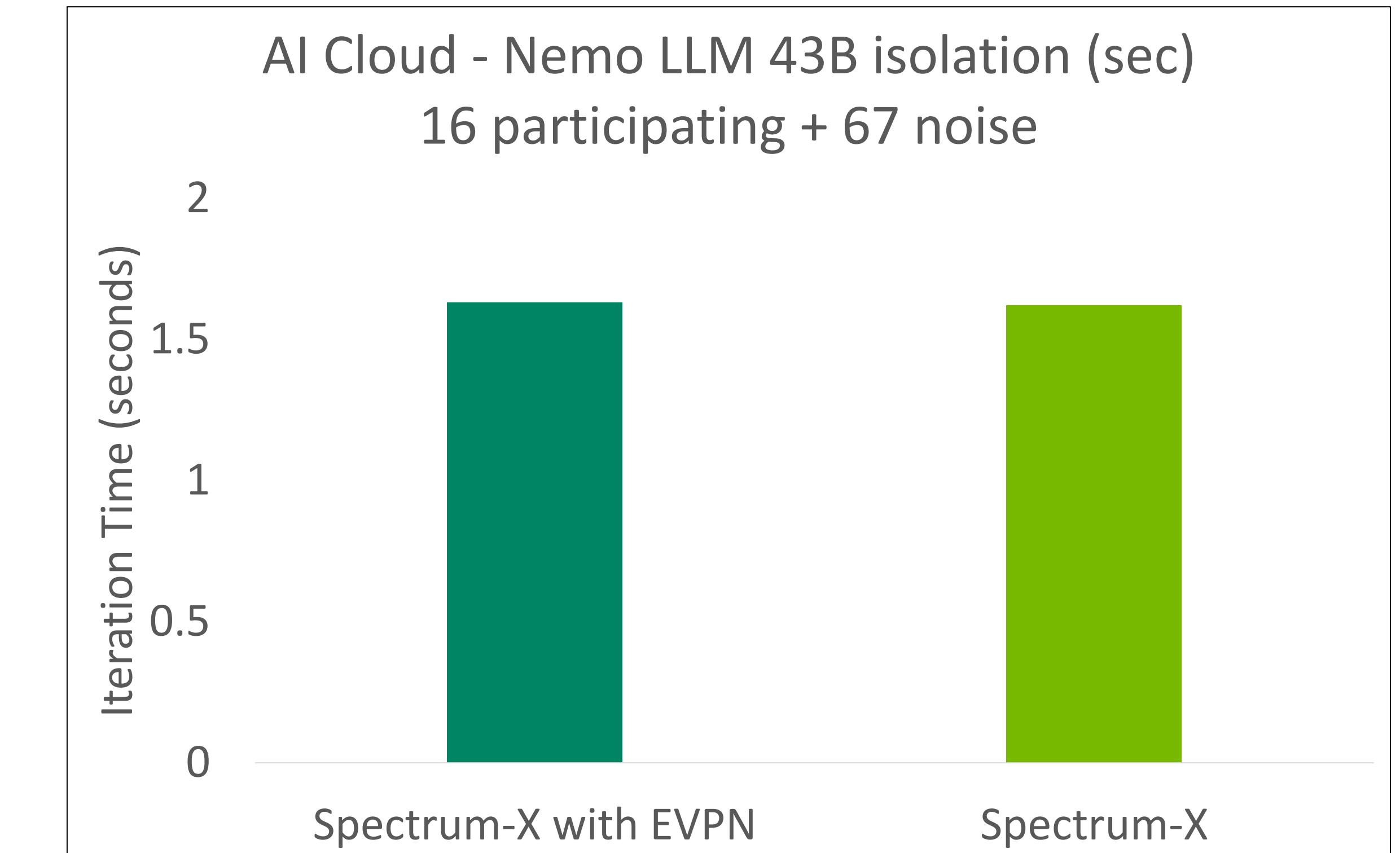
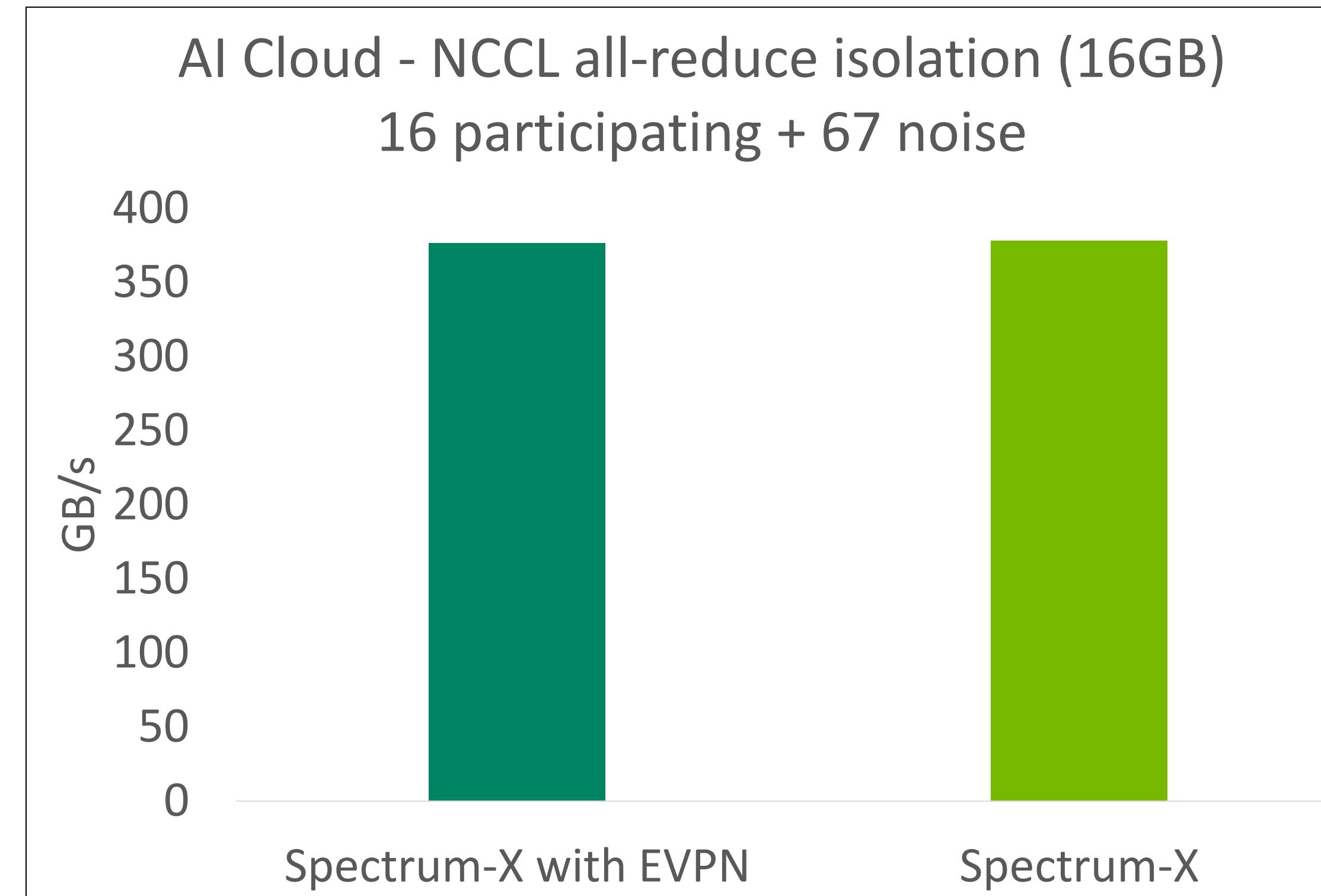
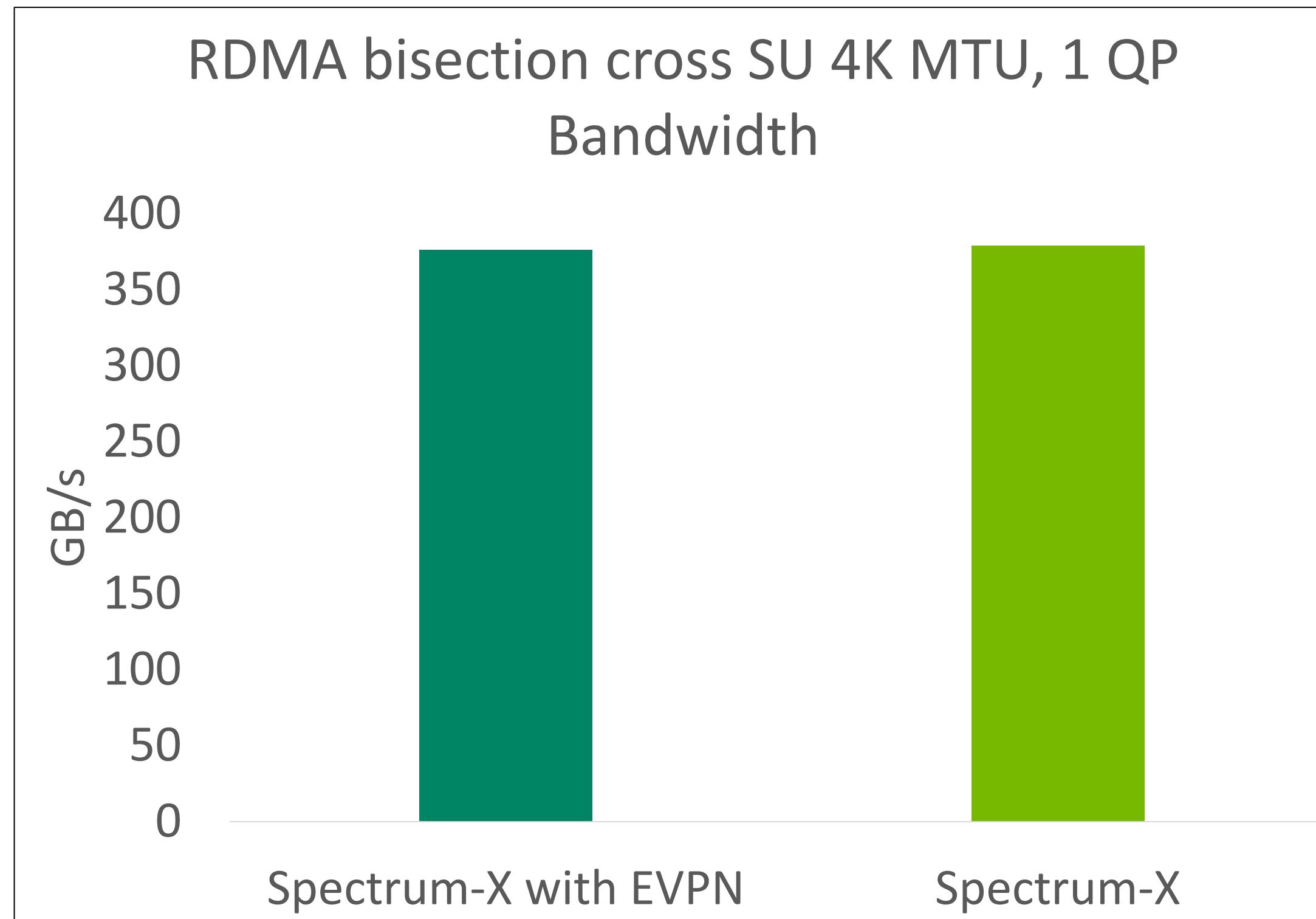
Spectrum-X accelerates iteration times for training the most common AI models such as Nemo and LLAMA.

Faster training iterations lead to faster job completion times, accelerating time to insight.

Spectrum-X accelerates training AI models in noisy AI Cloud environments

# Spectrum-X Performance Update

## Impact of Multi-Tenancy on AI Cloud Performance



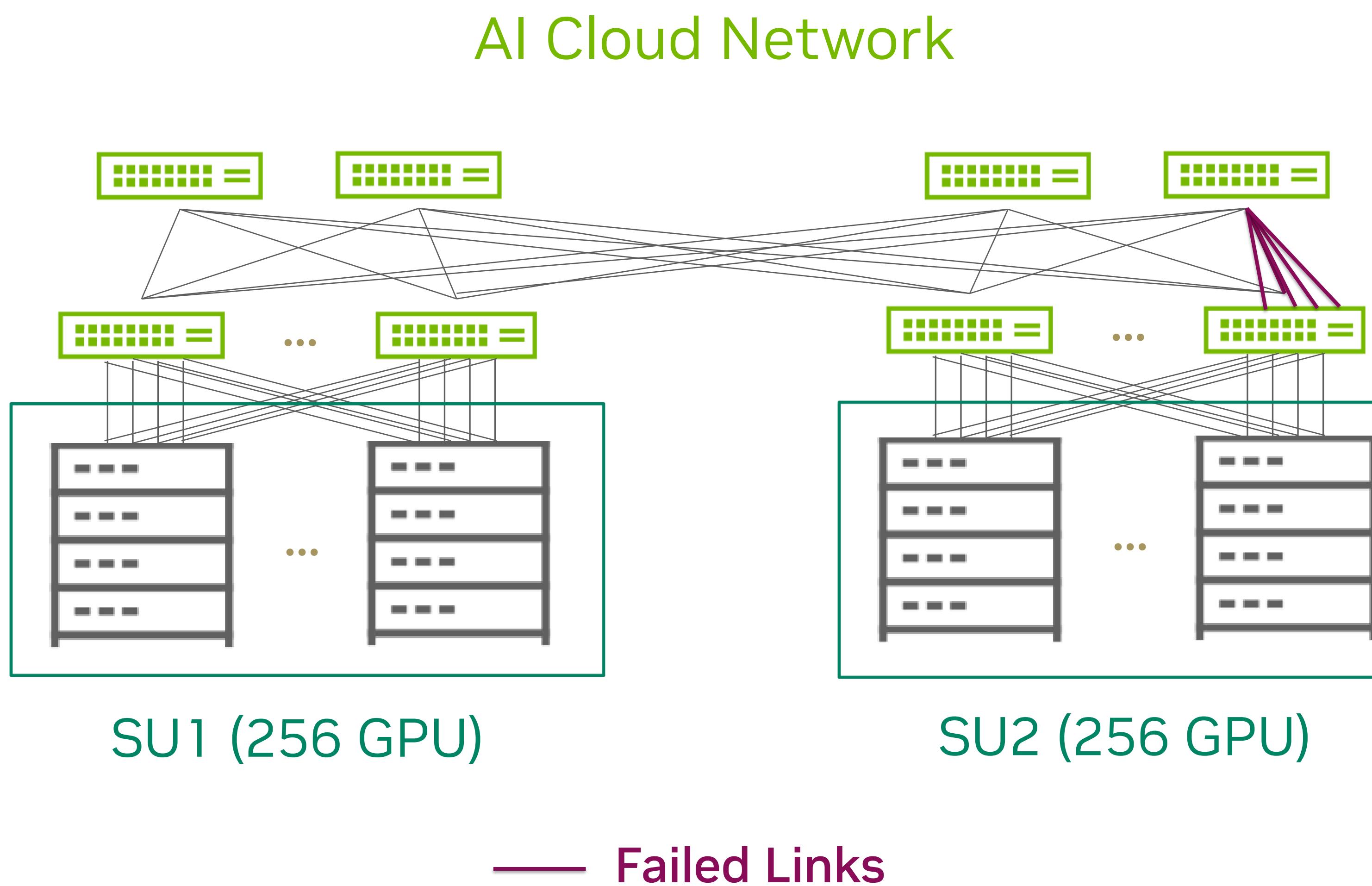
AI Clouds are multi-tenant architectures and require network virtualization.

Across the application stack, Spectrum-X performance is essentially the same (within 1%) when implementing EVPN VXLAN.

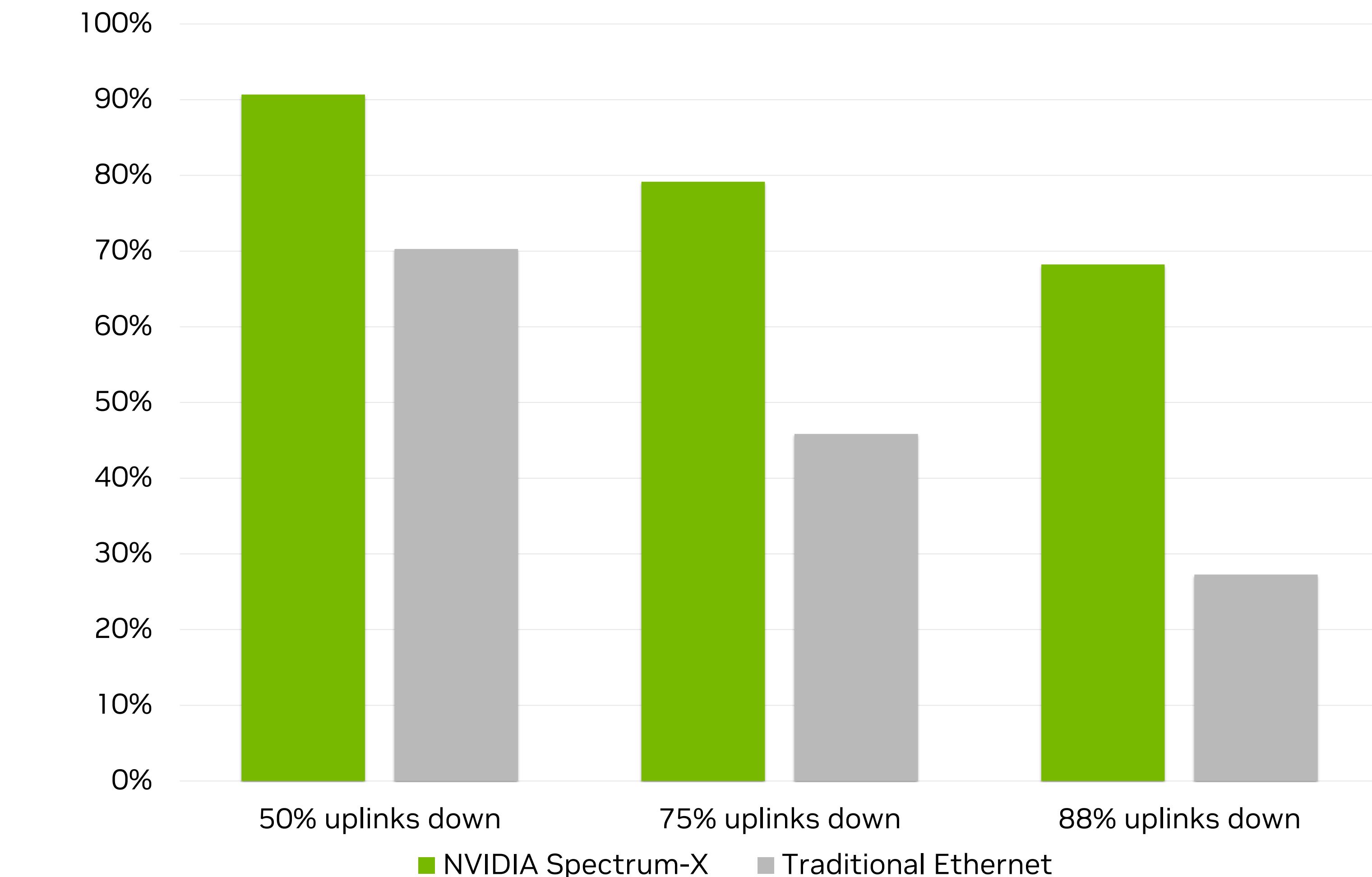
Spectrum-X maintains highest performance in multi-tenant environments

# Resilient Adaptive Routing Performance

Link Failures on Traditional Ethernet Lead to Outsized Drop in AI Performance



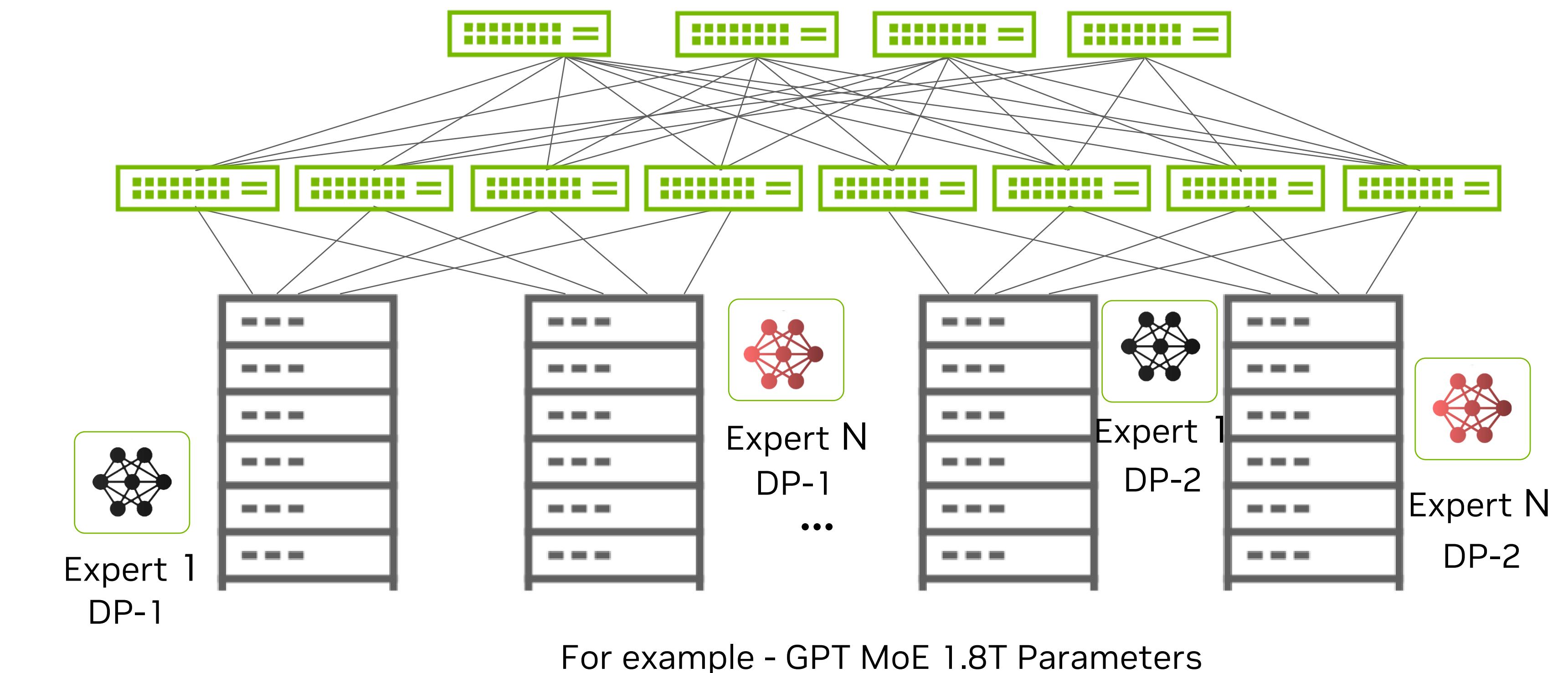
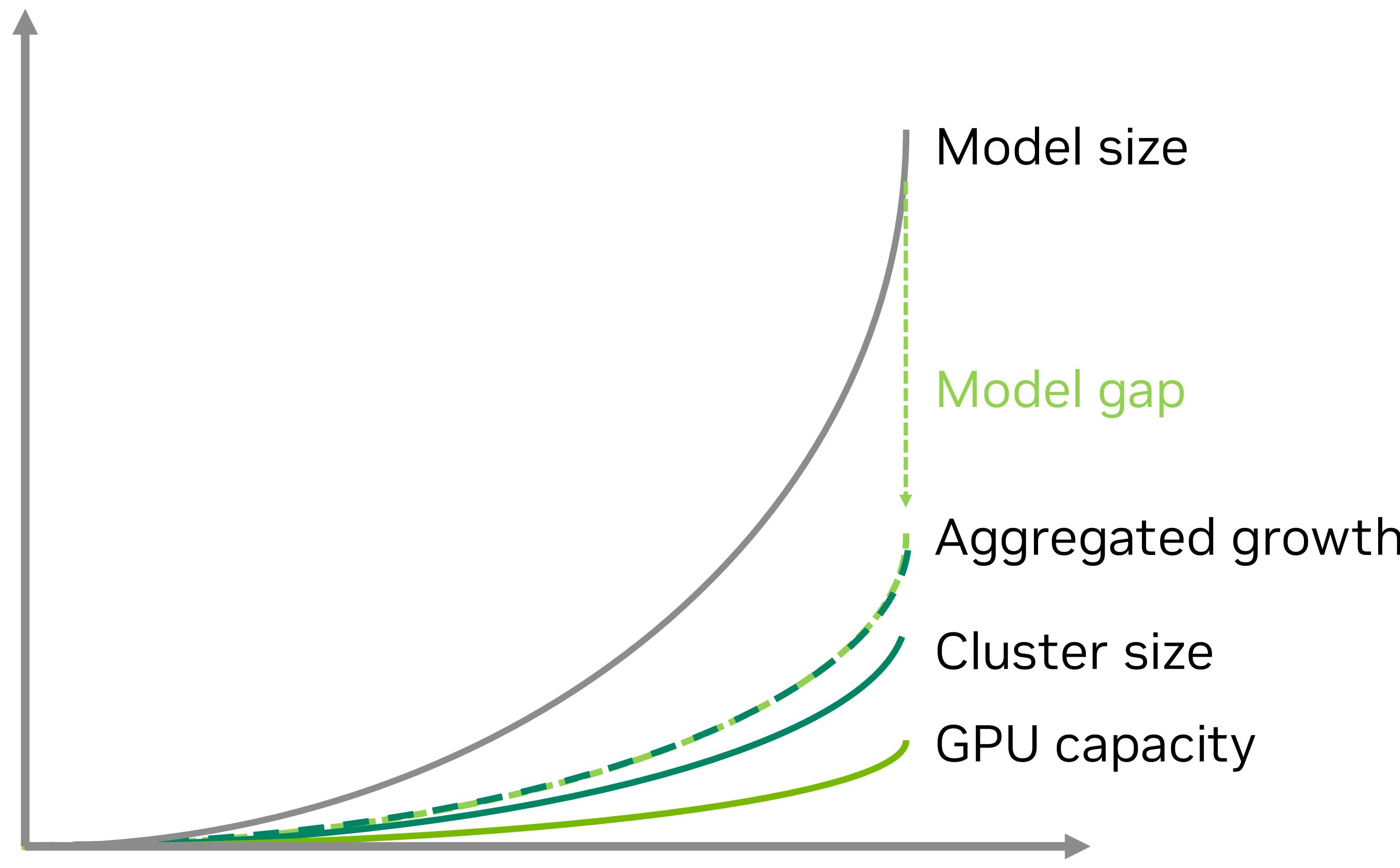
AI Network Performance  
during link failures



Spectrum-X utilizes global adaptive routing to rebalance NCCL flows and avoid failed paths

# Next Generation Models Communication Bottleneck

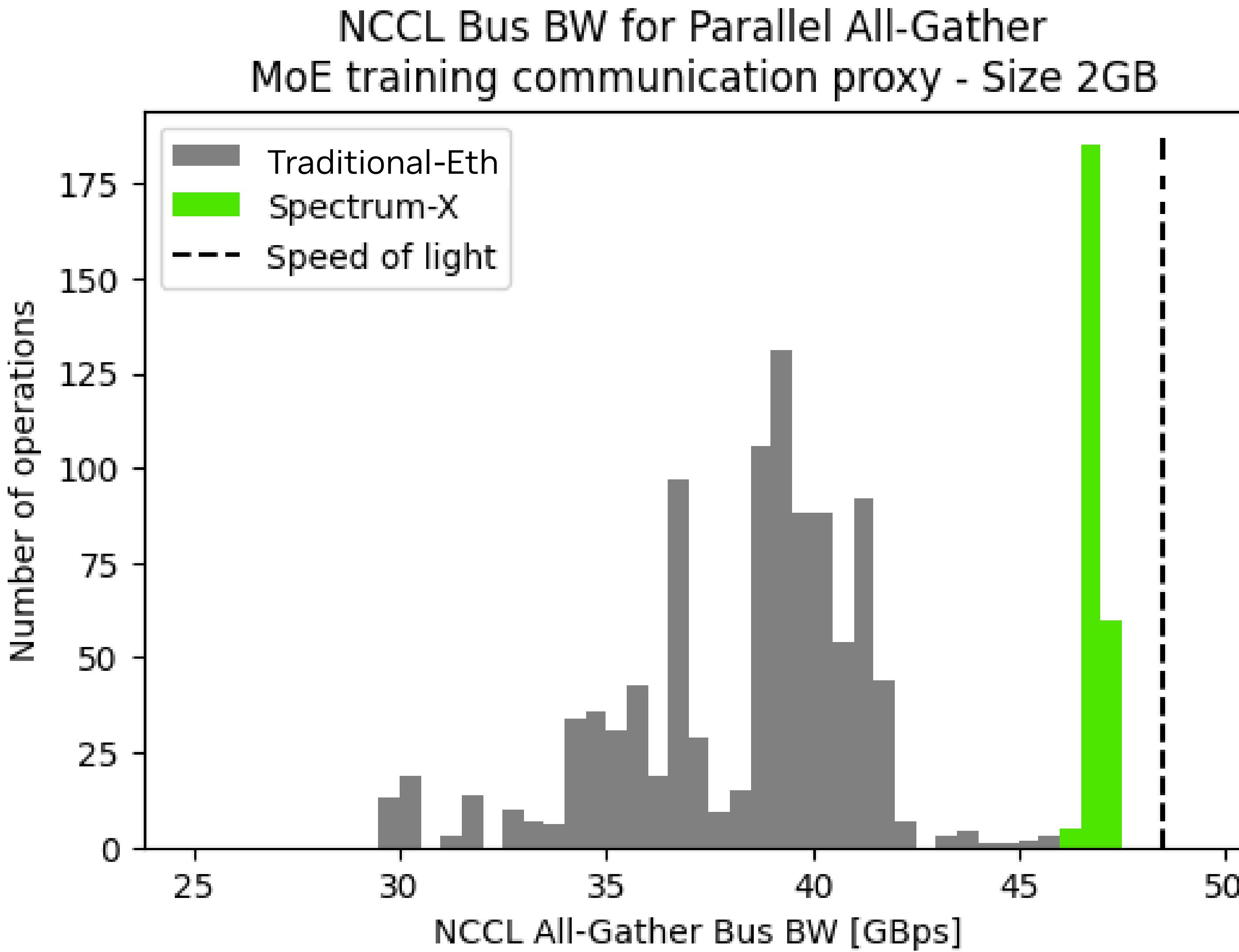
Spectrum-X Enables Mixture of Experts Techniques to Shine



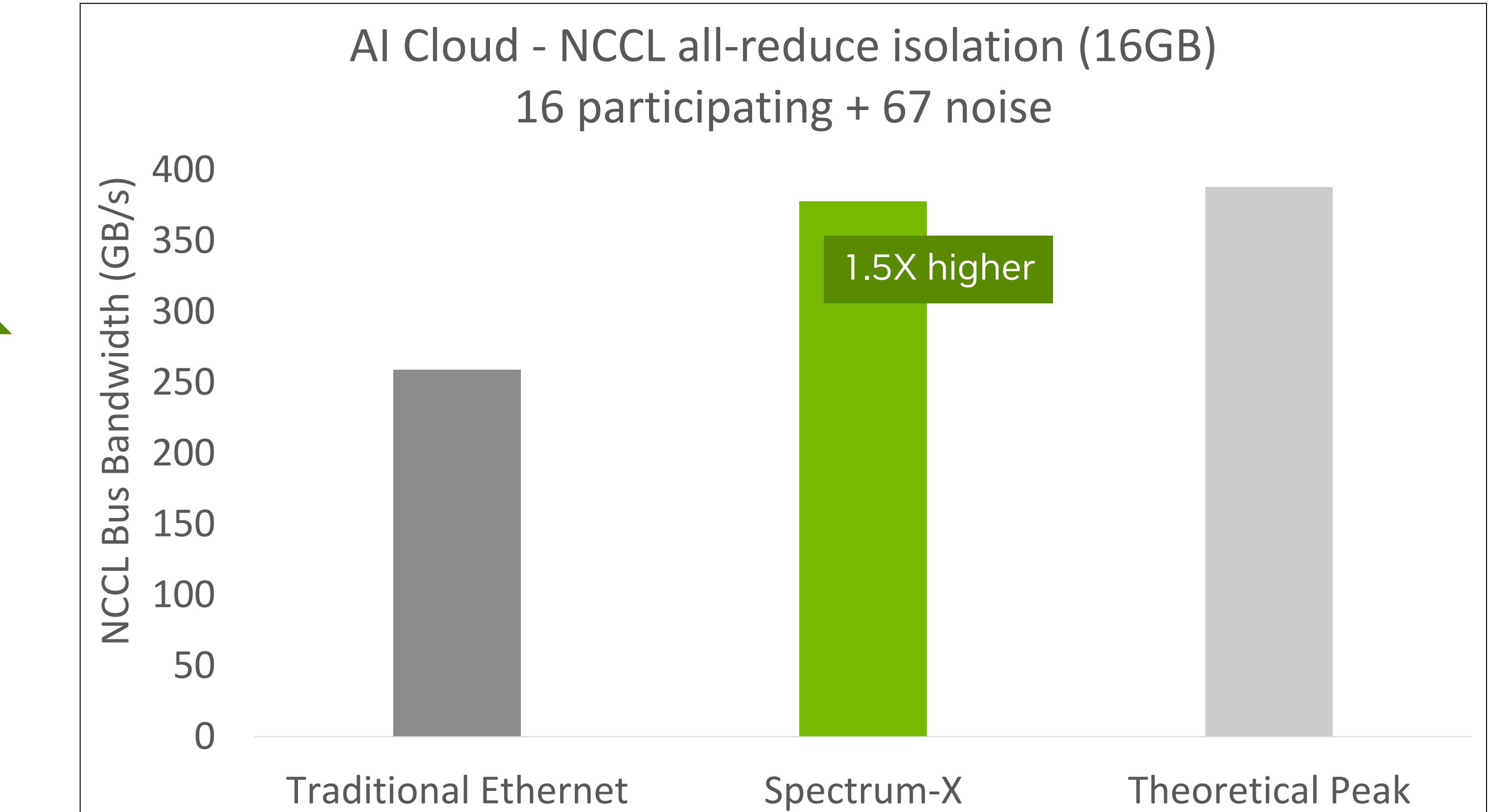
Spectrum-X handles the skewed, sparse and dynamic MoE traffic patterns, with no traffic collisions and predictable performance

# Next Generation Models Communication Bottleneck

## Spectrum-X Excels in Stringent Scenarios



Many groups in worst allocation  
running simultaneous all-gathers

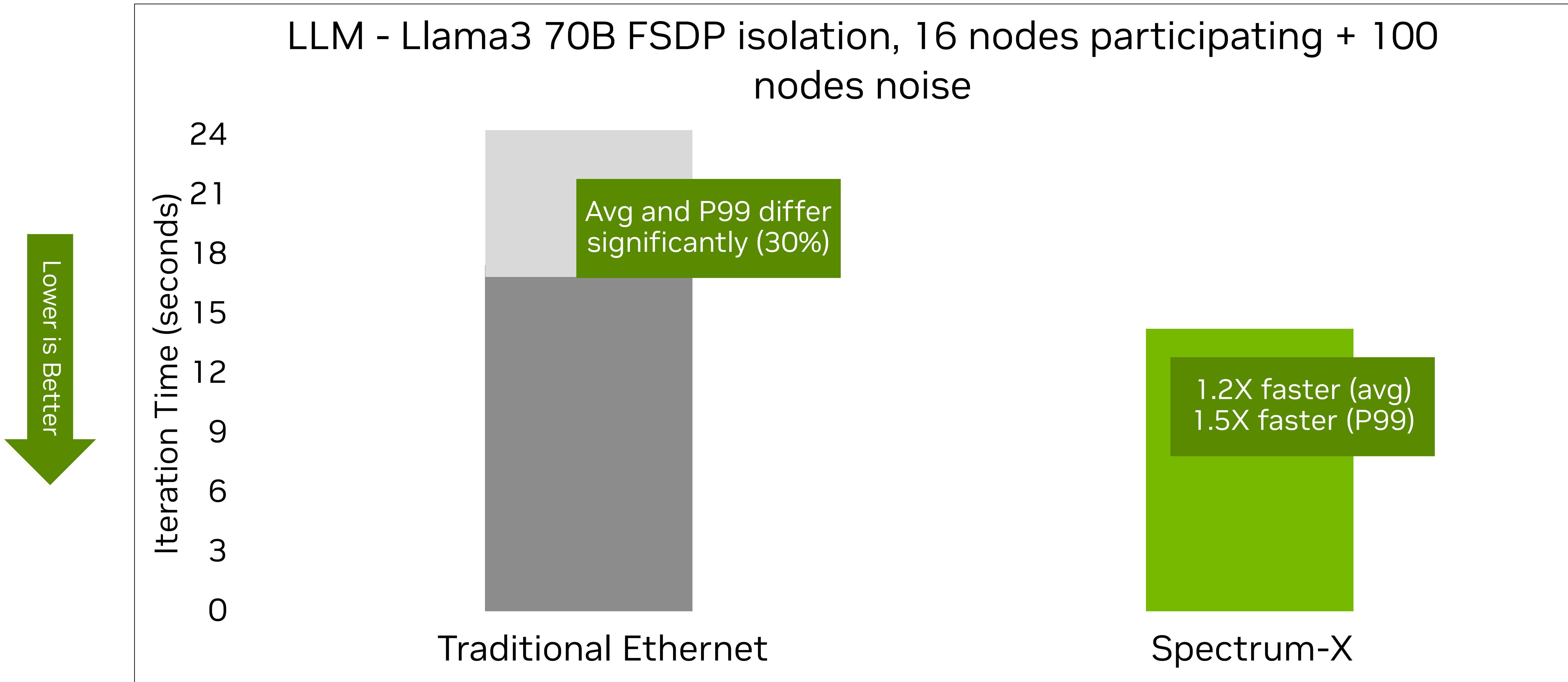


Spectrum-X maintains consistent performance under noise  
while traditional Ethernet shows degradation and variance.

Spectrum-X is ensuring multiple collective groups and experts can co-exist in a large-scale cluster  
→ This is what MoE is all about

# Spectrum-X Performance Update

LLM Isolation Results with Llama3



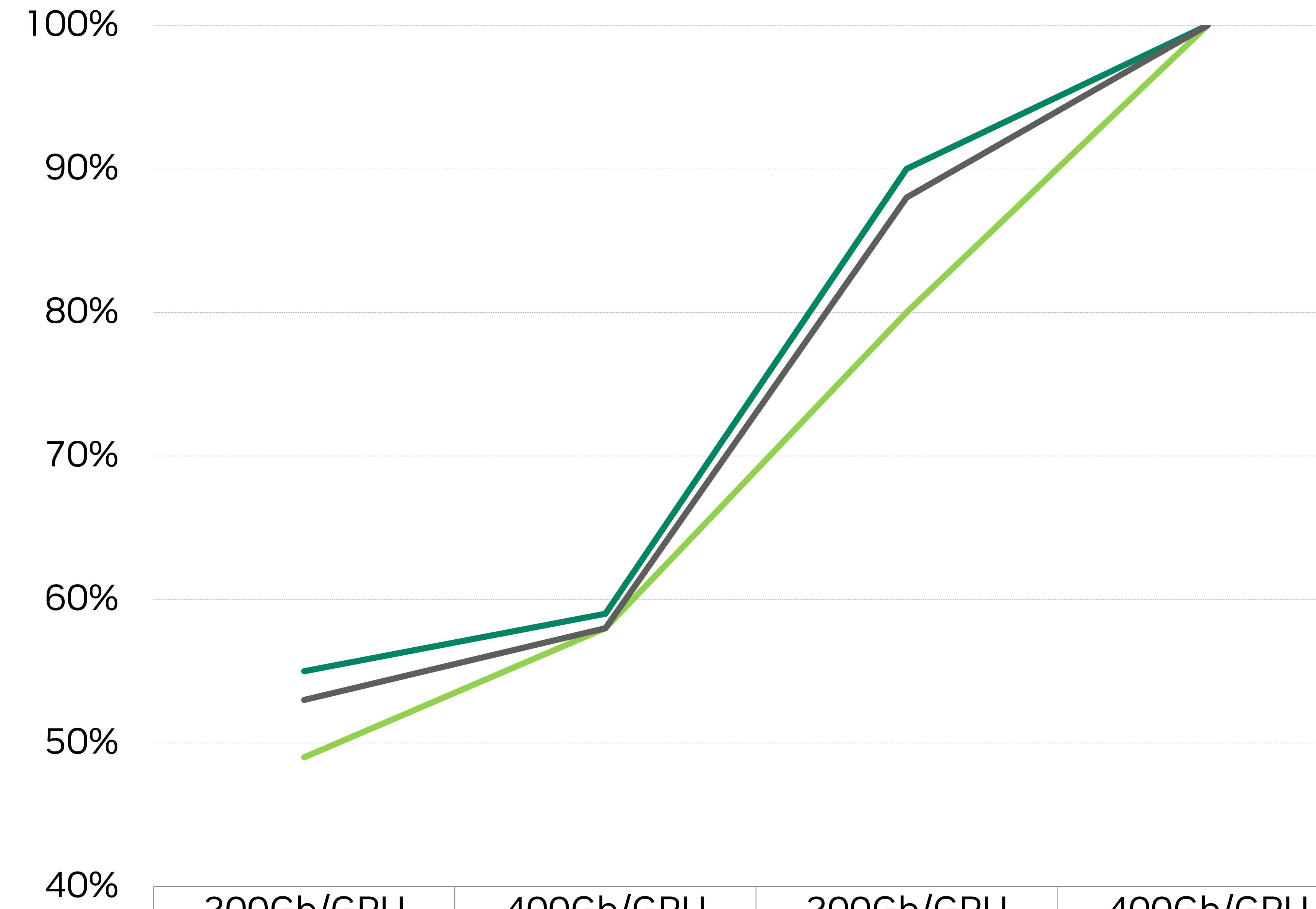
Spectrum-X performance isolation enables LLM training in noisy cloud environments.

Spectrum-X delivers identical average and worst-case performance (0.1% delta); traditional Ethernet degrades significantly.

Spectrum-X accelerates training large language models in AI Factories

# GPT3 175B – Perf/[GPU, TCO\$, Watt], 16K Hopper GPUs

Normalized to Spectrum-4 with 400 Gb/GPU



1.7X Performance / GPU

1.7X Performance / TCO\$

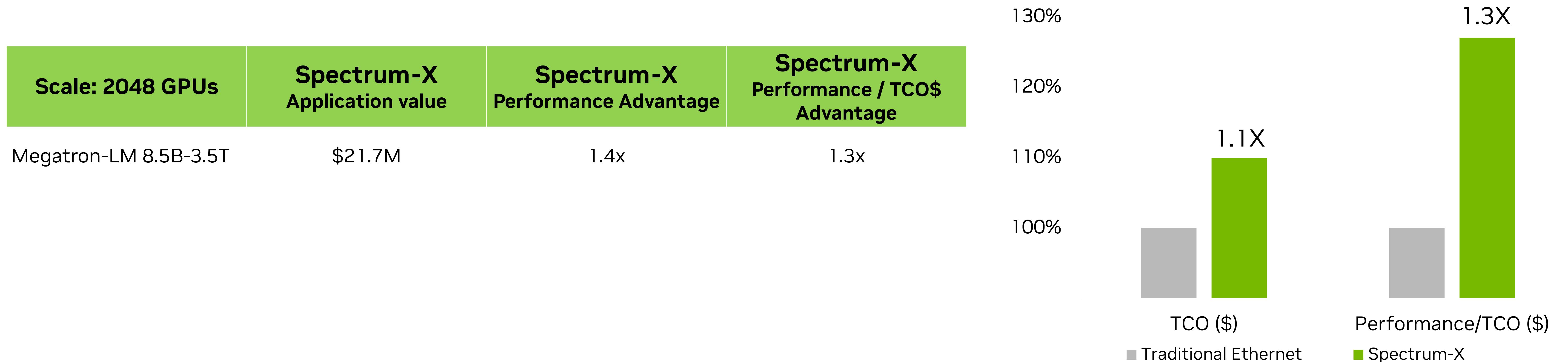
1.7X Performance / Power

	200Gb/GPU Traditional Eth	400Gb/GPU Traditional Eth	200Gb/GPU Spectrum-X	400Gb/GPU Spectrum-X
Perf / GPU	49%	58%	80%	100%
Perf / TCO\$	55%	59%	90%	100%
Perf / Power	53%	58%	88%	100%

# Performance and 3-Years TCO

TCO for 2048 GPUs	Spectrum-X 2K GPU Hopper, BF3	Traditional Ethernet 2K GPU Hopper, CX7
Server (GPU, CPU)	\$57.9M	\$57.9M
Network (Spectrum-X vs. Traditional Ethernet)	\$13.0M	\$5.8M
Rack	\$0.3M	\$0.3M
Power and Hosting	\$8.2M	\$8.2M
<b>TCO</b>	<b>\$79.4M</b>	<b>\$72.2M</b>

## TCO Comparison



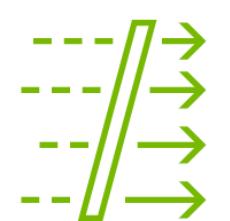
# **Spectrum-X Platform Components**

# NVIDIA Spectrum SN5600

The First Ethernet Switch  
Purpose-Built for AI



FAST



4X bandwidth capacity increase

EFFICIENT



4X reduction in solution footprint

SECURE



In-flight and at-rest encryption

GREEN



50% Reduction in solution power

51.2Tbps

Aggregate bandwidth

400/800GbE

100G SerDes technology

100B

Transistors

4N

NVIDIA design process

**400Gb/s**

Network Bandwidth

**16C**

Programmable Compute

**1:1**

GPU/SuperNIC Ratio

**<75W**

Power Envelope



**NVIDIA B3140H SuperNIC**

Optimized for E-W in GPU-Accelerated Systems

## **NVIDIA BlueField-3**

**Network Accelerator for Powering  
Generative AI Clouds**



**Peak AI Workload Efficiency**



**Secure Cloud Multi-Tenancy**



**Extensible Infrastructure**

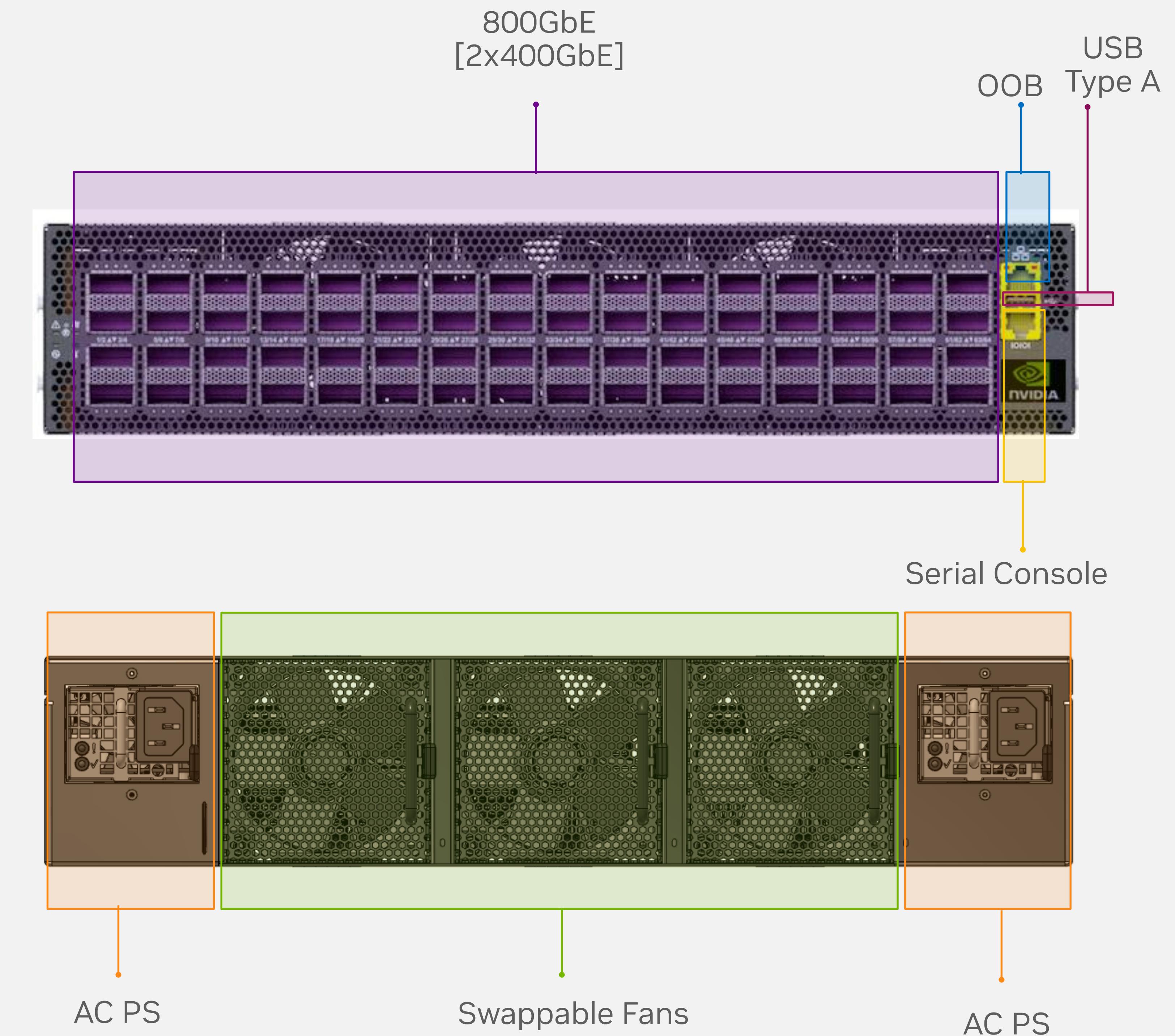


**Power-Efficient, Low-Profile Design**

# SN5600

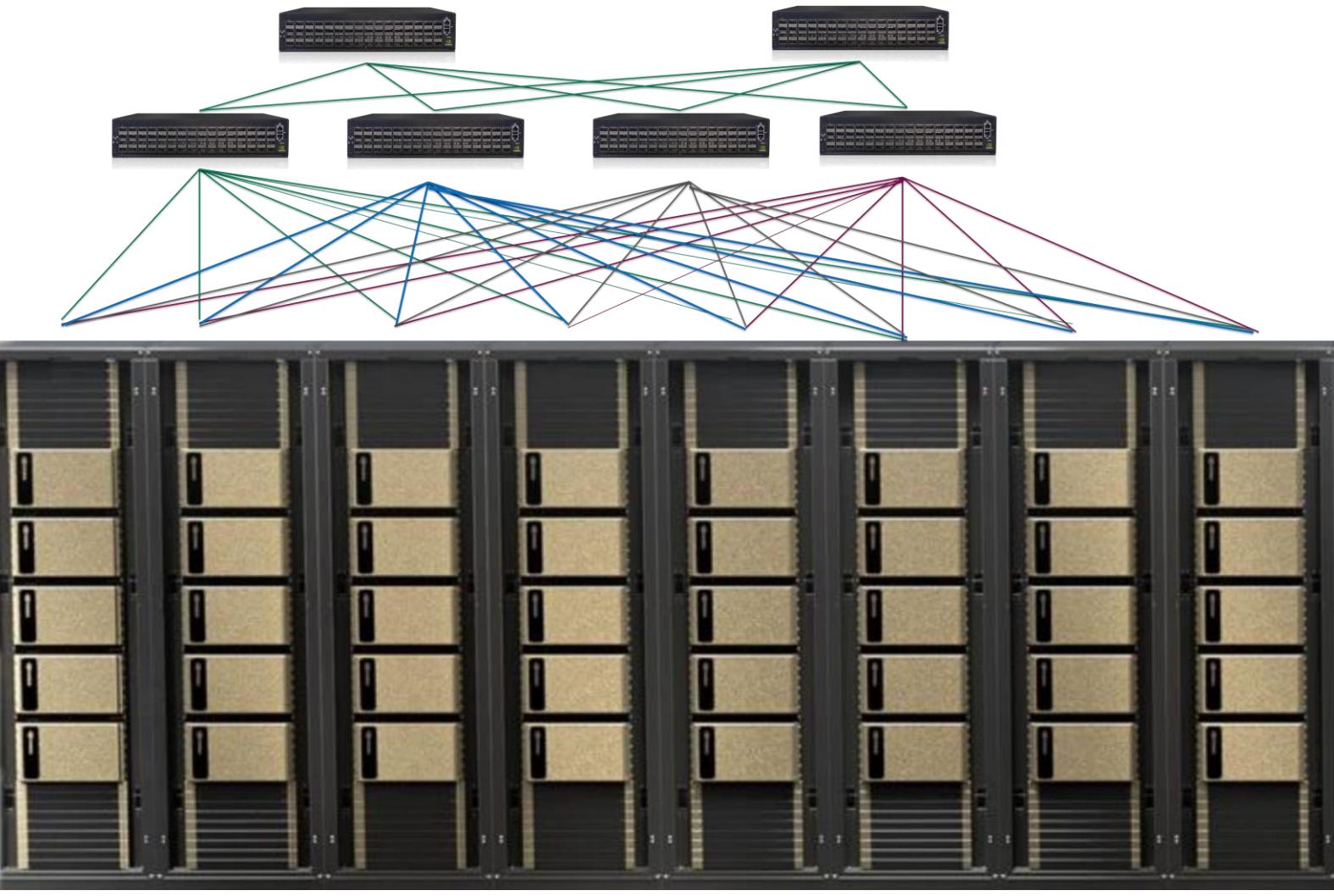
64x 800GbE / 128x 400GbE

Switch ASIC	▶ NVIDIA Spectrum-4
Switching Capacity	▶ 51.2Tbps
Ports	▶ 64 Cages: 800G or 2x 400G
System CPU	▶ x86, Six-Core Xeon ▶ RAM: DDR4 SDRAM 32GB ▶ Image storage: SATA SSD 256GB
System Power	▶ PS: AC, 1+1 redundancy, hot swap
Mounting Options	▶ Fixed ▶ Tool-less, Rack mobility
Dimensions	▶ H: 2U, 3.43" (87mm) ▶ W: 16.8" (428mm) ▶ D: 26" (660mm)
Airflow	▶ N+1 fans, hot swap, reverse



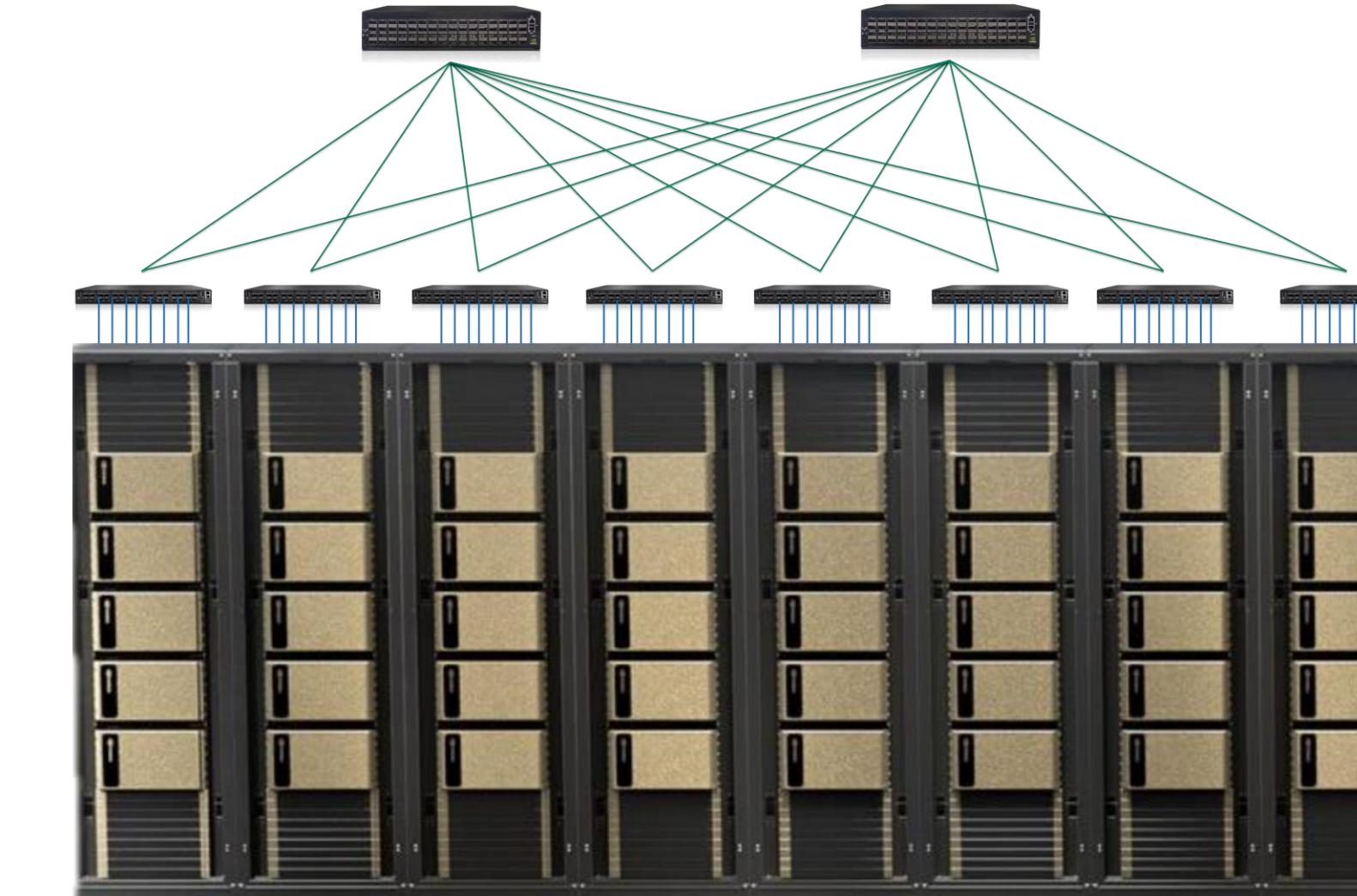
# Understanding Rail-Optimized vs. Top of Rack

NCCL-optimized performance with Spectrum-4



## Rail-Optimized End of Row Design:

- Defined by GPU connectivity
- NCCL-optimized topology
- Copper cables from leaf to spine
- Optics between leaf and servers
- Higher AI performance
- Lowers latency between GPUs
- Reduces spine traffic

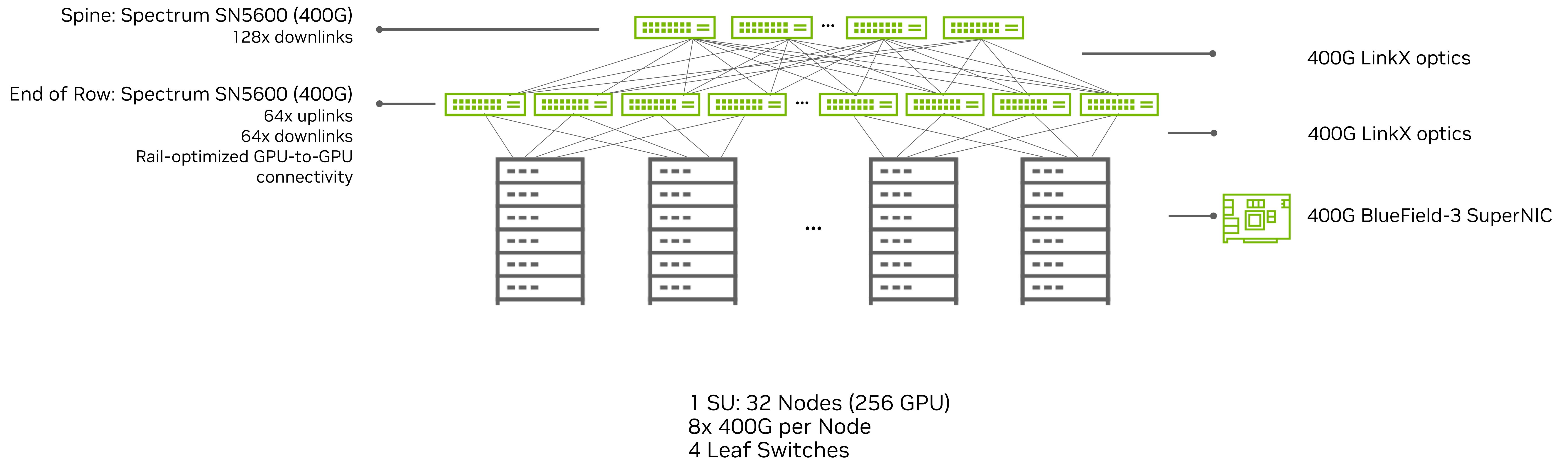


## Top of Rack Topology:

- Defined by physical proximity (rack)
- Cable-optimized topology
- Copper cables from server to leaf
- Optics between leaf and spine
- Lower AI performance
- 3x higher switch latency between GPUs
- Higher spine congestion

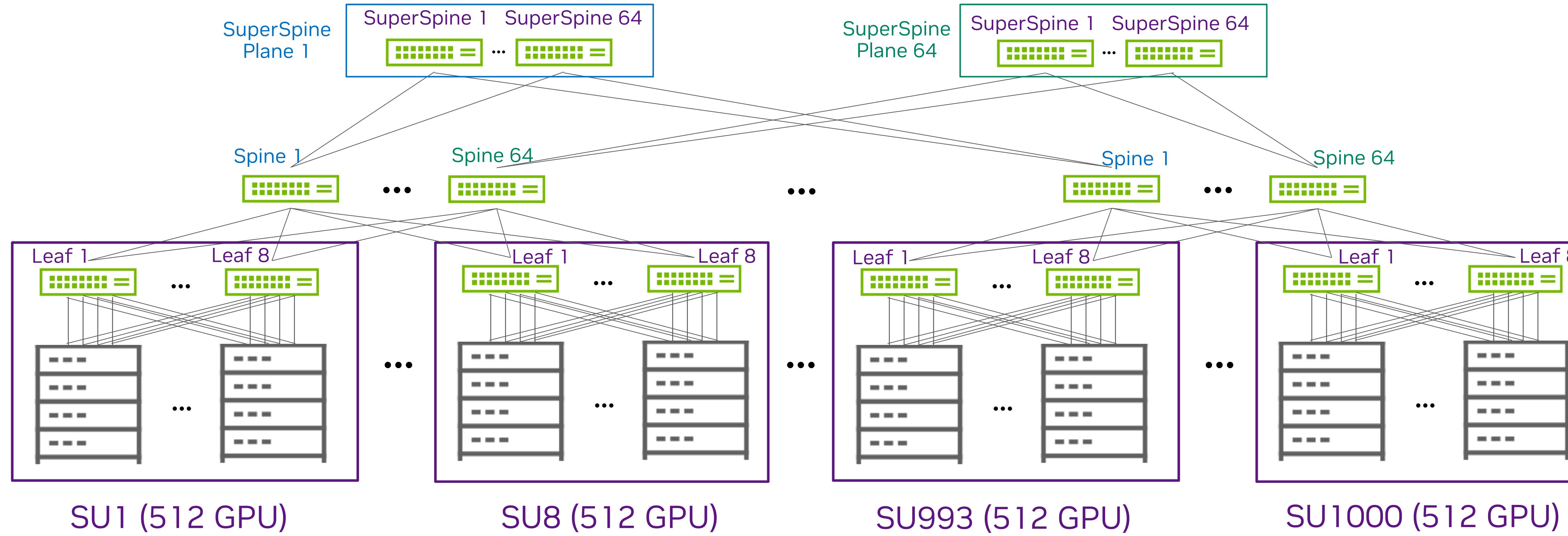
# Spectrum-X Rail Optimized Leaf and Spine

Spectrum SN5600 + BlueField-3 GPU-to-GPU Fabric for 8K Hopper GPU Cloud



# Rail-Optimized Scale Out Architecture

Up to 512k Hopper GPUs, Non-blocking Connectivity (64 Node SU)



Max of 5 ASIC hops between GPUs  
(11 required for modular chassis-based cluster)

# B3140H SuperNIC

Network accelerator for AI compute fabric

## Specifications

Network Speed	1 x 400Gb/s
Interface Type	QSFP112
Programmable Compute	8 x Arm A78 @ 2.0Ghz
Memory	16GB DDR5
Host Interface	Gen5 x16
TDP Power w/ Active Cables	<75W
Thermal solution	Passive
Form factor	HHHL

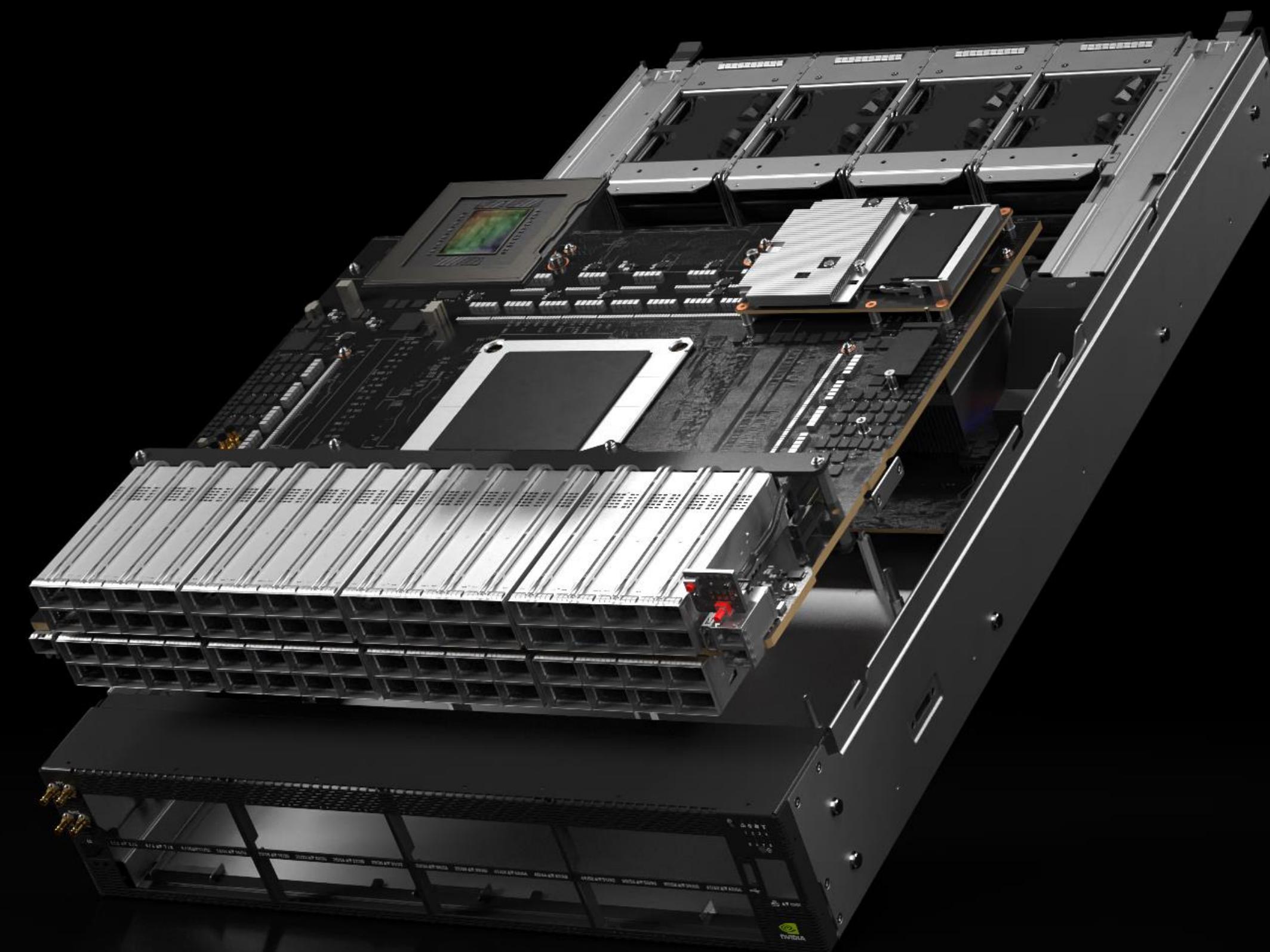
## Ordering Part Numbers

Crypto Disabled	900-9D3D4-00NN-HA0
Crypto Enabled	900-9D3D4-00EN-HA0

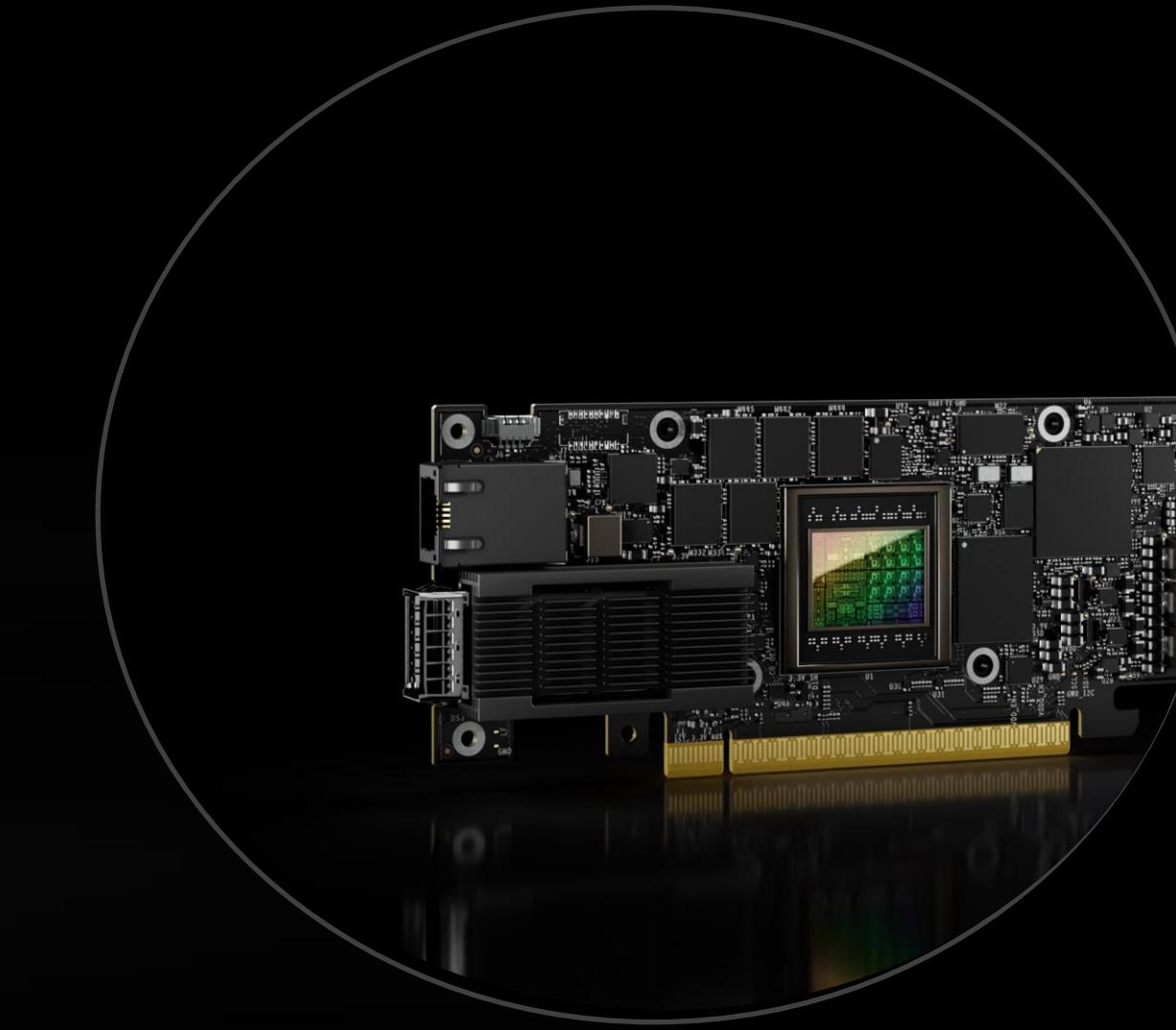


# Purpose-Built Ethernet Fabric for AI

## NVIDIA Spectrum-X Networking Platform



Spectrum SN5600 Ethernet Switch



BlueField-3 SuperNIC



1.6X Higher AI Network Performance

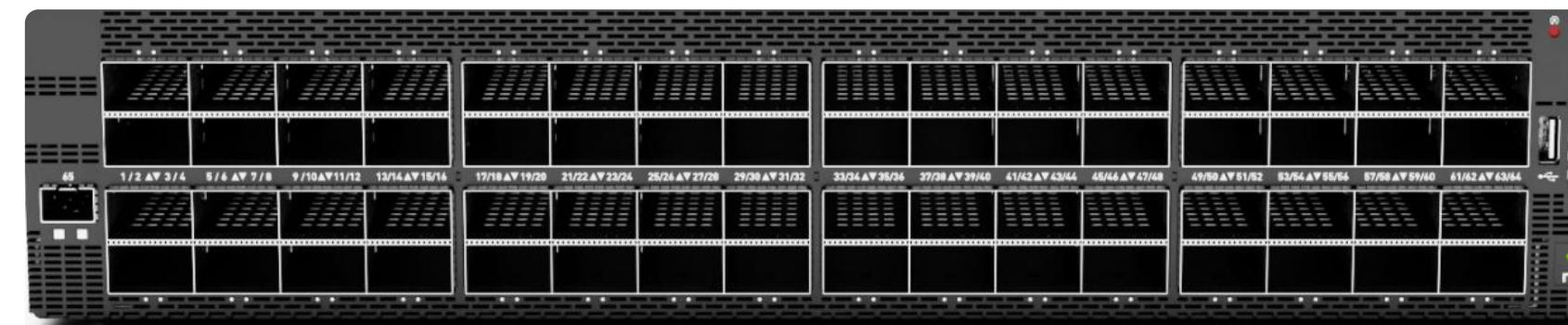


Standard Ethernet Connectivity

# Learn More About Spectrum-X

## Available Resources

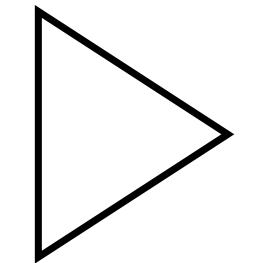
### NVIDIA Spectrum-X Networking Platform



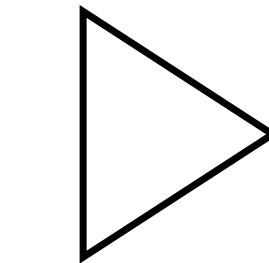
NVIDIA Spectrum SN5600  
Ethernet Switch



NVIDIA BlueField-3  
SuperNIC



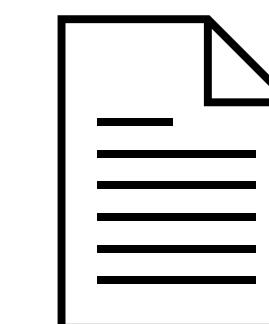
[Spectrum-X  
Intro Video](#)



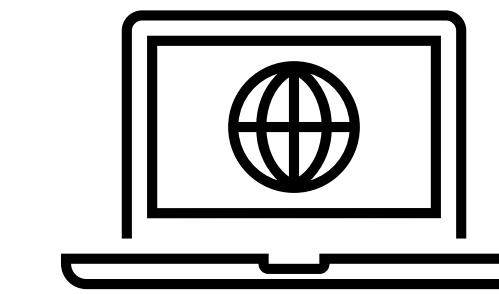
[Data Center Digital Twin  
Israel-1 Video](#)



[Spectrum-X  
Datasheet](#)



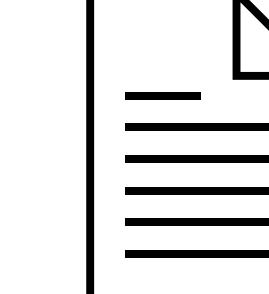
[Spectrum-X Technical  
Whitepaper](#)



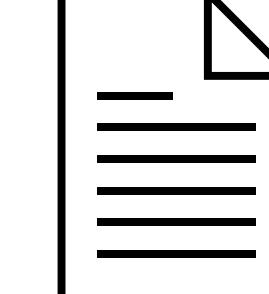
[Spectrum-X  
Webpage](#)



[Spectrum-X Technical  
Blog](#)



[Networking for  
AI Whitepaper](#)



[BlueField SuperNIC  
Whitepaper](#)

