AI Data Center Networks

CommScope

May 2024

Today's Agenda:

- What is Artificial Intelligence (AI)

- The Different Types of AI, Business Impacts & Applications

- Drivers of AI Growth

- AI Networks

- Fiber Connectivity for AI

- Physical Media Choices

- Data Center Network Planning

- Future of Networking

- Physical Layer Solutions For AI Networks

- Q&A

What Is Artificial Intelligence?

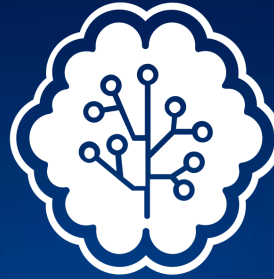*Q. Which image shows a dog (and why?)*

Generated by Adobe Firefly

Different Types of AI
Generative AI (Gen AI) & Inference AI

LARGE LANGUAGE MODEL (LLM) / NEURAL NETWORKS
(New AI GPU Clusters) Circa. 2016+
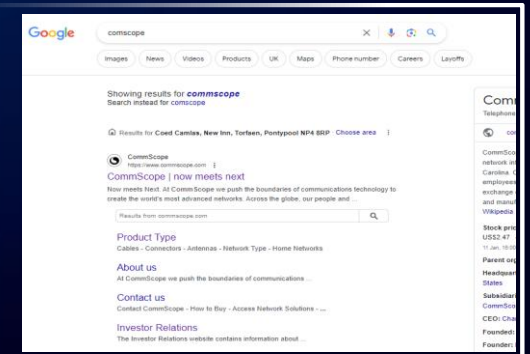
GEN AI
(Creates Brand New Content)

DATASETS

DEEP LEARNING
(DEEP AI)

MACHINE LEARNING
(NARROW/WEAK AI)

TRAINING (Traditional CPU Servers) Existed For Decades

INFERENCE AI
(Predictive)

AI Business Impact & Applications

Higher Operating Efficiencies

New Product & Services Offerings

Solving Societal Challenges

Gen AI Releases Humans From Repetitive Tasks

- Writing Software Code
- Mass Data Entry

Gen AI Technology Enabled:

- Personalized Travel Assistants
- Applications To Redesign Interiors
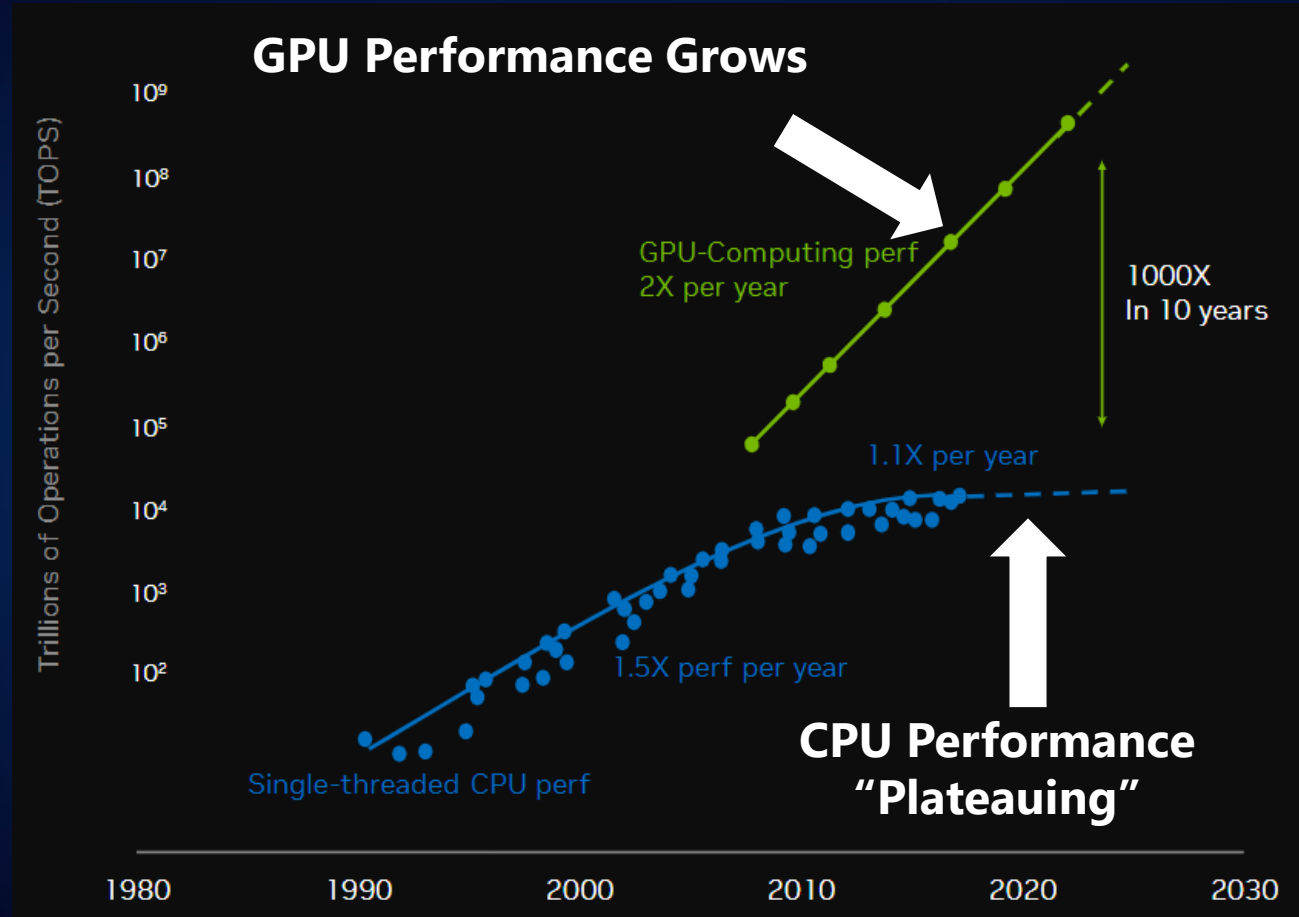
Applying Gen AI:

- For Climate Simulation
- To Identify At-Risk Patients In A Population
- To Accelerate Drug Discoveries

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Drivers of Gen AI Growth → GPU's

GPU Performance Grows

Trillions of Operations per Second (TOPS)

10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2

GPU-Computing perf
2X per year

1000X
In 10 years

1.1X per year

1.5X perf per year

Single-threaded CPU perf

CPU Performance "Plateauing"

1980   1990   2000   2010   2020   2030

CPU
Few Cores

GPU
'000s of cores

GPU's Deliver Massive Performance Gains, Demands More Bandwidth

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Inference AI Has Been Running Over Existing Data Center Infrastructure

WAN / Campus

Routers

Spines

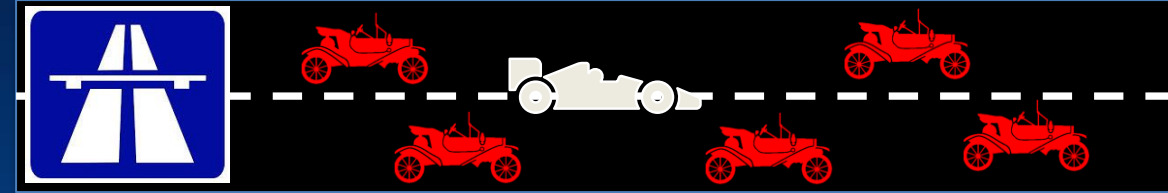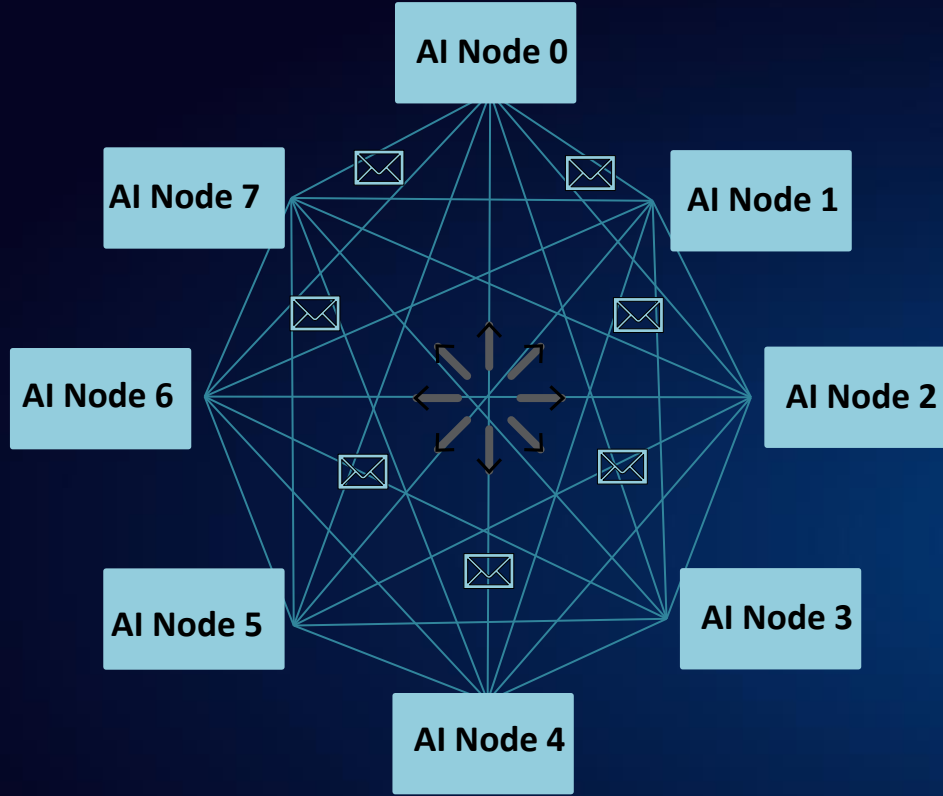East West Traffic

Leaf (ToR)
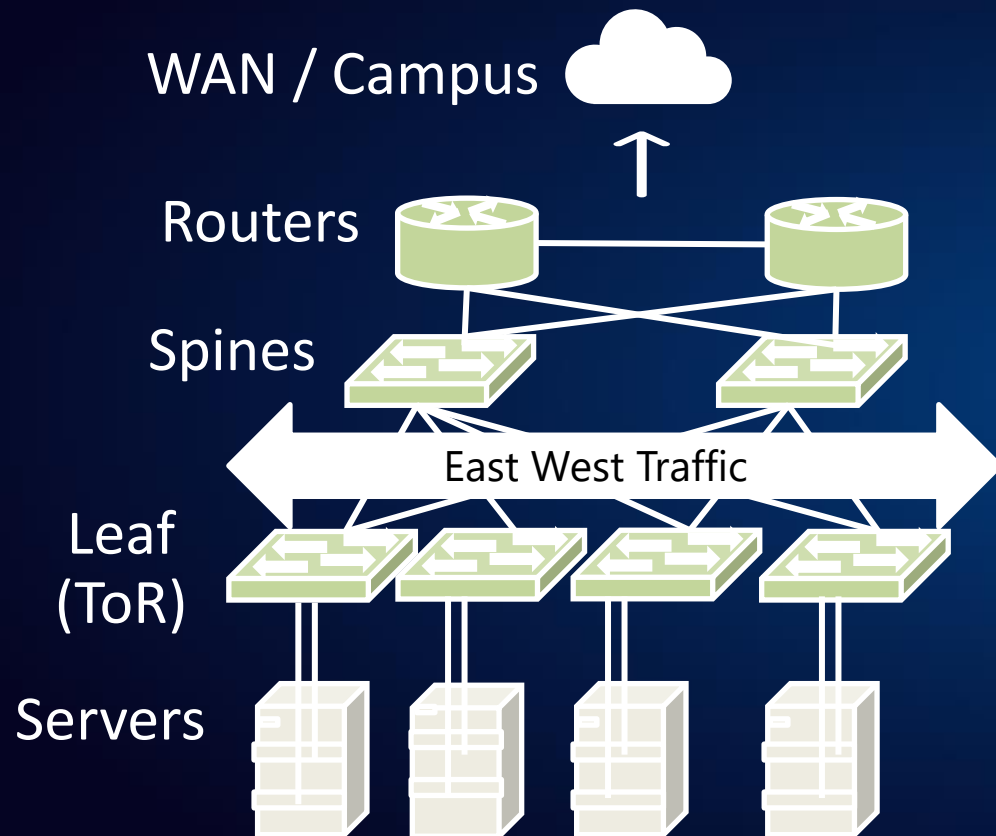
Servers

- Uses existing Clos architectures, with East – West traffic flows

- The network performance has matched the CPU based servers performance

- Ethernet has been a sufficient networking technology

Gen AI – A New & Complimentary Network Is Needed

WAN / Campus

New Gen AI Back End

Existing Front End

Routers

Storage Spine

AI Compute Spine

In Band Spine

Spines

Storage Leaf

AI Compute Leaf

In Band Leaf

Leaf

Out-of-Band Management Network

(Copper)

AI Cluster

Servers

Existing Ethernet Front End (Compute) Network

= Infiniband Networking   = Ethernet Networking
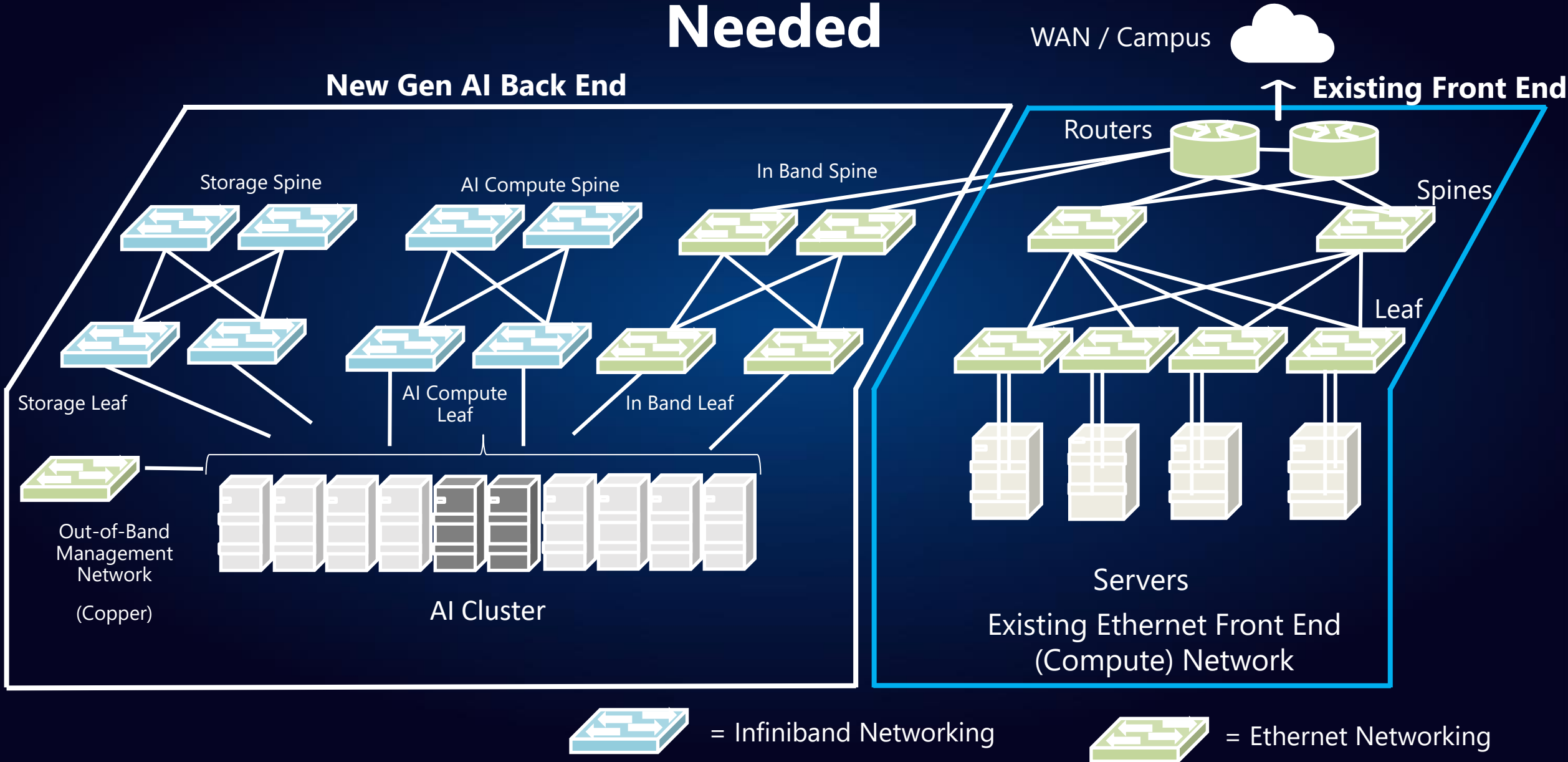
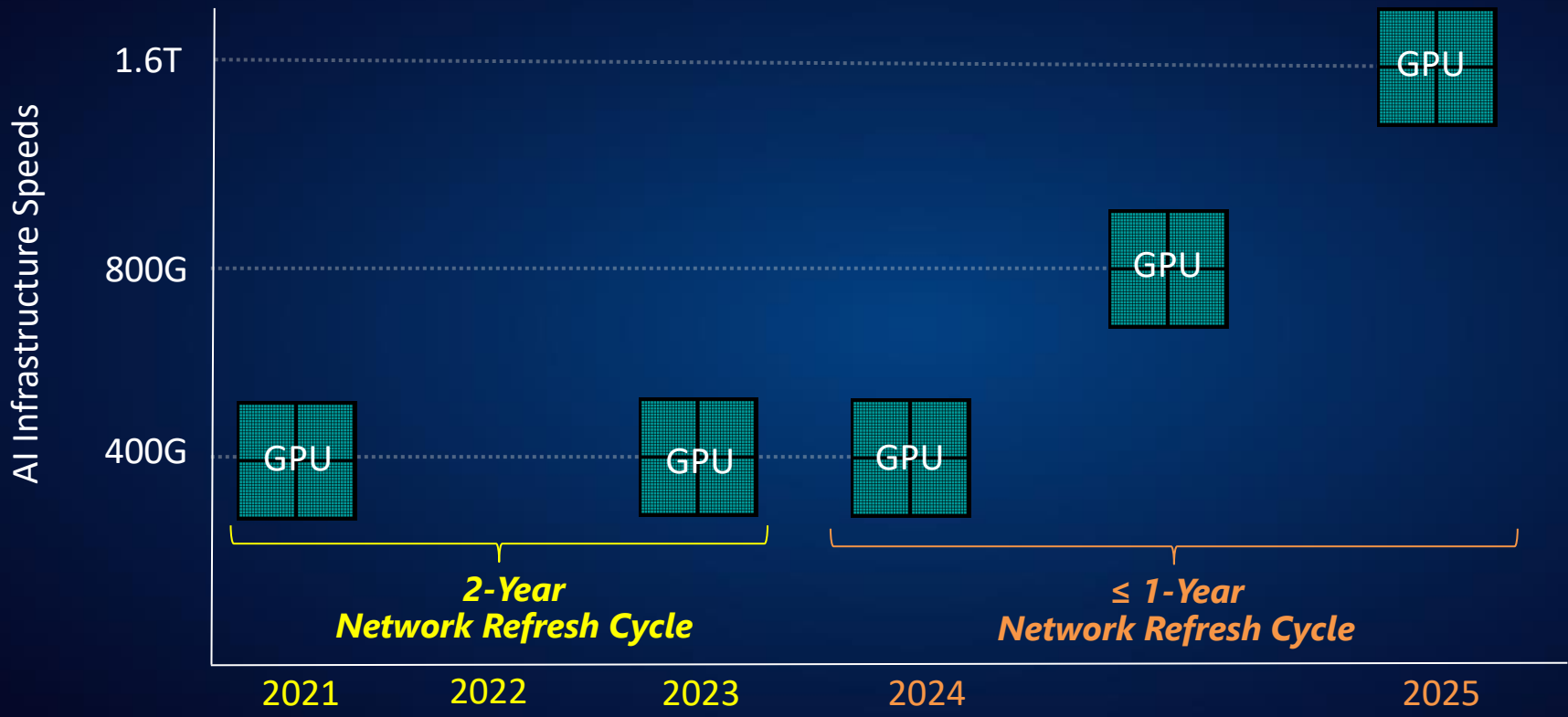# The GPU Enabled Server Is No Longer The "Bottleneck"

No GPU starts to work until **ALL** GPU's have their packets

To a GPU, poor infrastructure is like running a racing car during peak commuter traffic

AI Requires A High Quality, Low Latency, Lossless Fabric To Perform

Network Upgrades Required Every ~~5 Years~~ ~~2 Years~~ Year (GPU Releases)
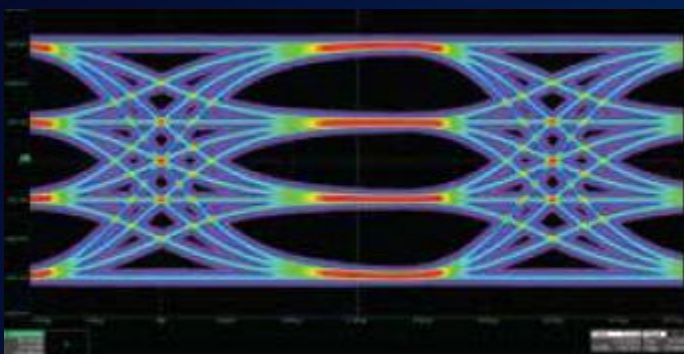
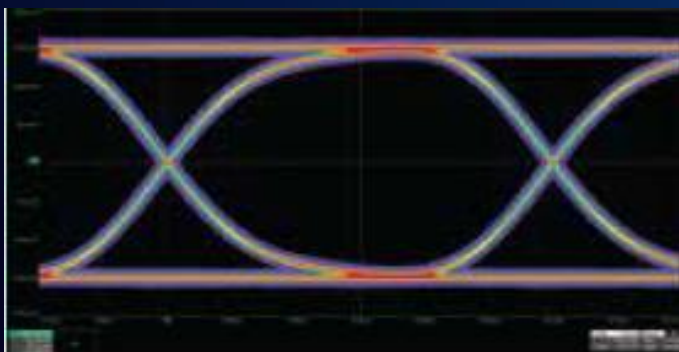# Tight Budgets With Higher Quality Components Needed

Higher Baud Rates

PAM4 (50Gb/s Lanes And Above)

End Face Quality Becomes Critical

NRZ (25Gb/s Lanes and Below)

Unwanted Back Scatter

UPC End Face

APC End Face

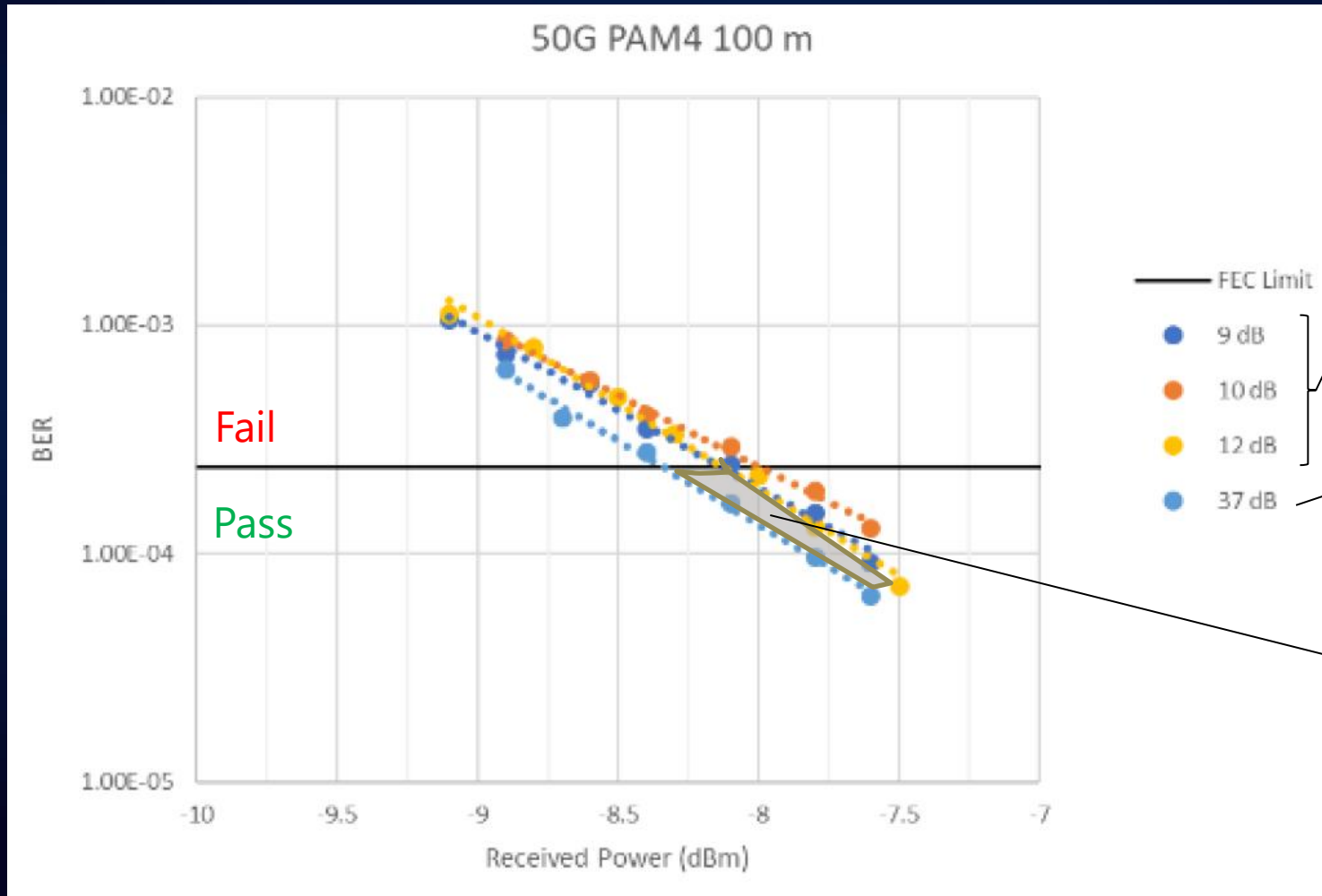Back Scatter Reflected Away From Transmitter
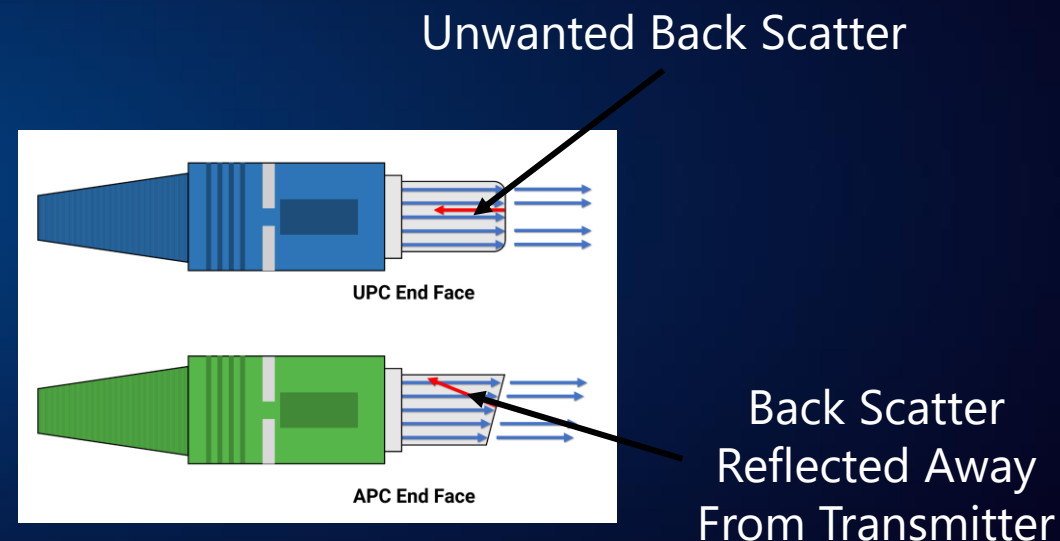
Standards above 100G recommending APC end faces for MMF and SMF
400G (NDR) Infiniband Rates
(Always check the transceiver being deployed)

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APC Connectivity - More Headroom - More Benefits

50G PAM4 100 m

More Errors

Bit Error Rate (BER)

Fail

Pass

Less Errors

FEC Limit
- 9 dB
- 10 dB
- 12 dB
- 37 dB

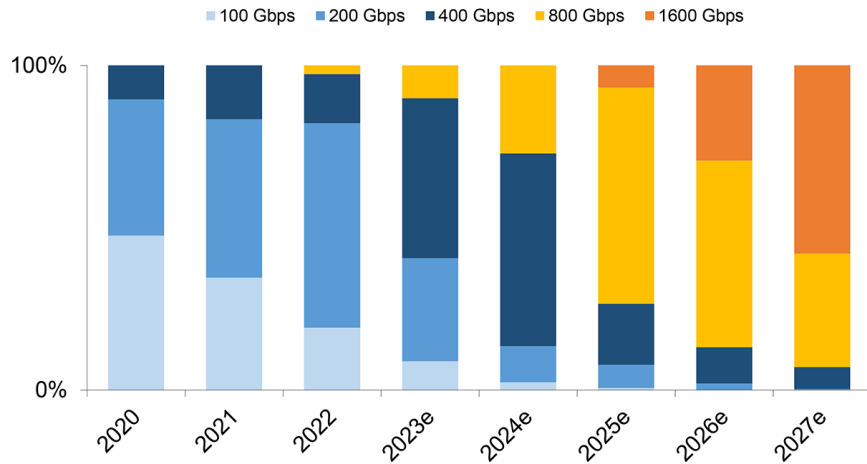UPC Connector Return Losses

Typical APC Connector Return Losses

APC Cabling enables detection of lower optical power levels

Benefit:
- Longer Channel Runs
- More Connectors/Channel
- More Design Flexibility

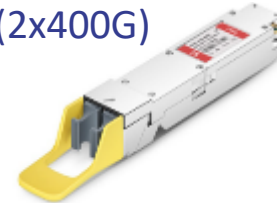*Source: 9*

AI Backend Networks - Bandwidth Hunger

Migration to High-Speeds in AI Clusters (AI Back-End Networks)

■ 100 Gbps ■ 200 Gbps ■ 400 Gbps ■ 800 Gbps ■ 1600 Gbps

*Includes both Ethernet and InfiniBand
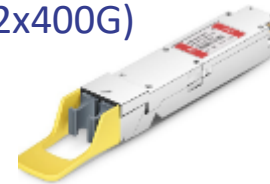* Source: Dell'Oro Group AI Networks Report December 2023

DELL'ORO GROUP

InfiniBand
(2x400G)

800GBASE-DR8 OSFP PAM4 1310nm 500m DOM
Dual MTP/MPO-12 SMF Optical Transceiver
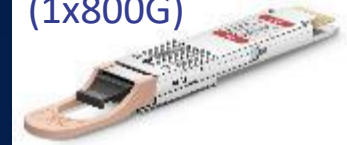Module for InfiniBand 2x NDR, Finned Top

Ethernet
(2x400G)

Generic Compatible 800GBASE-DR8 OSFP PAM4
1310nm 500m DOM Dual MTP/MPO-12 SMF
Optical Transceiver Module

Ethernet
(1x800G)

- *From 400G (today) to 800G/1600G ->*
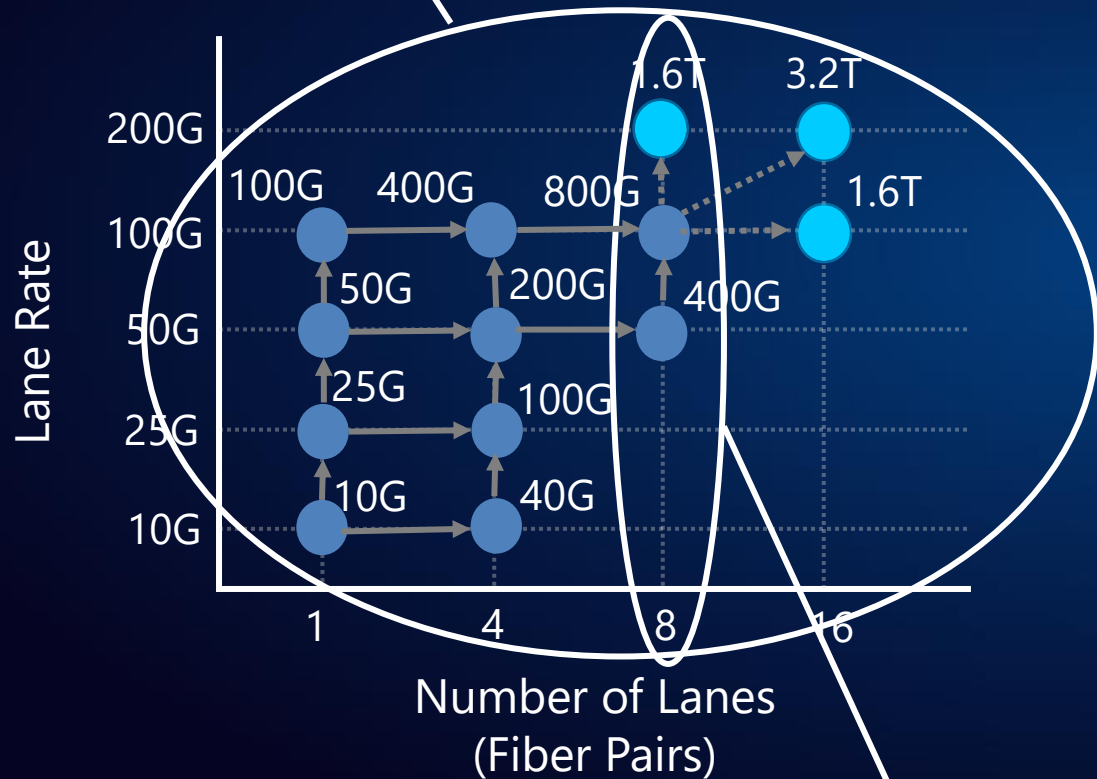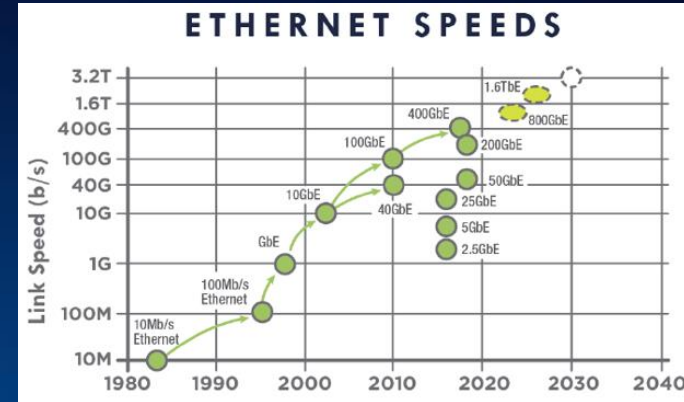 - Shift to 16 fiber-based architectures enabling migration and redundancy efficiencies

MPO-8/MPO-12
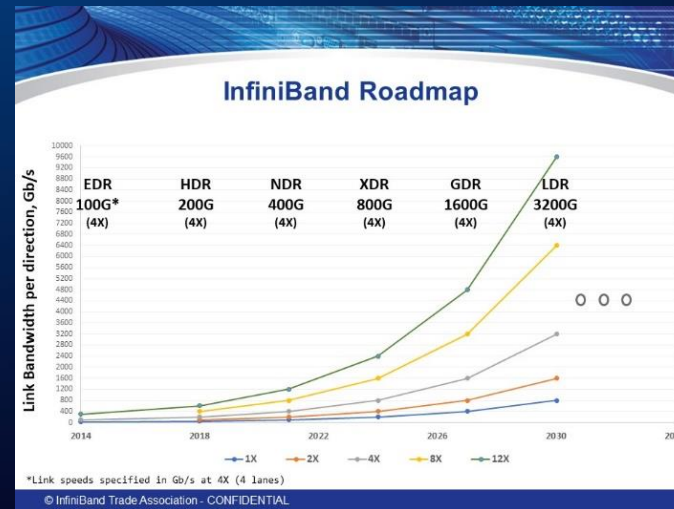
MPO-16

The Routes To High Speed Ethernet & Infiniband

Also Supported By 16F
Connectivity

Lane Rate

200G

100G 400G 800G 1.6T 3.2T

100G

50G 200G 1.6T

50G 400G

25G 100G

25G

10G 40G

10G

1   4   8   16

Number of Lanes
(Fiber Pairs)

Supported By 16F
Connectivity

ETHERNET SPEEDS

Link Speed (b/s)

3.2T — 1.6TbE
1.6T — 800GbE
400G — 400GbE
100G — 100GbE — 200GbE
40G — 40GbE — 50GbE
10G — 10GbE — 25GbE
1G — GbE — 5GbE — 2.5GbE
100M — 100Mb/s Ethernet
10M — 10Mb/s Ethernet

1980   1990   2000   2010   2020   2030   2040

Source: Ethernet Alliance

InfiniBand Roadmap

Link Bandwidth per direction, Gb/s

EDR	HDR	NDR	XDR	GDR	LDR
100G*	200G	400G	800G	1600G	3200G
(4X)	(4X)	(4X)	(4X)	(4X)	(4X)

2014   2018   2022   2026   2030   2034

*Link speeds specified in Gb/s at 4X (4 lanes)

—1X —2X —4X —8X —12X

© InfiniBand Trade Association - CONFIDENTIAL

Source: InfiniBand Roadmap – Advancing InfiniBand (infinibandta.org)

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Media Choices

Structured Cabling

- Supports multiple Network Speed Upgrades
  - No Need To rip-and-replace Infrastructure (better for ESG)
  - Simpler Upgrade Paths – no need to re-access ducts/pathways
  - Minimal Down Time
  - Main CAPEX Investment Once

- Structured cabling is transmission agnostic
  - Supporting both Ethernet **AND** Infiniband

- Modularity provides connector flexibility (VSFF, LC, MPO, MMC etc......)

- Fiber uses less space, and weighs, less than Copper DAC's

- Fixed backbone cabling supports a Rack-And-Roll approach
  - Quickly onnect cabinets to the network by simply using patch cords

AOC/DAC's

- Supports A Single Speed
  - Rip-and-Replace needed for every change in network speed
  - Need to re-access congested ducts/pathways
    - Risk of distrubance to adjacent cabling channels
  - More network downtime needed to dress-in individual links
  - AOC's/DAC's CAPEX required for every speed change

- AOC's/DAC's are transmission specific
  - Supporting Ethernet **OR** Infiniband

- Are Point-To-Point components
  - Not recommended by international standards as a subsitute for „Fixed Cabling" (aka Backbone Cabling)

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The Future Infiniband v Ultra Ethernet Alliance

InfiniBand

Ultra Ethernet Consortium

Structured Cable Supports Both Infiniband & Ethernet

	InfiniBand	Ultra Ethernet
Data Rates	: 200G / 400G / 800G	: 200G / 400G / 800G
Performance @ Scale	: **HIGH**	: **HIGH** / **MEDIUM**
Flexibility	: **LOW**	: **Medium**
	- Single Vendor	- Less Vendor Lock-In
	- Limited	- Larger Talent Pool
		- Structured Cabling Approach
		- Backwards Compatible With Existing Ethernet Networks
Network Growth	: **MEDIUM** / **LOW**	: **HIGH**
	- Limited application distances	- Enable Scale Networks
	- Uneven White Space Power Load	- Un-Limited # of devices
	- Limited # of device addresses	
	- Costly	

Data Centre Network Planning

Understand Power, Weight & Cooling Densities

Mismatch

- – Typical DC cooling 20 kW / 600mm^2
- – Power / AI Rack typically 40kW
- Will liquid cooling be used
- Impacts cabinet placement
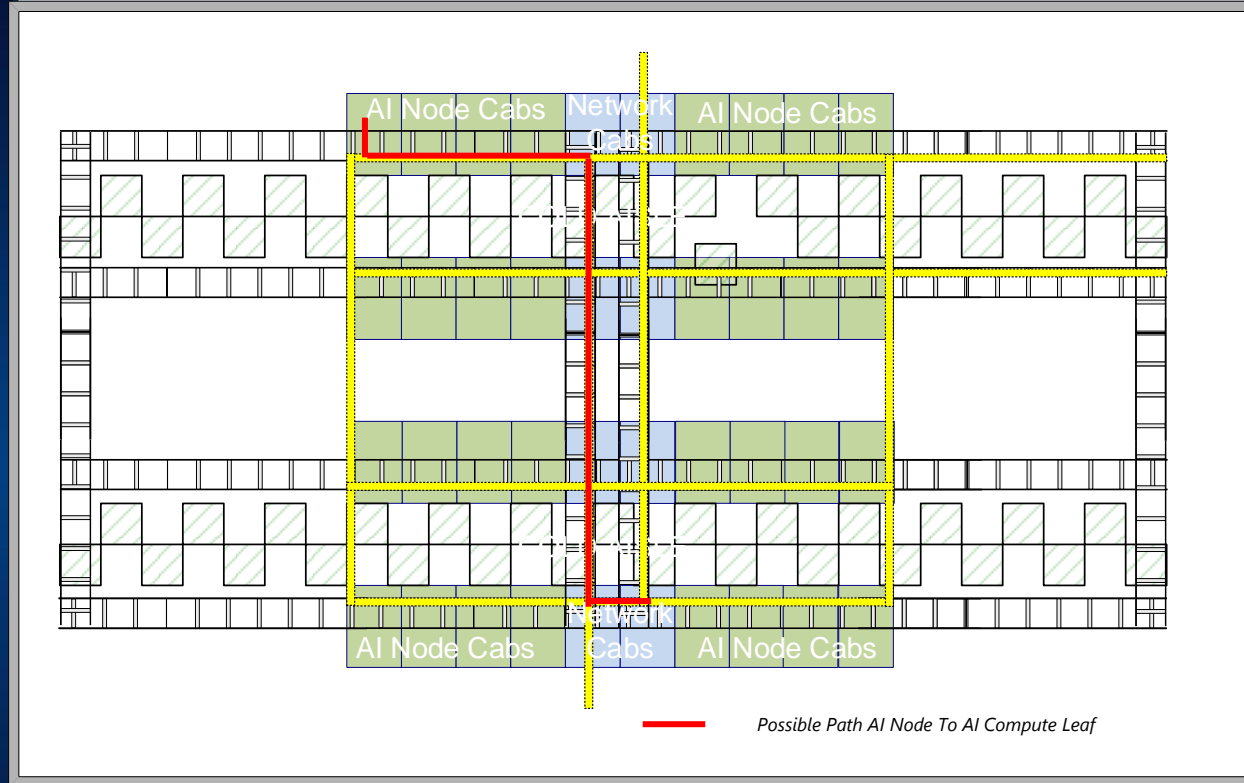
The Impact On Cable Run Lengths

- Distances impact optical budgets
- 50 metres maximum run length when spanning rows in a H100 configuration
- Use ULL fiber systems

Are Cable Ducts and Raceways Large Enough?

- Know the max fill ratio (70% worst case)
- Consider using 12 and 24 Inch Fiberguide©
- Check cable access In/Out of cabinets

Plan Ahead How To Dress In Cabling Bundles

- Ensure bend radii are maintained
- Patch lowest to highest device in rack

AI Node Cabs | Network Cabs | AI Node Cabs

AI Node Cabs | Network Cabs | AI Node Cabs

Possible Path AI Node To AI Compute Leaf

# of AI Nodes	# of Server Racks	# of Standard Units (SU's)	Approx. Number Cables (Fiber // Copper)
123	32	4	2,396+ // 317+

Commscope's Key Solution Set For Gen AI

To other clusters

AI Node

Plus Copper MiNO Cat6/6A for Out-of-Band Mgmt
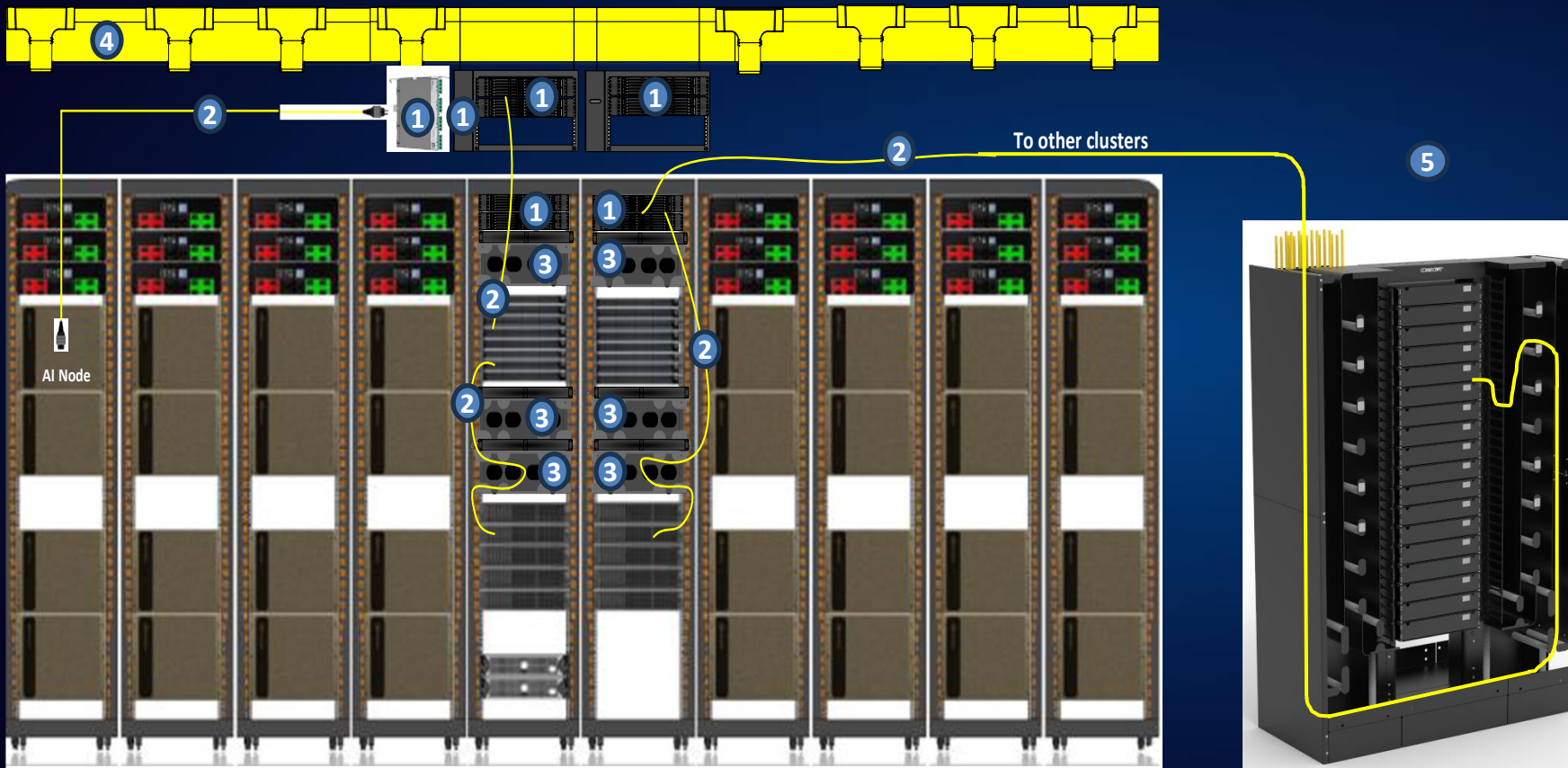
1 **Propel**
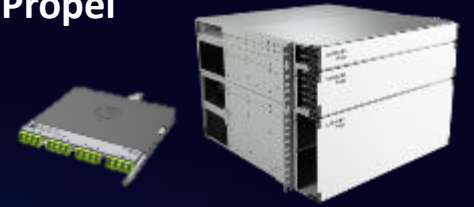
2 **MPO/VSFF Cable Assemblies**

3 **Cable Management Solutions**
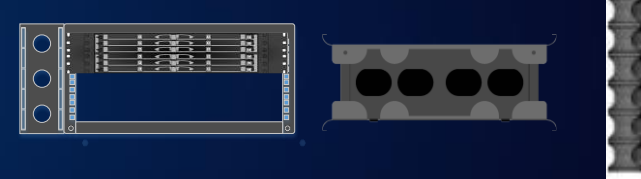
4 **FiberGuide**
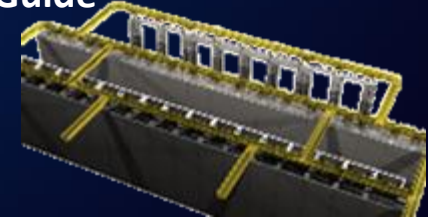
5 **Fiber Distribution Frames**

Gen AI Fiber Optic Cable And Connector Options
Trunk, Patch, & Day-2

EQUIPMENT CORDS:
APC (Angled Physical Contact) multimode & singlemode MPO connectors

MPO16   MPO8   MPO12   MPO24
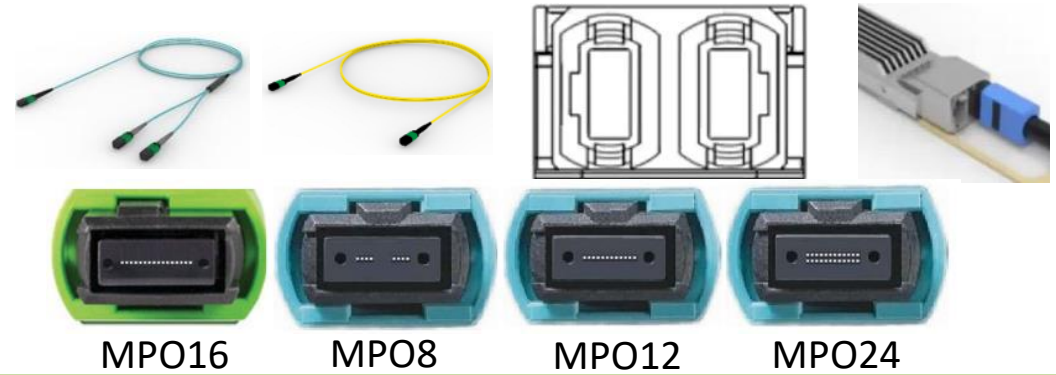
TRUNK CABLES:
Rollable Ribbon fiber cables save pathway space
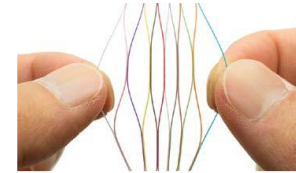
VSSF (VERY SMALL FORM FACTOR) ULTRA LOW LOSS (ULL) CONNECTIVITY, MULTI-PAIR MT:
High fiber count, Factory terminated quality through pathways (conduit and overhead), Save time and space

MMC16, 24   SN-MT
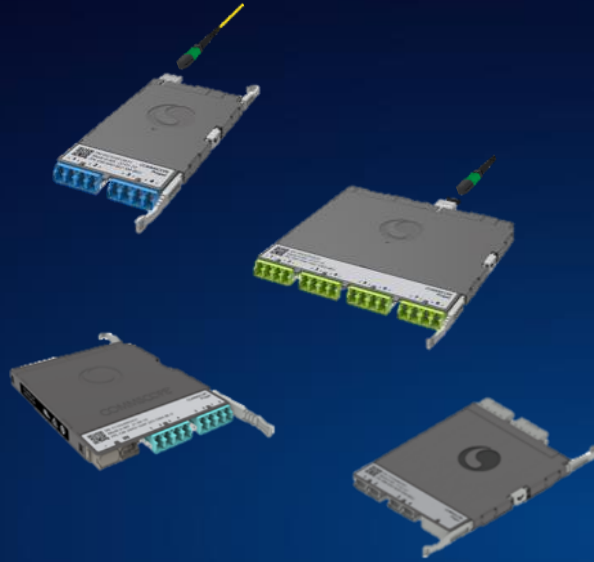
EXPANDED BEAM OPTICS (EBO) Developmental
No additional cleaning required, Day 2 simplicity on-site

EBO 12f, 16f

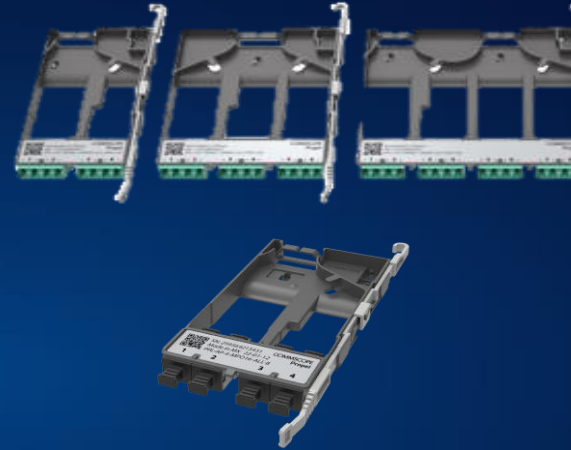# Propel™ Gen AI density aligned with **applications** & **future** in mind
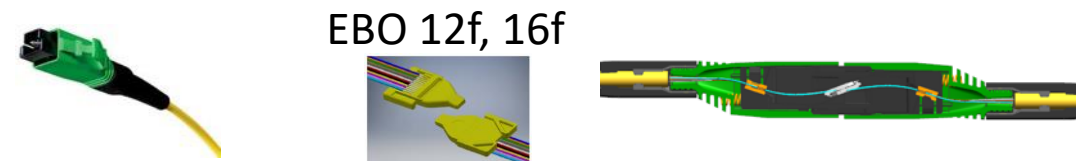
Panels

- 1, 2, & 4RU Sliding panels
- 72 Duplex LC/MPO per RU High Density (144f)
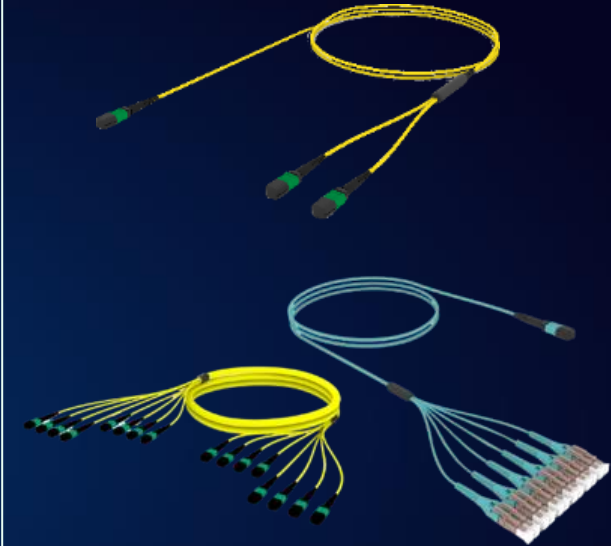- 144 SN per RU – Double Duplex Density (288f)

Modules & Cassettes (ULL)

- MM: LC, MPO8 & MPO16
- SM: LC, SN, MPO8/ and MPO16
- Front facing breakout
- Mesh 4x4
- CMODs (Cabled modules)

Adapter Packs / Splice Cassettes (ULL)

- LC, SN, MPO8, 12, 24 & MPO16
- Splice 12f, 24f
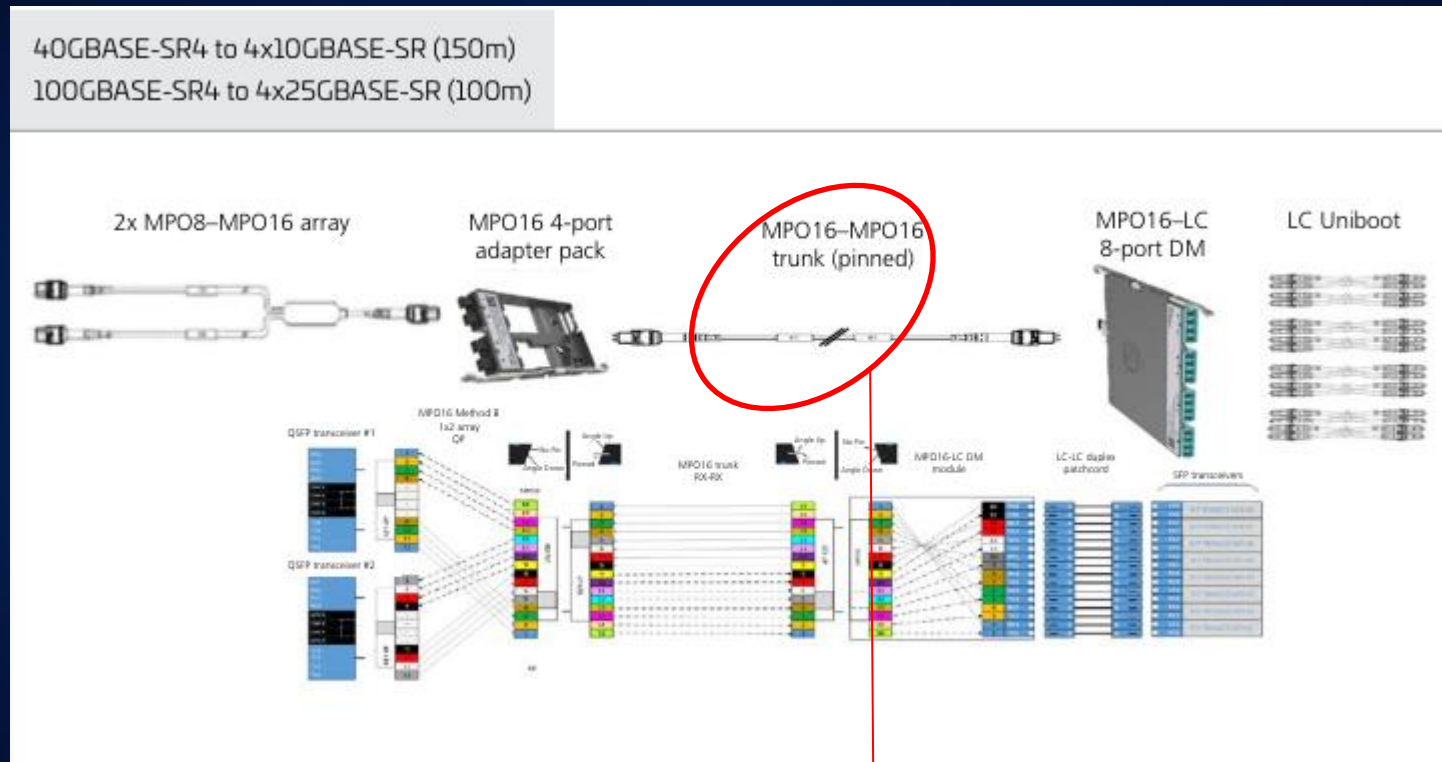
Cable Assemblies MM & SM APC options (ULL)

- MPO8, MPO12, MPO16, MPO24(MM only) Based Trunks
- Duplex LC Uniboot, SN, Patch and Array cable assemblies

Support for **multiple network generations** within the same panel

COMMSCOPE®

Fixed Structured Cabling Backbone = Best Way To Support Yearly Refresh Cycles

100G

4x 10/25G

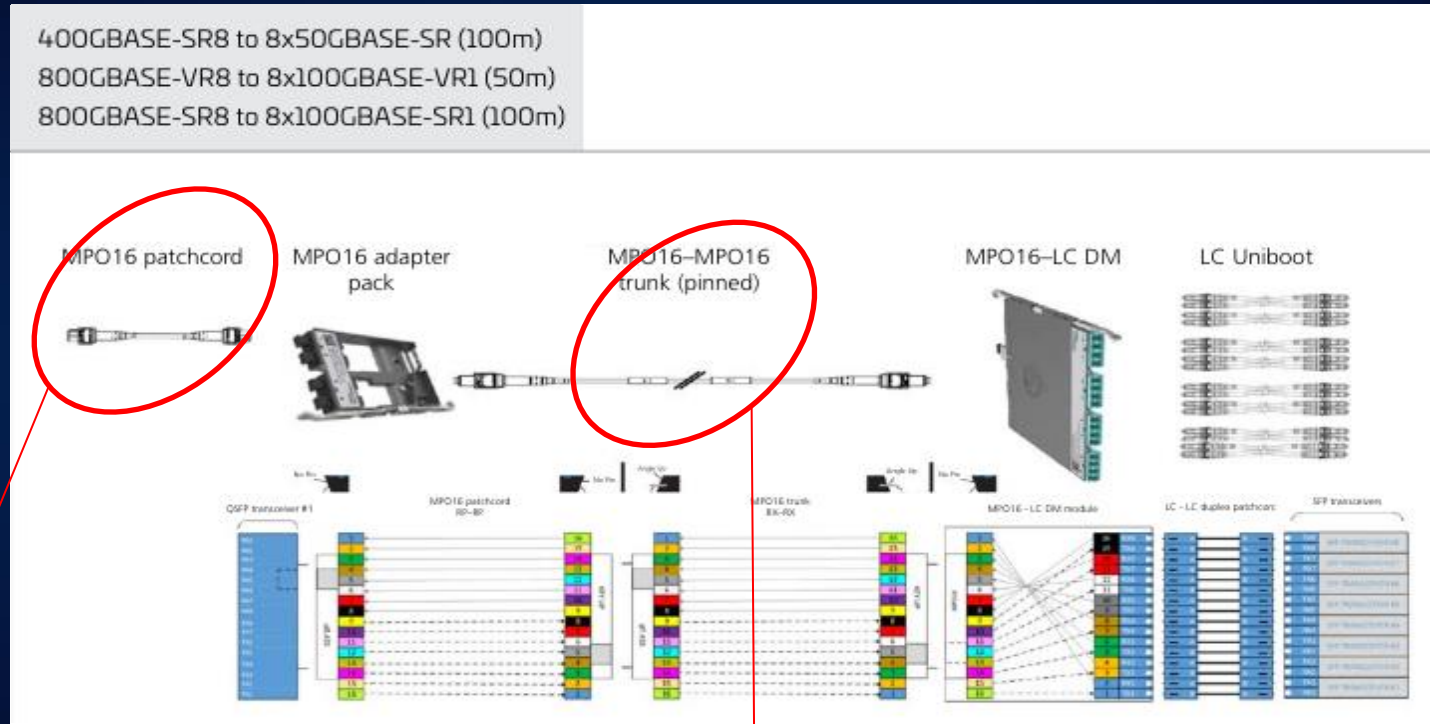
16F MPO APC Backbone

Gen AI Structured Approach To Support Yearly Refresh Cycle

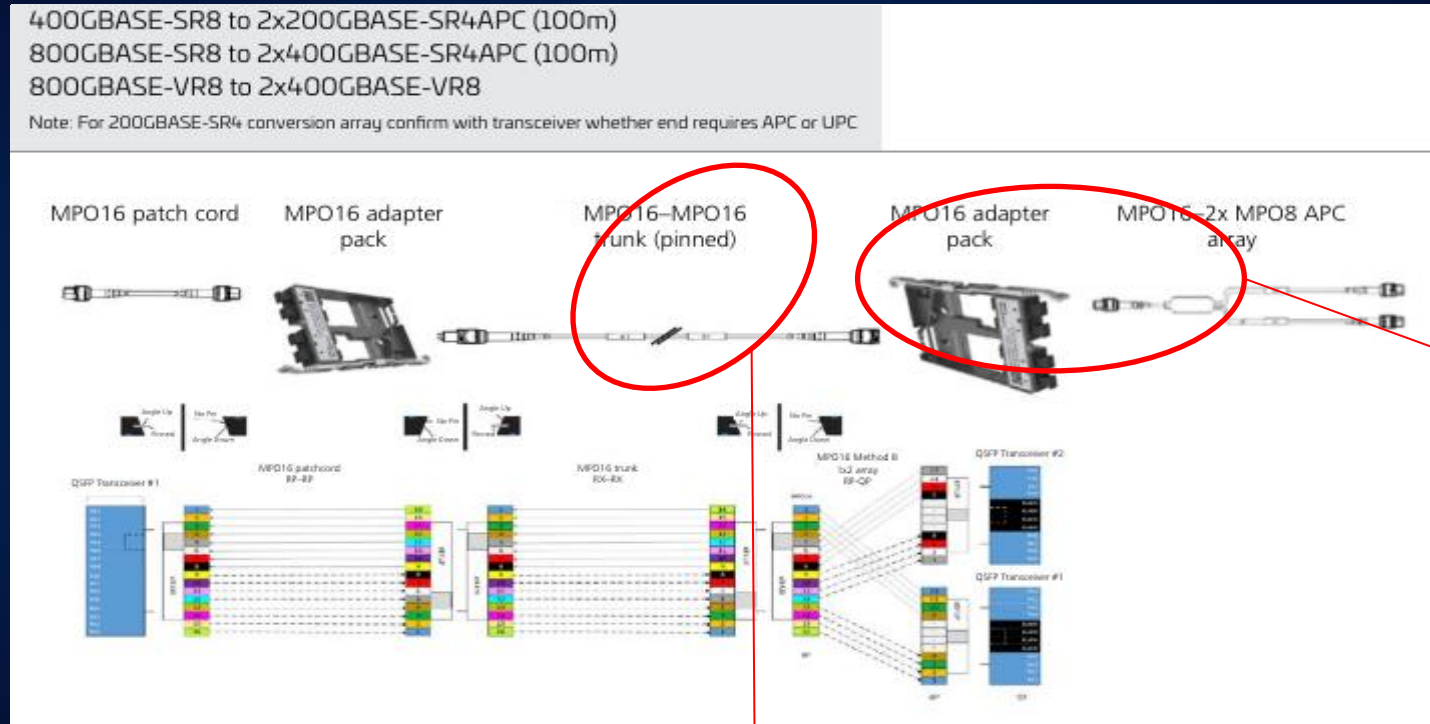400G   8x 50G

Replace a Patch Cord

16F MPO APC Backbone Remains

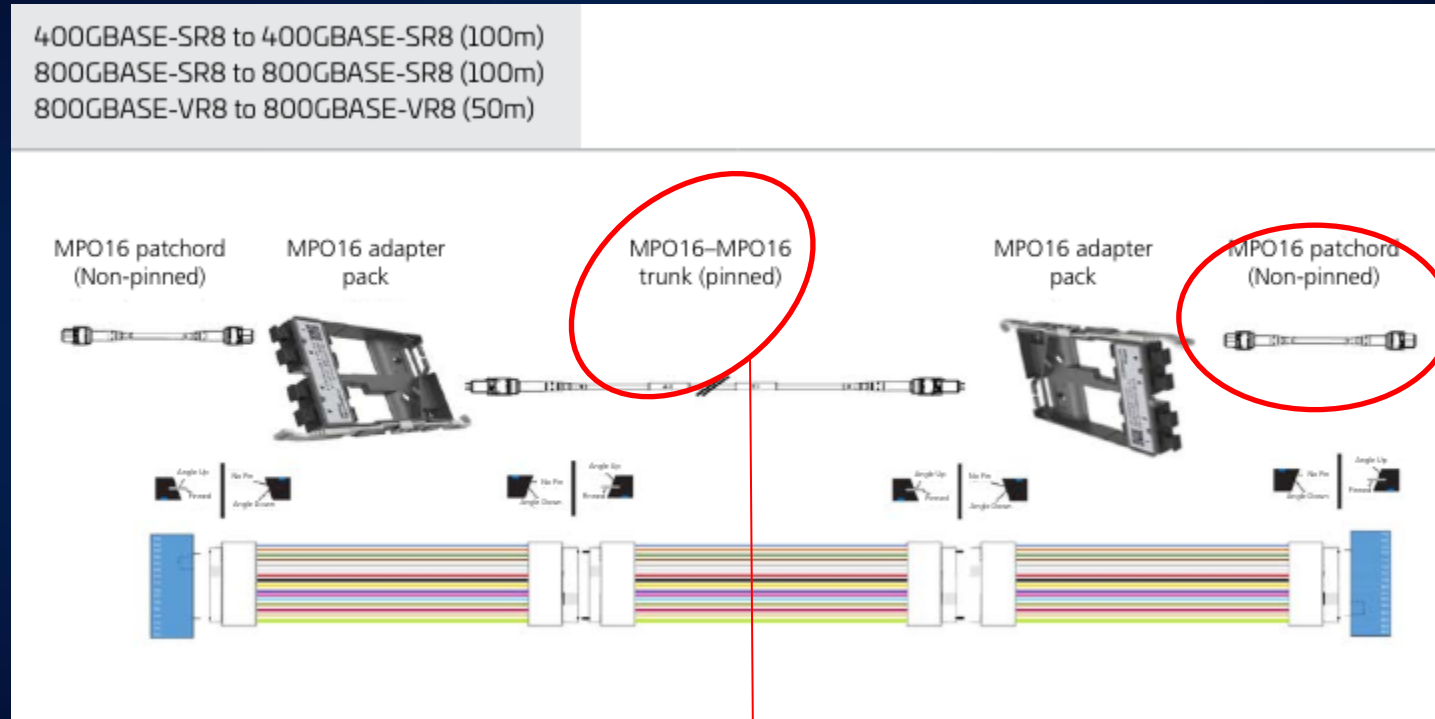# Gen AI Structured Approach To Support Yearly Refresh Cycle

800G

2x 400G

Replace a Patch Cord & Module

16F MPO APC Backbone Remains

Gen AI Structured Approach To Support Yearly Refresh Cycle

1x 800G   1x 800G

Replace a Patch Cord

16F MPO APC Backbone Remains

In Summary

- AI Is Growth Being Fueled By GPU's and new Service and Product offerings

- AI has 2x Networks – InfiniBand & Ethernet – Structured Cabling supports both

- 4x Speed change per year – 400G / 800G / 1.6T – Structured Cabling supports all speeds

- AI needs quality Structured Cabling components to support AI (APC / 16 Fibers / ULL) for extra design flexibility

- CommScope's Propel future proofed fiber platform, supports AI today and tomorrow